Corpus Christi, Nueces, and Aransas Bays

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Background

Corpus Christi Bay and Nueces Bay comprise the middle estuarine portion of Texas' Coastal Bend region (Figure 1; Burgan and Engle, 2006). Aransas Bay is part of the upper estuarine portion of the region. These bays make up part of the Coastal Bend Bays and Estuaries Program, one of the many estuarine areas in the U.S. Environmental Protection Agency's National Estuary Program (Holt, 1998). The Coastal Bend region is sub-humid and sub-tropical. Summers are long, hot, and humid, and winters are short and mild. The landscape around the estuaries is dominated by row crops, pastures, and brushy rangeland (Handley and others, 2007). The Nueces River, along with other smaller rivers and creeks, provides freshwater inflow—along with essential nutrients and sediment—into Nueces Bay, which feeds into Corpus Christi Bay (Holt, 1998). Freshwater inflow into the Aransas Bay comes from Mission River, Aransas River, and Copano Creek. The region is relatively dry otherwise and prone to droughts. Corpus Christi receives an average of 76.2 cm (30 in) of rain annually; evaporation usually exceeds 177.8 cm (70 in) (Holt, 1998; Handley and others, 2007). The San Antonio-Nueces Coastal Basin drains into Aransas Bay. The Nueces River basin covers 43,253 km^2 (16,700 $miles^2$), from northwest of San Antonio, flowing southeast to where it drains into Nueces and Corpus Christi Bays (Holt, 1998). The Nueces-Rio Grande basin covers approximately 18,648

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km^2 (7,200 $miles^2$) and flows partially into Corpus Christi Bay (as well as the upper Laguna Madre). The inflow from Nueces River has declined by approximately 20 percent over the past several decades, partly due to construction of lakes and reservoirs, particularly Lake Corpus Christi and Choke Canyon reservoir. The Corpus Christi Estuary receives approximately 35 percent of the total freshwater inflow of 1,480,178,205 cubic meters (m^3) (1.2 million acre-feet) in the region; the Aransas Estuary receives about 53 percent. Tidal range is only 0.46 m (1.5 ft) on the Gulf shoreline and 0.15 m (0.5 ft) in Nueces Bay. Strong winds are the primary force behind water circulation in the Coastal Bend estuaries.

The estuaries in Coastal Bend provide habitat and nutrition for many species of plants and animals, water purification, protection from storms, recreation and seafood, education, and maritime commerce (Holt, 1998). Coastal marshes comprise 45,729 hectares (113,000 acres), or 11 percent, of the aquatic habitats in Coastal Bend. There are 835 species of plants and 2,340 species of animals, including nearly 500 species of birds, in the Coastal Bend Bays area, not including those species that remain unidentified. Nineteen of these species are threatened or endangered. The only remaining natural population of the endangered whooping crane winters at Aransas National Wildlife Refuge. As the population of the Coastal Bend region grows, the amount of use and stress on the estuaries increases. Approximately 3 percent of Texas' population—560,000 people in 2000—live in Coastal Bend (Holt, 1998; Handley and others, 2007). Corpus Christi, whose population was estimated at over 316,000 in 2013 (U.S. Census Bureau, 2010), is the only city in Coastal Bend with a population greater than 20,000.

Agriculture, oil and gas production, manufacturing and shipping, national defense, and tourism dominate the economy in the Coastal Bend Bay area. Petroleum and chemical industries generate the most revenue, whereas tourism and military activities provide the most jobs. Oil production generates over $300 million, and gas production generates nearly $700 million each year. Approximately 25 percent of the jobs held in the Coastal Bend are related to tourism. Livestock and row crops such as cotton, sorghum, and corn dominate the agricultural sector in Coastal Bend. The Port of Corpus Christi was dredged to 13.7 m (45 ft) deep in 1990; it is the nation's sixth largest port. The port generates more than $1 billion in revenue, $60 million in taxes, and 31,000 local jobs. Military facilities in the area, employing nearly 12,000 people with a payroll over $300 million, include Corpus Christi Army Depot, Naval Air Station Corpus Christi, Naval Station Ingleside, and Naval Air Station Kingsville. Tourism generates over $20 billion annually. Nature tourism is the fastest growing element of this sector. Nearly one-third of both the state's commercial and recreational fishing harvest comes from the Coastal Bend area. Recreational fishing yields $37 million in taxes annually and a $546 million regional impact. Commercial fishing yields an average of over 3,628,739 kg (8 million lbs) of harvest per year (Burgan and Engle, 2006).

