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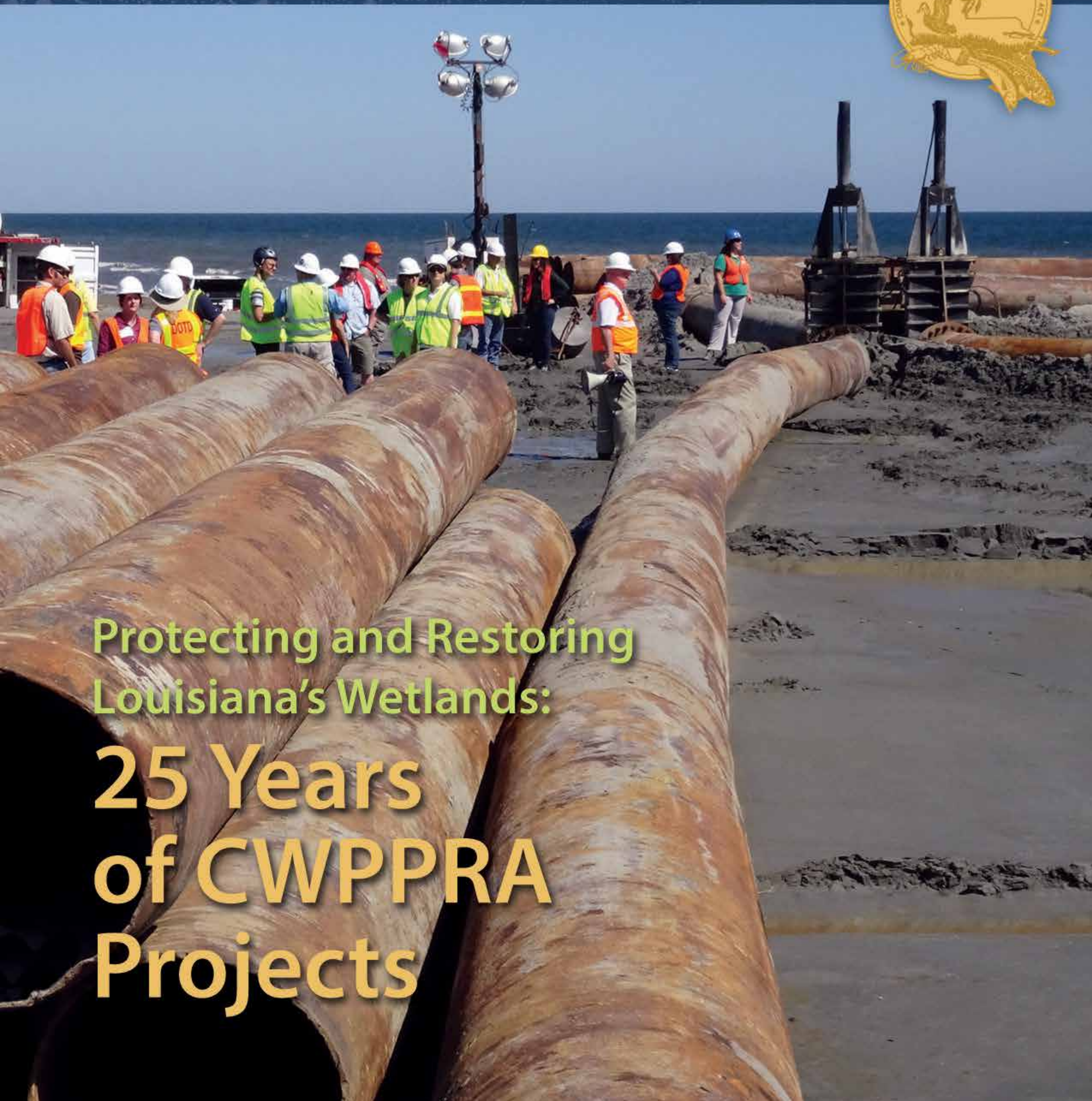
Louisiana Coastal Wetlands Planning, Protection and Restoration News

June 2016 Number 53



Protecting and Restoring Louisiana's Wetlands:

25 Years of CWPPRA Projects

June 2016
Number 53

WaterMarks is published two times a year by the Louisiana Coastal Wetlands Conservation and Restoration Task Force to communicate news and issues of interest related to the Coastal Wetlands Planning, Protection and Restoration Act of 1990. This legislation funds wetlands restoration and enhancement projects nationwide, designating nearly $80 million annually for work in Louisiana. The state contributes 15 percent of total project costs.

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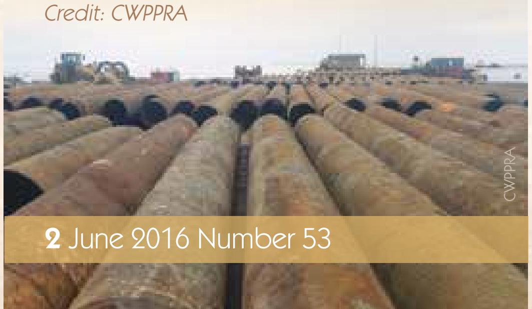
ABOUT THIS ISSUE'S COVER . . .

