Mustang Island State Park Geoenvironmental Atlas

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June 2024

Atlas Partly Funded by a
Texas Coastal Management Program Grant Approved
by the Texas Land Commissioner Pursuant to
National Oceanic and Atmospheric Administration
Award No. NA22NOS4190148

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by

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This project was funded in part by a Texas Coastal Management Program grant approved by the Texas Land Commissioner, providing financial assistance under the Coastal Zone Management Act of 1972, as amended, awarded by the National Oceanic and Atmospheric Administration (NOAA), Office for Coastal Management, pursuant to NOAA Award No. NA22NOS4190148. The award was administered through grant no. 23-020-008-D602 from the General Land Office of Texas to the Bureau of Economic Geology, The University of Texas at Austin. The views expressed herein are those of the author(s) and do not necessarily reflect the views of NOAA, the U.S. Department of Commerce, or any of their subagencies.

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Geoenvironmental Atlas

Researchers at the Bureau of Economic Geology at The University of Texas at Austin (Bureau) have created a geoenvironmental atlas of Mustang Island State Park that highlights the geologic, geomorphic, and wetland features, and coastal hazards unique to the park. This atlas is comprised of products that help park visitors, staff, and coastal resource managers visualize and define the geologic and geomorphologic characteristics that make Mustang Island State Park unique. The atlas enables visitors of the park to learn more about its natural environment or about hazards that impact the park. This atlas is built on concepts presented in the Padre Island National Seashore guidebook (Weise and White, 1980); Down to Earth at Mustang Island, Texas (Raney and White, 2002) and the Powderhorn Ranch Geoenvironmental Atlas (Paine and others, 2018).

The atlas also allows park staff and coastal resource managers to assess coastal natural hazards like shoreline change and susceptibility to storms and sea-level rise. It can be used to help understand the natural framework of the park and surrounding area, for example, how wetland environments have changed through time. They support the Texas Parks and Wildlife Department's mission to ensure that coastal parks are responsibly managed and conserved to ensure that all visitors can enjoy the park for generations to come.

Mustang Island

Mustang Island is a sandy barrier island that is approximately 30 km (18 mile) long located between Corpus Christi Bay and the Gulf of Mexico, south of San Jose Island (or St. Joseph's) and north of Padre Island (Fig. 1). A barrier island is a long, narrow island parallel to the coast that is built up by the deposition of sand. Barrier islands protect the mainland coast from open ocean waves and currents and the impacts of storms. They also shelter the bays by protecting critical habitat for many species of wildlife. Barrier islands are dynamic environments shaped by the day-to-day action of the wind, currents, waves, and tides and those same processes amplified by severe storms.

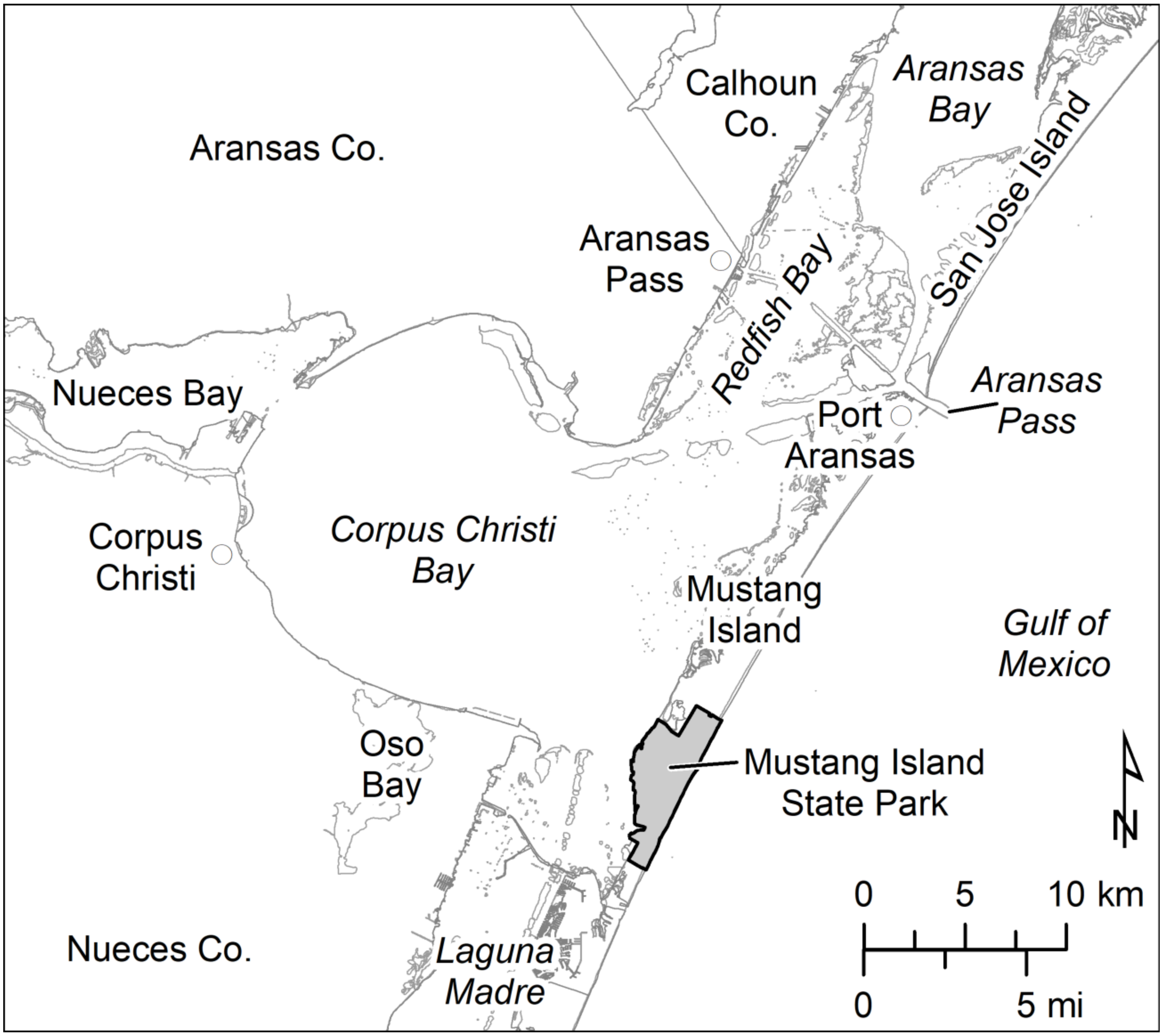

Figure 1. Mustang Island State Park location map.

Mustang Island State Park was acquired by the Texas Parks and Wildlife Department in 1972 and opened to the public in 1979. The park encompasses almost 5,000 acres of mostly pristine barrier island environments and includes 5 miles of Gulf of Mexico beach (Figs. 1 and 2). The park protects the natural habitat found on the island, providing a place where visitors can safely explore and learn about these valuable resources.

Mustang Island State Park 3D Virtual Field Trip

Bureau researchers used a DJI Mavic 2 Pro quadcopter unmanned aerial vehicle (UAV) to collect imagery along the Gulf (including the beach and foredune system) and bay shorelines at Mustang Island State Park. Twenty-seven missions were flown on March 2 and 3, 2023 for a total of 5,928 bayside and 1,614 shoreline images captured. A digital terrain model (DEM) and orthomosaics were produced from this UAV survey. The imagery and DEM were used to create a three-dimensional (3D) model and virtual field trip that highlights the habitats found within the park (Fig. 2, Raney and White, 2002). The 3D field trip can be found at: https://www.beg.utexas.edu/txcoastalsp3d/.

STOP 1. BEACH: The **beach**, the gently sloping shore of a body of water which is washed by waves or tides, is a highly dynamic environment (Fig. 3). The beach is constantly being rearranged by the daily forces of waves, tides, and weather. The **forebeach** is the sloping part of the beach lying between the limit of wave runup at high tide and the low-water mark of the run-down of the waves at low tide. This area is constantly under the influence of waves and is exposed, then submerged, by the rise and fall of tides. The **backbeach** is the upper zone of the beach lying between the high tide mark to the point where vegetation begins or there is a change in slope where the dunes begin. The backbeach is commonly under the influence of the wind; only during high-water events (storms, extreme high tides) do waves impact this zone.

STOP 2. DUNES: At the landward edge of the beach are sand dunes. The dunes are an almost continuous chain of sand ridges that form the spine of Mustang Island (Fig. 4A). The dune crests (the tops of the dune) are the highest elevation on the island. The height of these dunes may reach over 9m (30 ft), though 4.5 to 6 m (15 to 20 ft) is more common. The **foredune** is the first high ridge at the landward margin of the beach. Here at Mustang Island State Park, there are multiple dune ridges behind the foredune. The dune system is the main buffer against powerful, elevated waves that accompany a tropical cyclone. **Coppice dunes** are irregular mounds of sand crowned by plants that form at the seaward edge of the foredune on the upper part of the backbeach (Fig. 4B).

Over time, the sand pile grows larger and the plants grow taller to stay above the rising sand. Eventually, the coppice dunes can merge and form a new foredune ridge.

