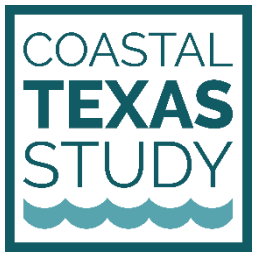

Coastal Texas Protection and Restoration Feasibility Study

Final Feasibility Report

Appendix A – Annex 1:

Significance of the Resources along the Texas Coast Proposed for Ecosystem Restoration Actions

August 2021

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1.0 SIGNIFICANCE OF THE STUDY AREA AND ITS RESOURCES

The consideration of significant resources and significant effects is central to plan formulation and evaluation for any type of water resources development project. Resource significance is determined by the importance and non-monetary value of the resource. The criteria for determining the significance of resources are provided in the federal Economic and Environmental Principles and Guidelines for Water and Related Land Resources Implementation Studies (United States Water Resources Council 1983) and in USACE planning guidance such as the Planning Guidance Notebook (Engineering Regulation [ER] 1105-2-100). Significance of resources and effects are derived from institutional, public, and technical recognition of the ecological, cultural, and aesthetic attributes of resources within the study area.

- ***Institutional significance:*** importance of an environmental resource as acknowledged by laws, executive orders (EO), rules, regulations, treaties, policy statements or adopted plans of public agencies or private groups.
- ***Public significance:*** importance of an environmental resource based on public recognition that may take the form of controversy, support, conflict, or opposition.
- ***Technical significance:*** importance of an environmental resource as based on scientific and technical knowledge or professional judgment of critical resource characteristics including: scarcity, representativeness, status and trends, connectivity, limiting habitat, and bio-diversity.

In ecosystem restoration planning, the concept of significance of outputs plays an especially important role because of the challenge of dealing with non-monetary outputs. The three sources of significance – institutional, public, and technical – and documentation on the relative scarcity of the resources helps determine the significance of the resources to be restored and helps to establish federal interest in the project.

The following sections describe the significance of the six habitat types the Coastal Texas Protection and Restoration Feasibility Stud (Coastal Texas Study) intends to focus restoration efforts on. Table 1 shows which recommended plan ER measures are directly (targeted habitat restoration through direct manipulation and construction) or indirectly (through restoration of other habitat types there are benefits) benefited by implementing the measure.

Table 1. Habitats benefited from the Recommended Plan ER Measures.

Measure	Estuarine Marsh	Rookery Islands	Oyster Reefs	Beach and Dunes	Seagrass Meadows	Hyper-Saline Lagoon
G-28	Direct/Indirect	Direct	Direct	--	--	--
B-2	Indirect	--	--	Direct	--	--
B-12	Direct	--	Direct	--	--	--
M-8	Direct/Indirect	Direct	Direct			
CA-5	Indirect	--	Direct	--	Indirect	--
CA-6	Direct/Indirect	--	--	--	--	--
SP-1	--	Direct	Direct	--	Indirect	--

W-3	--	Direct	Direct	Direct	Indirect	Indirect

1.1 Estuarine Marsh (Wetlands)

Estuarine wetlands (tidal or saline) are found either in dense continuous stands or in fringing narrow stands along bay shorelines and directly inland of beaches, dunes, and barrier islands within the study area. They are at the interface of land and sea where they form linkages between inland landscapes and the ocean. Estuarine marshes are a valuable resource that is highly productive biologically and chemically in which a variety of flora and fauna depend including three species protected by ESA (whooping crane, piping plover, and eastern black rail) and a number of species protected under State regulations. Estuarine wetlands provide habitat for numerous avian species including shorebirds, perching birds, wading birds, and gulls and terns. The estuarine wetlands also provide nurseries, shelter, and food for finfish, shellfish, and marine mammals. In fact, more than half of the fish caught for recreational or commercial purposes in the US depends on estuaries and their coastal wetlands at some point in their life cycle (Lellis-Dibble et al. 2008). Healthy coastal wetlands are among the most productive ecosystems on the planet, comparable to rainforests and coral reefs (Dahl and Stedman 2013).

This unique habit type also provides several ecosystem services that are vital to the health and well-being of our nation including: improving water quality by removing pollutants, nutrients, and sediments; protecting coastal areas from storm damage and sea level rise; buffering against erosive wave energies and storm surges; and supporting the tourism, hunting, and fishing sectors of the economy (EPA 2015, Dahl and Stedman 2013).

Despite the value of wetlands to fisheries and the economy, Texas has lost 52 percent of its original wetland base (Mitsch and Gosselink 1993). The Texas coast experienced a loss of approximately 200,000 acres of freshwater and estuarine wetlands between the mid-1950s and the early 1990s (from 4.1 million to 3.9 million acres). Of the 3.9 million acres remaining in the early 1990s, only about 15 percent (0.6 million acres) were estuarine wetlands (Moulton and Jacob 2000). While no more recent study has looked at wetland losses for the entire Texas coast, a number of studies focusing on specific areas have all concluded that there is a downward trend in the areal extent of wetlands. The largest degradation of wetland habitat consisted of interior losses of coastal emergent marsh and rice field wetlands (Tacha et al. 1992). Continued altered hydrologic regimes, lack of sediment input, subsidence, and saltwater intrusion will continue the trend of marsh conversion to less productive, saline habitats or open water. Under future RSLC conditions, rising sea levels will exacerbate the existing trend and lead to an increase in marsh loss. Although many Texas national wildlife refuges and wildlife management areas were established to conserve and mange wetland habitats specifically for the benefit of migratory waterfowl, additional protection and preservation measures are needed to reestablish hydrologic connectivity and reduce erosion of existing estuarine habitats along the coast.

USACE has many advantages to completing marsh restoration in conjunction with the many other ER measures proposed in this study as compared to a state or private organization looking to restore marsh. Through this study, the USACE has the ability to focus and site marsh restoration measures at locations that increase marsh habitat, but also provide shoreline stabilization and protection to other habitats, such as freshwater marshes, back bays, tidal flats, lagoons and even some developed areas.