Methodology Employed to Determine and Document Current Status

Black and white and natural color aerial photography was acquired, ranging in scale from 1:20,000 to 1:65,000 (White and others, 2006; Tremblay and others, 2008). The mapping protocol consisted of stereoscopic photointerpretation, cartographic transfer, and digitization in accordance with strict mapping standards and conventions. Other important aspects of the protocol included the use of the Cowardin Classification

System (Cowardin et al., 1979), groundtruthing, quality control, and peer review. Land, water, and areas where estuarine emergent wetlands (salt marsh) and palustrine emergent wetlands (fresh marsh) were present were included on the maps. The information derived from the photography was subsequently transferred using a zoom transfer scope onto a stable medium overlaying U.S. Geological Survey (USGS) 7.5-minute, 1:24,000-scale quadrangle basemaps. The groundtruthing phase was conducted to characterize wetland plant communities and compare wetland plant communities in the field with corresponding signatures on the aerial photographs. Draft maps were sent to the agency and staff for review and comments. All comments received were incorporated into the final maps prepared and delivered.

Methodology Employed to Analyze Historical Trends

Historical emergent wetland trends were analyzed by comparing changes in total areal coverage of emergent wetland habitat along a time sequence. Comparisons were made among data sums of emergent wetland coverage for 1956, 1979, 1992, and 2001-2006. Maps of emergent wetland distribution for these years were studied to determine the location of major changes of coverage. The 1956 data were derived from USDA 1:20,000 scale, black and white aerial photography. The 1979 and 1992 data were derived from NASA 1:65,000 scale, color infrared aerial photography. The 2001-2006 data were derived from USGS 1:40,000 scale, color infrared aerial photography.

Status and Trends

Emergent wetland monitoring during 1956, 1979, 1992, and 2001-2006 (Figures 2-5) illustrates the coverage change of emergent wetland habitat in Corpus Christi, Nueces, and Aransas Bays (Table 1). Corpus Christi, Nueces, and Aransas Bays gained 1,256 hectares (3,103 acres), or 12.7 percent, of their emergent wetlands between 1956 and 1979; they gained 5,052 hectares (12,485 acres), or 51.2 percent, between 1979 and 1992; and they lost 3,781 hectares (9,344 acres), or 38.3 percent, of their emergent wetlands between 1992 and 2001-2006. During the complete 51-yr time period this study encompasses, Corpus Christi, Nueces, and Aransas Bays gained 2,526 hectares (6,243 acres), or 25.6 percent, of emergent wetland habitat.

Table 1. Emergent wetland acreage in Corpus Christi, Nueces, and Aransas Bays for 1956, 1979, 1992, and 2001-2006

Emergent Wetland Type	**1956**		**1979**		**1992**		**2001-2006**		**Total Change 1956 to 2001-2006**	
	Hectares	Acres	Hectares	Acres	Hectares	Acres	Hectares	Acres	Hectares	Acres
Estuarine	2,953	7,296	3,997	9,877	5,287	13,064	3,090	7,636	138	340
Palustrine	6,911	17,077	7,122	17,598	10,885	26,896	9,299	22,980	2,389	5,903
Total	9,863	24,373	11,119	27,475	16,171	39,960	12,390	30,616	2,526	6,243

Between 1956 and 1979, Corpus Christi, Nueces, and Aransas Bays gained 1,044 hectares (2,581 acres), or 35.4 percent, of salt marsh. These bays gained 1,290 hectares (3,187 acres), or 43.7 percent, of salt marsh between 1979 and 1992; and they lost 2,196 hectares (5,427 acres), or 74.4 percent, of their estuarine emergent wetlands between 1992 and 2001-2006. A total of 138 hectares (340 acres), or 4.7 percent, of salt marsh was gained during the entire 51-yr study period.