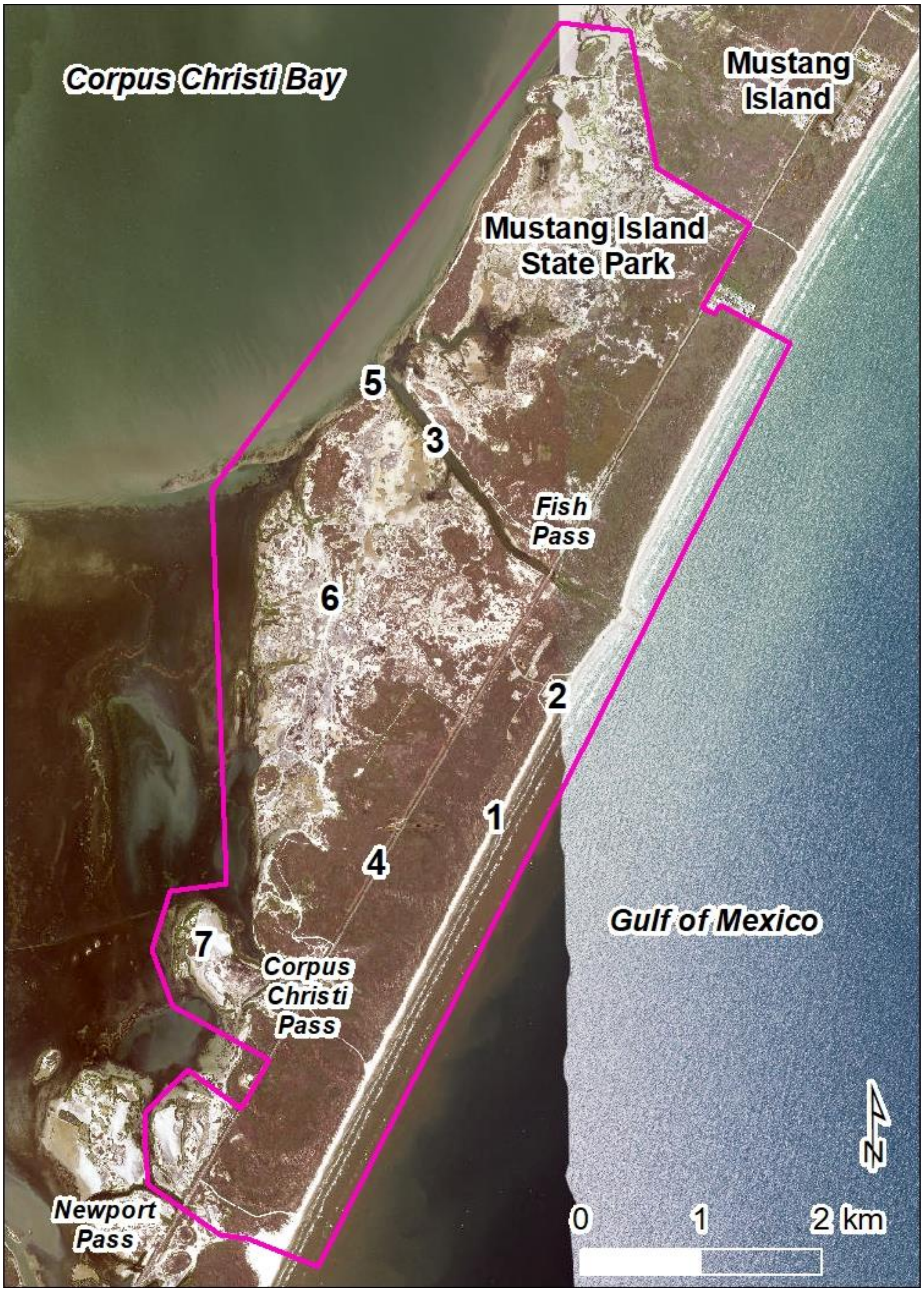

Figure 2. Mustang Island State Park map with virtual field trip stops labeled.

Figure 3. Gulf of Mexico beach in Mustang Island State Park. The darker, wet sand on the right of the photo is the forebeach. The backbeach is the zone from center of the photo landward to the start of the vegetation.

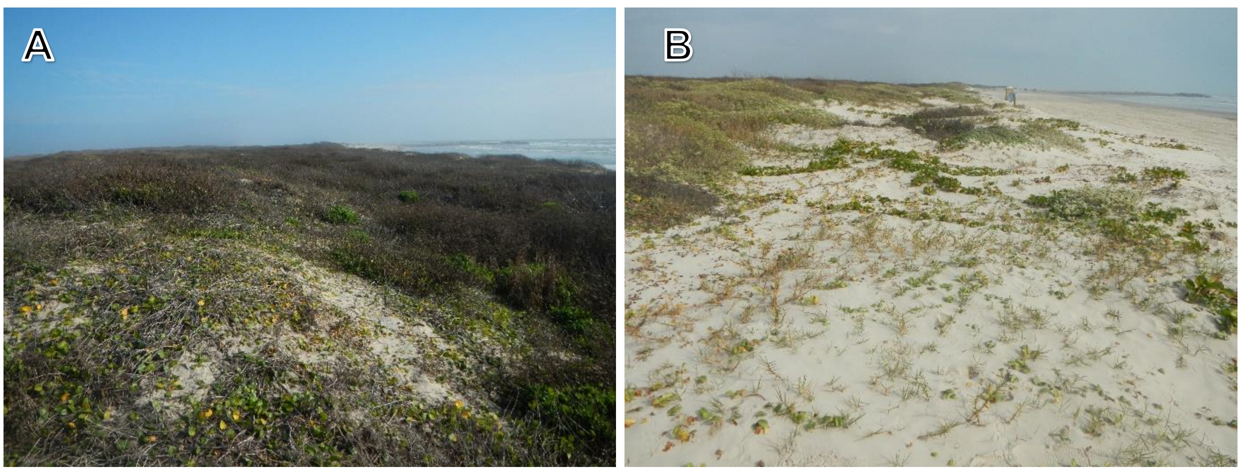

Figure 4. (A) View looking north along a dune ridge crest in Mustang Island State Park. There are multiple dune ridges in the dune complex along Mustang Island. (B) Coppice dunes forming at the landward edge of the beach.

STOP 3. FISH PASS: Fish Pass is a water exchange pass that was dredged through Mustang Island in the early 1970s to allow for the passage of water and aquatic wildlife between the Gulf of Mexico and Corpus Christi Bay (Fig. 5). The jetties that were constructed at the mouth of the pass were 750 ft long, which was not long enough to keep longshore currents from depositing sand and silt in the channel and causing the pass to close within a few years of construction. Hurricane Allen briefly reopened the pass in 1980 but it quickly refilled and has been closed to water exchange ever since. Additional sediment has been deposited at the mouth of the channel by wind, waves, and currents building up dunes and creating a beach between the jetties. The channel remains between the highway and the bay, and is a popular fishing and kayaking location.

Figure 5. The mouth of channel into the Gulf has been filled with sediment. Barren areas in the photo are wind tidal flats.

Longshore currents are currents that flow parallel to the shoreline, created by ocean waves approaching the shoreline at an angle. These currents erode, transport, and deposit sediment along the shore. Jetties are rock or concrete structures built along a tidal pass that helps to stabilize the pass. Much longer and more effective jetties can be found at Aransas Pass and Packery Channel at the northern and southern end of Mustang Island.

STOP 4. VEGETATED BARRIER FLAT: The most extensive environment on Mustang Island, and most barrier islands, is the **vegetated barrier flat**, a low-relief plain covered by plants, that extends from the back of the dunes almost to Corpus Christi Bay (Fig. 6). Within the state park, the vegetated barrier flat is covered by grass and other low vegetation, has depressions that host small freshwater ponds and marshes (Fig. 7), and has some areas of back-island sand dunes. Compared with the beach, dunes, and bay margins, the vegetated barrier flat is a less active and more stable environment. It is frequently inundated by tropical cyclones and is protected by the dune system. Where the dunes are breached, storm washover fans may aggrade the flat.

Figure 6. Vegetated barrier flat in Mustang Island State Park. The barrier flat lies between the landward edge of the dune ridge across the island to the low-lying bay margin environments. Notice the highway and poles running through the middle of the vegetated barrier flat. This is where infrastructure is built on barrier islands.

STOP 5. BAY MARGIN: Most of the bay margin has very low relief as the land gently transitions into the shallow waters of Corpus Christi Bay. The environments of the bay margin are controlled by subtle changes in elevation, depth of water, astronomical and wind-driven tides, and salinity. The main environments are salt marshes, marine grassflats, tidal flats, and narrow beach and storm berms (Fig. 8). These environments are of critical importance to the ecosystems of the bays and the Gulf of Mexico. These areas are nurseries for all of the commercially important species of fish and shellfish. The bays are also the wintering ground for many species of waterfowl.

Figure 7. Freshwater pond and wetland on the vegetated barrier flat near the state park camping facilities.

Salt marshes occur at the transition between areas of generally higher elevation dry land and the areas that are commonly covered by the waters of the bay. Salt marshes are saturated and poorly drained areas with salt-tolerant vegetation that are regularly flooded with saltwater with the rise and fall of tides or wind-driven increases in water level. The bay side of Mustang Island is a good place to see salt marsh. Low marsh soils are covered by water for some significant part of most days, and the high marsh generally is only slightly above high tide (Fig. 9A). Because the soils are water-saturated, they have very little oxygen. It takes special plants to survive in an environment that has this combination of salt water and very little oxygen in the soils. The plants at the bay shore are an important part of the ecosystem of the bay, and important to the geology of the bay. The plants help stabilize the shore and also trap sediments. Over time, the sediment trapped by the plants may cause the shore to build out into the bay.

Figure 8. A view to the south along the state park bay margin where Mustang Island meets Corpus Christi Bay. The dark spots in the water are grassflats or other aquatic beds. The narrow strips of light-colored sediment along the island are bay beaches. The vegetated areas are salt marshes, and the barren areas inland are wind tidal flats.

STOP 6. WIND TIDAL FLATS: On the bay side of the barrier island, the barren areas with very low relief are called **wind tidal flats** (Figs 8 and 9B). They are only slightly higher in elevation than the average high-water level of the adjacent bay. The wind tidal flats are occasionally flooded with water when strong winds push high tide waters onto the surface. Because they are so low lying, they also flood during tropical cyclones or significant rainfall events (as are some higher-elevation environments). Once the winds decrease or tropical cyclone has passed, the water that flooded the wind tidal flat recedes. Some water remains on the flat and eventually evaporates, leaving behind salt crystals and creating a surface with high salinity. Due to the changing water levels on the wind tidal flat and the high salinity of surface, it is very difficult for plants to survive, but algae can thrive. Algal mats develop on flats that alternate between emergent (a falling sea level) and submergent (a rising sea level) in fairly regular cycles (Fig. 9B). Algal mats usually break up and peel when they dry.

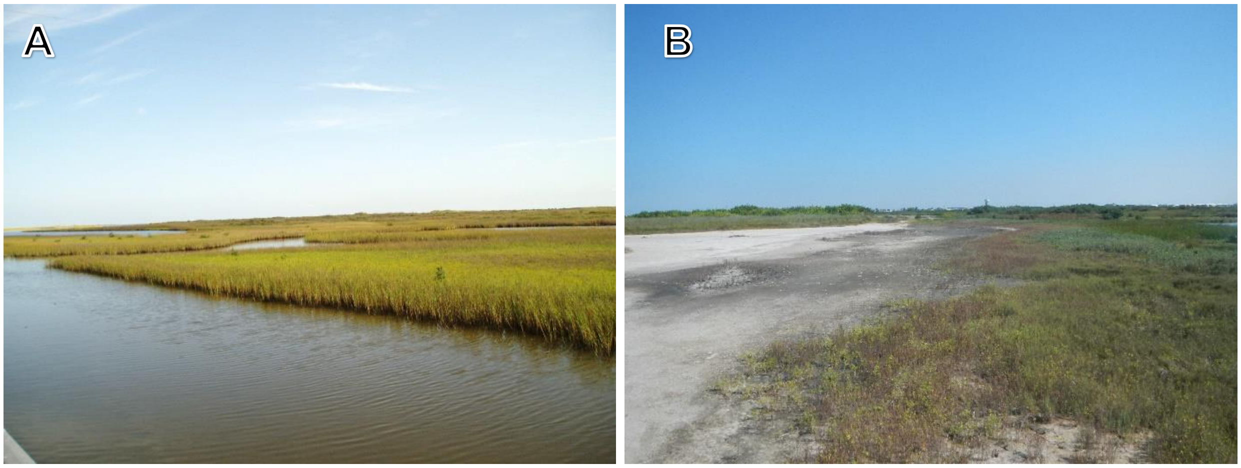

Figure 9. (A) Salt marsh along Fish Pass channel on Mustang Island. Photo courtesy of Tom Tremblay. (B) Wind tidal flats, algal mat (dark area), and salt marsh on Mustang Island.