It's no small job: Restoring Louisiana's coastal landscape involves scores of people working in numerous disciplines, from biologists to heavy equipment operators, from sociologists to structural engineers. For more than 25 years, the Coastal Wetlands Planning, Protection and Restoration Act has brought together employees from five federal agencies and the state of Louisiana dedicated to the creation or maintenance of viable coastal wetlands.

Credit: CWPPRA



CWPPRA

WATERMARKS

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U.S. Environmental Protection Agency, Region 6

Sediment, sand fencing and vegetation – barrier islands need them all

Over 25 Years, CWPPRA Projects Prove the Power of Combining Techniques

Barrier islands: They don't look like much of a force to protect your home and your family, your land and your life. Nonetheless, Louisianans rely on these ancient remnants of a decaying delta, lying miles away from the mainland and seldom rising higher than a few feet above the water, as their first line of defense against gulf-spawned disasters.

For the past 25 years, barrier island projects conducted under the Coastal Wetlands Planning, Protection and Restoration Act (CWPPRA) have been refining techniques to increase the stability and prolong the lives of the islands. "Barrier island restoration is a continuous learning process," says Jeanene Peckham, a project manager for the Environmental Protection Agency (EPA). "Each CWPPRA project has increased the body of knowledge or has added some method or design to the restoration tool box."

Rejoining an island cleaved in two

Geologically speaking, it is the nature of barrier islands to be constantly on the move. Their sediment washes away in one place to drift ashore in another. In an undisturbed system, old islands turn to shoals and disappear while new ones emerge as a river changes its course. But CWPPRA has recognized that interventions to keep the Mississippi River in its banks – and to keep its banks where society finds them convenient – disrupt the entire scheme. The deterioration of the Isles Dernieres was illustrating how channeling river-borne sediment to spill off the continental shelf deprives the barrier island system of material to offset erosion.

Formed from the remains of Louisiana's hurricane-fragmented Last Island, the Isles

Often no more than narrow strips of sand rising only inches above sea level, the appearance of barrier islands belies their importance. Without them, coastal Louisiana would be directly exposed to gulf storms, surges and waves that erode wetlands and threaten communities and infrastructure lying beyond them.

Dernieres chain is an arc of five islands shielding the wetlands of Terrebonne Parish. When CWPPRA undertook its restoration, the chain was among the fastest-eroding barrier islands on the planet. All of the islands were narrowing and shrinking, eroding both on the gulf side and the bay side. Without restoration, the entire chain was projected to vanish by 2010.

To increase the barrier islands' longevity and preserve their protective functions, CWPPRA began a series of projects. On CWPPRA's first Priority Project List (PPL) in 1991, Isles Dernieres Restoration East Island undertook

- to increase the island's size with fill material dredged from a borrow site adjacent to the island
- to raise dune height to buffer storm surges
- to erect sand fencing to capture wind-blown sediment
- to stabilize the sediment by planting native species of vegetation

Construction of the East Island project was completed in 1998 and succeeded in expanding the island's acreage by 97 percent. Using the same techniques to achieve similar goals, the Isles Dernieres Restoration Trinity Island project was approved on the second Priority Project List and completed in the summer of 1999. Restoration of a third island in the chain, Whiskey Island, occurred concurrently with East Island and demonstrated the economy of conducting geographically proximate projects in quick succession.

With these three islands reinforced, restoration specialists turned their attention to the breach that had severed East Island from Trinity Island. Unlike the earlier East, Trinity and Whiskey projects, which dredged sediment from landward sites to the north and east, the New Cut Dune and Marsh Restoration project took material from a borrow site in the Gulf of Mexico to build beach, dune and marsh habitats. The sediment closed the breach completely and formed a continuous barrier to waves and storm surge. By adding sediment to the system, the project increased the structural integrity of the island chain.

The projects are proving that the combined use of dredged sediment, sand fencing and vegetative plantings is an effective method for restoring barrier islands. They have extended the life expectancy of the Isles Dernieres and the protection they afford to estuarine resources and to the land-based infrastructure lying to the north in coastal Louisiana. "Although the islands have taken significant hits from storms, the restoration projects are functioning as designed," says Patricia Taylor, an environmental engineer and team leader in the marine, coastal and analysis section of the EPA. "Despite the system being starved of sediment, material is still moving down-drift along the shoreline in a natural pattern."

Learning from barrier island restoration

CWPPRA scientists and engineers cite the following when discussing lessons learned from

U.S. Environmental Protection Agency, Region 6

The decline of Louisiana's barrier islands is largely due to sediment deprivation within the entire hydrological system. Pumping sediment from a source outside of the system and piping it to the island to increase its physical mass adds needed material to the system while increasing the protective capacity of the barrier island.


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the Isles Dernieres barrier island restoration projects:

Borrow material location: Taking sediment from a site within the same hydrologic system merely moves available material from one place to another without addressing the underlying problem of sediment deprivation. While potentially increasing costs for transport, locating borrow sites outside the system in the Gulf of Mexico introduces new and much-needed material for sustaining the barrier islands. In 2004, CWPPRA excavated a borrow site three miles off shore for the restoration of Timbalier, another island in the Isles Dernieres chain. Hurricanes in 2005 and 2008 eroded Timbalier's eastern shoreline but the sediment used to restore the island remains within the system, nourishing and extending the island's western end. Other CWPPRA projects have heeded this lesson by exploring distant sites from which to import material.