Corpus Christi, Nueces, and Aransas Bays gained 211 hectares (522 acres), or 3.1 percent, of coastal fresh marsh between 1956 and 1979. These bays gained 3,763 hectares

(9,298 acres), or 54.4 percent, of fresh marsh between 1979 and 1992; and they lost 1,585 hectares (3,917 acres), or 22.9 percent, of coastal fresh marsh between 1992 and 2001-2006. A total of 2,389 hectares (5,903 acres), or 34.6 percent, of coastal fresh marsh was gained in Corpus Christi, Nueces, and Aransas Bays during the entire 51-yr study period.

Causes of Change

The main threats to the marshes of Coastal Bend include dredge and fill operations, oil and chemical spills, development, climate change, and sea-level rise (Holt, 1998). More than half of the shoreline on Nueces and Corpus Christi Bays has been altered during the last century. A great deal of it has been converted to hardened shoreline structures such as jetties, groins, breakwaters, and bulkheads. Extensive shell dredging occurred in the bays in the early 20th century, damaging reefs and bay bottoms and changing water exchange patterns between the bays. Significant changes in the water circulation and salinity levels of the Coastal Bend estuaries have been caused by the dredging of the Corpus Christi Ship Channel and inner coastal waterway along the coast, and, further inland, the damming of the Nueces, Frio, and Atascosa Rivers. Dredging is frequent to maintain the waterways. Inflow damming upriver has caused a significant change in flow in the past 60 years (Holt, 1998). The Nueces River's annual flow has decreased by 55 percent. The constructions of Lake Corpus Christi and Choke Canyon Reservoir and reduced inflows to the Nueces basin have contributed to this change in flow. Increased periods of drought due to climate change lead to reduction of freshwater inflow, especially from the lower mid-coast to south Texas. Agriculture has caused erosion, pollution, and increased nutrient loads (Holt, 1998). Oil and gas pipelines, boating, heavy seafood harvesting, and increasing recreational usage disturb coastal habitats. An increasing population has caused the use of the bay and its resources to become stressed and, in some cases, damaged or lost (Holt, 1998). Increased development has converted approximately 20 percent of the area's beaches and marshes to manmade structures. Estimates indicate 15 percent of Nueces Bay's surface area was lost to development of its Inner Harbor industrial complex over 70 years during the 20^{th} century. Heavy vessel traffic occurs through the Coastal Bend waters, predominately carrying oil and petrochemicals.

According to the National Coastal Assessment, the overall estuarine condition of the Coastal Bend Bays in 2000 and 2001 was poor (Burgan and Engle, 2006). This rating is based on a water quality index of fair, sediment quality and fish tissue contaminants indices of poor, and a benthic index rated fair to poor. Areas with poor quality water and sediment have been particularly affected by presence of metals, PCBs, organic contaminants, and fecal coliforms (Holt, 1998). Red and brown tides have caused damage in the Coastal Bend area, although their cause is uncertain. Some seafood harvested in the area has contained high levels of heavy metals, and shrimp trawling can cause increased suspended sediment levels in the water. Although point source pollution in the Coastal Bend has decreased over time, the main sources of pollutants are located in Nueces and Corpus Christi Bays. Nonpoint source pollution from urban and agricultural runoff and airborne pollutants is the greatest source of pollution in the bays. The numerous plants and animals found in the estuaries are threatened by loss of habitat, pollution, and over-harvesting, including bycatch. Some aquatic species appear to be in decline, such as pink and brown shrimp and blue crab. Bird species such as great and snowy egrets and Forester's tern are in decline. Bird species are threatened by habitat loss and degradation, limited freshwater, pollution, and human disturbances. It should be noted that part of the reason for the apparent increase in palustrine wetlands in Corpus Christi, Nueces, and Aransas Bays since 1992 is due to a scaling factor of the imagery. Additionally, climate variability has influenced expansion and contraction of mangroves in the Coastal Bend area and is a driver of habitat change. Some areas of salt marsh loss were converted to mangrove habitat during this study period, such as much of Harbor Island.