Additionally, the Coastal Texas Study authorization and scope allow locations to be selected that would complement federal, state and local conservation plans on lands often beyond their authority (e.g. private lands) that contributes to a synergistic landscape scale restoration effort. Additionally, implementing restoration on private lands increases the amount of marsh area that is protected from future development.

The access to and use of dredge material allows the USACE to supply material at a greatly reduced cost as compared to other interested organizations which would have to seek out a private source of sediment. Beneficially using dredge material retains the sediment within the littoral system by placing the dredged sediments from the navigable waterways onto adjacent beaches and reduces the loss that would have occurred if the dredged sediment was placed in the designated offshore or upland disposal site. It also retains space within the upland placement areas that allow for future placements without the need to seek new disposal sites or raise levees.

Institutional Significance: The institutional significance of estuarine marshes is acknowledged in numerous laws, executive orders (EO), policy statements and adopted plans of public agencies or private groups. The following is a summary of the most prominent; however, there are many more particularly at the local level where plans by public agencies and private groups have been developed for targeted bays, estuaries, or watersheds.

- *Endangered Species Act (ESA):* As indicated previously, three Federally-listed species are known to utilize the study area marshes and at least three species have been delisted, including bald eagle, brown pelican and wood stork. As well, a number of state listed species are dependent on estuarine marshes for all or part of their life cycle.

- *Magnuson-Stevens Fishery Conservation and Management Act:* Under the Act, all estuarine marshes are identified as Essential Fish Habitat (EFH), which provides aquatic features necessary for the survival of 25 species of fish managed by the Regional Fishery Management Council

- *Migratory Bird Treaty Act/Executive Order 13186:* The study area is within the Central Flyway and the upper part of the Texas coast is a convergence zone between the Central and Mississippi Flyways in which species from both flyways can be found. The Central Flyway sustains tens of millions of individuals of at least 300 species of migratory birds that funnel through the Texas coast (USFWS 2021). The Texas coast is the first/last stopover for numerous species migrating between temperate breeding areas in North America and wintering areas in Central and South America. Of these migratory species, many are also designated as conservation priorities due to declining, threatened, or otherwise vulnerable populations including: USFWS Species of Conservation Concern, US Shorebird Conservation Plan for the Gulf Coast Prairie Region, Partners in Flight Conservation Plan, North American Waterbird Conservation Plan, and the North American Waterfowl Management Plan.

- *Clean Water Act:* The Act identifies wetlands as a significant resource requiring protection and preservation to the greatest extent practicable and if impacted require mitigation to obtain "no net loss."

- *Coastal Zone Management Act:* Marshes are considered a coastal resource of national significance under the Act and are considered a Coastal Natural Resource Area (CNRAs) – Waters Under Tidal Influence and Coastal Wetlands under the Texas Coastal Management Program, which requires protection, restoration, and responsible development of coastal resources.
- *Coastal Barrier Resources Act:* The study area lies within system units and otherwise protected areas as identified by the Act. These areas are protected from development and the removal of features integral to coastal ecological systems, which include wetland areas.
- *Coastal Wetlands Initiative:* EPA established the Initiative, which seeks to confirm wetland loss and better understand contributing stressors; identify and disseminate tools, strategies, policies, and information to protect and restore coastal wetlands resources; raising awareness of the functions, values, and threats of coastal wetlands; and establish an Interagency Coastal Wetlands Workgroup.

Public Significance: The marshes provide nursery habitat for recreational and commercial fishing, both of which are cultural icons of coastal Texas. Wetlands and wildlife in the study area also attract birders, hunters, boaters and other outdoor enthusiasts, including members of the National Audubon Society and National Wildlife Federation.

Technical Significance: As indicated in the discussion, the extent of estuarine wetlands has been declining over the last 70+ years due to natural and human caused reasons. As sea level rise continues, wetland loss is expected to continue having a downward trend and marshes will become scarcer (status/trends/scarcity). Marshes are essential to the continued existence of whooping crane and black rail along with hundreds of other marsh-dependent birds that are of conservation concern. As well, marshes support critical life stages, such as breeding and nursery habitat, of many other fish and invertebrate species, and as the trend of loss continues, it is expected that each of these species will also begin to decline (limiting habitat). The diversity of marshes is some of the highest of all habitat types supporting hundreds of species and millions of individuals using the marshes to forage, roost, nest, breed, seek refuge, or complete life-stages, which is expected to see a downward trend as marsh loss continues (biodiversity).

Unique landforms and geographic features found along the Texas coast concentrate bird species through the study area, especially migrants and provides the first or last stopover for a significant number of migrating birds before they cross the Gulf of Mexico and fly to their breeding or wintering grounds (Connectivity). Additionally, the freshwater riverine and Gulf waters mix within the marshes and open water areas of the study area. This unique zone provides critical habitat for diadromous species. Marshes provide spawning and nursery habitat for many economically and recreationally important species. After their life stage in the marshes is complete, they move out to Gulf water until they return to spawn (Connectivity).

1.2 Rookery Islands

The coastal islands of Texas provide suitable habitat for over 26 species of colonial waterbirds and a variety of other coastal flora and fauna. Colonial waterbird and coastal shorebird populations are key

environmental indicators of estuary health and productivity. They represent the top of the food chain and reflect the system's overall health (Chaney and Blacklock 2003).

Colonial waterbirds specifically seek out coastal islands as "rookeries," places to nest and raise their chicks in large groups and find protection from predators and human disturbance. Rookery islands are isolated from the mainland and are too small to sustain predator populations, thereby providing optimal foraging, roosting, breeding, nesting, and rearing habitats for colonial waterbirds, including gulls, skimmers, herons, terns, pelicans, egrets and cormorants. Colonial waterbirds rely on open water, mud flats, estuarine wetlands and seagrass for foraging, which is ideally abundant near the islands. Nesting pairs on rookery islands can range from a few pairs to thousands of birds depending on the island size.