STOP 7. WASHOVERS: Newport Pass, 1852 Pass, and Corpus Christi Pass, form a complex of washover channels along southern Mustang Island. A **washover channel** is a temporary passage that occurs when ocean waters driven by powerful storms overtop or breach the beach and dune system of a barrier island creating a flow of water from the open ocean to the backside of the island. The sand and sediment that was eroded from the beach and dune is carried through these passages and deposited on the landward side of the island on the barrier flat, bay margin, or if powerful enough, all the way into the bay. The fan-shaped accumulation of sediment that is deposited during the storms are called **washover fans** (Fig. 10).

Washover fans are significant features in the building and expansion of barrier islands. Washover channels may transport many thousands of cubic yards of sediment in a single event and build a large washover fan. Over time, the washover features are modified by wind and rain, stabilized by back-island vegetation, and merged imperceptibly with the older parts of the barrier flat. You can find evidence of this process of beach and dune breaching and washover fan building at Newport Pass and Corpus Christi Pass at the southern end of Mustang Island State Park. Hurricane Allen opened these passes in 1980. On the Gulf side of the island, where the mouths of the washover channels are filled with sediments deposited by longshore currents, enough time has passed since the last island breaching for dunes to have formed across the channels. On the bay side of the island, landward of Highway 361, you can see the lobes of the washover fan covered with wind tidal flats and bay margin marshes.

Figure 10. Image of washover fan and remnant washover channel at Corpus Christi Pass on Mustang Island.

Hurricane Harvey

Bureau scientists study beach and dune systems to understand how major storms like hurricanes affect barrier islands. Working with students from Port Aransas High School, data is collected from sites on Mustang Island, including one in the state park, that documents changes to the beach and dune system due to tropical cyclones and post-storm recovery. This type of data is vital for scientists, decision makers, and coastal planners in understanding beach and dune dynamics on Mustang Island and elsewhere along the Texas coast. The state park provides an opportunity to examine the beach and dune system in a natural setting with minimal human impact compared to the developed parts of the island.

On August 17, 2017, Hurricane Harvey started as an Atlantic basin tropical depression, then crossed the Lesser Antilles as a weak tropical storm and dissipated over the central Caribbean Sea on August 19. However, after re-forming over the Bay of Campeche in the southern Gulf of Mexico on August 23, Harvey rapidly intensified into a category 4 hurricane before making landfall on San Jose Island (the island immediately northeast of Mustang Island) on August 25 with wind gusts of 132 mph and a storm surge of over 1.74 m (5.7 ft, as recorded at the Port Aransas tide gauge). The storm then stalled at tropical storm strength, with its center near the Texas coast for four days, dropping historic amounts of rainfall of more than 60 inches over southeastern Texas. On August 28, the storm center moved back offshore over Matagorda Bay, and Harvey made a second landfall near the Texas/Louisiana border on August 30, 2017.

The City of Port Aransas was devastated by impacts from a storm surge from the bayside and Aransas Pass, as well as from wind and rain damage. Harte Research Institute at Texas A&M University-Corpus Christi collected post-storm profiles at Mustang Island monitoring sites on September 5, 2017 (blue, Fig. 11), which were compared to pre-storm data collected by Port Aransas students in May (red, Fig. 11). Despite the proximity to the hurricanes landfall, the beach and dune system suffered minor impacts. Mustang Island beaches were planed (lowered), but there was no evidence of scarping on the dunes. The greatest impact to Mustang Island beach was documented at MUI01 (Fig. 11A), the profile closest to the south jetty at Aransas Pass and the center of the hurricane. Very little change to the beach was documented at MUI02 (Fig. 11C), the profile located in the state park, although the Visitors Center and other facilities (parking lots, restrooms, etc.) suffered serious damage. The beaches recovered to pre-storm conditions by the winter and spring of 2018 (Fig. 11).

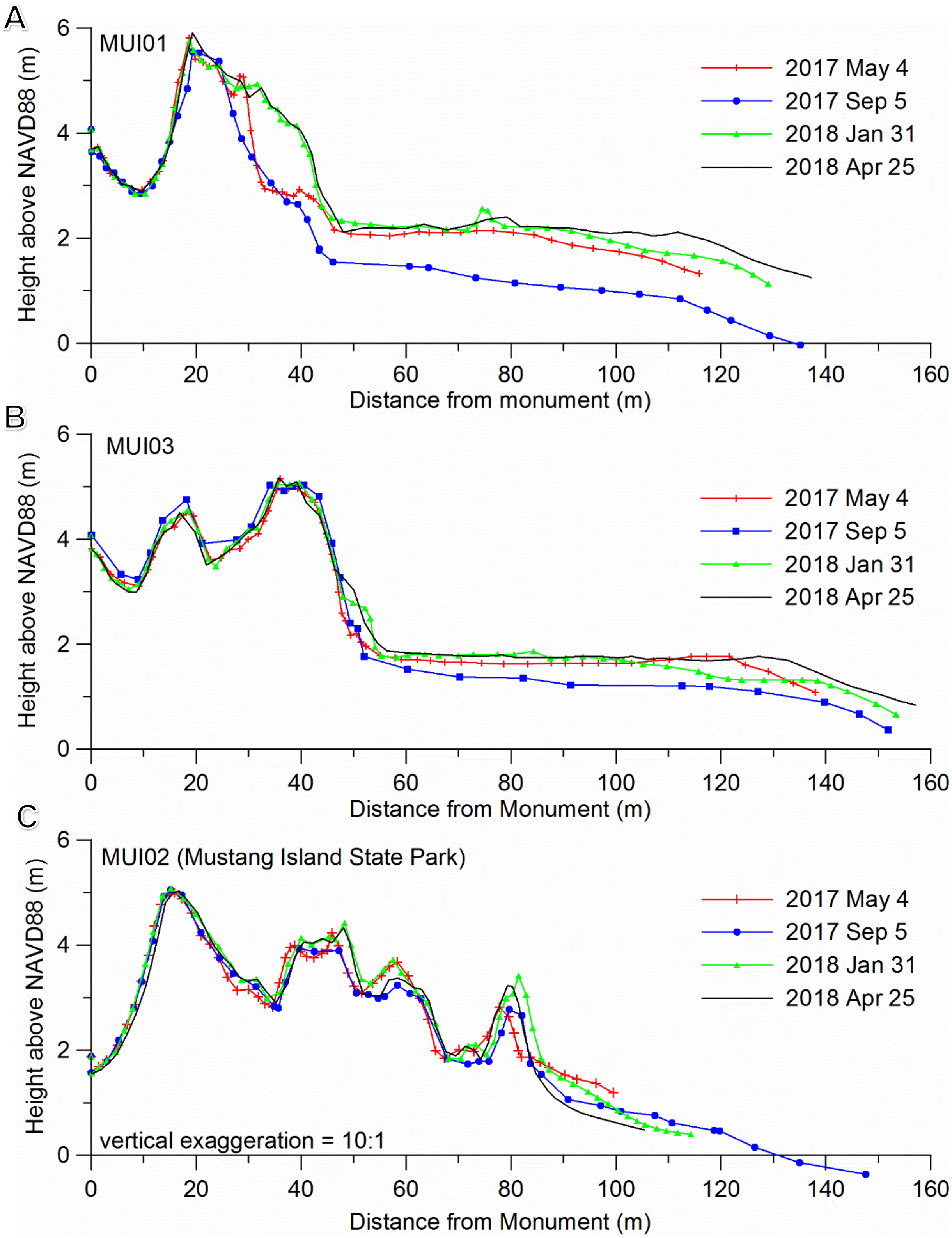

Figure 11. Mustang Island pre- and post-Hurricane Harvey profile data collected by Port Aransas High School and Texas A&M University-Corpus Christi at (A) MUI01, (B) MUI03, and (C) MUI02 (Mustang Island State Park).

An interactive 3D model developed for the Texas High School Coastal Monitoring Program (THSCMP) demonstrates two manners in which scientists interpret beach and dune changes and recovery from tropical cyclones. One manner is using beach profile data collected by students participating in THSCMP. The second approach is using elevation data to visualize shoreline and volume changes. The interactive 3D coastal model created to examine erosion and recovery on the Texas coast following Hurricane Harvey in 2017 can be accessed at https://www.beg.utexas.edu/visualizations/3d-coastal-model/.

Geoenvironmental Atlas Interactive Data Viewer

Bureau researchers have collected and created several datasets for the web-based data viewer component of the geoenvironmental atlas. The state parks map viewer is a custom-made Angular framework web app. It uses the ArcGIS JavaScript API to provide the map-related user interface elements. The map datasets are served by ArcGIS Enterprise 10.8.1 in a series of map and imagery services. The user interface allows the user to view data related to each park in a 3D viewport similar to that of Google Earth. It allows the user to toggle individual layers on and off for clearer viewing, and displays the terrain in true 3D, using data collected and processed by the Bureau (https://coastal.beg.utexas.edu/glostateparks/).

Datasets compiled for this atlas include:

1. Texas Parks and Wildlife Department (TPWD) State Park boundary.
2. Aerial photography from 1937, 1958, 2020, and 2022.
3. High-resolution topographic data from multiple Bureau lidar surveys and 2018 lidar data collected for the Texas StratMap program.
4. Historical and current bay and Texas Gulf coast shoreline positions mapped from georeferenced aerial photography and base maps.
5. Long-term and recent shoreline movement rates for the Gulf of Mexico and bay shorelines within each park.
6. Beach and dune volumetric data from a 2019 Bureau lidar survey.
7. Geologic map.

8. Bureau historical wetland status maps and U.S. Fish and Wildlife Services National Wetland Inventory data.
9. Maps of environmental geology, physical properties, environments and biologic assemblages, and active processes from the Bureau's Environmental Geologic Atlas of the Texas Coastal Zone publication.
10. Shoreline and vegetation line positions, beach profiles, and photography from Texas High School Coastal Monitoring Program field trips.

The purpose of the online data viewer and this atlas is to convey historical and current knowledge of the surface at Mustang Island State Park to the public, park staff, and decision markers so that the best and most complete data can be used to educate visitors about the environments present at the park and to influence management decisions that ensure responsible stewardship and future use.

Park Boundary

The boundary of Mustang Island State Park was adapted from a geographic information system (GIS) shapefile containing statewide polygon boundary data representing lands owned or managed by the State Parks Division of Texas Parks & Wildlife Department (TPWD, https://tpwd.texas.gov/gis/). The park boundary file was used to clip larger datasets (topography, shoreline database, wetland maps, etc.) so that the data presented in the viewer and this guide only pertain to Mustang Island State Park.

Historical and Recent Photography

The Bureau has Tobin Research, Inc. 1930s and 1950s quadrangle photomosaics as part of their historical aerial photo collection. The United States Geological Survey (USGS) subdivides the United States by using latitude and longitude lines to form the boundaries of four-sided figures called "quadrangles". A common quadrangle size for mapping purposes is the 7.5-minute quadrangle, meaning 7.5 minutes of latitude by 7.5 minutes of longitude. Mustang Island State Park falls within the 7.5-minute quadrangle called Crane Island NW. A photomosaic is several images pieced together to create an image of a larger area, in this case 7.5-minute quadrangles. For this project, Bureau researchers scanned the 1937 and 1958 Crane Island NW quadrangles at 600 dpi to create a digital image which was then georeferenced to the NAD83 coordinate system. Newer imagery acquired for the project, and used to georeference the photomosaics, includes U.S. Department of Agriculture (USDA) National Agricultural Inventory Program (NAIP) digital imagery photographed during the agricultural growing seasons in 2020 and 2022 (USDA 2022).