Monitoring for Emergent Wetland Health

The Mission-Aransas National Estuarine Research Reserve (NERR) has established long-term monitoring programs for submerged aquatic vegetation, emergent marshes, and most recently, mangroves (Evans and others, 2012). Monitoring efforts focus on gathering information on vegetation percent cover, species composition, growth, and canopy width and height. Surface Elevation Table (SET) stations have been installed to collect high-precision land elevation measurements across different habitats in the NERR (Evans and others, 2012). The Mission-Aransas NERR also participates in the System-Wide Monitoring Program (SWMP) with stations measuring water quality parameters (pH, conductivity, temperature, dissolved oxygen, and turbidity) and water level at 15-minute intervals, as well as collecting monthly nutrient samples (Evans and others, 2012).

Scientists from the University of Houston and Texas A&M University at Galveston are currently investigating the impacts of mangrove expansion into salt marsh habitats (Texas A&M University at Galveston and the University of Houston, 2014). They have set up a field experiment, within the boundaries of the Mission-Aransas

NERR, where data from biotic and abiotic variables is collected to assess ecosystem responses to a range of mangrove densities (Texas A&M at Galveston and the University of Houston, 2014). Early results point at mangrove expansion being affected by complex biotic interactions with salt marsh vegetation that varies across geographic latitudes (Guo and others, 2013).

Mapping and Monitoring Needs

The most comprehensive wetlands delineation datasets for Corpus Christi, Nueces, and Aransas Bays are: 1) the National Wetland Inventory (NWI); 2) NOAA's Coastal Change Analysis Program (C-CAP); and 3) the Status and Trends of Wetlands and Aquatic Habitats project by White and others (2006). The NWI dataset maps the areal extent of wetlands and surface waters as defined by Cowardin and others (1979) wetland classification. NWI data coverage is available for Corpus Christi, Nueces, and Aransas Bays. Mapping for Corpus Christi Bay was updated in 2008 using 2006 sub-meter true color and 2004 NAIP color-infrared imagery (U.S. Fish & Wildlife Service, 2008). Similarly, mapping for Aransas Bay was most recently updated in 2010 using 2008 NAIP 4-Band imagery (U.S. Fish & Wildlife Service, 2010). The scale of NWI data varies from 1:10,000-1:24,000. The NOAA C-CAP classification is derived from Landsat TM scenes collected in 2010-2011 for Texas and Louisiana and analyzed according to a standard land cover classification protocol (NOAA, 2014). The resolution of the dataset is 30-m and includes developed land, palustrine and estuarine wetlands, palustrine and estuarine aquatic beds, and water classes. Additional C-CAP coverage is available for 1996, 2001, and 2006. A more detailed wetland delineation has been completed as part of the "Status and Trends of Wetlands and Aquatic on Texas Barrier Islands Coastal Bend" project completed by White and others (2006) for the Texas General Land Office. Habitat delineation was done using 2002-2004 1-m resolution aerial imagery and mapped at a 1:4,000 scale. Wetlands were mapped following the classification by Cowardin et al. (1979). Although the scale of this dataset is well-suited for many applications, its geographic extent is limited, only covering the barrier island system protecting Aransas, Red Fish, and Corpus Christi Bays. The three wetlands delineation datasets offer different spatial and temporal resolutions that may be appropriate for regional studies. However, there is still a need for site-scale (~ 1:6,000) wetlands mapping across Corpus Christi, Nueces, and Aransas Bays with higher temporal resolution to better track, document, and understand wetlands change patterns. The USGS just released an emergent marsh vegetation type classification extending from Corpus Christi to the Florida-Alabama State boundary (Enwright and others, 2014).

The University of Texas at Austin, Bureau of Economic Geology is currently mapping mangroves to establish a baseline to monitor their expansion in Texas Coastal Bend. The study seeks to establish a standardized protocol to map mangroves using automatic classification algorithms applied to hyperspectral imagery (Texas General Land Office, 2014). Mangrove habitat mapping will complement existing wetlands status and trends mapping efforts (Texas General Land Office, 2014).