Recent trends (2000 through 2020) indicate a decline for many of the species surveyed along the Texas coast, which can be attributed to predator presence (including humans) and habitat erosion or conversion (USFWS 2021). It is thought that suitable nesting habitat is the most limiting factor for most of the waterbird species in the area.

The importance of coastal rookeries to bay ecosystems, beyond providing bird habitat, is well documented in terms of enhancing fisheries production, recreational bird watching opportunities, and photography. Rookery islands on the back side of the barrier islands and adjacent bays also provide natural wave attenuation and erosion protection for bay shorelines and wetlands along navigation channels. In addition to providing quality bird habitat, the islands have been noted as providing suitable habitat for establishment and growth of seagrass meadows through modification of tides and currents and the increase in nutrients from bird defecation.

Prior to the Gulf Intracoastal Waterway (GIWW) dredging projects of the early 1900s, birds were dependent on natural islands for nesting. When the GIWW was completed in the mid-20th century, dredged material heaped along its sides formed new "islands" that became replacement rookery sites. However, these GIWW dredge spoil islands also began eroding because of limited natural processes encouraging natural beach building and accretion, deepening of adjacent waters for navigation channels, increased ship traffic, loss of oyster reef structure due to commercial harvesting, and relative sea level rise (CBBEP 2010). Erosion has led to the complete loss of several nesting islands, and the partial (and ongoing) loss of almost all others over time (Hackney et al. 2016). Where remnant islands remain, only a small portion of the islands remains dry and provides minimal suitable habitat to serve as a rookery for colonial nesting birds. The net loss of island areas has reshaped the colonial waterbird utilization patterns of islands along the Texas (CBBEP 2020). This trend of declining island area and changes to colonial waterbird utilization patterns, populations, and species diversity is expected to continue into the future. Consequently, these changes have increased the need for active ecological restoration actions needed to maintain suitable nesting habitat (CBBEP 2020).

Increased and focused management efforts have been underway to improve existing habitat and create new habitat over the past 15 years by US Fish & Wildlife Service, Texas Parks & Wildlife Department, Bay & Estuary Programs, Audubon Texas, The Nature Conservancy, and local academic institutions (Stanzel 2018). One way to address the loss of rookery islands is the creation of new, strategically located islands. Island creation and restoration projects are expensive, requiring extensive engineering, permitting, dredging, equipment mobilization and construction costs. However, island creation and restoration are considered essential to address the declines in waterbird populations (CBBEP 2020). The USACE is

uniquely suited to carrying out this type of project because of access to a breadth of engineering experience and feasibility of beneficially using dredge materials to create the islands, which also offsets some of the cost that other agencies or interested stakeholders may not be able to take advantage of. As well, stakeholders are prioritizing restoration efforts to areas where it most critical and where it is not cost-prohibitive due to remoteness or availability of sediments from private sources. Specifically for the Coastal Texas Feasibility study, island restoration can be used as a multi-purpose measure by restoring islands in strategic areas that benefit colonial waterbirds, but also provides coastal storm defenses, shoreline stabilization, and protection and restoration for other habitats including marshes and seagrass meadows. This multi-purpose focus gains more benefits from the restoration action than a focused effort that is often implemented by interested stakeholders, which also makes it more likely to be implemented especially if remoteness or costs are higher than for typical island creation or restoration actions.

Institutional significance: Rookery Islands are not specifically targeted under any laws, executive orders, or regulations. Rather their significance is recognized because of the dependence of protected species on islands and their overall benefit to the coastal system.

- *Endangered Species Act (ESA):* The least tern and wood stork are known to use rookery islands in the study area, as well as the delisted brown pelican. The State of Texas also lists several colonial waterbirds as Threatened or Endangered under Texas Parks and Wildlife Code, including the reddish egret and white-faced ibis.

- *Migratory Bird Treaty Act/Executive Order 13186:* All 26 species of colonial waterbirds dependent on islands are considered migratory birds and are protected under the Act and EO. Many of these species are also designated as conservation priorities in conservation plans including: USFWS Species of Conservation Concern, US Shorebird Conservation Plan for the Gulf Coast Prairie Region, Partners in Flight Conservation Plan, and North American Waterbird Conservation Plan. For example, the North American Waterbird Conservation Plan (2004) indicates 14 colonial or semi-colonial water bird species deemed as "Moderate Risk" and 6 species deemed at "High Risk" utilize the study area and rookery islands along the Texas coast.

- *Island Preserves/Sanctuaries:* The Audubon Society and The Nature Conservancy have purchased or leased several islands along the Texas coast to preserve and manage the islands as rookery island preserves or sanctuaries. Many of the waterbirds that nest along the Texas coast nest at these preserves/sanctuaries, including the largest Reddish Egret and Roseate Spoonbill colonies in the world.

Public Significance: Rookery Islands provide for ecotourism opportunities, primarily in the form of bird watching. Birders from all over the world visit the Texas coast every year to observe nesting colonial waterbirds. As indicated in the discussion, rookery islands enhance commercial and recreational fisheries for which many people partake in recreational fishing or consumption of seafood.

Technical Significance: As indicated, natural rookery islands are nearly gone and man-made islands are disappearing at a rapid rate and when combined with sea level rise, the remaining islands within the study area are predicted to disappear within the next 50 years, many within the next 10 years (status/trends/scarcity). Rookery islands provide nesting habitat which has been identified as a limiting factor for colonial waterbirds (connectivity/limiting habitat). The disappearance of rookery islands is

directly correlated to the downward trend of colonial waterbird diversity and population in the study area (status/trends/limiting habitat), which hosts some of the world's largest populations of colonial. Diversity on the islands is significant considering as many as 26 species of birds could be found on an island than is only a few acres in size (biodiversity).