Lidar Data

Numerous topographic lidar datasets were collected to include in the state park atlas, the 3D field trip, and to develop other datasets. Lidar, light detection and ranging, is a remote sensing technique that uses a pulsed laser to measure distance from the instrument to the Earth’s surface. The Bureau owns and operates an airborne lidar system that has been used to collect precise elevations from the Texas coast. Some of the Bureau lidar datasets include the entire island from the Gulf of Mexico shoreline to the bay shoreline, but most only include a swath along the beach/dune system. The Bureau has lidar data for Mustang Island State Park from 2000, 2003, 2005, 2010, 2011, 2012, 2017, and 2019. An additional dataset collected for this project is an airborne lidar survey flown by Fugro USA Land, Inc. in 2018 as part of the Texas Strategic Mapping (StratMap) program. The StratMap data was downloaded from the Texas Geographic Information Office (TxGIO, formerly TNRIS) Data Hub (https://data.tnris.org/). A high resolution (1-m) digital elevation model constructed from the airborne lidar data collected for StratMap is included in the data viewer (Fig. 12). A digital elevation model, or DEM, is a representation of the Earth’s surface at the time a dataset has been collected. The 2018 StratMap dataset is the most recent that covers the entire park. The Bureau recently completed a full coast lidar survey that covers the entirety of Mustang Island from the Gulf shoreline to Corpus Christi Bay. The 2024 DEM will be added to the online viewer once the data has been processed.

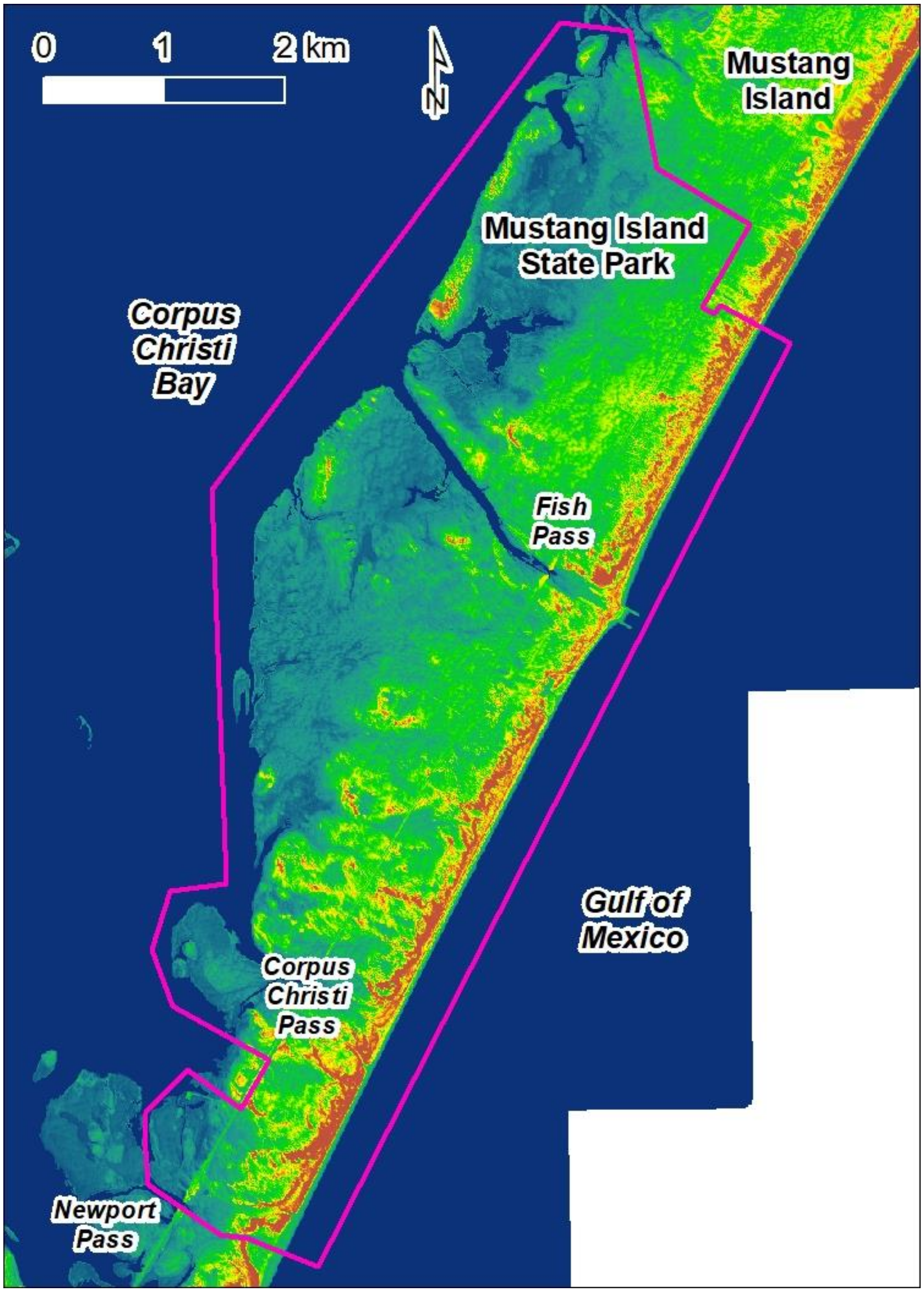

Figure 12. High-resolution (1-m grid cell size) digital elevation model (DEM) of Mustang Island State Park, created from the 2018 StratMap lidar data. The pink line is the state park boundary that was modified from TPWD and used to clip larger datasets.

Shorelines

Shorelines are the dynamic boundary between land and water. The Bureau maintains a digital database that contains numerous shoreline positions for the Gulf of Mexico coastline and select Texas bays that are used to calculate rates of shoreline change. These shorelines come from numerous sources including photography, GPS, and lidar.

Shorelines used in older Bureau studies were mapped directly on aerial photomosaics (quadrangles) then optically transferred to 1:24,000 scale, 7.5-minute USGS topographic base maps (Caudle and Paine, 2024; Paine, Caudle, and Andrews, 2021). With the advent of ArcGIS, those paper maps were scanned to create a digital file, then imported into ArcGIS, georeferenced in NAD27 (datum of the USGS topographic maps), and transformed into the NAD83 coordinate system. The shoreline positions were then digitized in ArcGIS. The 1995, 2007, parts of the 2016, 2020, and 2022 shorelines were mapped digitally within GIS by digitizing the wet beach/dry beach boundary as depicted on high-resolution, georeferenced aerial photographs. The 1996 Gulf shoreline was surveyed using differentially corrected GPS data acquired from a GPS receiver mounted on a motorized vehicle. Shoreline positions were extracted from lidar data collected in 2000, 2010-2012, parts of 2016, and 2019.

For this project, the original paper maps were again scanned at 600 dpi to create a digital image, georeferenced in NAD27, and transformed into the NAD83 coordinate system. The shoreline positions on the paper maps were compared with the shorelines that were contained in the Bureau database. In some instances, particularly along the bay shorelines, positions were revised if they did not match with the database. In other instances, older shorelines that were notated on the paper maps were not included in the digital database. They were digitized and added to the data for the park. The georeferenced 1937 and 1958 photos were also used to verify shoreline positioning. In areas where there were differences between the paper maps and the georeferenced photographs, the shoreline position from the photomosaics were digitized in ArcGIS. By using directly georeferenced imagery, errors can be eliminated that can be introduced through the transfer to paper maps, georeferencing in the older NAD27 coordinate system, and transformation to the newer NAD83 coordinate system. Table 1 lists the shoreline vintages that have been assembled to include in the data viewer.

Table 1. Shorelines included in the data viewer. GOM stands for Gulf of Mexico shoreline and CC Bay stands for Corpus Christi Bay shoreline.

Shoreline Type	**Year**	**Source**
GOM & CC Bay	1867	U.S, Coast Survey Topographic Map (NOAA)
GOM & CC Bay	1937	black & white mosaiced photography (Tobin Research, Inc.)
GOM & CC Bay	1958	black & white mosaiced photography (Tobin Research, Inc.)
GOM	1969	black & white aerial photography (NOAA)
GOM & CC Bay	1974	black & white aerial photography (GLO)
GOM & CC Bay	1982	false-color infrared aerial photography (GLO)
GOM	1990	black & white aerial photography (GLO)
GOM & CC Bay	1995	GPS
GOM	2000	Bureau lidar
GOM	2007	TOP imagery
GOM	2010	Bureau lidar
GOM	2011	Bureau lidar
GOM	2012	Bureau lidar
GOM	2016	USACE lidar & NAIP imagery
GOM	2019	Bureau lidar
GOM & CC Bay	2020	NAIP imagery

Mustang Island State Park has approximately 8.6 km (5mi) of Gulf of Mexico shoreline. These shorelines are susceptible to erosion by non-storm waves, storm surge and storm waves, and relative sea level rise. The Corpus Christi Bay shoreline in the state park is characterized by back-barrier salt marsh, wind tidal flats, and narrow bay-margin beaches. Bay-margin marshes and tidal flats have low elevation, minimal slope, and muddy sand or sandy mud substrate. These shorelines are highly susceptible to erosion by non-storm waves and to land loss by submergence related to relative sea level rise. They have a low susceptibility to erosion related to storm surge and storm waves because they are inundated before storm passage. The exception is if the shoreline is near a washover channel. Then they are highly susceptible to change due to storm surge and waves. The position of the bay shoreline has experienced significant positional change between 1867 and 2020 (Fig. 13).

