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*Engineering With Nature®*

# Engineering With Nature® Principles in Action: Islands

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Engineer Research and Development Center

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# Abstract

The Engineering With Nature® (EWN) Program supports nature-based solutions that reduce coastal-storm and flood risks while providing environmental and socioeconomic benefits. Combining the beneficial use of dredged sediments with the restoration or creation of islands increases habitat and recreation, keeps sediment in the system, and reduces coastal-storm and flood impacts. Given the potential advantages of islands, EWN seeks to support science-based investigations of island performance, impacts, and benefits through collaborative multidisciplinary efforts. Using a series of case studies led by US Army Corps of Engineers (USACE) districts and others, this technical report highlights the role of islands in providing coastal resilience benefits in terms of reducing waves and erosion as well as other environmental and socioeconomic benefits to the communities and the ecosystems they reside in.

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# Preface

The project was funded by the US Army Engineering Research and Development Center (ERDC), Engineering With Nature® (EWN®) Program. Dr. Todd Bridges was the national lead, and Dr. Jeff King was the deputy national lead of the EWN Program.

At the time of publication, Mr. James Lindsay was chief, Environmental Risk Assessment Branch; Mr. Warren P. Lorentz was division chief, Environmental Processes and Engineering Division; the deputy director of the ERDC Coastal and Hydraulics Laboratory (ERDC-CHL) was Mr. Keith Flowers, and the director was Dr. Ty Wamsley. Mr. Jace Ousley was Headquarters US Army Corps of Engineers Acting Navigation Business Line manager, and Mr. Charles E. Wiggins, ERDC-CHL, was the ERDC technical director for Civil Works and Navigation, Research, Development, and Technology Transfer portfolio. The deputy director of the ERDC Environmental Laboratory was Dr. Brandon Lafferty and the director was Dr. Edmond J. Russo Jr.

COL Christian Patterson was commander of ERDC, and Dr. David W. Pittman was the director.

The results of the Peanut Island, Snook Islands, Mordecai Island, Swan Island, Baptiste Collette Bayou Bird Islands, and Horseshoe Bend Island case studies are also available at EWN's website (https://ewn.erdc.dren.mil/, EWN 2021a–f).

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# 1 Introduction

The Engineering With Nature® (EWN®) Program studies and implements nature-based solutions that also provide environmental and socioeconomic benefits to complex engineering problems. To that end, EWN coordinates collaborative multidisciplinary efforts to quantify the potential advantages of islands through science-based investigations that examine island performance, added benefits, and the effect on the surrounding ecosystem. Our team of scientists and engineers, together with our partners, pursue novel ways to create and restore islands that produce the desired engineering outcomes while also achieving substantially greater environmental, social, and economic benefits. One such novel way is combining the beneficial use of dredged sediments with the restoration or creation of islands, which increases habitat and recreation, keeps sediment in the system, and reduces coastal-storm and flood impacts.

## 1.1 Background

Islands are vanishing at an alarming rate, especially along the Gulf of Mexico and the US Atlantic Coast (CPRA 2007; Erwin et al. 2011). The degradation and loss of islands are due to the combined processes of sea-level rise, subsidence, and inadequate sediment supply.

Islands often consist of multiple habitats, such as beaches, dunes, and marsh, which together make up a multiple-lines-of-defense strategy which has a greater capacity to reduce waves and erosion than a single habitat type alone (Lopez 2009; Guannel et al. 2016). Regardless of their habitat composition or size, islands can increase coastal resilience by reducing waves and erosion to nearby shorelines while providing habitat and recreation opportunities (Gailani, Whitfield, and Murphy 2021). Restoring and creating islands using dredged sediments has the added benefit of keeping sediment in the system, helping islands keep up with rising sea levels.

Despite these advantages, the perceived uncertainties of islands' ability to reduce coastal-storm and flood impacts are considered a barrier to their implementation. These uncertainties include the long-term performance of islands relative to conventional engineered solutions and their ability to adapt to changing conditions such as sea-level rise as they grow and mature over time. In addition, ecological uncertainties related to the replacement of subtidal habitat with higher elevation habitat, known as *habitat trade-offs*, are also cited as a barrier to implementation.

To address the loss of islands and the need to quantify the resilience performance and other ecological benefits, US Army Corps of Engineers (USACE) combines dredged sediments with island restoration and creation with the formation of multiagency, multidisciplinary collaborations to conduct the required research to facilitate more widespread acceptance of island restoration and creation practices.

## 1.2 Objective

This report presents island case studies that demonstrate the multiple benefits achievable when applying EWN best practices using dredged sediment to restore coastal islands. This technical report documents six nearshore island projects located along the US Atlantic Coast in New Jersey, Maryland, Florida, and the Gulf Coast in Louisiana. Documenting beneficial sediment use to restore coastal islands will provide a more complete understanding of these projects so these concepts can be integrated into other dredging projects, thereby providing substantial environmental, social, and economic benefits as part of ongoing USACE maintenance dredging activities.

## 1.3 Approach

Through a series of case studies led by USACE districts and others, this technical report highlights the role of islands in providing coastal resilience, environmental, and socioeconomic benefits to their communities and ecosystems.

# 2 Case Studies

## 2.1 Baptiste Collette Bayou Bird Islands, Louisiana

### 2.1.1 Background

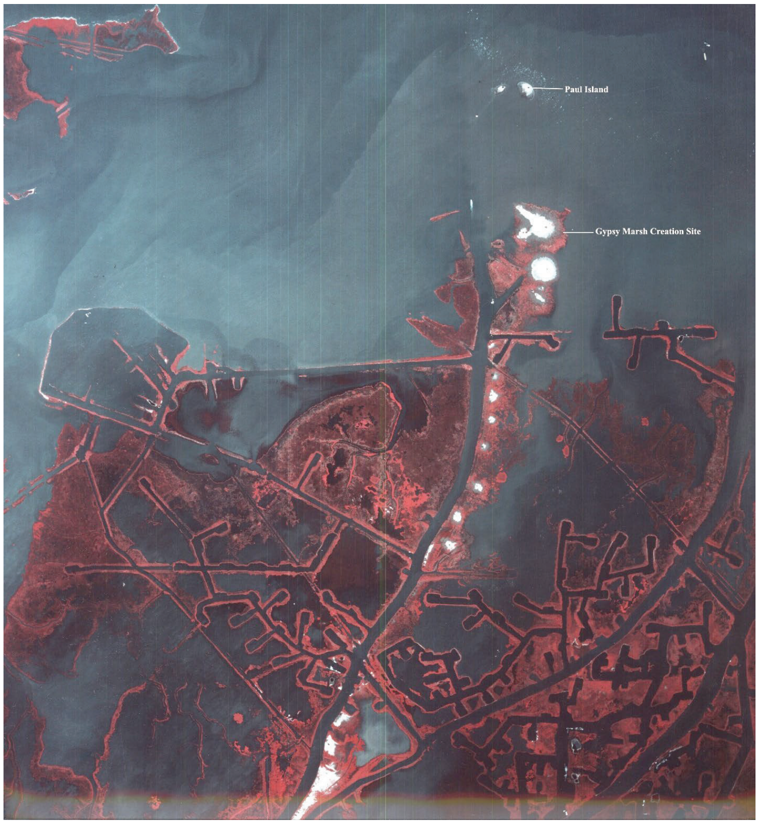
Dating to the late 1860s, Baptiste Collette Bayou was a small canal that extended between the Mississippi River and the historic Breton Island Sound. In a series of storm-related events and USACE dredging authorizations beginning in the early 1900s, a subdelta that developed covering as much as 52 km$^2$ (20 mi$^2$) by 1959 began to deteriorate because of considerable subsidence and ponding.* The inception of the channel occurred in 1968 from a congressional authority in the River and Harbor Act approved 13 August 1968 to enlarge the waterway.† Work began with emergency dredging events in 1972 and 1973 to provide relief to barge traffic on the Gulf Intracoastal Waterway while the Inner Harbor Navigation Canal lock was closed. The first bird island was born of this emergency maintenance.

Construction of additional bird islands by beneficial use of dredged sediments on the east side of the jetty channel began in 1977 when the New Orleans District (CEMVN) began to maintain Baptiste Collette regularly. The aerial image below (Figure 1) shows the bayou as it existed in 1978, soon after beneficial-use activities began. The district focused their efforts on creating island habitats that could serve as nesting habitats for a wide variety of shorebirds. The bird islands are subject to storms and wave energy from the Gulf of Mexico. Sediment placement to create habitat on the west side of the jetty channel began in 1988.

* For a full list of the spelled-out forms of the units of measure and the unit conversions used in this document, please refer to *US Government Publishing Office Style Manual*, 31st ed. (Washington, DC: US Government Publishing Office, 2016), 248–52, 345–47, https://www.govinfo.gov/content/pkg/GPO-STYLEMANUAL-2016/pdf/GPO-STYLEMANUAL-2016.pdf.

† River and Harbor Act of 1968, Pub. L. No. 90-483, 82 Stat. 731. https://www.govinfo.gov/content/pkg/STATUTE-82/pdf/STATUTE-82-Pg731.pdf.