1.3 Oyster Reefs

Oyster reefs were once a dominant structural and ecological component of estuaries around the globe, fueling coastal economies for centuries (Beck et al. 2011). Oysters are considered critical ecosystem engineers, which is when one or a few species produce reef habitat for an entire ecosystem (Lenihan and Peterson 1998). Within the shallow estuaries of the northern Gulf of Mexico, including all along the Texas coast, the eastern oyster is the dominant reef building organism. Oyster reefs provide habitat for more than 300 species of marine aquatic species (Wells 1961) that facilitate ecosystem functioning and support of vibrant fisheries, including recreationally and commercially important species. Research shows oyster reef habitat supports nearly 4.5 times the aquatic biomass found in seagrass beds and roughly 11.5 times the aquatic biomass found in marsh edge habitat, making it the most valuable Texas coastal resource. Lost habitat caused by declines in oyster reefs is also linked to broader drops in coastal biodiversity, which has both intrinsic and economic value (Lotze et al. 2006, Airoldi et al. 2008).

Native oyster reefs provide many ecosystem services including water filtration, food and habitat for many animals (e.g., fish, crabs, birds, and humans), shoreline stabilization and coastal defense, and fisheries. For example, oysters filter suspended solids from surrounding waters, thereby increasing water clarity (Newell 2004), which can then enable seagrass growth. The same filtration service can also reduce the likelihood of harmful algal blooms, which have important impacts ecologically and economically (Cerrato et al. 2004, Newell and Koch 2004). Oysters can also help to remove excess nutrients from coastal bays by facilitating denitrification in surrounding sediments, which has tremendous economic value in areas where nutrient removal is a high priority for coastal policymakers (Newell et al. 2005). Additionally, oysters also serve as natural coastal buffers, absorbing wave energy directed at shorelines and reducing erosion caused by boat wakes, sea-level rise, and storms (Meyer 1997, Piazza et al. 2005). Their buffering ability plays an important role in protecting and building coastal marshes, island rookeries, and seagrass beds, which can in turn provide their own flood and erosion reduction benefits. All of these ecosystem services can enhance tourism and recreation by improving and protecting coastal habitats, increasing species diversity, and increasing sport fisheries (Lipton 2004). Each of the ecosystem services provided by oyster reefs would require multiple additional actions per service to compete with the natural benefits of oysters, many of which would require construction of hardened structures or manipulation of natural systems that could result in further degradation of natural habitats. The economic value of oyster reef ecosystem services ranges from $10,325 to $99,421 per hectare per year (not including the value of harvested oysters), depending on where the reef is located (Grabowski et al. 2012).

While there is little doubt that overexploitation has been the primary driver of decline in oyster abundance through the US and globally, coastal development, water quality degradation, alteration of freshwater flows and oyster disease have also contributed to the loss of habitat (zu Ermgassen et al. 2016). The decrease in living biomass of oysters in US estuaries is estimated to be 88 percent over the past 120 years along (zu Ermgassen et al. 2012), and losses likely greatly exceed this estimate, since of the mapped areas on which this estimate was based were already heavily exploited before baselines

could be established. Beck et al. (2011) found that 85 percent of oyster reefs globally have been lost due to overharvesting, hurricanes, disease and changes in freshwater flows, while just 20-50 percent of original oyster reefs remain in the Gulf of Mexico including in Galveston, Matagorda, and Copano bays and Sabine Lake in Texas. The reported functional decline in oyster reefs is likely to have broad consequences for habitat provision and thus biodiversity and fisheries production, as well as the ecosystem services provided by oyster reefs and their contribution to other threatened coastal habitats (Peterson et al. 2003, Humphries and La Peyre 2015, Zu Ermagassen et al. 2015).

Oyster fisheries in the Gulf of Mexico, including within the study area, are probably the last remaining opportunity to achieve both large-scale oyster reef conservation and sustainable fisheries (Beck et al. 2011). While scientists and managers focus attention on relatively few well-known estuaries with oysters, such as the Chesapeake Bay (Jackson et al. 2001, Lotze et al. 2006), needs are not being met elsewhere and opportunities are being missed (Beck et al. 2011). TPWD and other stakeholders have undertaken significant and valuable oyster restoration projects in bays where historic oyster reef presence was highest. However, the focus has been in these prime historic areas, but many other equally valuable and suitable sites remain a lower priority. That is where the Coastal Texas Study can greatly contribute to the recovery of oyster reefs along the Texas coast and in the Gulf of Mexico while increasing coastal protection. Through this project, the ecosystem services provided by oyster reef can be taken advantage of to achieve CSRM goals (e.g. shoreline stabilization and coastal defense), and other ER goals (e.g. protecting marsh or rookery island restoration areas, improving habitat conditions of sensitive habitats, or providing additional food sources for birds or other wildlife) in areas that are not as high of a priority. This study doesn't focus just on the most sensitive and needed sites specific to oyster restoration but expands to other areas where oyster restoration can achieve many objectives. Natural coastal protection is most effective when multiple habitat types are able to work in concert to maximize the overall benefits to coastal communities. Other interest groups and stakeholders to oyster restoration have specific focuses and may not have the jurisdiction (e.g. private lands) and/or ability (e.g. monetarily or feasibility) to complete the complimentary actions that makes the Coastal Texas oyster restoration plan so effective.

Institutional Significance: Very few laws or regulations protect oyster reefs, rather they are conserved through recreational and commercial harvest regulations set by the TPWD and NMFS and under broader laws that recognize oysters as a significant coastal resource. Many state and local agencies and private organizations have developed estuary, bay, and/or watershed conservation plans that address conservation needs and restoration goals of oyster reefs; however, they will not be specifically identified here.