Restoration and Enhancement Opportunities

Net wetland losses due to relative sea-level rise have been projected through 2100 by SLAMM model outputs for Corpus Christi Bay (Brenner and Thompson, 2013). Marshes are expected to gradually migrate inland given the space to accommodate such movement is available. A way to mitigate the impacts of future wetland losses is to plan in advance for this marsh migration. A study conducted by The Nature Conservancy for the Coastal Bend Bays Estuary Program identifies priority areas to be acquired and/or sustainably managed to preserve the space necessary for marsh migration. The information generated by the study can be used to inform present and future conservation and land acquisitions plans (Brenner and Thompson, 2013). Identified priority conservation/acquisition areas include parcels adjacent to existing management areas such as Mission-Aransas NERR, Naval Air Station, Mustang Island State Park, Cone Nature Preserve, and Shamrock Island Preserve (Brenner and Thompson, 2013).

Earlier in 2013, the Texas General Land Office held a series of meetings along the coast to develop a list of key coastal issues and obtain feedback on potential projects (Gibeaut and others, 2014). The Texas coast was divided into four regions, and for each region a list of potential projects was reviewed by a Technical Advisory Committee (TAC). Feedback provided by the TAC for Region 3 (Aransas, Refugio, San Patricio, Nueces, and Kleberg counties) indicates wetlands/habitat loss, impacts to fish and wildlife, and bay shoreline erosion as the top three issues of concern and priorities (Gibeaut and others, 2014). Reviewed proposed projects directly benefiting emergent wetlands in the region included: land acquisitions (4); conservation easements (1); and shoreline and marsh restoration efforts (8) (Gibeaut and others, 2014).

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Figure 1. Watershed for Corpus Christi, Nueces, and Aransas Bays.

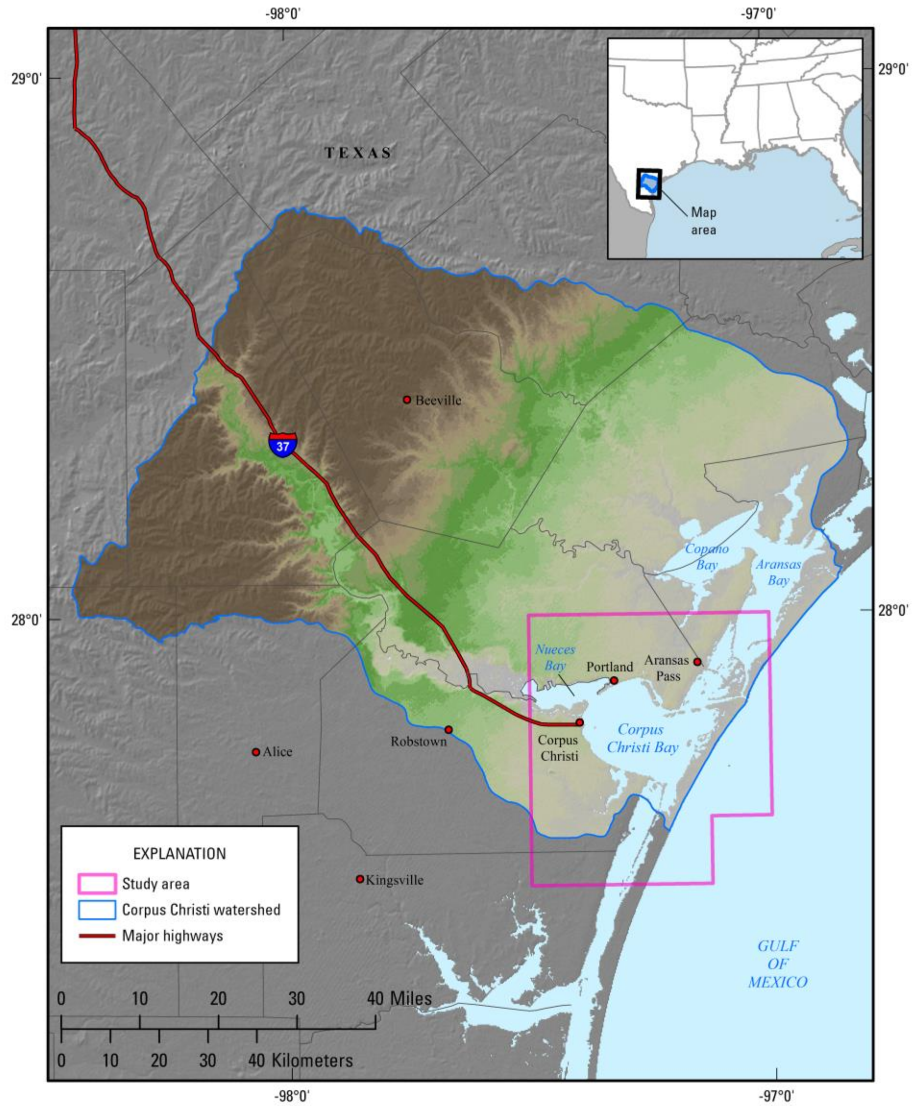

Figure 2. Distribution of emergent wetlands in Corpus Christi, Nueces, and Aransas Bays, 1956.