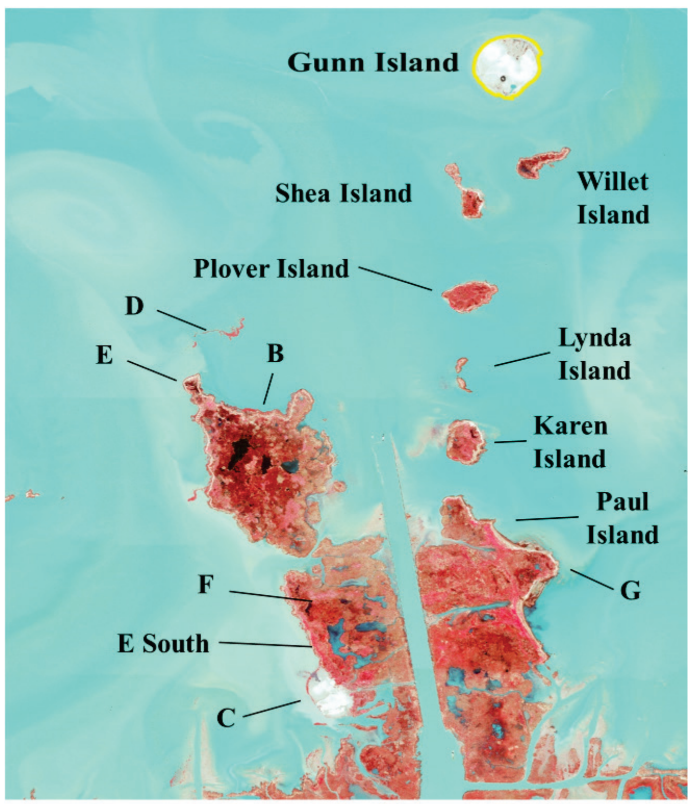
Figure 1. Aerial photograph of Baptiste Collette Bayou, Louisiana, in 1978 showing the recently placed dredged sediment (*white areas* denote bare ground of placed sediment) that began the prior year. North is at the top of the photo. (Image credit: CEMVN)




### 2.1.2 Project description

Beneficial use of sediment from maintenance of the Baptiste Collette Bayou channel occurs on an annual basis with the placement of dredged sediment in shallow open water either on the east or west side of the channel. The unconfined placement is designed to create a wetland habitat adjacent to the waterway's jettied entrance and islands seaward of the jetties suitable for colonial nesting seabirds. The use of dredged sediment to create or restore coastal habitat, considered innovative in the late 1970s, has become the current state of the practice. Created habitats include marsh, scrub-shrub, bare land, and beach. Following the creation of an island, CEMVN almost annually places sediment from subsequent maintenance activities to prevent vegetative succession, keeping the island relatively vegetation-free for colonial nesting seabirds (for example, black skimmers, terns) that prefer bare sand for nesting. In cases where pelican nesting has been observed, vegetation is left undisturbed to encourage return during future nesting seasons. The most recently constructed island, Gunn Island, was established in 2014 to accommodate shoaling further out in the bar channel and to avoid enlarging the existing islands while maintaining sufficient spacing between them. The initial construction of Gunn Island involved placement of approximately 119,000 $yd^3$ (90,982 $m^3$) of sediment,* although this placement did not result in the island breaking the water surface. The most recent examples of beneficial-use activities on Gunn Island include placement of 836,000 $yd^3$ (639,170 $m^3$) of sediment in 2018 to achieve a +6.0 ft (1.8 m) mean low gulf elevation, creating roughly 12 ac (5 ha) of birds nesting habitat. In 2019, 943,000 $yd^3$ (720,975 $m^3$) of dredged sediment was placed on Gunn Island, creating an additional 56 ac (23 ha) of bird nesting habitat. Figure 2 shows the bird islands as of 2019.

Figure 2. An aerial photograph of Baptiste Collette Bayou, Louisiana, in 2019 shows the beneficial use of wetland habitat and islands created over time, including Gunn Island, established in 2014. Earlier sediment placement areas were named using letters of the alphabet. (Image credit: CEMVN)




* For a full list of the unit conversions used in this document, please refer to *US Government Publishing Office Style Manual*, 31st ed. (Washington, DC: US Government Publishing Office, 2016), 345–7, https://www.govinfo.gov/content/pkg/GPO-STYLEMANUAL-2016/pdf/GPO-STYLEMANUAL-2016.pdf.

### 2.1.3 Monitoring

Nesting surveys were performed regularly prior to 2000 to develop data and other supporting evidence to promote the recognition of the islands as beneficial by the resource agencies. Surveys have relied on ground observations to estimate numbers of birds using the island habitat for nesting and other purposes and have documented 76 species of salt and freshwater plants on these sites. Additional monitoring is recommended to more thoroughly understand the effectiveness of dredged-sediment placement for creating the islands and quantify ongoing efforts' successes. An understanding of how the seabirds respond to the placement activities in Baptiste Collette Bayou is needed to determine the broader ecological and other benefits of sediment placement strategies so these best practices can be optimally applied here and elsewhere.

### 2.1.4 Study results

The monitoring results compiled on the Baptiste Collette Bayou Bird Islands indicate that the islands created using dredged sediment have been providing meaningful nesting habitat for various seabirds since observations began in 1986. That year, several thousand birds were observed nesting on Plover Island (Figure 2), including Caspian terns, royal terns, black skimmers, gull-billed terns, and sandwich terns. The island was designed to use sediment beneficially, specifically for use by seabirds for nesting and other purposes. In August 2020, when a second monitoring effort was performed, the Louisiana Department of Wildlife and Fisheries observed over 50,000 nesting seabirds on Gunn Island (Figure 2), composed of approximately 75% royal terns, 15% Caspian terns, and 10% black skimmers, gull-billed terns, and sandwich terns (Figure 3). The success of the islands as nesting habitat are attributed to a combination of remoteness to discourage terrestrial predators, small size to limit the spread of avian disease, presence of bare sand, and elevation sufficient to prevent tidally and storm-driven inundation.

Figure 3. Photograph of tern nestlings hatched on Gunn Island, Louisiana, in August 2020. (Photo courtesy P.J. Hahn)

Using an adaptive management approach to design and construct additional islands has proved to be successful. One such example is maintaining at least a 1,200 ft (366 m) gap between the islands to reduce the likelihood of predators reaching the outer islands. The islands' exposure to the open waters of the Gulf of Mexico results in degradation of the islands over time. But the availability of sediment dredged from the channel offers a reliable and sustainable supply of clean sediment for maintaining the islands' structure and multiple environmental and other benefits.

### 2.1.5 Project significance

In 2020, as part of the Baptiste Collette Bayou Bird Island chain, Gunn Island hosted the state of Louisiana's most significant nesting tern colony, which was believed to have been displaced from the low-lying Breton Island by tropical storm overwash. Since the initial construction of the Baptiste Collette navigation channel, over 1,000 ac (405 ha) of coastal habitat have been created by the placement of dredged sediment during routine maintenance dredging events. The bird nesting islands have been identified as a US Important Bird Area (https://www.audubon.org/important-bird-areas) because of the essential habitat they provide to significant numbers of breeding Caspian and gull-billed terns, brown pelicans, and black skimmers (CEC 1999). Five species of terns have been recorded as breeding on these islands. Research to document ecosystem services at sites like these will play a meaningful role in determining the efficacy and optimal use of such beneficial-use applications in the future.

## 2.2 Peanut Island, Lake Worth, Florida

### 2.2.1 Background

Peanut Island, located in the Lake Worth Lagoon (LWL) within Palm Beach County, Florida, was initially created in 1918 using the material excavated when the Lake Worth Inlet was created (Figure 4). First called Inlet Island, the island was renamed Peanut Island for a planned peanut-oil shipping operation that failed in 1946. The island originally encompassed only 10 ac (4.0 ha). By 1923 the port was using the island as a spoil storage site for the maintenance of the inlet and the port shipping channel. In 1991 the port sold the northern half of the island to the Florida Inland Navigation District (FIND) as a sediment storage site for intracoastal waterway maintenance dredging (ACERC 2007a).

Figure 4. Aerial photograph of Peanut Island and Lake Worth Inlet, Florida. (Photo courtesy of drone footage, David C. Carson)

### 2.2.2 Project description

In 2021, as a result of continued sediment deposition from maintenance dredging, Peanut Island, a dredge material management area, comprised approximately 86 ac (34.8 ha). The primary use of the island will continue as a sediment storage site, but the port authority and FIND have made the perimeter of the island available to the public as a park through a long-term arrangement with Palm Beach County (ACERC 2007a). The park hosts passive and active recreational use facilities that include beaches, swimming and snorkeling areas, picnic and camping areas, docking facilities, a fishing pier, sidewalks, trails throughout the island, and environmental enhancement areas (ACERC 2007a).

In 1996, authorization was finalized for a public park at the northeast corner of the island, a 10 ft (3.0 m) wide concrete hiking trail around the island perimeter, a snorkeling area, a barge docking facility with proposed bulkhead and spoil access road, an observation deck, and restroom facilities. In addition, the proposed park itself consisted of a campground, picnic areas, ranger station and maintenance building, restroom with shower, a boat dock, and fishing pier.

In 1998, Palm Beach County Environmental Resources Management (ERM) began planning a habitat enhancement project at the Lake Worth Golf Course. The Peanut Island makeover project included offloading 1.2 million cubic yards (0.92 million cubic meters) of dredged material to Snook Islands (see case study below, Section 2.3).