- *Magnuson-Stevens Fishery Conservation and Management Act:* Under the Act, oyster reefs are identified as EFH, which provides aquatic features necessary for the survival of fish managed by the Regional Fishery Management Council
- *Coastal Zone Management Act:* Reefs are considered a coastal resource of national significance under the Act and are considered a CNRA – Oyster Reefs.

Public Significance: As indicated in the discussion, oysters and oyster reefs are significant due to their economic value from commercial harvesting for the food industry, as well as the ecosystem

services they provide including the benefits they provide for recreational and commercial fisheries and coastal defenses.

Technical Significance: As indicated in the discussion, oyster reefs are scarce, and the status and trends indicate significant decreases both within the study area and globally from historic mapped locations. They are also technically significant due their ability to support more aquatic biomass than any other aquatic habitat (diversity), including numerous aquatic species that are protected under other laws or of conservation concern and their ability to benefit other habitats such as marsh, seagrass meadows, and rookery islands. Without oyster reefs, the diversity of marine environments is expected to continue declining (limiting factor). The Corps has extensive experience with oyster reef building because of an history mitigating for coastal navigation projects.

1.4 Beach and Dunes

Coastal beach and sand dune systems support a broad range of flora and fauna owing to the diversity of the ecological niches found within them. Part of this diversity is due to the complex topography and its associated vegetation communities, creating a wide range of habitats from dry dune crests and wet dune slacks – a (usually seasonal) wetland habitat — between the dune ridges to the dry backbeaches and wet foreshore or nearshore habitats. Specifically for the dunes, internal diversity is generated by the aspect on steep dune slopes and by successional processes in both dry and wet dune habitats with development from largely bare sand through to grassland and eventually scrub or woodland as a natural climax community (Everard et al. 2010). As for the beaches, they may appear barren and devoid of life, but it actually supports a rich community of invertebrates which forms a link in the coastal food chain. These two habitats together support loafing, nesting and foraging habitat for millions of shorebirds composed of 38 of the 52 species known to occur in the US, nesting habitat for five species of sea turtles, and spawning and nursery habitat fish.

The beach and dune system provide many ecosystem services including: sediment storage and transport, wave dissipation and associated buffering against extreme weather events; dynamic response to sea level rise; breakdown of organic materials and pollutants; water filtration; nutrient mineralization and recycling; scenic vistas and recreational opportunities; and functional link between terrestrial and marine environments (Defeo et al. 2009). The most common ecosystem services the public and most officials recognize are a beach and dune system's ability to naturally reduce impacts from coastal storms and the economic value of tourism by beachgoers.

Beaches and dunes are naturally dynamic environments and will fluctuate in size and shape from year to year based on the effect of wind, waves, tides, and storm events. While short-term weather related changes from hurricanes and unseasonably high tides can be variable, the long-term changes due to sea level rise, combined with lack of coarse-grained sand supply, and annual erosion have contributed to increased shoreline retreat of the beach and dune systems along the Texas coast. Comparison of the 1930s to 2012 and 1950s to 2012 datasets, show that the percentages of advancing and retreating shorelines are similar; nearly 20% advance and 80% retreat (Paine et al. 2014). Between the 1930s and 2012, the annual land loss was calculated at 178 acres/year and the total land loss during that time frame was 14,597 acres (Paine et al. 2014). In general, the Gulf shorelines undergoing the greatest rate of erosion (more than -8 ft/year [-2.5 m/yr]) are located between Sabine Pass to Rollover

Pass, on Galveston Island west of the seawall, Quintana Beach to Sargent Beach, Mustang Island (north of Packery Channel), Padre Island near Port Mansfield Channel, southern Padre Island (Willacy County and Cameron County sections), and the southern portion of Brazos Island near the Rio Grande, all of which are within the study area for which some of the recommended plan measures would focus on.

Like the other restoration target areas, USACE through this study has the ability to focus beach nourishment and dune construction measures on locations that increase beach and dune habitat, but also provide shoreline stabilization and protection to other habitats, such as marshes, back bays, tidal flats, lagoons and even some developed areas. Additionally, the Coastal Texas Study authorization and scope allow locations to be selected that would complement federal, state and local management plans, such as erosion response plans and conservation and restoration plans. As well, USACE access to beneficial use of dredge material reduces the overall cost of the restoration action and retains space within the upland disposal site potentially resulting in a long-term cost savings to the dredging program.

Institutional Significance: In general, beach and dune regulation is limited and while beaches and dunes are called out as specific areas worth protecting, they are in larger overarching laws and regulations intended to protect the entire system. The most applicable laws are listed below. Although there are local and private conservation plans that aim to protect and restore beaches, they are not specifically called out here.

- *ESA:* Beaches and dunes provide habitat for seven Federally-protected species including piping plover, red knot, and five nesting sea turtles (green, Kemp's Ridley, loggerhead, leatherback, and hawksbill). As well, at least one species that has been delisted (brown pelican).
- *Coastal Zone Management Act:* The beaches and dunes in the study area lie within the Coastal Zone and are considered CNRAs – Gulf Baches, Critical Dune Areas, and Critical Erosion Areas.
- *Coastal Barrier Resources Act:* The study area lies within system units and otherwise protected areas as identified by the Act. These areas are protected from development and the removal features integral to coastal ecological systems, which include beach and dune areas.
- Coastal Erosion Planning and Response Act (CEPRA): The Act provides for protecting critically eroding areas along the Texas coast. Texas Administrative Code (TAC §§15.1-15.10) and Texas Natural Resources Code (TNC Subchapter H. Coastal Erosion, Sec. 33.601) provides the definition, authority and the rules for identifying "eroding areas" as an area experiencing historical erosion rates of greater than two feet per year and "critical erosion areas" as areas where a threat exists as defined in the TAC. Most of the Texas Gulf shoreline (about 80%) qualifies as critical coastal erosion areas. beaches in the study area are considered eroding areas.
- Federal/State Managed Areas: Only about 80 miles of the undeveloped Texas coast is developable. The balance is held in natural seashores, national wildlife refuges, and national, state, county, and municipal parks. The most notable along the Texas coast is the Padre Island National Seashore, which is managed and owned by the National Park Service. Padre Island National Seashore is a 113-mile long barrier island that was set aside as part of the national park system in order "to save and preserve, for purpose of public recreation, benefit, and inspiration,

a portion of the diminishing seashore of the United States that remains undeveloped" (16 US § 459d).