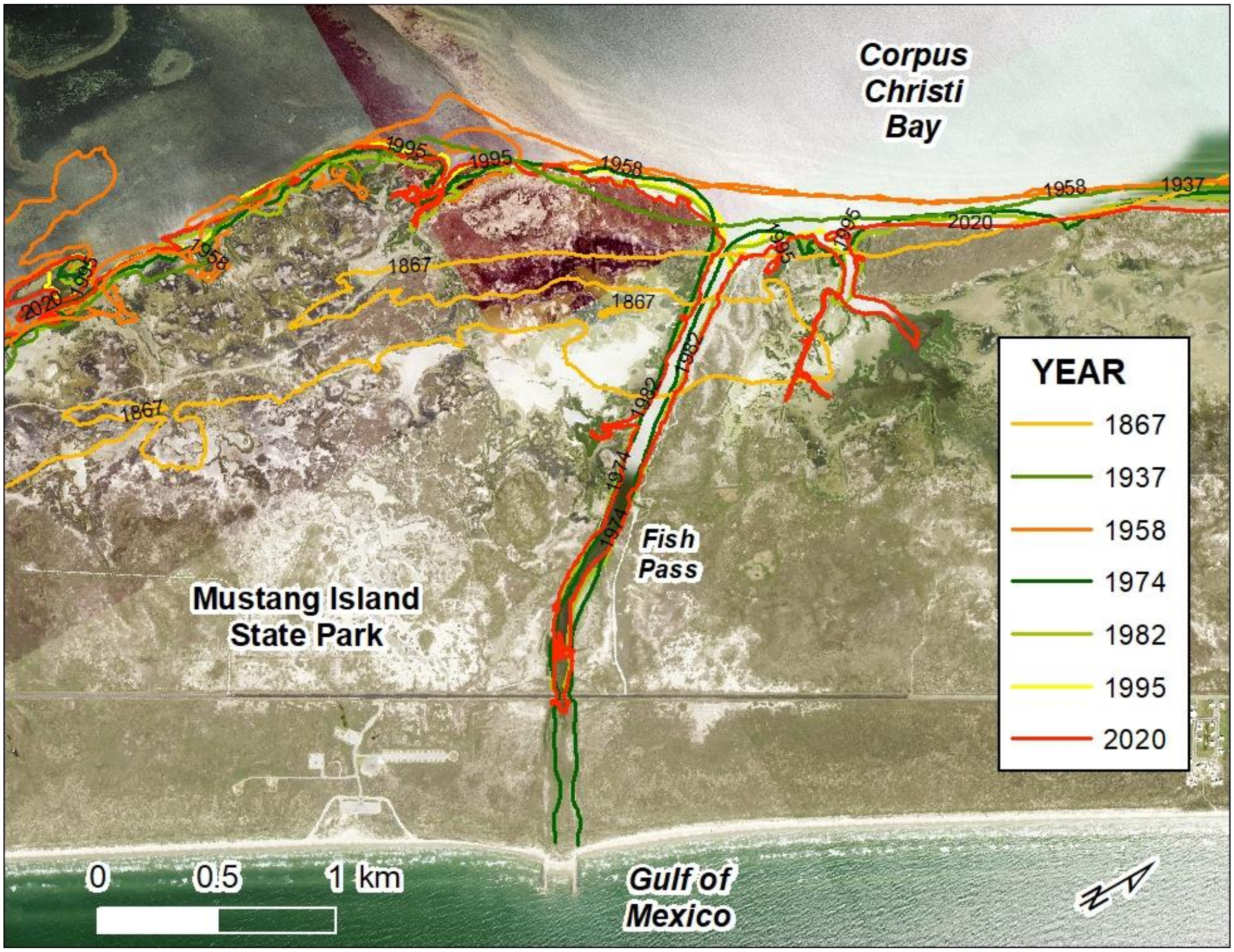

Figure 13. Position of Corpus Christi Bay margin shorelines along a portion of the Mustang Island State Park shoreline between 1867 and 2020.

Shoreline Movement

Texas coastal shorelines include bay and Gulf of Mexico frontage along the barrier islands and mainland shores. In Mustang Island State Park, these shorelines include Gulf beaches, salt marshes, wind tidal flats, and bay beaches. Common coastal processes that include wind-driven waves, storm surge and storm waves, and relative sea-level rise contribute to the dynamic nature of these coastal boundaries, leading to shoreline retreat or advance through removal or addition of sediment, or by submergence and emergence. It is important to monitor the movement of these coastal boundaries, determine coastal land loss and gain, and characterize shoreline movement and its potential impact on the varied activities, uses, and functions of coastal land, vegetation, and habitat.

Bureau researchers conduct studies that update rates of shoreline movement; characterize shoreline types; and access shoreline vulnerability to sea-level rise, non-storm waves, and storm surge and waves. The most recent update to Gulf of Mexico shoreline movement for the entire Texas coast was completed through 2019 (Paine, Caudle, and Andrews, 2021). The last study to look at shoreline change in Corpus Christi Bay was completed in the 1980s (Morton and Paine, 1984). For this project, long-term and short-term Gulf and bay shoreline change rates were calculated based upon the shorelines assembled for this project.

Calculating rates of shoreline movement starts with importing shorelines into an ArcGIS geodatabase, then creating a baseline to cast shore-parallel transects using the GIS-based extension software Digital Shoreline Analysis System (DSAS v. 5.1; Himmelstoss and others, 2021). Transects were cast at 25-m intervals along Gulf of Mexico shorelines and 50-m intervals along the bay shoreline. Rates of change and associated statistics for the 1937 to 2022, 1958 to 2022, and 2000 to 2022 periods were calculated using the transect locations and the selected shorelines for the Gulf shoreline. Rates of change and associated statistics for the 1937-2020, 1958-2020, and 1982-2022 periods were calculated for the bay shorelines. The intersection of the transect lines with the latest shoreline was used to create GIS shape files containing the rates, statistics, and period of shoreline change measurements and the measurement transects bounded by the most landward and seaward historical shoreline position for each measurement site. For additional information and details regarding Texas Gulf and bay shorelines and calculating shoreline change rates, see Paine, Caudle, and Andrews, 2021 as well as the Bureau's Texas shoreline change website (https://www.beg.utexas.edu/research/programs/coastal/the-texas-shoreline-change-project). To learn more about shoreline change in recently studied Texas bays, see Caudle and Paine, 2024 (Galveston Bay); Paine, Caudle, and Andrews, 2016 (Copano, San Antonio, and Matagorda Bays); as well as the Bureau's Texas bay shoreline change project website (https://www.beg.utexas.edu/research/programs/coastal/texas-bay-shoreline-change).

According to the most up-to-date movement calculations for the entire Texas Gulf of Mexico shoreline (from Sabine Pass at the Texas/Louisiana border to the Rio Grande at the Texas/Mexico border), the average rate over the longer-term monitoring period (1930s to 2019) is retreat at 1.27 m/yr (4.2 ft/yr), over the intermediate-term monitoring period (1950s to 2019) is retreat at 1.42 m/yr (4.7 ft/yr), and for most recent, short-term monitoring period (2000 to 2019) is retreat at 1.25 m/yr (4.1 ft/yr) (Paine, Caudle, and Andrews, 2021). For these same time periods, Mustang Island shorelines retreated at a low net rate of 0.29 m/yr (0.7 ft/yr) between the 1930s and 2019, averaged a higher rate of retreat of 0.72 m/yr (2.4 ft/yr) between the 1950s and 2019, and a slight net advance at 0.15 m/yr (0.5 ft/yr) during the most recent monitoring period (2000 to 2019, Paine, Caudle, and Andrews, 2021). Mustang Island was one of only two geologic features on the Texas coast that had net shoreline advance from 2000 to 2019 (Paine, Caudle, and Andrews, 2021). Shoreline change rates along the Gulf of Mexico coast in Mustang Island State Park averages minimal retreat (moving landward) at 0.39 m/yr (1.28 ft/yr) between 1937 and 2022 (Fig. 14). Between 1956 and 2022, that rate increases to 0.84 m/yr (2.74 ft/yr) of retreat. For the most recent monitoring period, 2000 to 2022, the shoreline retreated at a much lower rate, 0.12 m/yr (0.39 ft/yr). The shoreline in the state park reported slightly higher rates of retreat than the average rates for Mustang Island over all three monitoring periods, but significantly lower rates when compared to the whole Texas coast.

Shoreline change rates for the Corpus Christi Bay coastline in Mustang Island State Park averaged low rates of retreat, 0.23 m/yr (0.74 ft/yr), for the longest-term (1937 to 2020) monitoring period (Fig. 14). The rate increased for the 1958 to 2020 monitoring period to 1.18 m/yr (3.86 ft/yr) of retreat. During the most recent monitoring period, 1982 to 2020, the net average rate of change along the back-barrier island shoreline switched to advancement at 0.28 m/yr (ft/yr). Shoreline types along Corpus Christi Bay coastline include narrow beaches or spits at 29% of sites, salt marsh at 63% of sites, and wind tidal flats at 9% of the sites in the state park. Table 2 shows the net average rate of shoreline movement along those shore types over the three monitoring periods.

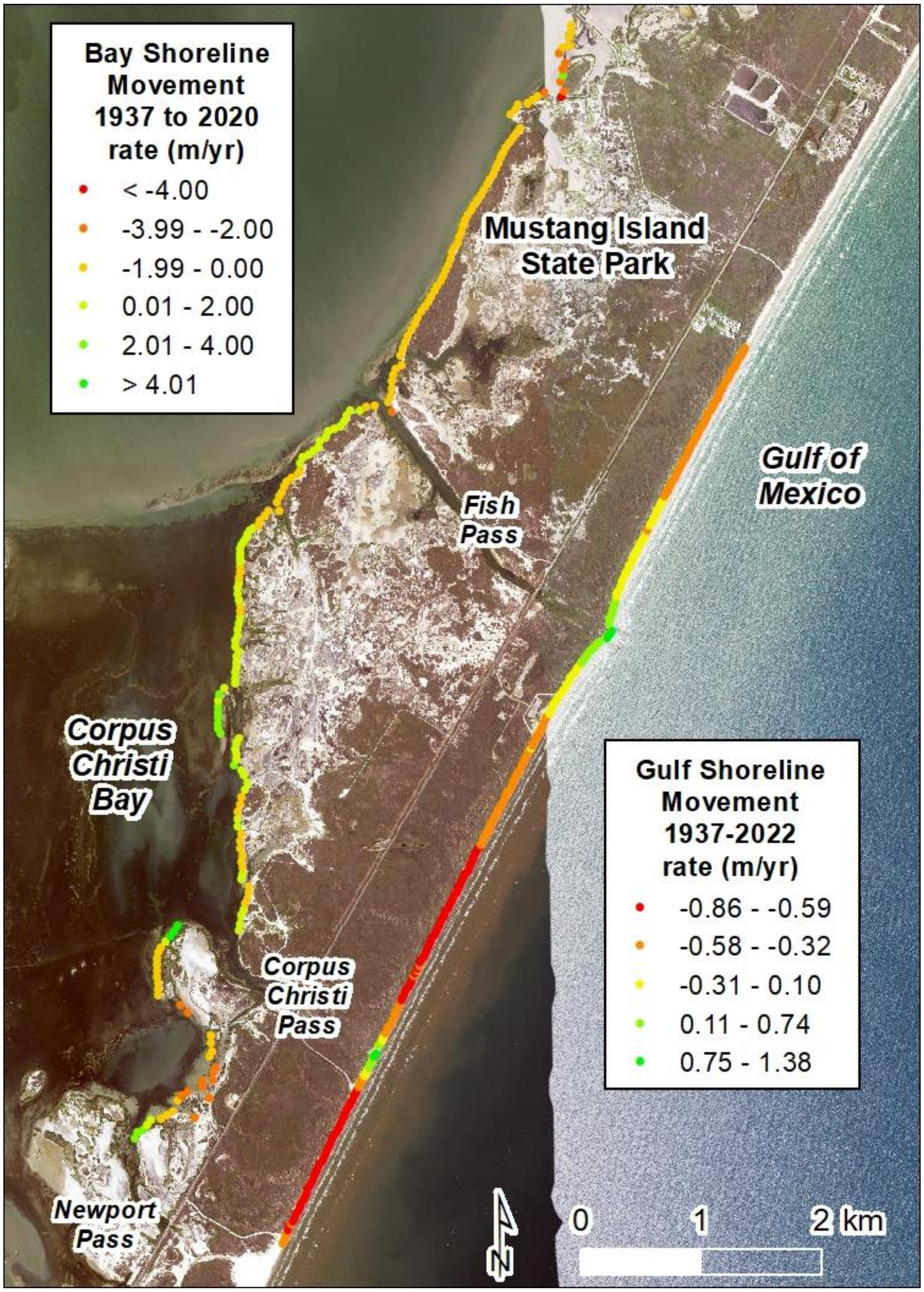

Figure 14. Net rate of long-term movement for the Gulf of Mexico shoreline and the Corpus Christi Bay shoreline in Mustang Island State Park. The Gulf rates were calculated from shoreline positions from 1937 and 2022 and the bay rates were calculated from shoreline positions from 1937 and 2020.