In 2002, enhancements continued, with the addition of two floating Americans with Disabilities Act (ADA)–compliant docking structures and flushing channels to restore existing mangroves. These enhancements, and a further realignment and modification of the mangrove boardwalk, were conducted to avoid impacts to existing mangroves.

Peanut Island has four separate reef sites. The fishing pier and east dock sites contain concrete tetrahedrons, modules, and caprock deployed in 2000 and 2011. Major enhancements occurred on the island in 2005, including creation of the 10 ft (3.0 m) deep snorkel reef, which is protected by limestone and granite boulders. Between 2006 and 2012, six breakwater reefs were added on the east and south sides of the island. These multiple structures encompass 1.7 ac (0.69 ha) in depths ranging from 2 to 4 ft (0.6 to 1.2 m).

In 2008, limestone rock (500 tn; 454 t) was used to construct three breakwaters on Peanut Island's shoreline. One breakwater built on the east side of the island and two smaller structures were created on the southeastern shoreline. The structures not only slow beach erosion and provide shoreline protection, but they also offer reef habitat. The breakwater reefs are very popular with snorkelers and provide a variety of restored habitats for fish, invertebrates, and birds.

Sediment was dredged from the Peanut Island boat docks and fishing pier in 2009 and reused on-site to stabilize the beach and prevent further erosion of the walking path. The sediment was also used to recontour the snorkeling lagoon and create 0.4 ac (0.16 ha) of intertidal *Spartina alterniflora* (salt marsh cordgrass) habitat, which stabilizes the shoreline, increases nutrient uptake, and provides important wildlife habitat (ACERC 2007a).

In 2012, the project was designed to improve the tidal flow within the snorkeling reef system and provide increased shoreline protection and reef habitat on the island's east shore (Figure 5). The existing rock infrastructure was modified because of the area experiencing ongoing problems with poor water quality and minimal tidal flushing. Removal of 720 tn (653 t) granite rock in a Y-shaped groin and an additional 1,300 tn (1179 t) of granite rock along the southwest lagoon side occurred. The rock was relocated to create a breakwater (crib) structure to reduce wave energy and protect a walkway along the eastern shoreline. Additionally, 890 tn (807 t) of granite was placed behind two breakwaters to enhance the areas. These breakwaters provide shoreline protection and artificial reef habitat in an area that is void of natural resources. Snorkelers use the reef system because of the clear oceanic water, fish, coral, and other reef resources that it provides, located as it is adjacent to the Lake Worth Inlet.

Additional enhancement activities were constructed in 2013 to install two 110 ft (34 m) long emergent reef structures for shoreline protection and reduction in wave energy and provide artificial reef habitat for both marine life and recreational snorkeling. Also constructed was the placement of limestone rocks in discrete piles to create an artificial snorkel reef trail within two separate areas on the eastern side of the island.

Figure 5. Aerial photograph showing the breakwaters and reef improvements and the snorkeling lagoon created on the east and south side of Peanut Island. (Photo courtesy of drone footage David C. Carson)

### 2.2.3 Monitoring

Multiple surveys have been completed in this area over the years. The most recent survey available was completed on 1 August 2013. The survey was conducted with snorkel and GPS equipment and included surveys of the east shoreline east of emergent reef structures, and south-southeast of the boardwalk and crib structure.

### 2.2.4 Study results

During the 2007 site visit, only two years after the limestone rock boulders were installed, five hard coral species and a gorgonian were observed. Unusual sightings included spaghetti worms (*Eupolymnia crassicornis*) and an unidentified octopus. The site visit in September 2012 documented 12 different species of corals. Several of these corals have attained larger sizes, such as 30 cm for boulder brain coral (*Colpophyllia natans*) and 20 cm for symmetrical brain coral (*Diploria strigosa*). Other species of note were several sponges, urchins, clams, and tunicates. The site is close to clear Gulf Stream waters, which flow into the area semidiurnally, creating a unique and diverse reef community.

As of 2012 the monitoring of the area indicated that a total of 26 families and 63 species of fish were present. Haemulidae (grunt) and Scaridae (parrotfish) were represented by the most species, with 11 and 10 species, respectively. Unusual sightings included a black grouper (*Mycteroperca bonaci*) juvenile.

By 2013 a 1.7 ac (0.69 ha) area east of existing emergent reefs consists of scoured rocky and rubble substrate with patches of course sand not suitable for seagrass habitat. No seagrass has been found within this area, and no corals or macroalgae colonization is occurring on the rocky-rubble substrate within a 0.90 ac (0.364 ha) area east-southeast of the boardwalk. This area contains 0.26 acre of intermixed *Halophila johnsonii* and *Halodule wrightii* seagrass with density varying between 1%–5% coverage of *Halophila johnsonii* along the waterward edges to small patch of 15%–25% coverage along the shoreward edge. *Hadodule wrightii* was mostly found along the shoreward edge of the bed, with an estimated 5%–15% coverage, with the most significant coverage of intermixed seagrass occurring in the center at an estimated 15%–25% coverage.

### 2.2.5 Project significance

The projects at Peanut Island have improved tidal flushing to northern LWL, providing needed habitat and recreational opportunities. Peanut Island also provides a buffer to the city of Riviera Beach, reducing shoreline erosion.

USACE has the authority, provided by Section 1135* of the Water Resources Development Act of 1986, as amended, to plan, design, and construct fish and wildlife habitat restoration measures and has partnered with Palm Beach County to construct many restoration projects within the LWL through the Section 1135 program, including the Munyon Island, Snook Islands, and John's Island restoration projects.

* Water Resources Development Act of 1986, 33 U.S.C. § 2309a, 746–47 (2020). https://www.govinfo.gov/content/pkg/USCODE-2020-title33/pdf/USCODE-2020-title33-chap36-subchapV-sec2309a.pdf.

## 2.3 Snook Islands, Lake Worth, Florida

### 2.3.1 Background

The Snook Islands project site is located adjacent to the Lake Worth Golf Course (LWGC) in the LWL in central Palm Beach County, Florida (Figure 6). The LWL is a 22 mi (35.5 km) long coastal lagoon with two oceanic inlets (TNC [2014]).

In the late 1800s, developers began dredging and filling the wetland edges of LWL, an activity that would continue into the 1970s. As a result, inter- and shallow subtidal resources were decimated. By 2020, 94 marinas and hundreds of private docking structures were scattered along the shoreline of the lagoon. Approximately 70% of the lagoon shoreline is bulkheaded, while less than 30% of the remaining shorelines remain in a natural state, and even fewer are fringed with mangroves (LWLMP 2021).

Figure 6. Aerial photograph of Snook Islands, Lake Worth, Florida, in 2016. (Photo courtesy of drone footage David C. Carson)

The LWGC has approximately 1.2 linear miles (1.9 km) of shoreline along the western shore of central LWL. The existing upland portions of the LWGC were created through the dredging and filling of inter- and subtidal wetland resources and associated bulkhead construction. These dredge and fill activities associated with LWGC construction along the shoreline resulted in a steep littoral profile, with elevations dropping quickly from +4.0 feet (1.2 m) referenced to the National Geodetic Vertical Datum of

1929 (NGVD) at the shoreline to −7.0 feet (2.1 m) NGVD just offshore. This steep grade reduced the area suitable for developing inter- and shallow subtidal resources such as mangroves, seagrasses, and oyster reefs. In fact, prior to the Snook Islands construction, open-water dredge holes as deep as −23.0 feet (7.0 m) NGVD and nearshore depths below −10.0 feet (3.0 m) NGVD were typical, and the shoreline was fringed with three species of mangroves (red, *Rhizophora mangle*; black, *Avicennia germinans*; and white, *Laguncularia racemosa*), intermixed with exotic Australian pine (*Casuarina* sp.) and Brazilian pepper (*Schinus terebinthifolius*). The bulkhead along the LWGC failed over time, leading to erosion of the shoreline from wind- and wake-generated wave energy (Figure 7).

Figure 7. Failed shoreline armoring (shown) was replaced with vegetative habitat. (Photo courtesy Palm Beach County ERM)

### 2.3.2 Project description

In 1998, Palm Beach County Environmental Resources Management (ERM) began planning a habitat enhancement project at the LWGC to remediate the loss of suitable substrate for inter- and shallow subtidal biotic communities caused by the dredging and bulkheading to create the upland golf course. This enhancement included reconstruction of the sediment topography, through dredge sediment placement, to depths appropriate for re-establishment of intertidal and subtidal habitats, such as seagrasses, oysters, and mangroves. Peanut Island (see case study above, Section 2.2), a dredged material management area, for the maintenance of Lake Worth Inlet and the Port of Palm Beach shipping channel, became a ready source of sediment as the island's dredged material storage was at capacity. Additionally, Peanut Island was in the planning stages of a continued island makeover between 1996 and 2012. Approximately 1.2 million cubic yards (0.92 million cubic meters) of sediment was transported 10 mi (16 km) from Peanut Island to create the Snook Islands (ACERC 2007b), a series of five islands, interconnected with oyster, mangrove, and rock sills and living shorelines, that extend parallel to the shore in LWL (Figure 8).