Public Significance: The public values beaches as a recreational resource. Beaches are the leading US tourist destination and a survey found that 72 percent of Americans expressed a favorable opinion of beach summer vacations, 40 percent spent their allotted vacation days at the beach, and 52 percent planned a holiday at the beach in the following 12 months (Houston 2018). Additionally, beach erosion is the number one concern that beach tourists have about beaches (Houston 2018).

Technical Significance: As indicated, the beach and dune system along the Texas coast is rapidly eroding at a rate higher than can be naturally sustained particularly under future sea level rise conditions. Couple that with shorelines that have been or could be developed and the extent of quality beach and dune system greatly diminishes (status/trends/scarcity). Even for undevelopable shorelines, such as along the Padre Island National Seashore which is the longest stretch of undeveloped barrier island in the world, erosion threatens their representativeness as high-quality beach and dune habitat (representativeness). For nesting sea turtles, wintering piping plover and red knots, and other wintering and breeding shorebirds of concern, continued loss of suitable habitat would continue to result in declining populations and diversity because part or all of their life stages are dependent on this essential habitat (biodiversity/limiting habitat/connectivity). Additionally, the beach and dune system provides connectivity between the marine and terrestrial environments through input of nutrients and foods for fish, shorebirds, and invertebrates (connectivity).

1.5 Seagrass Meadows

One of the most biologically productive and recreationally and economically valuable habitats is seagrass meadows, also sometimes referred to as seagrass beds. Five seagrass species occur in Texas including shoal grass (*Halodule wrightii*), turtle grass (*Thalassia testudinum*), manatee gree (*Syringodium filiforme*), widgeon grass (*Ruppia maritima*), and star grass (*Halophila engelmannii*). These species represent highly specialized marine flowering plants (but not actually true grasses) that grow rooted and submersed in the higher salinity waters of Texas bays and estuaries. Seagrasses help to increase bottom surface areas, allowing for larger and more diverse communities of organisms to exist and provides substrate on which many other organisms can grow especially smaller attached algae and filter-feeing animals including sponges, bryozoans, and tunicates. This habitat type provides difficult to replace ecological functions such as foraging and nursery habitat for waterfowl, fish, shrimp, crabs, and other economically important estuarine species as well as sea turtles, manatees, and countless invertebrates that are produced within or migrate to seagrasses (USFWS 2021). For example, seagrasses along the Texas coast provide wintering habitat for over half of the world's population of redheaded ducks, with about 80 percent of the North American population occurring in the Laguna Madre alone (Ducks Unlimited 2017). Aquatic organisms' abundance in seagrass meadows is 10 to 100 times greater than in open bay bottom areas. Almost 40,000 fish and one thousand times as many small invertebrates are supported by a single acre of seagrass (TPWD 1999).

Seagrass meadows provide many ecosystem services including dampening the effects of strong currents, preventing erosion of shorelines and scour of bay bottoms, enhancing water clarity and

water purification (e.g. reducing eutrophication and phytoplankton blooms and removing toxic organic compounds from the water column and sediments), providing protection to fish and invertebrates, and carbon sequestration. Seagrasses help to reduce wave action with their above ground leaf structure and erosion with their below ground root and rhizome structure, thus keeping the substrate firm and maintaining water clarity. (TPWD 1999)

Most Texas seagrass meadows occur along the middle to lower Texas coast where waters are warm, clear, and have higher salinities (82% in Laguna Madre, 18% in mid-coast bays, and 0.1% in the Galveston Bay system). Seagrass mapping and monitoring have been so infrequent and variable in scope along most of the Texas coast that little can be said about trends. Based on approximately decadal mapping of Laguna Madre seagrasses from the 1960s to 1998 and annual sampling of permanent stations within seagrass meadows from 2011 to 2017, the total area of seagrass coverage has changed minimally (McKinney et al. 2019). However, seagrass community composition is in flux. Until about 2000, larger, more "climax" species like manatee grass gradually displaced the "pioneer" shoal grass, which is the preferred forage of redheads (McKinney et al. 2019). Ducks Unlimited (2017) estimates that since 1965, more than 40 percent of shoal grass has been lost. This process was interrupted in the Upper Laguna Madre in 2012 and 2013 by a multi-month episode of hypersalinity (>50 ppt) that reduced the area dominated by manatee grass by two-thirds. In the Lower Laguna Madre, Hurricane Alex in June 2010 caused large stormwater discharges into the lagoon that decreased the salinity to near freshwater and eliminated manatee grass almost entirely from the whole system (McKinney et al. 2019).

Aerial photographs from the 1950s indicate seagrasses were once present in Galveston Bay and ranged from 2,500 to 5,000 acres. Between the 1950s and late 1980s, approximately 1,700 acres of seagrass meadows disappeared and by 1987 they were gone from West Bay and the western shore of Upper Galveston Bay, leaving about 400 acres in Christmas Bay and less than 300 acres in upper Trinity Bay (Pulich and White 1991). In 2005, TPWD estimated that seagrasses in Christmas Bay had increased to about 436.6 acres. Federal, state, and local agencies and special interest groups are working toward achieving the goal set in the Galveston Bay Plan, which calls for creation of 1,400 acres of seagrass beds.