Table 2. Average shoreline movement by shoreline type for the three monitoring periods.

Bay-margin Shore Type	1937-2020 m/yr	1937-2020 ft/yr	1958-2020 m/yr	1958-2020 ft/yr	1982-2020 m/yr	1982-2020 ft/yr
Beach or Spit	-0.79	-2.58	-1.79	-5.87	0.67	2.20
Marsh	0.13	0.43	-0.84	-2.74	0.01	0.03
Tidal flat	-0.94	-3.08	-1.59	-5.21	0.90	2.94

Volumetrics

Volumes and their relationship to elevation help identify areas where sediment has accumulated, as well as areas where little sediment is stored near the shoreline. Peak elevations along the foredunes help identify areas susceptible to breaching and overwash during tropical cyclone passage. The Bureau calculated volumetrics data from the 2019 lidar data which is presented as peak elevations along the Texas Gulf shoreline and as volumes above threshold elevations ranging from 1 to 9 m (3 to 30 ft) relative to the NAVD88 elevation datum (Paine, Caudle, and Andrews, 2021). These volumes can be cast as total volume above a threshold elevation for a given shoreline segment, or as “normalized” alongshore volumes above a threshold elevation, calculated by dividing the volume within the shoreline segment by the alongshore length of the segment. Peak elevations and normalized volume above 1 m elevation along the shoreline are presented in the state park online viewer. To view shoreline movement rates and volumetrics data for the entire Texas coast, visit the Bureau’s Texas shoreline change project interactive map (https://coastal.beg.utexas.edu/shorelinechange2019/).

Peak elevations and beach and foredune volumes generally increase southward toward the central Texas coast, where Mustang Island is located. Peak beach and foredune elevations are relatively high along nearly all of Mustang Island. Peak elevations are above 7.5 m (24.6 ft) along 50% of the Mustang Island shoreline, much higher than the whole-coast average (Paine, Caudle, and Andrews, 2021). Within the state park, peak elevation averages 6.7 m (22 ft) with about 50% of the shoreline having peak dune crests above 7 m (23 ft).

Beach and dune system sediment volumes above 1 m (3 ft) of elevation follow a similar trend to the peak elevations: beach and foredune volumes are high along the entirety of Mustang Island. Along the Texas Gulf shoreline, the average volume of sediment above 1 m (3.3 ft) elevation per meter alongshore is about 230 m^3/m (70 yd^3/ft, Paine, Caudle, and Andrews, 2021). For Mustang Island, the average volume of sediment above 1 m (3.3 ft) elevation per meter alongshore is 457 m^3/m (183 yd^3/ft, Paine, Caudle, and Andrews, 2021). Along the 5 miles of state park shoreline, the average volume of sediment is 466 m^3/m (186 yd^3/ft). All of the sites in Mustang Island State Park have sediment above the 4.5 m (14.8 ft) elevation threshold.

Geologic Map

This layer of the interactive data viewer depicts the surficial geologic units found in Mustang Island State Park mapped from field investigations, digital elevation models, and 2022 aerial photography. This new geologic mapping has units similar to those found in the Environmental Geologic Atlas (later in atlas), but has been updated to follow mapping conventions developed through the Texas STATEMAP geologic mapping program (https://www.beg.utexas.edu/research/areas/geologic-mapping). In recent years, Bureau scientists have focused mapping on the Texas Gulf Coastal Plain to address a variety of needs, including planning and managing lands in sensitive coastal environments and studying erosion, habitat change and land loss, and geologic hazards. All units within the park are late Holocene in age (<5,000 years old) and represent bay-margin marsh, beach, washover, spit and tidal flat; Gulf-margin beach, barrier flat, dune, and washover channel; and eolian dune (Fig. 15). Geologically, the map units found in the state park are very young. To understand why the barrier island formed where it did, you have to go further back in time to understand how the Texas Coastal Plain developed.

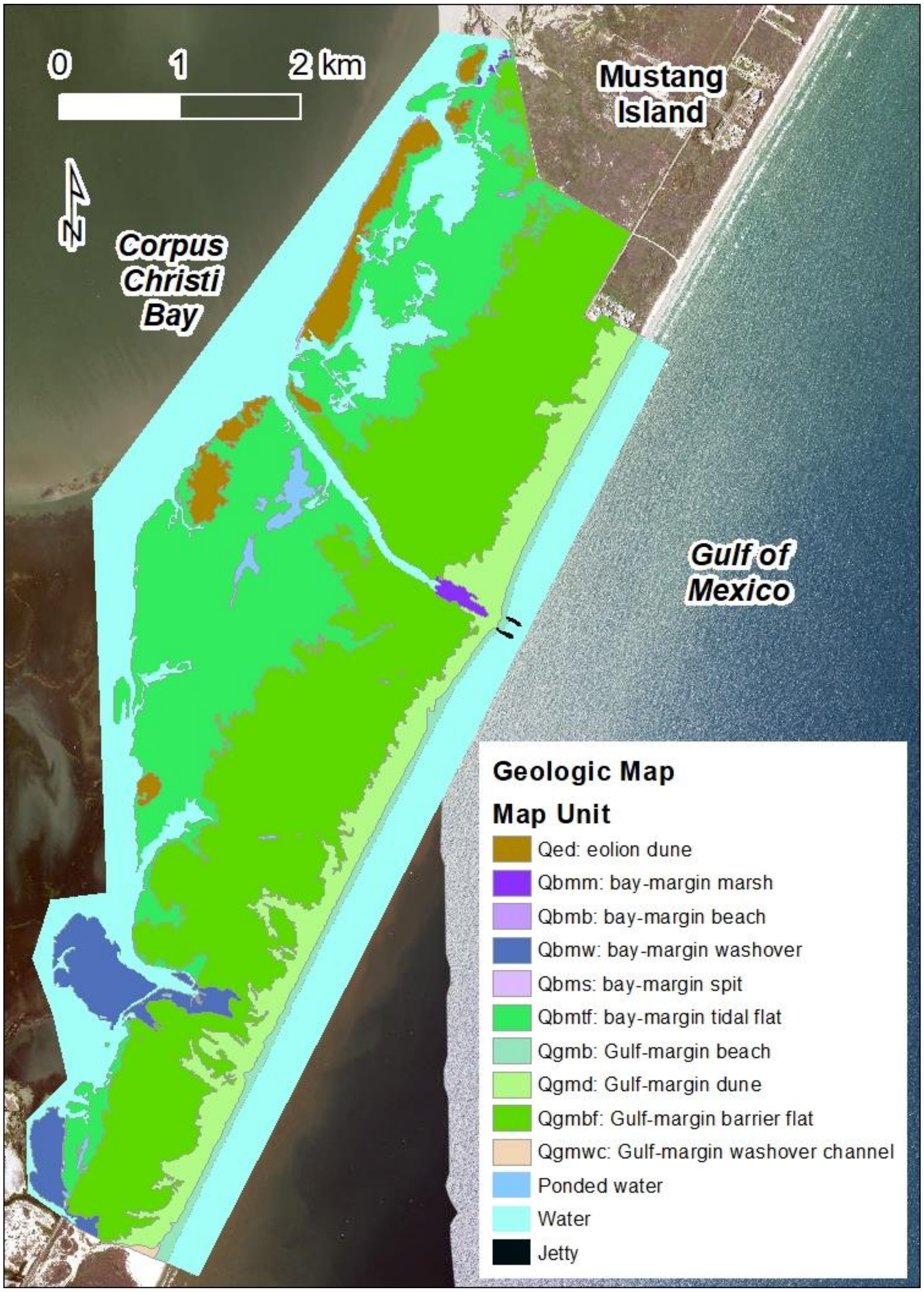

Figure 15. Geologic map of Mustang Island State Park.

The last 2 million years of Earth's history was a time period called the Pleistocene, which fluctuated between periods of massive glaciation (cold periods where water was trapped in glaciers and sea level was lower) and interglacial stages. During the interglacial periods, climate was warmer and wetter. The melting glaciers and increased rainfall created large rivers that transported a huge amount of sand, silt, and mud to the coastal plain to be deposited at the edge of the Gulf of Mexico. As sea level fell during the cold glacier periods, the rivers carved deep channels through the sediments, creating wide river valleys.

About 18,000 years ago, the last glacial stage ended, and sea level was approximately 100-120 meters lower than today. As Earth warmed, the glaciers and ice sheets melted, causing large amounts of water to flow into the oceans and causing sea level to rapidly rise and fill the old river valleys. About 5,000 years ago, climate and sea level stabilized at near current levels (Fig. 16), although they are still rising. At the same time, the modern barrier islands of the Gulf coastline began to form. Sediments that were carried to the coast by rivers and eroded and deposited in the shallow nearshore were redistributed by wind, waves, currents, and storms. The stabilizing of sea level produced conditions that allowed for large barrier islands like Mustang Island to form.