Borrow material characteristics: Both the early projects on East Island and Whiskey Island assumed that the excavated material would be of sufficient quality to self-stack without containment. When that proved incorrect, construction was delayed while containment dikes were built. Later projects analyzed available material before selecting a borrow site so as to ensure the sediment was appropriate for the project's design.

Sand fencing orientation: On East Island sand fencing was placed parallel to the shoreline. For subsequent projects, restoration specialists tested the efficacy of using a double row of fencing and of placing fencing in a zig-zag configuration. These experiments proved that, to capture sediment and build dunes, the optimum siting of sand fencing was perpendicular to the prevailing winds. To minimize loss after placing dredged sediment at a site, project leaders learned to erect sand fencing and plant vegetation as quickly as possible.

Dune design height and width: The elevation of natural dunes on Trinity Island was about two and a half feet, but the restoration project built dunes eight feet high. While a higher dune creates a more formidable obstacle to storm surge, the elevation prevents a naturally occurring dune habitat from developing. Further, fill material intended to increase the island's size buried a productive salt marsh and mangrove habitat, converting them to bare land. Designs for subsequent projects increased the likelihood of realizing natural habitats by building elevations of dune and marsh to match the existing landscape.

Planting vegetation by hand gives natural processes a boost. Plants help to stablize newly dredged acreage and nurture the development of an island's natural habitats.

Unconfined beach fill: Placing high-quality sediment on a beach without containment dikes invites nature to do the work. "Essentially we're introducing material into the environment where natural forces can shape and blend it," says Taylor. "On both Timbalier Island and New Cut, we placed sediment on the front edge of the dunes and let the waves work it into the system."

Diverse plantings: "Conditions on barrier islands are harsh," says Taylor. "We have to depend on natural forces to water and care for plantings. To increase the odds of survival, we've learned to mimic nature by providing different plant species for landscape diversity." Timbalier Island was the first barrier island project to use the now-common practice of installing eight or more plant species.

Hardscaping: Restoration projects on Raccoon Island used segmented breakwaters to trap sediment and reduce erosion. While achieving these goals, breakwaters are more disruptive to natural patterns of littoral drift and more expensive to build than is restoring an island using dredged material and vegetation. Analyzing projects on Raccoon Island and East Timbalier Island, on which a rubble seawall had been built prior to the CWPPRA project, engineers questioned the use of hard structures for barrier island restoration.

Maintenance: The first projects allocated no funding for maintenance, the concept being to restore an island and leave it to evolve naturally over the 20-year project life. Soon the need for a degree of maintenance became apparent – sand fencing may need to be repaired, sediment replenished to maintain elevation, or vegetation installed to encourage its quick spread into newly created areas. Including maintenance in a project's scope also ensures eligibility for funds from the Federal Emergency Management Agency should a natural disaster incur damage during the project's life.

An ongoing commitment to secure island benefits

CWPPRA's experiences have brought into relief some of the distinctive challenges of restoring barrier islands:

- the complexity of working with the intrinsically transient nature of barrier islands
- the importance of understanding the submerged part of an island system
- the difficulty of locating and transporting sediment of appropriate character and in sufficient quantity to nourish beaches and build marshes
- the obligation to address the public's expectation of permanence

"The measure of success of barrier island restoration depends on your point of view," says Taylor. "For an engineer, success may be measured by a project's performance over time, how well it withstands events. A project could be deemed successful if, at the end of its 20-year life span, the island is in the same condition as it was at the time of construction.

"But a coastal resident might determine success by the island reducing storm surge. A bird's standard of success may be finding habitat in which to nest and raise its young. Resiliency of design, meeting project goals, restoration of habitat for endangered species – all of these factors comprise success of a barrier island restoration."

Taylor points out that if nothing is done the islands will disappear. "It's not uncommon to continually nourish beaches," she says. "It's done all over the country, primarily to support recreation and improve tourism. Sometimes people don't realize the value of Louisiana's barrier islands, 15 miles from the mainland, but they are a vital part of the coastal ecosystem. As long as we want the benefits that the islands provide, we will have to pay the cost of restoring them."

U.S. Environmental Protection Agency, Region 6

Fencing traps sand to increase the island's mass. Vegetation helps to secure the soil, reducing loss from wind and wave action during storms.

U.S. Fish & Wildlife Service

Testing methods to force out unwelcome water and salinity

Hydrologic Restoration Matures as a Component in Many CWPPRA Projects

The way that water flows in Louisiana's wetlands has been manipulated ever since humans figured out how to control it for their own purposes. Whether building levees for flood protection, draining marshes for farming or development, or dredging canals for navigation or resource extraction, coastal Louisianans have pursued their social and economic goals in a wetland environment that was seemingly endless and eternal.

But within the past decades the results of altering the wetlands' hydrology have become evident: Disrupted drainage patterns create ponds, impoundments and waterlogged marshes. Infiltrating salt water kills freshwater plants; their root mass disintegrates and the soil falls apart. Without waterborne sediment and nutrients to replenish them, the wetlands deteriorate and sink.