Institutional Significance:

- *ESA:* Seagrasses, particularly in the Laguna Madre, provide habitat and forage for two Federally-protected species including green sea turtle and West Indian manatee. As well, at least one species that has been delisted (brown pelican).
- *Magnuson-Stevens Fishery Conservation and Management Act:* Seagrass meadows are considered EFH because at least seven federally-managed fish species depend on seagrasses for all or part of their life history including: spotted sea trout, red drum, black drum, blue crabs, and white and brown shrimp.
- *Coastal Zone Management Act: Seagrasses within the* study area lie within the Coastal Zone and are considered Coastal Natural Resource Areas (CNRAs) – Submerged Aquatic Vegetation.
- *Clean Water Act:* Seagrasses are considered a wetland under Section 404 of the Act and is protected from fill activities, stormwater runoff and other water quality issues. As well, state

water quality standards as regulated under Section 401 of the Act must be attained or working toward attainment and are regularly monitored. Water quality management and monitoring is critical to seagrass survival as they are sensitive to changes in water quality.

- *Texas Seagrass Conservation Plan*: The State of Texas developed a seagrass conservation plan to identify resource management problems, enumerate planning objectives, and develop long- and short-range strategies and actions to protect and preserve Texas seagrasses.
- *TPWD Parks and Wildlife Code, Title 1, Subchapter B:* In 2013 the Texas Legislature passed a statewide law making it illegal to uproot seagrass anywhere along the Texas coast.
- *Redfish Bay State Scientific Area (RBSSA)*: Redfish Bay was proclaimed a state scientific area in 2000, which includes 32,000 acres of seagrass meadows. Initially voluntary "prop-up" zones were established to avoid further damage to seagrass habitat, but when those efforts failed, mandatory regulations were created in 2006 that prohibited the uprooting of seagrasses in RBSSA.

Public Significance: The public recognizes the value of seagrasses and the recreational and commercial fisheries they support, as well as the ecosystem services they provide.

Technical Significance: Seagrasses have been recognized as a biological indicator of estuarine water quality and ecosystem health because of their sensitivity to nutrient enrichment and eutrophication (Dennison et al. 1993, NOAA-ORCA 1995, Grovers et al. 2014).

As indicated in the discussion above, seagrasses are restricted to higher salinity bays and estuaries along the Texas coast (trends/status) and high quality, representative seagrasses are limited to the Laguna Madre (scarcity). Remaining seagrass meadows support the life stages of many fish, marine mammals, birds, and invertebrate species and are more productive than open bay bottom areas or estuarine marsh habitats (biodiversity/connectivity). Sustainment of seagrass meadows is critical to conserving the green sea turtle and West Indian manatee both of which require seagrasses as a food source (limiting habitat).

1.6 Hyper-Saline Lagoon

The Laguna Madre of Texas is the one of two coastal, hypersaline lagoon systems (also referred to as a negative estuary) in North America and comprises one of only five such lagoons worldwide. The Laguna Madre of Tamaulipas, found in Mexico, is the other hypersaline lagoon in North America and is only separated from the Laguna Madre of Texas by the Rio Grande Delta. Together they form the largest hypersaline system in the world. Because of low freshwater inflow (no rivers drain into the lagoon), little rainfall, high evaporation, low tidal range, and shallow bathymetry the salinity of the Laguna Madre of Texas (hereafter referred to as the Laguna Madre) often exceeds that of seawater (Tunnel et al. 2002). Despite harsh conditions imposed by high salinities, the Laguna Madre is an extremely productive bay system and is renowned among anglers for its world class fisheries.

There are eight major habitats associated with the Lower Laguna Madre – seagrass, jettied tidal inlets, oyster reefs, mangroves, salt marsh, wind-tidal flats, dredge material islands and open bay bottom. The dominant and critical habitat for the lagoon is seagrasses. The lagoon's clear shallow waters promote the growth of extensive seagrass beds and about 82% of the remaining seagrass habitat in Texas is in the Laguna Madre system (McKinney et al. 2019). These seagrass meadows provide protective nursery areas

for larval and juvenile fish, shrimp and crabs as well as cover and feeding areas for adult fish including spotted seatrout and red drum (see section 1.5 for a more detailed description of the significance of seagrass meadows). Open bay bottoms provide habitat for numerous invertebrates and 131 species of fish that are recreationally and commercially important (Jones et al. 2018). Additionally, 10 natural islands and hundreds of dredge material islands are present that provide rookery habitat for colonial waterbirds (Tunnel et al. 2002).

Due to its high salinity, emergent marshes are virtually absent from the system except for a few patches of salt marsh, though black mangroves are sparse in the intertidal zone. Instead, the abundant wind-tidal flats fill the role of marshes by converting plant biomass to animal biomass where the water meets the land. Flooding and exposure of this habitat is unpredictable because they are caused by wind-tides rather than astronomical tides. Wind-tidal flats are usually barren except for large areas colonized by blue-green algae mats called algal flats. The unique processes that result in algal flat formations only exist in a few locations worldwide, including the Persian Sea, Red Sea, and Eastern Mediterranean Sea (Morton and Holmes 2009). Wind-tidal flats provide important habitat for a variety of coastal wildlife from migratory waterfowl, shorebirds, wading birds, and other estuarine-dependent species like shrimp and various finfish (White et al. 1986). Dramatic losses in areal extent of wind-tidal flats since the 1950s are largely due to global sea-level rise and human impacts (White et al. 1983, Tunnel et al. 2002).

Historically, salinities in the lagoon were frequently recorded as excessively hypersaline (over 100 ppt), but over the last 50+ years salinities have moderated to moderately hypersaline (40-80 ppt) because of water circulation changes caused by construction of the GIWW (constructed in 1949) and Mansfield Pass (constructed in 1962). In 2011, it was determined that Mansfield Pass would not be dredged regularly, and the pass closed. Since closure, the salinity in the lagoon has steadily increased. Combine reduced circulation and lower salinity seawater with the point and non-point source runoff contributing excess nutrients, some of which is contributed by the USACE's GIWW extension to the Port of Harlingen, and the lagoon struggles to maintain water quality that supports the abundance of seagrasses and the diversity unique to the lagoon and leads to harmful algal blooms, also known as red tides and brown tides (Jones et al. 2018).