In 2005 this makeover amounted to over 1,560 barge loads of sediment, which had 30% by volume of rock rubble intermixed. The project resulted in the creation of 10 ac (4 ha) of red mangroves, 2.8 ac (1.1 ha) of *Spartina* marsh, 2.3 ac (0.9 ha) of oyster reef, and approximately 50 ac (20 ha) of seagrass recruitment area. Approximately 28,000 tn (25,401 t) of 1–3 ft (0.3–0.9 m) diameter limestone boulder riprap was used to create the oyster reefs and mangrove planting breakwaters (FIND 2019) (Figure 8). Part of the project included mangrove propagules to be collected by volunteers and raised in a nursery to the 6–8 leaf stage. They were then planted on 10 different occasions by volunteers as construction of the islands and shoreline planters were completed. *S. alterniflora* was also planted as sections of the shorelines were completed.

In addition, non-native vegetation from approximately 5 ac (2 ha) of the LWGC shoreline was removed, and approximately 1,800 ft (548.64 m) of shoreline armor (riprap, concrete rubble, and collapsed seawall) was removed or buried in situ in areas where the seawall was still intact.

Snook Islands Wetlands Restoration Phase II began in 2013, which included constructing two additional mangrove islands and oyster reefs. The additional habitat created included 0.45 ac (0.18 ha) of oyster reef, 0.74 ac (0.30 ha) of red mangroves, and 7.17 ac (2.90 ha) of additional seagrass habitat. Open areas were created to improve bird use of the shoreline and mudflats as well as increase use by fish and other wildlife.

Figure 8. Postconstruction (2016) aerial image of the Snook Islands, Florida, in low tide. (Photo courtesy of drone footage David C. Carson)

### 2.3.3 Monitoring

Postconstruction monitoring of the mangroves, marsh plantings, oyster reefs, and seagrasses were conducted initially from 2006 to 2010 for compliance purposes; however, they continue to be monitored under various habitat-enhancement and protection action plans and strategies to aid in the overall management determinations of the LWL (LWLMP 2021).

The first postconstruction seagrass inventory was conducted during the summer of 2006 and continued each year until 2010. Because of limited visibility (few inches, several centimeters) monitoring was conducted by performing a wading survey of the entire area using viewing tubes, during the lowest tides, to determine the presence of seagrasses. Wire survey flags were placed around the edges of the observed grass beds, which were mapped to submeter accuracy, using GPS. This method proved effective for one-third to one-half of the potential seagrass areas. Between the years of 2011 and 2015, monitoring occurred during limited opportunistic visits during the peak seagrass growing season (June–September) in areas historically well covered by seagrass within the lagoon. The success criteria of seagrass continue to be monitored yearly along with overall abundance within the lagoon.

### 2.3.4 Study results

Prior to construction, there was a seawall with an immediate drop into an anoxic dredged hole. Construction improvements created a gradual sloping intertidal wetland shelf and shallow submerged areas recruiting seagrass. Completed in 2005, project construction eliminated the original shoreline armor along the golf course and replaced it with a soft, vegetated shoreline. The offshore islands and oyster reefs provide protection from wind and wave energy, stabilizing the formerly eroding shoreline. In 2004 Hurricanes Frances and Jeanne made landfall near the project site. Because the project was well underway, no damage was sustained to the project or the LWGC shoreline.

Following construction and planting, the survival and re-establishment of the benthic communities proceeded rapidly. For example, the planted red mangroves achieved a survival rate of approximately 80% after two years, and the *S. alterniflora* plantings matured and coalesced in approximately two years. Oysters (*Crassostrea virginica*) have colonized the oyster reefs and base of the mangrove planting wave breaks and have also colonized the shoreline areas where the rubble is exposed. No quantitative oyster surveys have been completed to date, but qualitative observations suggest significant coverage.

Three seagrass species occur in the project vicinity: *Halophila decipiens* (paddle grass), *H. johnsonii* (Johnson's seagrass), and *Halodule wrightii* (shoal grass). *Halophila johnsonii*, a listed threatened species under the Endangered Species Act,[*] was observed recruiting to the newly placed fill even as the initial construction and associated turbidity continued prior to project completion in 2005.

In 2006 *H. johnsonii* had become established along the entire 1.2 mi (1.9 km) length of the project, covering a total of 1.2 ac (0.5 ha). Only a few small beds of *H. decipiens* were observed. Densities of both species were high wherever they occurred. In 2007 a second survey revealed that in a single year, seagrass cover had increased more than 10 times to 14.1 ac (5.7 ha). *Halodule wrightii* was observed in at least two locations, and cover of *Halophila decipiens* increased. *H. Johnsonii was* the most abundant seagrass species present, as it is throughout the LWL, with 90%–95%

* Endangered Species Act of 1973, 16 U.S.C. 35 § 1531 et seq. (2019). https://www.govinfo.gov/content/pkg/USCODE-2019-title16/pdf/USCODE-2019-title16-chap35.pdf.

cover. From 2008 to 2010, seagrass acreage increased considerably, from 1.2 to 44.5 ac (0.49 to 18.0 ha) (Figure 9).

Figure 9. Snook Islands, Lake Worth, Florida, seagrass cover survey results 2006–2010 (excerpted with permission from ACERC 2007b).

Fish and wildlife usage of the project site increased dramatically after construction. Wading birds, shorebirds, and ospreys regularly use the site as feeding and resting areas. Schools of juvenile fish swim in the shallows and the *Spartina* at high tide. Manatees have also been observed feeding on the *Spartina*. A pair of American oystercatchers (*Haematopus palliatus*), a listed species of special concern in Florida, first nested on top of the mangrove riprap wave break in 2004, and the breeding pair successfully fledged a chick in the summer of 2007 (Figure 10). American oystercatchers have since continued to successfully nest and fledge multiple chicks yearly. Currently, there are four nesting pairs of oystercatchers using the dredged-sediment islands. Recent counts within the LWL indicate an 81% overall fledge success and total fledged chick count of 29.

Figure 10. American oystercatchers (*Haematopus palliatus*) began nesting on top of a mangrove riprap wave break in 2007. (Photo courtesy David C. Carson)

### 2.3.5 Project significance

This project provided an opportunity to add almost 100 ac (40.5 ha) of intertidal and shallow subtidal resources to the LWL. Projects such as this one are necessary to offset the historic loss of natural resources. Living shorelines provide an alternative to seawalls and armoring by reducing shoreline erosion. Constructing the offshore mangrove islands and oyster reefs provided an increased buffer against waves and boat wakes, precluding the need to construct a new seawall and restoring valuable fish and wildlife habitat.

In 2012, the Snook Islands Natural Area Public Use Facilities were created to allow visitors to view wildlife and fish and explore the lagoon waters. Public-use amenities provide recreational opportunities and educate the public and include a boardwalk with an observation platform, kayak launch structure, day-use docks, boat-trailer parking, bicycle racks, benches, fishing pier, and informational kiosks. Additionally, the day-use docks provide boater access to downtown Lake Worth, generating revenue for local businesses.

## 2.4 Mordecai Island, Barnegat Bay, New Jersey

### 2.4.1 Background

Mordecai Island is an undeveloped back-barrier island that runs parallel to the Barnegat Bay shoreline of Beach Haven, New Jersey (Figure 11). In addition to providing habitat for a wide range of estuarine organisms and nesting shorebirds (Burger et al. 2001), the island serves as a wave break, protecting the adjacent developed shoreline of Beach Haven from the erosive action of waves generated in Barnegat Bay.

Figure 11. Aerial photograph of Mordecai Island, New Jersey, in 2019. (Photo credit: National Oceanic and Atmospheric Administration [NOAA])

Over the past century, persistent wave action has taken a toll on Mordecai Island, resulting in a loss of roughly 50% of its total area and leading to a breach that effectively separated the island into two lobes (Figure 12). Continuing erosion threatened the existence of Mordecai Island, its biological communities and habitat, and the vital role that it plays in protecting the Beach Haven shoreline.

Figure 12. *Left*, Mordecai Island in 2014 before sediment placement, and *right*, in 2018 after placement.

### 2.4.2 Project description

In 2015 USACE–Philadelphia District (CENAP) used sediment dredged from the New Jersey Intracoastal Waterway (NJ ICW) to fill the erosional gap separating the two remaining parts of Mordecai Island. The project design involved using ~30,000 $yd^3$ (22,936 $m^3$) of sediment to create a central, high-elevation mound intended to provide habitat for shorebird nesting. The placement area was later planted with native salt marsh and transitional and upland vegetation (Figure 13).