Hydrologic restoration projects conducted under the Coastal Wetlands, Planning, Protection and Restoration Act (CWPPRA) have attempted to return sites of altered hydrology to a more natural condition. By controlling the level and flow of water, projects have reduced expanses of waterlogged marsh and reduced saltwater intrusion. Over the years, CWPPRA's techniques have been as simple as plugging a canal with rock and as elaborate as building electrically operated structures of concrete and steel.

Portrait of a hydrologic restoration project

After construction of the Calcasieu ship channel nearly a century ago, wetlands in the Calcasieu-Sabine Basin slowly began converting from freshwater to intermediate marsh and from intermediate marsh to brackish and saline. Degradation continued as saltwater circulated through the numerous small access canals now connecting once separate bayous. Drainage patterns disrupted by construction of navigation and mineral

While some hydrologic features are quite simple and rely on gravity to operate, others, such as this one in the Sabine Wildlife Refuge, are complex mechanical structures requiring electrical power to raise or lower multiple gates.

extraction channels left low, interior marshes waterlogged behind spoil banks for extended periods of time. Erosion along lengthening lake and navigation shorelines threatened the highly organic marsh soils and the salt-intolerant plant communities they support.

The Sabine National Wildlife Refuge lies within the Calcasieu-Sabine Basin. In the 1970s, two weirs with gates and one culvert were installed in an effort to manage hydrology in the eastern portion of the refuge. However, their design proved inadequate to control the inflow of salt water and to drain waterlogged marshes. Within 20 years, corrosion had severely curtailed even the limited functionality of the structures.

Under the federal sponsorship of the U.S. Fish and Wildlife Service partnering with the state of Louisiana, the CWPPRA project Replace Sabine Refuge Water Control Structures at Headquarters Canal, West Cove Canal and Hog Island Gully sought to curtail saltwater intrusion, enhance the discharge of excess water from the marshes and increase opportunities for ingress and egress of estuarine-dependent species. The project replaced the three existing, inadequate structures with

- a structure at Hog Island Gully Canal with four 7½ -foot-wide gates, three of which have exterior flap gates, and two 3-foot-wide gates, providing a total area of 306 square feet. Assuming that the water level is at marsh elevation, each gate is 8 feet deep. Each opening is equipped with slide gates that can preclude all water flow.
- a structure at Headquarters Canal with three culverts 5 feet in diameter, providing a total area of 59 square feet. The top of each culvert is at marsh level and is equipped with an exterior flap gate that can be raised, closed and

U.S. Environmental Protection Agency, Region 6

Cutting gaps into spoil banks releases water from impounded areas and encourages more natural drainage patterns to develop. Projects improving hydrology in boggy areas such as in the Lac des Allemands watershed foster the return of vegetation and the creation of habitats that thrive in a healthy swamp ecosystem.

After modeling and study, CWPPRA fashions a low-cost solution to a common problem

The CWPPRA project to address ecological degradation in the Lac des Allemands watershed (Hydrologic Restoration and Vegetative Planting in the des Allemands Swamp) was approved for PPL 10 in 2001. The proposed strategy called for installing two siphons to bring sediment- and nutrient-laden Mississippi River water into the area, cutting gaps in spoil banks, installing culverts and planting trees.

As the project moved through the initial phases of engineering and design, restoration specialists began to figure the real costs of acquiring land rights and digging a canal across roads and through a town to bring river water into the Bayou Chevreuil. Weighed against the cost, the anticipated benefit of the siphons dwindled.

The project's sponsors, Louisiana's Coastal Protection and Restoration Authority and the Environmental Protection Agency, studied possible modifications to make the project viable. Increased precision in modeling allowed engineers to predict the effectiveness of the project without the siphons. "We focused on an impounded area of about 2,400 acres," says Garvin Pittman, the CPRA project manager, "and modeled how cutting gaps in spoil banks at different places and at various depths affected nutrient delivery, water levels, drainage patterns and tidal exchange. When we determined the best approach to restoring the conditions of a healthy, freshwater cypress swamp, we revised locked. The center culvert has a sluice gate.

- a structure at West Cove Canal with three 7½ -foot-wide gates, two of which have exterior flap gates, and two 3-foot-wide gates, providing a total area of 242 square feet. Assuming that the water level is at marsh elevation, each gate is 8 feet deep and is equipped with slide gates that can preclude all water flow.

Approved in 1994, construction was completed in 2001, but the project was not immediately fully operational. Malfunctioning electrical service to the large structures at Hog Island Gully and West Cove canals prevented their performing according to design. In 2005 Hurricane Rita battered the project, and Hurricane Ike aggravated the damage in 2008. Nevertheless, the structures succeeded in reducing the frequency of spikes in salinity and water levels compared to pre-construction rates.

Modified and repaired, the structures have been fully operational since 2011. The gates precisely control the inflow of saline water into thousands of acres of interior brackish and intermediate marshes. With increased capacity to evacuate water from marshes of low elevation after rain or flooding events, the structures reduce the frequency and duration of waterlogging stress on vegetation. The existing vegetative communities are being maintained, and emergent and submergent vegetative growth is enhanced.