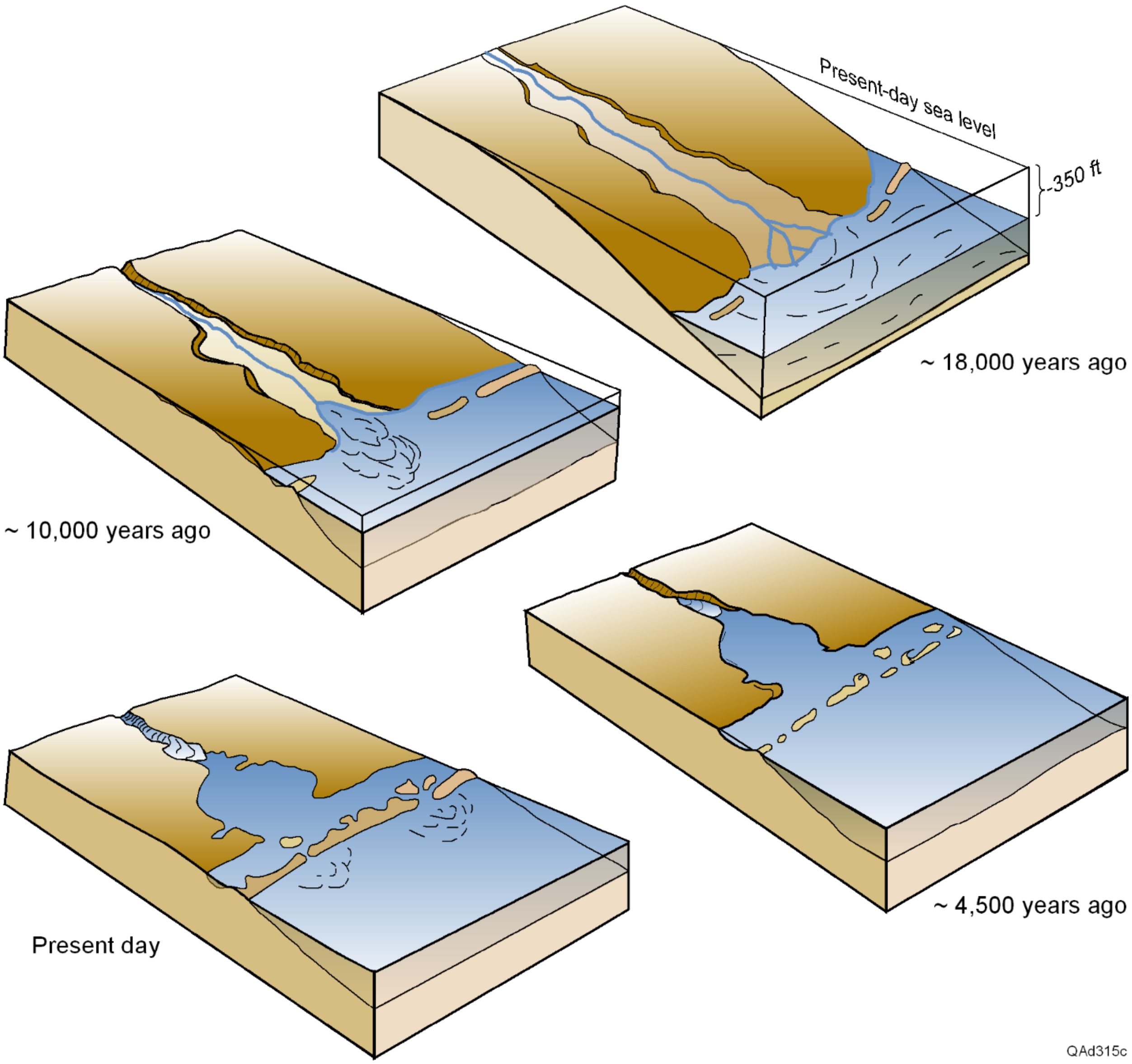

Figure 16. Schematic illustrations showing the effects of rising sea level on the evolution of ancient river valleys into the modern-day coastal environment.

Wetland Mapping

Coastal wetlands enhance water quality, provide flood protection, buffer against erosive storm surges, present unique recreational opportunities and provide high-quality habitats for fish and shellfish production and migratory waterfowl. Coastal wetland and aquatic habitats are essential components of inland and barrier island environments along the Texas coast. These valuable resources are highly productive biologically and chemically, and a variety of flora and fauna depend on part of this ecosystem. Scientific investigations of wetland distribution and abundance are needed to effectively manage the habitats and guide mitigation or restoration projects.

The Bureau has undertaken coast-wide studies of the status and trends of wetlands and aquatic habitats along the Texas portion of the Gulf of Mexico. Based on these studies, the Bureau produced a series of GIS datasets and reports designed to determine the status and historical trends of wetlands and associated aquatic habitats. These datasets are vital tools for coastal scientists, managers, planners, and decision makers. The study of status and trends are based on wetlands interpreted and mapped on recent and historical aerial photographs. The wetlands were mapped based upon the vegetation, hydrology, and geography at the time imagery was acquired. These datasets represent the extent, approximate boundary location, and type of wetland at time of imagery collection, the habitat boundaries and type may change through time.

The most recent Bureau wetland status study for Mustang Island State Park was determined by mapping wetlands on color-infrared (CIR) photographs taken in 2002, 2003, and 2004 (White and others, 2006) with historical wetland distribution based on 1956 black-and-white and 1979 CIR photographs. The U.S. Fish and Wildlife Service (USFWS, 1983, unpublished digital data of wetland maps) mapped historical wetland distribution using methods established through the National Wetlands Inventory Program. The Bureau obtained the 1956 and 1979 wetland map GIS files from USFWS and partly revised them to be more consistent with wetlands interpreted on the 2002-04 photographs (White and others, 2006). Mapping of the wetland and aquatic habitats was done by interpreting and delineating habitats onscreen in GIS at a scale of 1:5,000. This allowed for more detailed mapping. The 2002-04 maps were used to make comparisons with the historical mapping to determine habitat trends (White and others, 2006). The 1956, 1979, and 2002-04 wetland status maps are included in the data viewer. For this project, the most recent USFWS National Wetland Inventory data are also included (https://www.fws.gov/program/national-wetlands-inventory/data-download).

The wetland mapping by the USFWS and Bureau follows the classification determined by Cowardin and others (1979) in *Wetlands and Deepwater Habitats of the United States*. Wetlands are classified by system (marine, estuarine, riverine, palustrine, or lacustrine), subsystem (reflective of hydrologic conditions), and class (descriptive of vegetation and substrate). The systems represented in Mustang Island State Park include estuarine, palustrine, and marine (Table 3). The 1979 and 2002-04 maps were also classified by subclass (subdivisions of vegetated classes only) and water regime (Table 4). The 1956 wetlands were mapped only down to class.

A wetland trend analysis was completed by examining the distribution of wetland habitats as mapped in 1956, 1979, and 2002-04. Wetland classes were emphasized in the trend analysis over water regime and special modifiers, in part because wetland habitats were only mapped to the class level on the 1956 photography. Also, water regime classification can be influenced by local or shore-term events such as precipitation (for example, the 1950s Texas drought) and tidal cycles.

The estuarine system consists of many types of wetland habitats. Estuarine subtidal unconsolidated bottom (E1UB 2002-04), or open water (E1OW 1956 and 1979), occurs in the bays and adjacent salt and brackish marshes. Unconsolidated shore (E2US 2002-04) includes tidal flats (E2FL 1956 and 1979) and algal mats (E2AB 2002-04). The emergent areas around estuarine waters consist of low and high marshes (E2EM) that contain a variety of salt-tolerant and brackish-tolerant plants or scrub-shrub (E2SS 2022-04) that contain mangroves. The mapping of the boundaries between estuarine and palustrine systems is subjective based upon proximity to estuarine water bodies and vegetation types. A pond or emergent wetland is typically placed in the palustrine system if it is separated from the estuarine system by an upland break.

Mapped palustrine areas included the following classes: unconsolidated bottom or open water ponds (PUB 2002-04, POW 1956 and 1979), emergent wetlands (PEM), scrub-shrub (PSS 2002-04), and flats (PUS 2002-04). The palustrine emergent wetlands are fresh or inland marshes not inundated by tidal waters. The marine system consists of the Gulf of Mexico open water (M1UB 2002-04, M1OW 1956 and 1979) and Gulf beaches (M2US 2002-04, M2BB 1956 and 1979).

Table 3. Wetland codes and descriptions from Cowardin and others (1979). Codes listed below were used in mapping the wetlands in the Galveston Island State Park area based upon the interpretation of 2002-04 photography. The codes varied in some cases from the 1956 and 1979 maps.

NWI code (water regime)	**NWI description**	**Common description**
E1AB1	Estuarine, subtidal aquatic bed, algal	Estuarine seagrass
E1AB3	Estuarine, subtidal aquatic bed, rooted vascular	Estuarine seagrass
E1UB	Estuarine, subtidal unconsolidated bottom	Estuarine bay (Corpus Christi Bay)
E2AB1 (N, P)	Estuarine, intertidal aquatic bed, algal	Algal mat
E2EM1 (N, P)	Estuarine, intertidal emergent, persistent	Estuarine bay marshes, salt and brackish water
E2SS3	Estuarine, intertidal, shrub-scrub, broad-leaved evergreen	Estuarine scrub-shrub wetland
E2US (M, N, P)	Estuarine, intertidal unconsolidated shore	Estuarine bay, tidal flats, beaches
M1UB	Marine, subtidal, unconsolidated bottom	Gulf of Mexico
M2US (N, P)	Marine, intertidal, unconsolidated shore	Gulf beach
PEM1 (A, C)	Palustrine, emergent persistent	Freshwater marshes, meadows, depressions, or drainage areas
PSS1 (A)	Palustrine, scrub-shrub, broad-leaved deciduous	Freshwater scrub-shrub wetland
PUB	Palustrine, unconsolidated bottom	Pond
PUS	Palustrine, unconsolidated shore	Freshwater flats
U	Upland	Upland

Table 4. Water-regime symbols and descriptions (Cowardin and others, 1979).

Nontidal	
A	Temporarily flooded: Surface water present for brief periods during growing season, but water table usually lies well below soil surface. Plants that grow both in uplands and wetlands are characteristic of this water regime.
C	Seasonally flooded: Surface water is present for extended periods, especially early in the growing season, but is absent by the end in most years. When surface water is absent, the water table is often near the land surface.
Tidal	
M	Irregularly exposed: Land surface is exposed by tides less often than daily.
N	Regularly flooded: Tidal water alternately floods and exposes the land surface at least once daily.
P	Irregularly flooded: Tidal water floods the land surface less often than daily.

In 2002-04, wetland and aquatic habitats covered 1,011 ha (2,498 ac) within Mustang Island State Park (Fig. 17) and 1,281 ha (3166 ac) were classified as uplands. A hectare (ha) is 10,000 square meters (100 m by 100 m) and equal to 2.47 acres (ac). The estuarine system is the largest of the wetland systems mapped covering 910 ha (2,249 ac), 90% of all wetland and aquatic habitats (Fig. 18). Approximately 454 ha (1,123 ac) of estuarine tidal flats and algal flats (E2US and E2AB) were mapped in the study area. These two habitats make up 45% of the wetlands and aquatic habitats. The estuarine intertidal emergent wetland habitat (E2EM) consists of 312 ha (772 ac) of salt or brackish marshes. This habitat makes up 31% of the study area, excluding the upland unit. Aquatic beds (E1AB) comprise 138 ha (341 ac), or 14% of habitats. The total mapped area of Gulf beaches in Mustang Island State Park was 63 ha (157 ac), 6% of mapped wetland and aquatic habitats in 2002-04, palustrine marsh was 35 ha (87 ac), 3.5% of habitats; and palustrine open water (OW, freshwater ponds) and surrounding flats were approximately 2 ha (5.5 ac), less than 1% of mapped wetland and aquatic habitats in 2002-04.