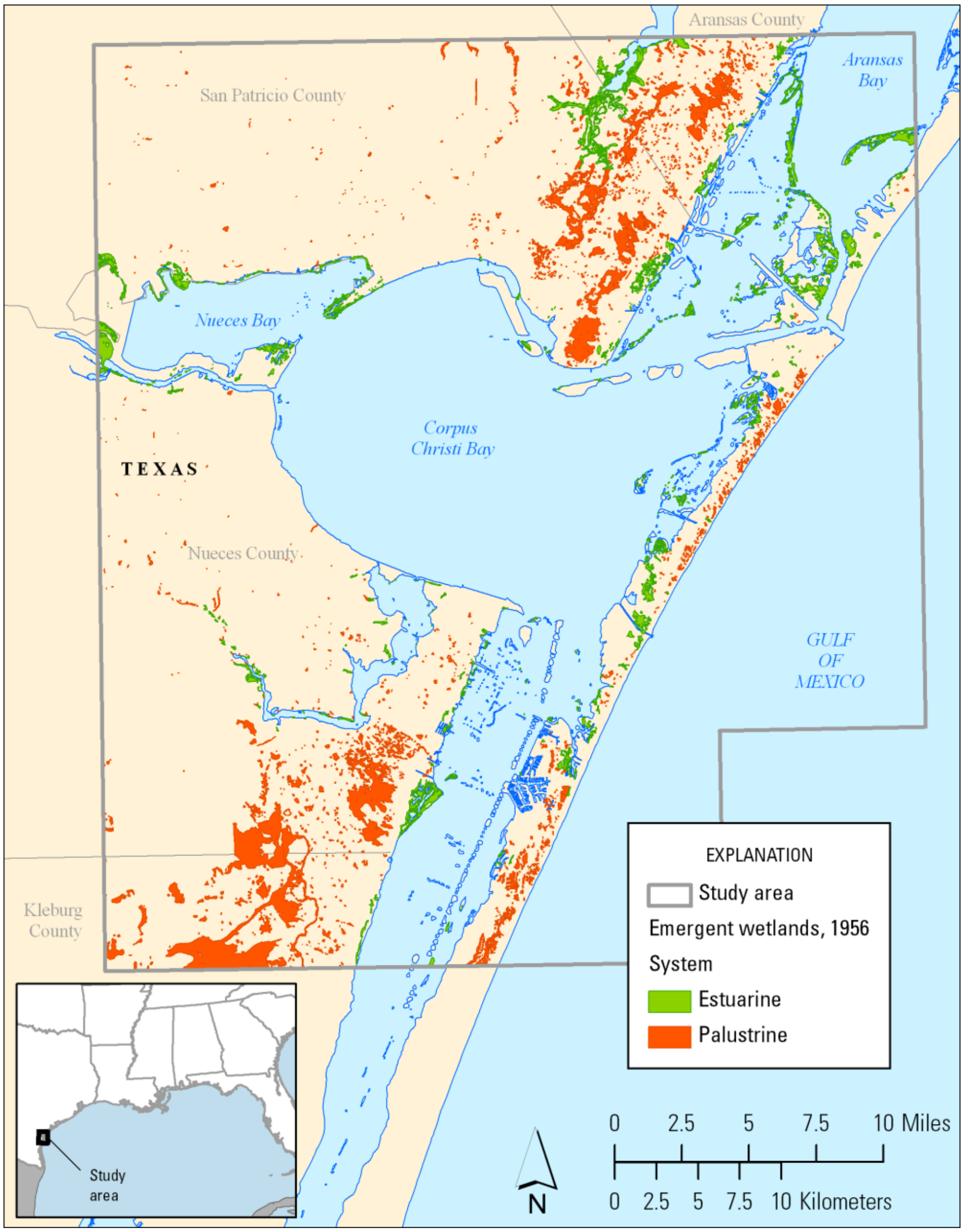

Figure 3. Distribution of emergent wetlands in Corpus Christi, Nueces, and Aransas Bays, 1979.