Lessons learned from hydrologic restoration

The concept of hydrologic management is simple: obstruct or increase water flow, depending on the intent. In its early days, CWPPRA conducted numerous hydrologic restoration projects; 27 were approved on the first six Priority Project Lists (PPL). In contrast, no hydrologic restoration project was a candidate for PPL 25 in 2015. However, this does not mean that hydrologic manipulation is no longer undertaken; rather, hydrologic features are incorporated into other project designs.

"In a very basic sense, a diversion distributing sediment-laden water over an area is a hydrologic restoration project," says Darryl Clark, a senior fish and wildlife biologist with the U.S. Fish and Wildlife Service. "Many projects incorporate the goals and even the technologies of hydrologic restoration, but after 25 years of on-the-ground experience, CWPPRA has learned that the aim of restoring a marsh is better realized by combining hydrologic controls with other approaches."

Compared to marsh creation techniques that require little maintenance, costs for operating and maintaining hydrologic restoration projects are high. "While some methods of hydrologic management are passive, relying on gravity to move water through culverts or over weirs, many projects require operations," says Clark. "Whether it takes two people in a boat all day to remove stop logs from variable crest weirs spread throughout a marsh or one person to push a button and close a slide gate, we've learned that personnel is essential to these projects functioning properly."

the project to eliminate the siphons, improve hydrology by using gaps and culverts in impounded areas and reestablish the forest by planting tree seedlings."

In June 2013, the CWPPRA Task Force approved the project's new scope and in January 2016, approved its funding. "The impounded area has been degrading slowly for years," says Barbara Aldridge, EPA's project manager. "Once we construct the project's hydrologic restoration features, annual monitoring will indicate if the swamp is responding as we expect it to. We'll evaluate the condition of the gaps and the health of the cypress and tupelo seedlings and undertake whatever maintenance is needed to reverse the present trajectory of this weakened ecosystem."

The project illustrates the flexibility of the CWPPRA program to incorporate new information and ideas even after a project is under way. "Adaptive management is built right into the process," says Pittman. "Because this project includes funds for a 20-year monitoring and maintenance program, scientists and engineers will be observing and adapting its operations to the end of its life."

The first CWPPRA project to restore a swamp ecosystem, Hydrologic Restoration and Vegetative Planting in the des Allemands Swamp will likely inspire other efforts throughout coastal Louisiana. "The same problem – impoundments due to roads, railway beds, neighborhoods and other man-made obstacles – occurs in many places," says Pittman. "This inexpensive CWPPRA project could easily be adapted by parishes, refuges and other localities. The project will provide them with before-and-after data to show results and justify spending the money. The project presents a prototype for swamp restoration."

Nature itself seems to be throwing up challenges to conventional hydrological techniques. "Marshes at the mouth of the Mississippi River are sinking at an accelerated rate, making the operation of structures problematic," Clark says. "A rising sea level increases the difficulty of draining water off the marshes. As changing ecological conditions diminish the efficacy of some of our methods, some people suggest expanding the use of pumps to move the water. But pumps require operators, driving up costs and driving down reliability, and pumps do not allow the movement of fisheries in and out of the managed marshes."

Each of CWPPRA's hydrologic restoration projects has added insight and refined techniques to increase the effectiveness of managing water to enhance marsh recovery. Some lessons have pertained to the engineering and design of hydrologic structures:

- Remotely operated electrical controls may fail in a hurricane.
- Heavy flap gates may not open as desired when there is little difference in water pressure on either side of the gates.
- While concrete withstands waves and salt water, structures built of aluminum and wood corrode and decay, seldom lasting 20 years.
- Computer modeling can test design options to determine which are likely to achieve project goals most efficiently and effectively.
- Modifying a structure after observing its operations can significantly improve its performance.
- Projects that require operators or maintenance are likely to diminish the performance and increase the expense of wetland restoration.

Some lessons have influenced how subsequent CWPPRA projects have been conducted:

- Goals and objectives of projects are stated with specificity.
- Land rights at the project site are acquired early in the process.
- Reference areas within project sites are designated so that conditions can be compared and the effects of a project determined.
- A continuous record of site conditions is now standard.
- Changes in salinity and tidal exchange, along with biomass, are factors to consider in assessing a project's achievement.
- The effectiveness of a project cannot be adequately determined within its first three years.

The yardstick for measuring marsh recovery is the kind and coverage of vegetation growing in the designated area. While an increased floral presence suggests stabilization of land mass and possibly even gains in acreage, plant species indicate how saline the waters are and whether the marsh is of the type desired – freshwater, intermediate or brackish. Comparing present vegetation to that of earlier times reveals the impact of hydrologic restoration on the targeted wetlands.

"It's easy to determine the short-term effect of a hydrologic restoration project," says Clark. "Recording changes in water levels and testing salinities on either side of a structure quickly indicate a project's influence. But it may take years to determine if those changes are successful in achieving the ultimate goal of helping a marsh to recover and thrive." WM

Darryl Clark, U.S. Fish and Wildlife Service

Hydrologic features don't have to be fancy to be effective. Simple structures consisting of flapgated culverts and the elemental force of gravity can improve hydrological conditions by accomplishing such things as forcing water from areas of excess fresh water or preventing the ingress of salt water.