Figure 13. Aerial photography of the Mordecai Island placement area in 2019; planting occurred in 2016. The stakes visible are left over from the goose exclusion fencing installed during planting. (Photo credit: NOAA)

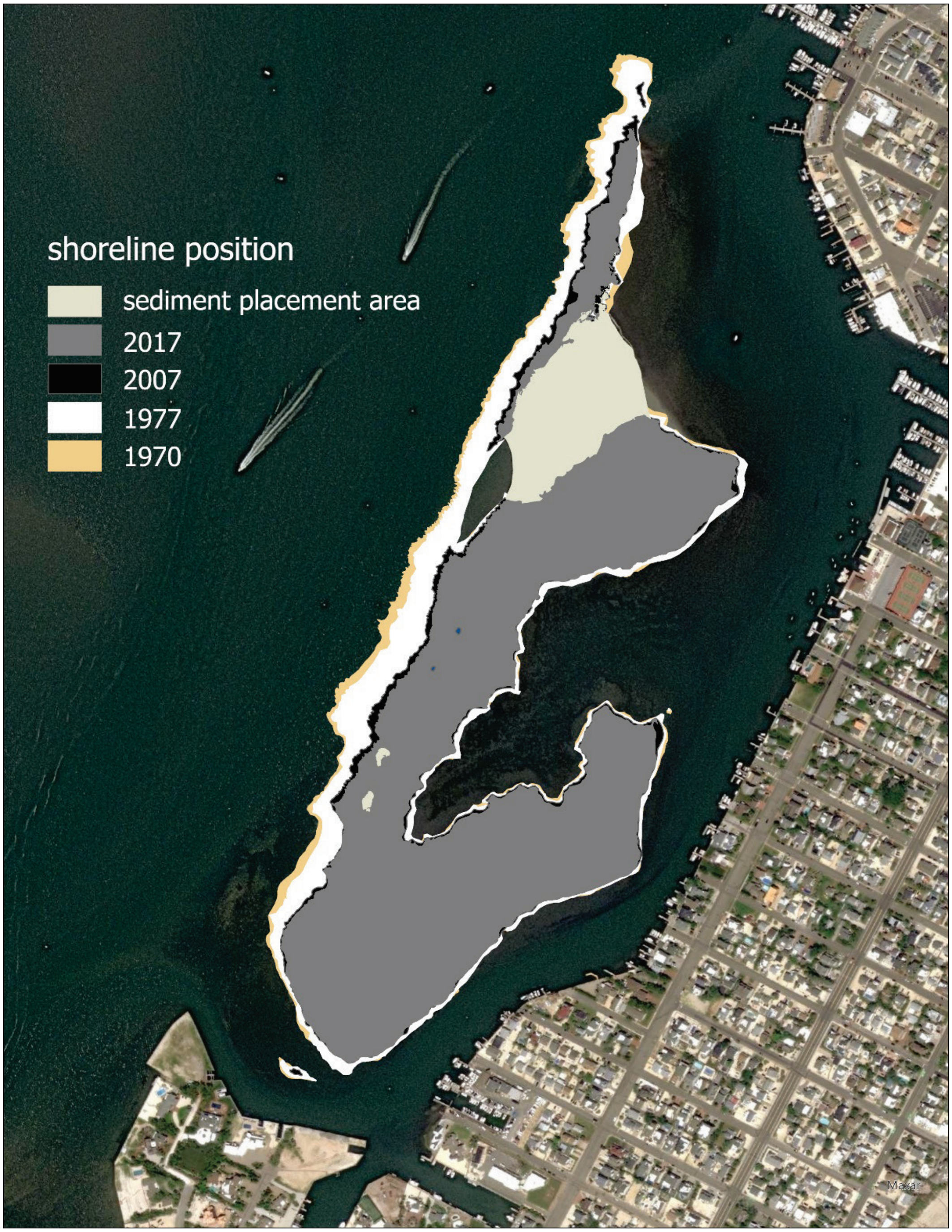
### 2.4.3 Monitoring

To determine the effectiveness of dredged-sediment placement and other shoreline modifications in stabilizing the island and to quantify the success of ongoing restoration efforts, CENAP partnered with the National Oceanic and Atmospheric Administration (NOAA)'s National Centers for Coastal Ocean Science (NCCOS) and the Mordecai Land Trust to track changes in surface elevation and shoreline position over time and to monitor changes in biological communities. NOAA–NCCOS is also evaluating potential environmental impacts of these activities by monitoring saltmarsh vegetation, seagrass cover, and the abundance and diversity of nearshore benthic invertebrates. Tracking changes in each of these groups both within the placement area, and in nearby undisturbed regions, is key to understanding the broader ecological impacts of sediment-placement activities.

### 2.4.4 Study results

To better understand the amount of erosion occurring along the western side of the island that experiences high boat wakes, NOAA–NCCOS developed digital elevation models from drone aerial photography and conducted shoreline change analyses using a combination of historical aerial imagery and on-the-ground surveys. An analysis of elevation change between 2017 and 2019 showed a redistribution of sediments within the placement region that without additional sediment and stabilization by planting is likely to result in the formation of a channel and, ultimately, lead to the island being separated once again into two lobes. Similarly, analyses of historical shoreline positions indicate that between 1970 and 2019 the western shoreline of Mordecai Island retreated at an average rate of 0.83 m (2.7 feet) per year, leading to a cumulative loss of roughly 15 ac (6 ha) of land (Davis et al. 2020). However, there is also evidence that the shoreline stabilization structures along the southwestern shoreline have minimized erosion on the adjacent shoreline (Figure 14). In addition, there was no evidence of impacts to the subtidal infaunal community, which has been a concern for in-water sediment-placement activities such as the Seven Mile Island Living Innovation Lab (SMIIL).

Figure 14. Aerial image of Mordecai Island overlaid with the polygon data layers showing shoreline retreat on the western edge. Since 1970, the western shoreline retreated at an annual rate of 2.6 ft (0.8 m), a cumulative loss of 130 ft (40 m). (Image credit: NOAA)




### 2.4.5 Project significance

Shoreline erosion is a significant source of the sediments that end up clogging navigation channels and leading to the need for maintenance dredging; it is also a cause of habitat loss for marsh islands like Mordecai. Beneficial use of sediments to restore these habitats can help solve these problems. Monitoring and continued data collection will inform adaptive management strategies and further document the rate of ecosystem service provision and protective capacity of Mordecai Island. Research to capture appropriate ecosystem variables at demonstration sites like this one will play a pivotal role in determining the efficacy and optimal use of such applications.

## 2.5 Swan Island, Chesapeake Bay, Maryland

### 2.5.1 Background

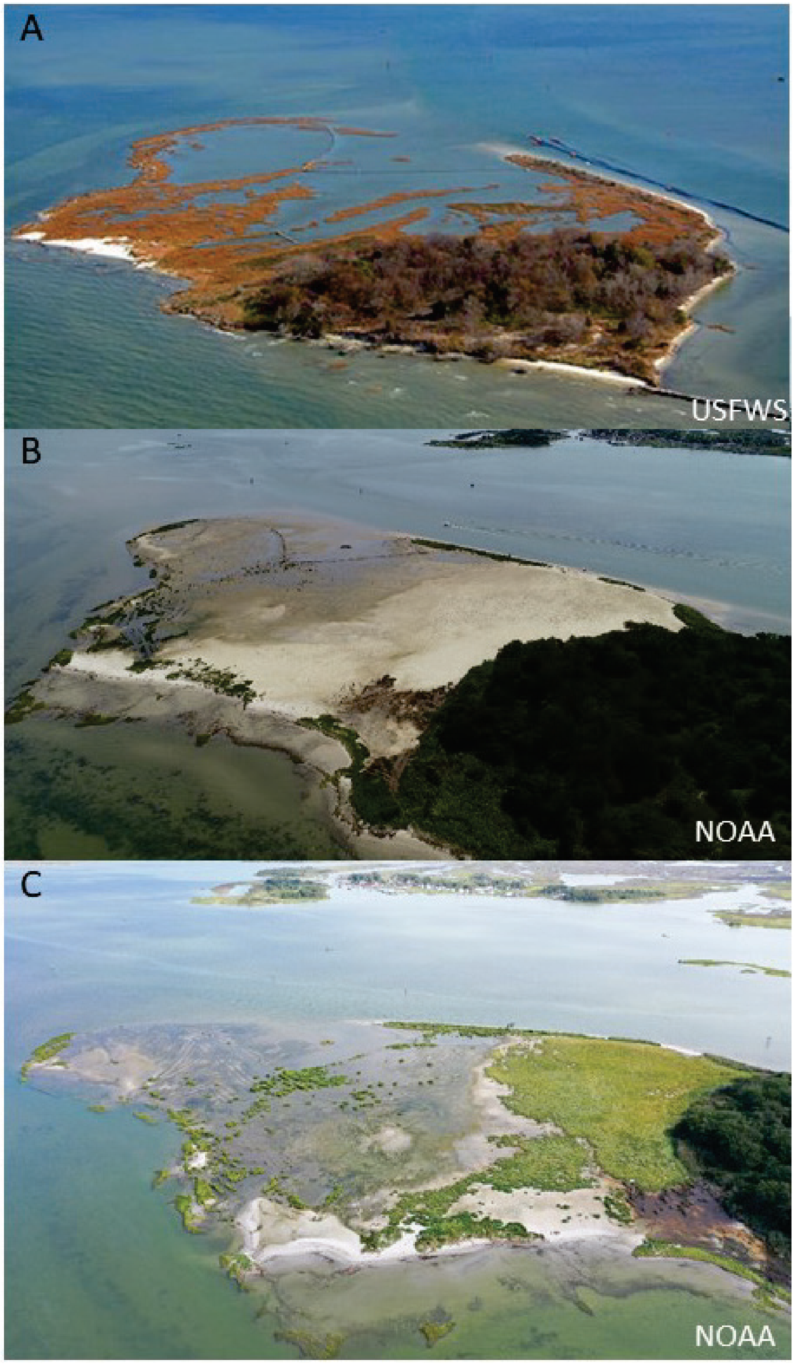
Coastal islands and marshes of the Chesapeake Bay are disappearing along with the critical ecosystem services and shoreline-protection benefits they provide (Erwin et al. 2011). Swan Island, Maryland, is a 25 ac (10 ha) island within the Martin National Wildlife Refuge in Tangier Sound, Chesapeake Bay. This region experiences high rates of shoreline erosion and subsidence, which have deteriorated the island's natural habitat and reduced its ability to shelter the nearby town of Ewell, Maryland from wave energy (Kearney and Stevenson 1991; Perini Management Associates 2014). To counter such losses, USACE–Baltimore District (CENAB) used dredged sediments from a nearby navigation dredging project to enhance Swan Island's natural habitats. Ultimately, this project will increase the long-term resilience of Swan Island and its capacity to defend adjacent shorelines from wave energy (Figure 15).