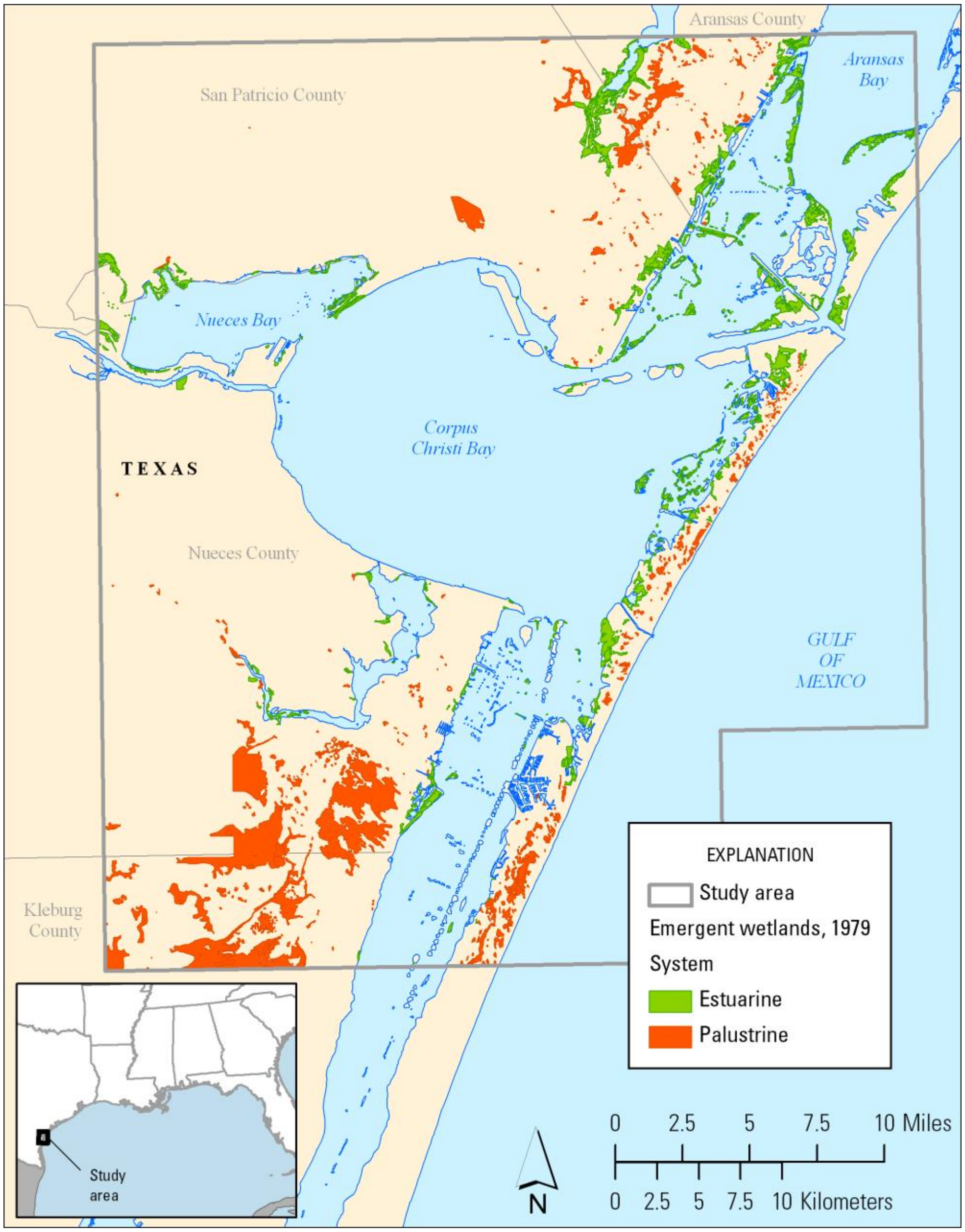

Figure 4. Distribution of emergent wetlands in Corpus Christi, Nueces, and Aransas Bays, 1992.