USDA Natural Resources Conservation Service

Shielding shorelines with materials old/new, natural/fabricated, living/inert

Innovations Invigorate CWPPRA's 25-year Battle for the Marsh Edge

In coastal Louisiana, causes both natural and man-made have been driving land-loss rates for decades. Combining with storms, sea-level rise and subsidence, flood protection levees and channels constructed for navigation or for oil and gas pipelines have weakened the wetlands and multiplied the miles of marsh edge vulnerable to erosion. As shorelines succumb, water bodies merge, and these enlarged expanses of open water intensify the erosive forces of wind and wave energy.

To slow erosion in Louisiana's marshes, the Coastal Wetlands Planning, Protection and Restoration Act (CWPPRA) has conducted numerous shoreline protection projects. For 25 years, CWPPRA's scientists and engineers have been testing various materials and techniques to determine which provide the most effective shoreline protection under the wetlands' challenging conditions.

Searching for alternatives to rock

Old as the Earth itself, rock was and remains the first go-to material for shoreline protection. Facing the onslaught of wind and breaking waves, stone does not budge. Impervious to weather, rock endures. Consequently, tons of rock have been imported from out-of-state quarries to armor miles of shoreline in Louisiana's wetlands.

"Numerous projects have used rock quite effectively," says Quin Kinler, a resource conservationist with the Natural Resources Conservation Service. "But rock is heavy, and there are places where our wetlands' soft, organic soils will not support its weight. The rock simply sinks below the surface of the water. For these places, we need something else."

One such place is in the Barataria Basin, where the tidal

Nothing beats rock to dash waves and protect land and vegetation from erosion, but sometimes Louisiana's wetlands' soft soil cannot support its weight. Scientists and engineers are rising to the challenge to invent durable alternatives for protecting vulnerable shorelines without diminishing the wetlands' ecological functions.

marshes of the lower basin are separated from the freshwater marshes of the upper basin by a dwindling strip of land. To keep the two systems from joining into a single, large body of water and to prevent the freshwater system from converting to salt water, in 1998 CWPPRA approved the Barataria Basin Landbridge Shoreline Protection project. Construction of the first of its four units began in 2001. "We knew at the outset that using rock in this area faced a problem," says Kinler, who served as the project manager. "To determine the areas that would support rock, we conducted an extensive geotechnical analysis of soils 30 to 50 feet deep. For areas that would not support rock, we looked for other materials and techniques."

Because of the size of the site, the work was performed in several phases. This allowed testing five innovative types of shoreline protection, each using different materials and installation methods. At regular intervals over the course of a year, each type was evaluated for constructability, stability and applicability in the project area. Proving superior in structural stability and with lower maintenance costs, the concrete pile structure was selected for the project, adding another choice to the roster of shoreline protection methods.

Satellite images reveal the effectiveness of shoreline protection along the Barataria landbridge. Outside the barriers, the water is rough and choppy. Inside, the water shimmers like silk. With the concrete pile structure serving both to deflect wave action and to contain marsh-nourishing sediment deposited on its landward side, clumps of vegetation grow toward the protective line.

CWPPRA learns the power of combining techniques

To reduce erosion, the Barataria landbridge project took an old and time-tested approach – fortifying shorelines with an impermeable barrier – and used new methods and materials adapted to the site's conditions. But Louisiana's soils and shorelines vary; rock and fabricated walls are not appropriate in every location. Some of CWPPRA's shoreline protection projects have relied on hardscape; some have tested experimental ideas and explored the synergy of combining approaches.

Live and inert materials secure a shoreline

Although vegetation cannot survive where erosion is severe, Kinler says, plants can protect a shoreline from minor problems. Projects often combine vegetative plantings with other techniques to encourage the development of marsh habitat and stabilize land accretion. Completed in 1995, the early CWPPRA project Boston Canal/ Vermilion Bay Bank Protection used rock dikes to shield the banks of the bay and the canal

A concrete barrier effectively stills wave action and allows sediment to accrete and vegetation to take root on its landward side. Experimental in design and construction, the concept was one of five tested in the first phase of the Barataria Landbridge project and proved to be the one best suited for conditions in the project area.

USDA Natural Resources Conservation Service from wave-induced erosion. In addition, approximately 14 miles of Vermilion Bay's shoreline was planted with smooth cordgrass (*Spartina alterniflora*) to buffer waves and decrease erosion. At the end of the project's life, in 2015, land had been built in open water behind the dikes on both sides of the canal, although some erosion was occurring along the structures' flanks.

Sediment-trapping earthen terraces join the fight against erosion

In Little Vermilion Bay, wind and waves eroded shorelines and prevented sediment from settling. To reduce wave action and increase sediment deposition, the 1996 Little Vermilion Bay Sediment Trapping project took material dredged from the Gulf Intracoastal Waterway and built 23 earthen terraces, totaling 33 acres, and planted them with smooth cordgrass (*Spartina alterniflora*). Fourteen years after the terraces were built, most were in very good condition. Flora had expanded significantly, with emergent vegetation becoming established between terraces.