Figure 15. Swan Island, Maryland, high-marsh habitat looking north in 2020. (Photo credit: NOAA)

### 2.5.2 Project description

In October 2018, CENAB began dredging the navigation channel between Swan and Smith Islands in the Chesapeake Bay. Approximately 60,000 $yd^3$ (45,873 $m^3$) of dredged sediments were placed on the 12 ac (4.8 ha) low-lying footprint of Swan Island (Figure 16). The restoration plan included the creation of low dunes (+3 to +4 ft mean lower low water, MLLW; +0.9 to +1.2 m) and the installation of 200,000 high (*Spartina patens,* +3 ft MLLW; +0.9 m) and low intertidal marsh (*Spartina alterniflora,* +2 ft MLLW; +0.6 m). The island was transformed from one characterized by low and highly fragmented marsh to one with a broader range of habitats that sit higher in the tidal frame (Figure 16).

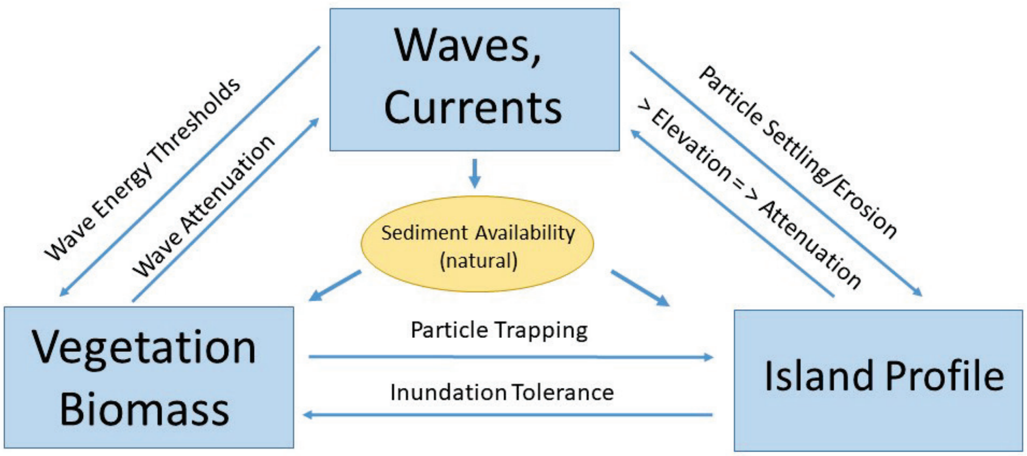
Figure 16. Swan Island, Maryland, preconstruction (*A*) in 2017 and postconstruction (*B*) in 2019 and (*C*) 2020. (Image credits: US Fish and Wildlife Service, NOAA)




### 2.5.3 Monitoring

The Swan Island restoration presents an opportunity to evaluate the efficacy of managing coastal islands to protect and enhance their long-term resilience to storms and sea-level rise. Project success is being measured through the collaborative efforts of a multidisciplinary project team with members from ERDC, CENAB, NOAA–NCCOS, the US Fish and Wildlife Service, and the Maryland Department of Natural Resources. Initially, the project team came together in a series of iterative, group-mediated workshops to develop project goals and a conceptual model describing interactions between the island's physical properties and biological communities (Grant and Swannack 2008). The outcome was a refining of the team's project goals, a conceptual model (Figure 17), a monitoring program, and the development of a monitoring and adaptive management plan (MAMP) (Herman et al. 2020).

Figure 17. Simplified resilience conceptual model for Swan Island. These hydrodynamic, ecological, topographic (elevations), and sediment parameters are required to understand the performance of Swan Island in reducing wave energy and erosion to nearby shorelines.




The overarching project seeks to quantify the coastal-resilience performance of Swan Island in terms of reducing wave energy and erosion to nearby shorelines and habitats. Researchers are collecting pre- and post-restoration data such as sediment (total suspended solids, accretion); hydrodynamic (waves, currents, water level); ecological (vegetation); and topographic (elevations) parameters (Herman et al. 2020; Davis et al. 2021). These data will be used to develop and evaluate integrated hydrodynamic and ecological models that will answer questions such as How resilient is the island and its habitats against rising sea level and periodic storm events? or How much wave attenuation does Swan Island provide the town of Ewell?

The MAMP tracks progress and serves as a blueprint for the project team for all monitoring aspects (for example, which, how, and how often data is collected) and the adaptive-management approach. This plan includes reporting, data management, roles and responsibilities, performance metrics, and decision thresholds for adaptive management.*

### 2.5.4 Study results

Two years of postrestoration monitoring has been completed. As of September 2020, the high marsh was characterized by vigorous ingrowth of planted *S. patens*, with 50% cover in elevations from 0.5–0.9 m (1.6–2.9 feet) NAVD88 (North American Vertical Datum of 1988). However, below 0.4 m (1.3 ft) NAVD, the low marsh experienced significant mortality, triggering the adaptive management threshold for percent cover determined in the MAMP. Accordingly, in June 2021, the team installed 25,000 low-marsh (*S. alterniflora*) plants. Shoreline erosion, elevation change, and trends in the aerial extent of the island's various vegetative communities are also being measured and tracked over time, using georeferenced, drone-based imagery products such as digital elevation models (Figure 18) and habitat classification maps (Figure 19). Trends in these data will be evaluated with respect to water movement (waves, tides, and currents) through the model development process, which is ongoing. Ultimately, the resulting simulation model will quantify the relationships between physical and ecological changes in Swan Island and the impact of these changes on its long-term resilience.

* P.E. Whitfield, J.L. Davis, A.M. Tritinger, D.M. Szimanski, J.Z. Gailani, and J. K. King, *Monitoring and Adaptive Management Plan for Swan Island*. Draft Report. Vicksburg, MS: US Army Engineer Research and Development Center.

Figure 18. Elevation change in meters NAVD88 between September 2019 and September 2020. The >3 m increase shown in *dark blue* on the western side of the Island is because of high-marsh growth. (Image credit: NOAA)