Water circulation is one way the lagoon salinities and overall water quality can be moderated. Since Mansfield Pass was one of only two passages into the Lower Laguna Madre, opening Mansfield Pass would help is restoring the circulation. The USACE is the only agency that can legally modify Mansfield Pass because of its classification as a Federal waterway; therefore, USACE an ideal partner in contributing to the larger efforts to conserve the Laguna Madre.

Institutional Significance:

- *ESA:* The seagrass meadows and open bay environment support federally-listed species such as the West Indian manatee, green sea turtle, loggerhead sea turtle, and possibly Kemp's ridley. while tidal flats support piping plover and rufa red knot and recently delisted species such as the brown pelican and peregrine falcon. Nearly 75 percent of the piping plover population winters in Texas, and of those most winter in the Laguna Madre (Newstead 2014). Several species of fish, birds, and mammals inhabit the areas in and around the Laguna Madre are protected under State Law.

- *Magnuson-Stevens Fishery Conservation and Management Act:* The Laguna Madre has been identified as EFH for adult and juvenile white shrimp, brown shrimp, red drum, juvenile pink shrimp and gray snapper. EFH in the lagoon includes estuarine wetlands, estuarine mud and sand substrates and submerged aquatic vegetation.

- *Migratory Bird Treaty Act/Executive Order 13186:* The Laguna Madre is within the Central Flyway. The Laguna Madre contains some of the largest expanses of undisturbed wetland complexes in the Western Hemisphere and is one of the most significant coastal areas for aquatic bird life on the entire Gulf of Mexico coast. Large numbers of migrating and wintering shorebirds use wind-tidal flats and barrier beaches; smaller numbers use various other emergent habitats, such as washover passes and coastal wetlands. Wind-tidal flats of the Laguna Madre represent the largest continuous expanse of wintering habitat for shorebirds between breeding grounds and more distant wintering grounds in South America. Additionally, the Laguna Madre has been designated as an Important Bird Area by the Audubon Society.

    - Thirty-eight waterfowl species have been documented along the lower Texas coast, including about 80 percent of the North American redhead duck population who use shoal grass meadows and other habitats within the Laguna Madre as their primary wintering grounds.

    - Thirty-four colonies of waterbirds were identified in the Laguna Madre and included 23 species of herons, egrets, ibises, pelicans, terns, gulls, and skimmers that use vegetated and unvegetated shorelines habitats for nesting. The only major American White Pelican coastal colony exists in the Laguna Madre.

- *Clean Water Act:* The Act identifies seagrasses and tidal flats as significant resources requiring protection and preservation to the greatest extent practicable and if impacted require mitigation to obtain "no net loss." Additionally, Section 401 regulates water quality which is important in sustaining the lagoon.

- *Coastal Zone Management Act:* The barrier island, lagoon, wind-tidal flats, reefs, and seagrasses are all considered coastal resources of national significance under the Act and are each considered a CNRAs – State Submerged Lands, Submerged Aquatic Vegetation, Tidal Sand or Mud Flat, Oyster Reef, Hard Substrate Reef, Coastal Barriers, Coastal Shore Areas.

- *Coastal Barrier Resources Act:* Portions of the Lower Laguna Madre and the Padre Island Barrier Island are designated as otherwise protected areas.

Public Significance: The Laguna Madre is world renowned among anglers for its world class fisheries. The Laguna Madre is most known for its spotted seatrout fishery; however, red drum and black drum are also prevalent and sought after. Additionally, the lagoon offers fishing opportunities for snook, gray snapper, Florida pompano and barracuda which are only found in the Lower Laguna Madre and are absent from Upper Laguna Madre or most other Texas bays. The sport fishing industry in the Laguna Madre is estimated in value at about $180 million per year and supports about 1,327 jobs (POI 2017). As well, other ecotourism activities, such as birdwatching, sea turtle observations, and wildlife safaris, contribute to the local economy and encourage protection and preservation of habitats and superior water quality (Jones et al. 2018)

Technical Significance: The Laguna Madre is a significant resource frequently studied by governmental, academic, and private organizations. In a comprehensive literature review Tunnell et al. (2002) identified over 1,400 citations over a 70 years period that were linked to the uniqueness of the lagoon and its habitats, species using the Laguna Madre, conservation concerns and problems in the lagoon, and adjacent waters and lands that influence the Laguna Madre. Additionally, in response to growing population pressures, pollution problems, and GIWW O&M dredging threatening the lagoon, The Nature Conservancy commissioned a book compiling all known information about the Laguna Madre to move ahead with a science-based conservation agenda.

The Laguna Madre is best known for its hypersaline condition, large overwintering redhead duck population, numerous protected species, vast seagrass meadows, and great fishery productivity (biodiversity). In addition to the best-known features, there are other unique lesser-known, but important characteristics, such as: the most extensive wind-tidal flats and clay dunes in North America; the only strain of high-salinity-adapted oysters in North America; the only natural rocky shorelines in Texas; the only serpulid worm reefs in Texas, and the only locality of oolite (calcium carbonate) and gypsum crystal formation in Texas (Judd et al. 2002) (biodiversity/scarcity). With much of the upper and lower Laguna Madre shorelines protected from development by large ranches on the west and Padre Island National Seashore on the east, these bays are as remote and pristine as can be found and has contributed to the protection and conservation of some species and habitats (Tunnel and Judd 2002). Additionally, the Laguna Madre makes up about 20 percent of Texas' protected coastal waters (representativeness).

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