Renourishing dunes and restoring marsh rejuvenate a headland's borders

Severe shoreline retreat at West Belle Pass Barrier Headland weakened protection of interior marshes and landward infrastructure. To increase the headland's longevity and prevent it from breaching, West Belle Pass Barrier Headland Restoration project, authorized in 2006, rebuilt the beach and dunes and restored the back barrier marsh with material dredged from the navigation channel Belle Pass. Constructing a wide, back-barrier marsh platform is apparently contributing to extending the headland's longevity.

Offshore breakwaters and vegetative plantings combine to build oceanfront land

In 1996, the Raccoon Island Demonstration project proposed that segmented breakwaters could reduce erosion by diffusing wave energy off shore and promoting sediment accretion along the beach. Following the success of the demonstration, in 2002 CWPPRA authorized the Raccoon Island Shoreline Protection and Marsh Creation project, which doubled the number of breakwaters, added a small jetty, or groin, and built a back marsh platform. The project succeeded in increasing the island's footprint and preserving it through several severe storms. Plantings to restore native vegetation will complete the project.

The promise of protecting shorelines with living walls may yet be realized

Proposing to deliver the dual benefits of abating shoreline erosion and enhancing oyster production, in 2007 the Terrebonne Bay Shore Protection Demonstration project installed six experimental fabrications for protecting shorelines while providing a structure for oyster colonization. To varying degrees each material is proving effective in performing both tasks, but with the installations less than ten years old, no conclusion can yet be drawn as to the viability of using oysters to build long-term and self-renewing shoreline protection.

Lessons from CWPPRA's shoreline protection projects

Since 1991, CWPPRA has conducted more than 30 projects to protect shorelines of lakes, bays, canals and beachfronts. Using the results of early projects to modify and improve current techniques, CWPPRA has contributed significantly to developing effective approaches to shoreline protection in Louisiana's coastal environment. Lessons from the last 25 years include

- Pre-construction soil borings, surveys, and geotechnical investigations are essential to successful projects, as is correctly determining elevations of dikes and structures.
- The distance and orientation of structures relative to the shoreline influence their performance and must be adapted to conditions at each site.
- Louisiana's soft marsh soils cannot always support the weight of using rock to armor shorelines.
- Depending on the strength of underlying soils, rock dikes may sink somewhat. Project maintenance should anticipate adding rock to preserve appropriate elevations.
- Using impenetrable materials to shield shorelines from erosion may disrupt ingress and egress of marine organ-

Disappointment becomes the springboard to success

In 2004, the CWPPRA project Bayou Sale Shoreline Protection was promising to reduce wetland loss along the eastern shoreline of East Cote Blanche Bay by using rock dikes to deflect the wave energy generated over open water. The project had received CWPPRA approval and funding when, in the engineering and design phase, restoration specialists confronted several intractable problems: Shallow water conditions challenged accessibility, subterranean oil and gas infrastructure presented obstructions, and soft soils in the project area proved incapable of supporting the weight of rock. With no proven alternative to rock, the project team was unable to identify a shoreline protection technique that would address site conditions within the anticipated budget. The project was deauthorized.

But this disappointment inspired the search for new approaches, culminating in CWPPRA's Non-Rock Alternative to Shoreline Protection Demonstration project. Casting a world-wide call for proposals, the project assembled a multi-disciplinary team that subjected respondents to a rigorous evaluation, ranking each on 40 criteria. Four of the highest-ranking proposals were funded to test in the "worst of the worst" conditions that Louisiana had to offer.

"Three proposals were installed between November 2013 and May 2014 and the fourth in November 2015," says Loland Broussard, a civil engineer with NRCS and the project manager. "Historically, the shoreline at the test site was losing 50 feet or so every year. Soils here are semi-fluid as far as 18 feet down. If a new concept proves effective and durable at this site, we can confidently believe it can be used anywhere."

Buoyancy Compensated Erosion Control Modular System

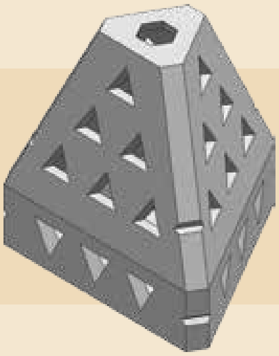
Individual modules of four-sided, Styrofoam-filled concrete shells, sloped to the front and rear with an enclosed bottom, are placed in approximately 5 feet of water and secured to one another with cables to form a continuous line parallel to the shore.

Contractor: Jansen, Inc., Ferndale, Washington

Wave Attenuation Devices (WAD®s)

Each individual modular unit is a pyramid-shaped concrete structure with tapered triangular openings on each of its three sides. Units are are connected to each other at the base and placed in a double row parallel to shore in approximately 4 to 5 feet of water. The design significantly reduces the energy of waves as they pass through the structure.