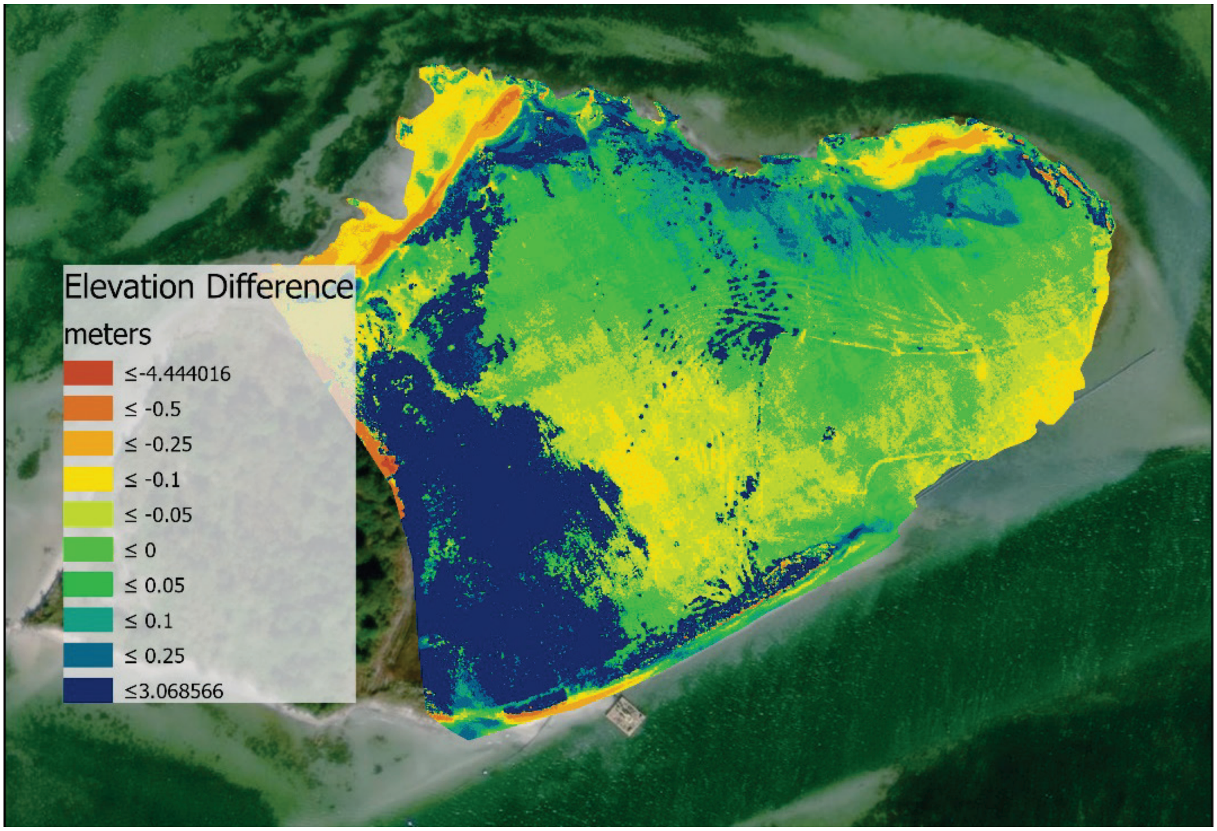
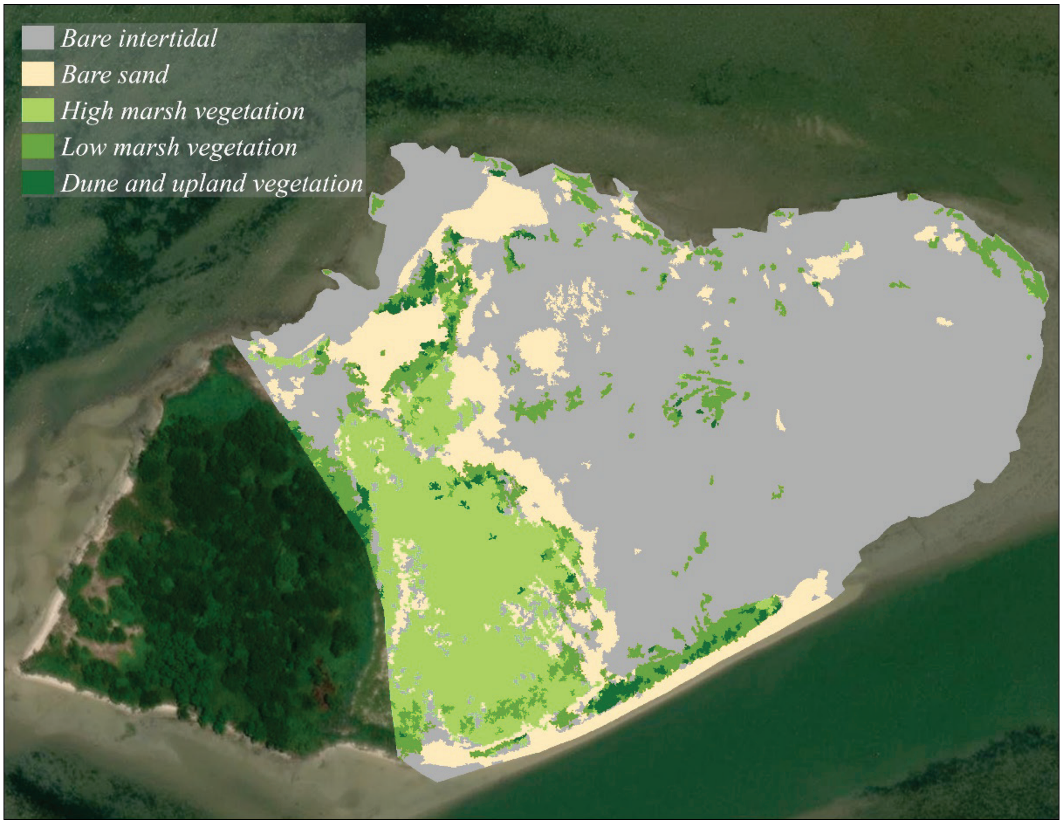


Figure 19. Swan Island habitat classification map developed from drone-based imagery from September 2020. (Image credit: NOAA)




### 2.5.5 Project significance

The restoration of Swan Island is expected to have multiple benefits in terms of reducing wave energy and erosion to nearby shorelines and communities, increasing recreational opportunities and providing much-needed migratory bird and wildlife habitat. Nearby communities, like the town of Ewell, also benefit from the routine maintenance of navigation channels, which provide access to nearby fishing grounds, tourism, and commerce.

In addition, the products developed through the monitoring of this project will inform the design and placement of future island-restoration activities and will be used by regulatory agencies involved in permitting island restoration projects. Monitoring data collected for this project are being used to develop and evaluate an integrated hydrodynamic and ecological model to address how the island and its ecological communities will respond to physical forcings, like storms and sea-level rise. These modeling efforts will also address current information gaps on the impacts of island-restoration activities on nearby ecosystems and the protective benefits provided by these islands. The results will inform how restoring these islands can achieve EWN triple-win benefits.

## 2.6 Horseshoe Bend Island, Atchafalaya River, Louisiana

### 2.6.1 Background

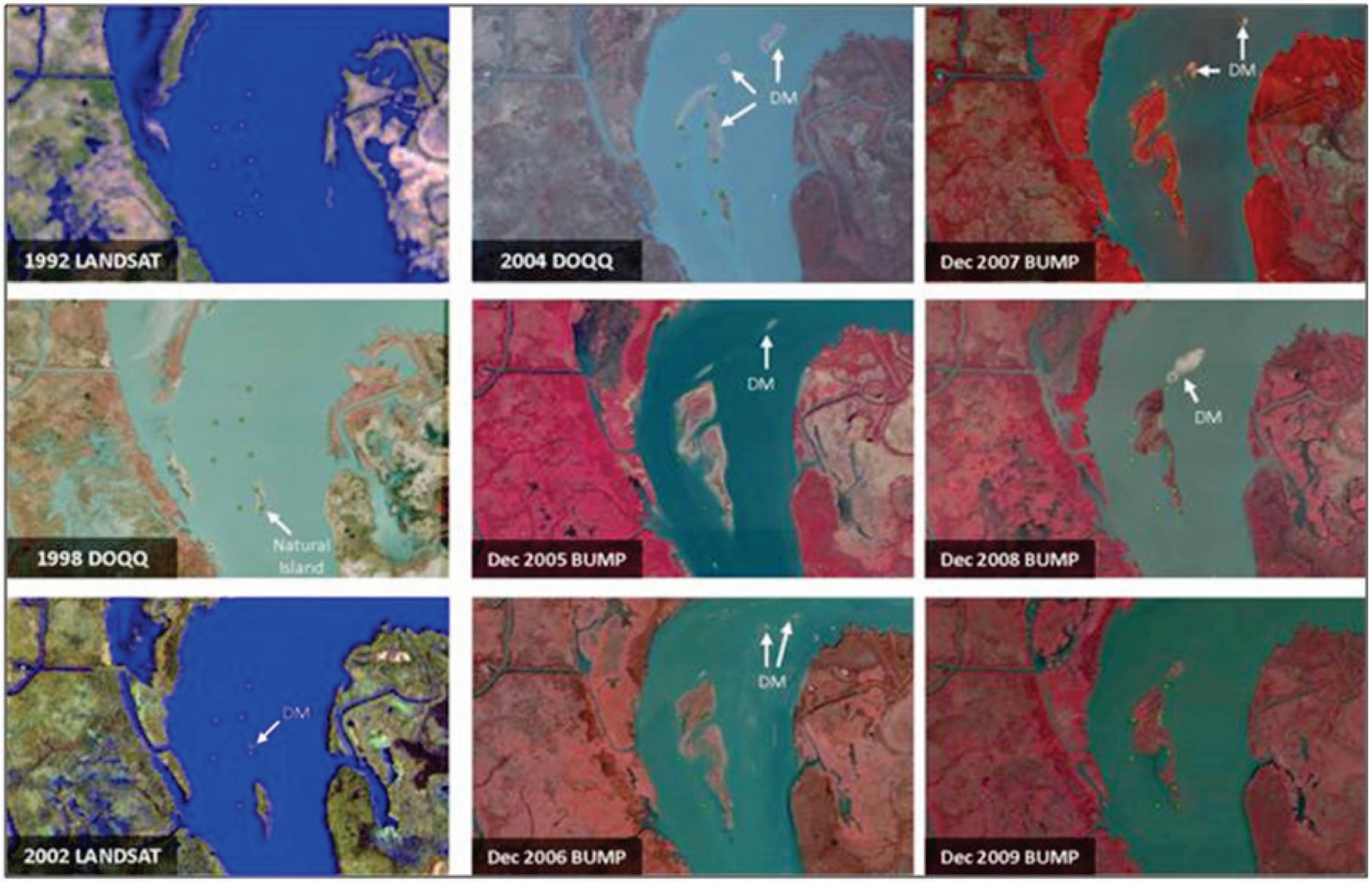
During the 1990s, placement of shoal material dredged from Horseshoe Bend of the lower Atchafalaya River occurred at wetland-development sites located along the riverbank lines adjacent to the channel. The capacity of these placement sites was nearly exhausted by 1999. Thus, to meet the anticipated disposal requirements for future channel maintenance, CEMVN evaluated three placement alternatives: (1) convert the wetland-development sites into upland disposal areas; (2) open-water placement of dredged sediment via a long-distance pipeline into the open waters of Atchafalaya Bay; and (3) mounding of material at mid-river, open-water placement sites within a 350 ac (142 ha) area immediately adjacent to the navigation channel and upriver of a small naturally forming island (Suedel et al. 2015; Foran et al. 2018). The third alternative was selected on a demonstration basis to investigate the impacts of mid-river placement on shoaling trends downriver of the site. Beginning in 2002 strategic placement of the sediment dredged from Horseshoe Bend occurred at the mid-river, open-water placement area. Placement of between 0.5 to 1.8 million cubic yards (0.4 to 1.4 million cubic meters) of sediment was conducted every one to three years, which influenced and contributed to the development of an approximately 86 ac (35 ha) island mid-river (Figure 20). Sediment dredged from the adjacent federal navigation channel during routine maintenance was strategically placed in mounds upriver of the island over a period of 12 years. The mounded sediment was dispersed by the river’s currents to self-design the unconfined island over time. While the strategic placement of dredged sediments upriver of the naturally occurring island was initially conducted to reduce dredging costs and promote the island’s growth, additional environmental, navigation, and climate-change benefits were realized using this innovative placement practice.