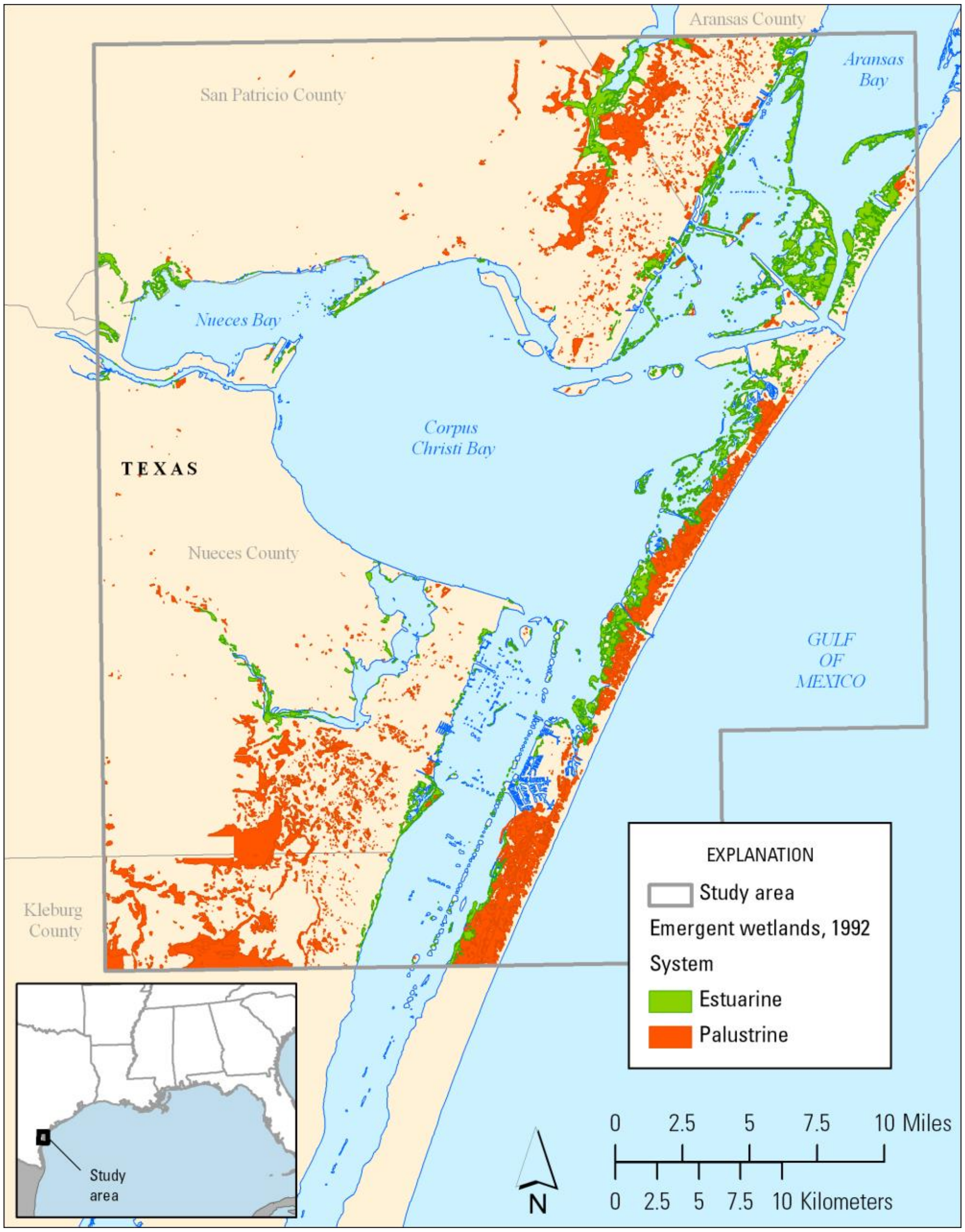

Figure 4. Distribution of emergent wetlands in Corpus Christi, Nueces, and Aransas Bays, 2001-2006.