Contractor: Living Shoreline Solutions, Inc., Dade City, Florida



EcoSystems Units

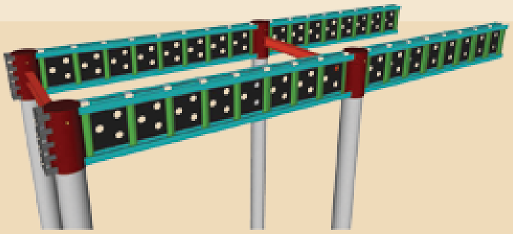
The pile-supported, 12-inch-tall concrete units, adjustable to any water depth and wave height, convert wave energy to calm water. Each custom-molded unit, weighing approximately 1,100 pounds, is made of concrete reinforced with fiberglass and doesn't sink. Averaging eight units per pile, piles are driven on a five-foot center and allow a 0.2-foot gap between units.

Contractor: Walter Marine Artificial Reefs, Inc., Orange Beach, Alabama

Integrated Shoreline Solutions – Wave Screen System

Two vertical walls made of perforated HDPE sheeting and supported by steel pilings are installed alongside each other in a straight configuration parallel to the shoreline. The base of a wall set in approximately 4.5 feet of water rises 1 to 1.5 feet above the bay bottom.

Contractor: Royal Engineers & Consultants, Inc., Lafayette, Louisiana



Images used by permission of the contractors

Monitoring will continue until May 2017, but preliminary results from the three early installations are promising. Compared to the reference area, in which the historical trend of land loss continues, shoreline loss rates have dropped by 90 percent, to less than five feet a year. Although protection is the goal, trapped sediment and land accretion is a complementary benefit.

Each technique offers an advantage to overcoming the environmental and physical challenges to shoreline protection, whether it be a design with no component that penetrates the subsurface, or with dual capacity for dissipating wave energy and maintaining transport of marine organisms to the shore, or with materials that increase buoyancy while distributing weight.

This is not the first CWPPRA demonstration project to seek alternatives to rock, and its design incorporated lessons learned from the others. "One stipulation for proposals was longevity of materials," says Broussard, "and we quite purposefully selected a site that would be a rigorous testing ground to be sure a non-rock alternative will survive in Louisiana's challenging environment."

For 25 years CWPPRA has explored the limits of tried and true techniques and has supported the development of innovative, effective, affordable approaches to protecting vulnerable shorelines and the ecosystems that lie beyond them. These new approaches excite hope in coastal areas worldwide. Any community threatened by erosion or confronting the risks of sea-level rise may be looking to Louisiana for information, inspiration and insight to meet their challenges.

isms, whereas penetrable barriers do not prevent salt water from entering interior marshes.

- In addition to deflecting wind and waves, physical barriers may serve to restrain dredged material deposited to nourish a marsh.
- Plantings can help to stabilize and secure a protected shoreline but by themselves will not survive in highly erosive areas.
- While typically not requiring operation, structures should be inspected regularly to prevent or arrest failure.
- Materials used for shoreline protection need to withstand wetland conditions, including sun, salt water and wave energy, for at least the typical 20-year life span of a CWPPRA project.

Land loss in Louisiana continues to endanger not only the coastal ecosystem but the well-being of a nation that depends on the region for seafood, shipping and oil- and gas-industry infrastructure. "Drastic times require drastic measures," says Kinler. "By testing new techniques and approaches, CWPPRA's shoreline protection projects are demonstrating ways to address the worst cases of erosion in order to give the wetlands a chance to survive and recover." WM

U.S. Environmental Protection Agency, Region 6

Experience has improved the implementation of even simple measures to rebuild Louisiana's coastal landscapes. Learning the best direction to set sand fences and the best methods of establishing native vegetation has increased the potential for success in CWPPRA projects over 25 years.

WATERMARKS

Louisiana Coastal Wetlands Planning, Protection and Restoration News

June 2016 Number 53

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DR. MARGARET REAMS, Associate Professor, Department of Environmental Sciences, Louisiana State University, Baton Rouge; Spring 2009

Any meaningful solution will cause major changes in the coastal landscape. That feels threatening to the many groups who … have a stake in the wetlands. ... In a democracy, science will never have the final word in forming public policy. But it's vitally important that scientific knowledge is available to every party that influences the policy-making process.

TED FALGOUT, Director, Port Fourchon; Fall 1998

If we're going to have any hope of handling the massive problem of coastal wetlands loss, it's going to be because the sometimes adversarial relationships between government and industries like [Port Fourchon] have been replaced by partnerships.

SHERRILL SAGRERA, Board Member, Coalition to Restore Coastal Louisiana; Spring 2001

The coast slipping away isn't just a statistic—it's often happening just beyond our backyard. … What [Cajuns like me] have to offer isn't science, but it's real-life experience. … science needs the sense of urgency that can only come from experiencing the collapse of our coastal wetlands firsthand.

DENISE REED, Professor, Earth and the Environment, University of New Orleans; Summer 2007

We can make Louisiana look like it used to, but it wouldn't be sustainable — it would continue to deteriorate. … If the goal is to return the ecosystem to a level of sustainability so that land loss is slow and balanced by gain — that goal can be achieved.

MEAD ALLISON, Professor, Earth and Environmental Sciences, Tulane University; Fall 2005

Whatever we do in restoration won't be a permanent fix. If we successfully restore a barrier island or marsh, it's possible that a single major hurricane will slice it up again. But … it will have done its work by protecting thousands of people, industries and infrastructure. … we should see that as success.