Figure 20. Behind the dredge California, the river island at Horseshoe Bend on the lower Atchafalaya River, Louisiana, is being self-designed by dredged sediment strategically placed upriver (*lower right*), allowing the river's energy to disperse the sediment. The dispersed sediment contributes to the island's growth, thus creating environmental and other benefits. (Photo credit: Wings of Anglers, courtesy of Great Lakes Dredge and Dock)

### 2.6.2 Project description

A CEMVN and ERDC project team was formed to generate data and other information regarding ecosystem classification and mapping and floral and faunal composition of the island. To help understand how and why the island was formed over the last 12 years, USACE conducted studies to better understand the hydrology of the river used to transfer the mounded material onto the island. Information regarding ecosystem classification and mapping and floral and faunal composition of the island were conducted to document environmental and other benefits being realized (Suedel, Fredette, and Corbino 2014). In addition, multiple moderate- and high-resolution aerial photographs available from prior to 2002 to the present documented the growth of the island (Figure 21). To address this goal, the project objective focused on demonstrating how dredged sediment can be used beneficially to nourish a naturally forming river island. Biology, ecology, and hydrodynamics were examined to catalog the island's maturation to determine the effectiveness of this individual project in restoring, creating, enhancing, and protecting the coastal Louisiana landscape.

Figure 21. Imagery displaying Horseshoe Bend Island location prior to dredged-sediment placement and subsequent formation (1992 and 1998 images), establishment, and growth since strategic dredged-sediment placement began in 2002. (Images credit: USACE–New Orleans District)



### 2.6.3 Monitoring

The study used a multifactor ecological assessment including (1) landscape geomorphology, (2) ecosystem classification, (3) floral communities, (4) avian communities, (5) aquatic invertebrates, (6) soils and biogeochemical activity, and (7) hydrodynamic and sediment modeling (Berkowitz et al. 2017). Ecological components comprising primary producers, microbial communities, invertebrates that form the basis of aquatic food webs, and higher organisms were studied, providing a comprehensive assessment of dredged-sediment-supported wetlands. This framework can be used in future studies examining the ecological, societal, and economic value of the strategic placement of dredged sediment applied in this manner.

### 2.6.4 Study results

Results demonstrate that Horseshoe Bend Island is providing four distinct habitat types and biogeochemical functions at rates comparable or exceeding observations made at a traditional dredged-sediment-supported island and a natural reference island in the area. Thus, the island supports complex communities of vegetation, invertebrates, soil microbes, and higher organisms (that is, avian species; Figure 22). Moreover, the distribution of forested, shrub-scrub, emergent, and aquatic-bed habitat types also corresponds to the natural distribution reported throughout the study area. This wide variety of vegetation includes >85% native species, with species-richness values exceeding observations from both traditional dredged-material-supported and natural reference areas.

The design used at Horseshoe Bend Island resulted in landscape and landform characteristics (for example, distance from shore, flooding regime) that support a large, successful wading bird rookery (Figure 22; Berkowitz et al. 2015). Horseshoe Bend Island also supports more invertebrate abundance and diversity than natural islands in the region, which lack the emergent aquatic-bed landforms resulting from the strategic placement of dredged materials. Finally, the soils at Horseshoe Bend Island display a capacity to sequester nutrients and other compounds and perform water-quality functions at levels comparable to natural wetlands in the region (Berkowitz et al. 2016).

Figure 22. A diverse assemblage of native plant and animal life has colonized Horseshoe Bend Island, including the native American lotus (*Nelumbo lutea*; *upper left*), various amphibians (*lower left*), and juvenile glossy ibis (*Plegadis falcinellus*; *right*) observed during nesting season. (Photo credits: *Top* and *bottom left*, Burton Suedel; *right*, Nathan Beane)

### 2.6.5 Project significance

This innovative beneficial use of dredged sediment for creating Horseshoe Bend Island can be applied in other riverine project scenarios. The success of this project demonstrates the potential benefits of applying the EWN practice of using natural processes to maximize benefits, including reducing demand on limited resources, minimizing the environmental footprint of projects, and improving wetland-creation and restoration outcomes.

Economic benefits are also being realized as the enlarging island has reduced the overall cross-sectional area of the river, increasing the river's flow through the navigation channel to velocities sufficient to mitigate shoaling and maintenance dredging requirements. Costs were lower than the conventional approach because all other placement alternatives required additional equipment and land rights to convey dredged material over long distances. Signs of human activity, such as the presence of shotgun shells, signify that the island is also being used for hunting.

Intentionally aligning natural processes in the river with engineering processes via strategically mounding dredged material is realizing tangible environmental, social, and economic benefits (Foran et al. 2018). To this day, the island continues to provide multiple benefits. It offers a means of beneficially using dredged sediments from the adjacent federal navigation channel to sustain and grow the island over time (Figure 23).

Figure 23. Aerial image of the northern end of Horseshoe Bend Island after placement of 500,000 $yd^3$ (382,280 $m^3$) of dredged sediments in late January 2020. The energy from the lower Atchafalaya River will disperse the sediment to shore up the western portions of the island. Periodic strategic placement is a sustainable beneficial use of sediments dredged from the adjacent federal navigation channel. (Photo credit: CEMVN)

Investigations quantifying the multiple environmental and other benefits of using dredged sediment to create such riverine islands will provide a more complete understanding of the formation of the island so that this concept can be integrated into other dredging projects in coastal Louisiana and elsewhere, thereby providing substantial environmental, social, and economic benefits as part of ongoing USACE maintenance dredging activities. To this end, USACE is currently applying these practices and lessons learned at other locations along the Louisiana Gulf Coast and within CENAP, among others.

# 3 Summary

This report presents a series of island case studies demonstrating EWN principles in action. The islands showcased have been created or maintained using dredged sediments from nearby navigation channels, representing an excellent example of the economic and environmental benefits of pairing the beneficial use of dredged sediments with routine channel maintenance. All islands provide some form of ecological services, such as valuable habitat for wildlife while reducing waves and erosion to nearby shorelines.

The lack of quantitative information on island performance regarding its ability to reduce wave energy and erosion, and the potential impacts to subtidal habitats, are often cited as a barrier to implementation. On-the-ground island projects combined with pre- and postconstruction monitoring to evaluate island performance and benefits are required to advance this practice. Addressing these uncertainties requires multidisciplinary collaborations to conduct applied research and document lessons learned for the entire project life cycle, from planning and design to adaptive management.

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# Abbreviations

| | |
|---|---|
| ADA | Americans with Disabilities Act |
| CEMVN | New Orleans District |
| CENAB | Baltimore District |
| CENAP | Philadelphia District |
| ERM | environmental resources management |
| EWN | Engineering With Nature |
| FIND | Florida Inland Navigation District |
| LWGC | Lake Worth Golf Course |
| LWL | Lake Worth Lagoon |
| MAMP | monitoring and adaptive management plan |
| MLLW | mean lower low water |
| NAVD | North American vertical datum |
| NCCOS | National Centers for Coastal Ocean Science |
| NJ ICW | New Jersey Intercoastal Waterway |
| NOAA | National Oceanic and Atmospheric Administration |
| SMIIL | Seven Mile Island Innovation Laboratory |
| USACE | US Army Corps of Engineers |

# REPORT DOCUMENTATION PAGE

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Engineering With Nature® Principles in Action: Islands

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**14. ABSTRACT**
The Engineering With Nature® (EWN) Program supports nature-based solutions that reduce coastal-storm and flood risks while providing environmental and socioeconomic benefits. Combining the beneficial use of dredged sediments with the restoration or creation of islands increases habitat and recreation, keeps sediment in the system, and reduces coastal-storm and flood impacts. Given the potential advantages of islands, EWN seeks to support science-based investigations of island performance, impacts, and benefits through collaborative multidisciplinary efforts. Using a series of case studies led by US Army Corps of Engineers (USACE) districts and others, this technical report highlights the role of islands in providing coastal resilience benefits in terms of reducing waves and erosion as well as other environmental and socioeconomic benefits to the communities and the ecosystems they reside in.

**15. SUBJECT TERMS**
Environmental engineering; Coastal engineering; Artificial islands; Islands--Restoration ecology; Flood control; Shore protection

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