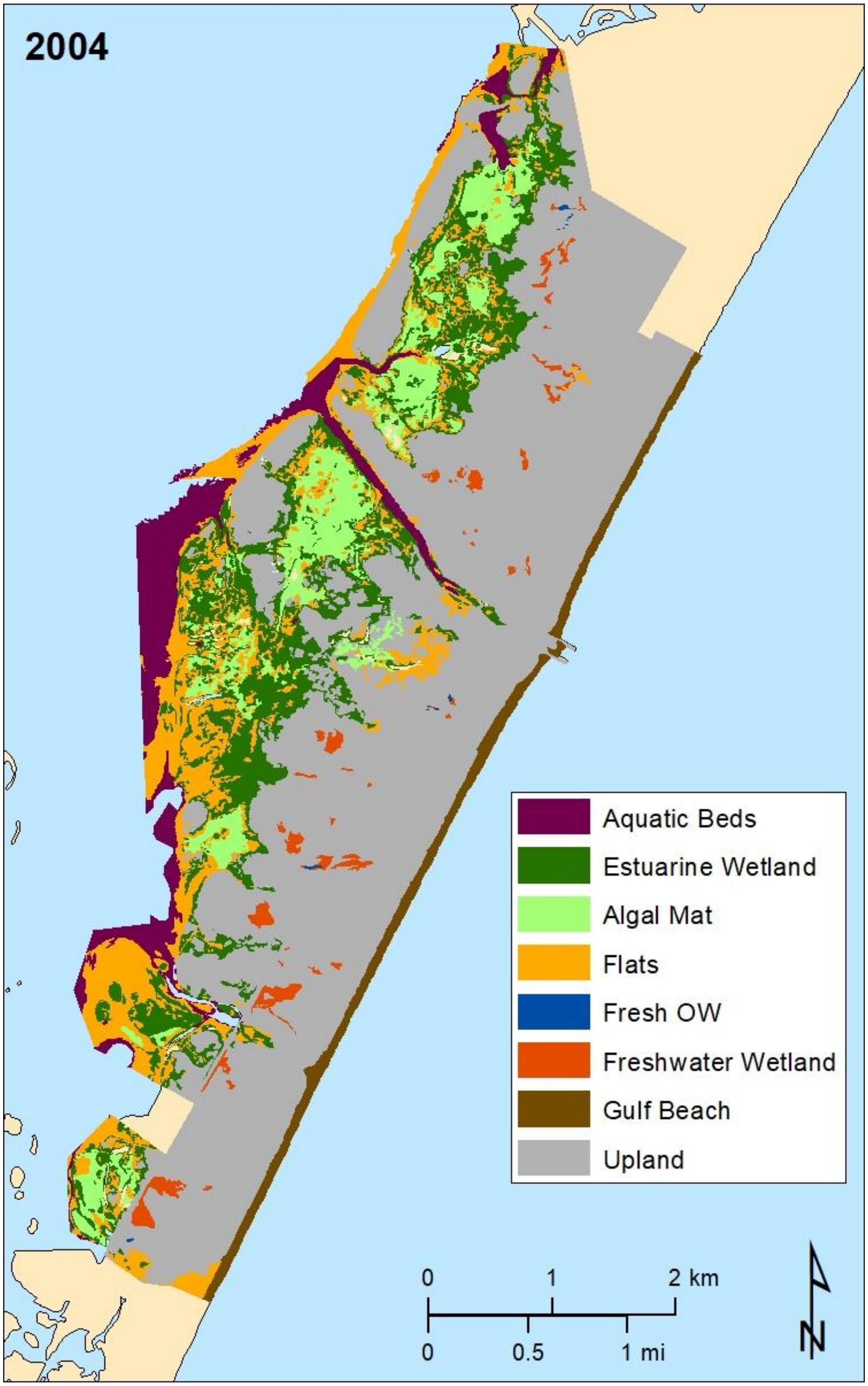

Figure 17. Areal distribution of habitats in Mustang Island State Park in 2002-04. Modified from White and others, 2006.

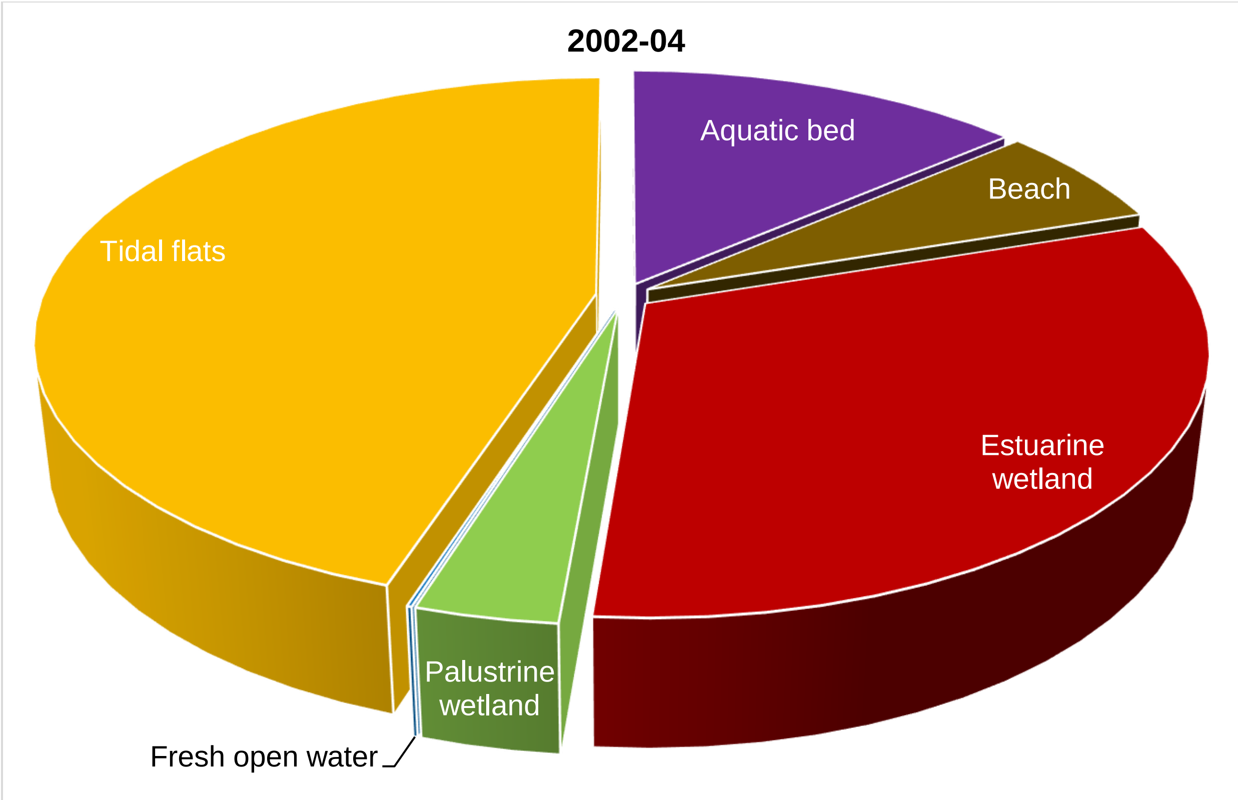

Figure 18. Areal extent of mapped wetland and aquatic habitats in 2002-04. Modified from White and others, 2006.

Broad wetland classes were emphasized over water regimes in analyzing historical trends due to the limitations of the 1956 mapping. The total area of estuarine marshes has increased between the mapping periods, from 163 ha (403 ac) in 1956, to 250 ha (617 ac) in 1979, to 318 ha (785 ac) in 2002-04 (Table 5, Figs. 19 and 20). The total area of palustrine marsh increased from 1956 (16 ha, 40 ac) to 1979 (80 ha, 197 ac), but decreased by almost 60% by 2002-04 (35 ha, 87 ac). In Mustang Island State Park, tidal flats and algal mats have decreased significantly over time. In 1956, these habitats covered 1,033 ha (2,554 ac), decreased to 284 ha (702 ac) in 1979, then increased to 455 ha (1,125 ac) in 2002-04 (Table 5, Figs. 19 and 20).

Table 5. Total area (ha and acres) of major habitats, including uplands, in 1956, 1979, 2002-04. Modified from White and others, 2006.

	1956		1979		2002-04	
Habitat	**ha**	**acres**	**ha**	**acres**	**ha**	**acres**
Aquatic Beds	34	83	303	749	138	341
Estuarine Marsh	163	403	250	617	318	785
Tidal Flats & Algal Mats	1,033	2,554	284	702	455	1,125
Palustrine Marsh	16	40	80	197	35	87
Ponds	3	6	3	6	1	3
Gulf Beach	124	308	97	240	63	157
Uplands	873	2,158	1,304	3,222	1,281	3,166

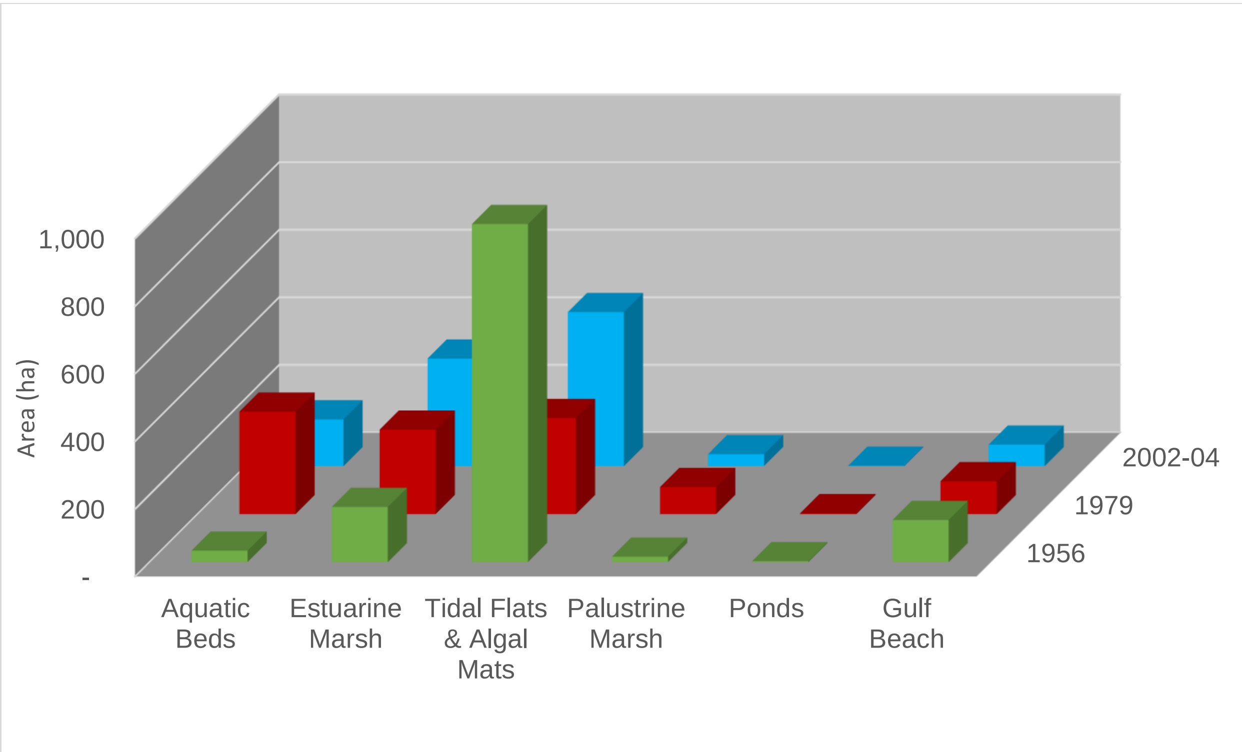

Figure 19. Areal distribution of habitats in Mustang Island State Park in 1956, 1979, and 2002-04. Modified from White and others, 2006.

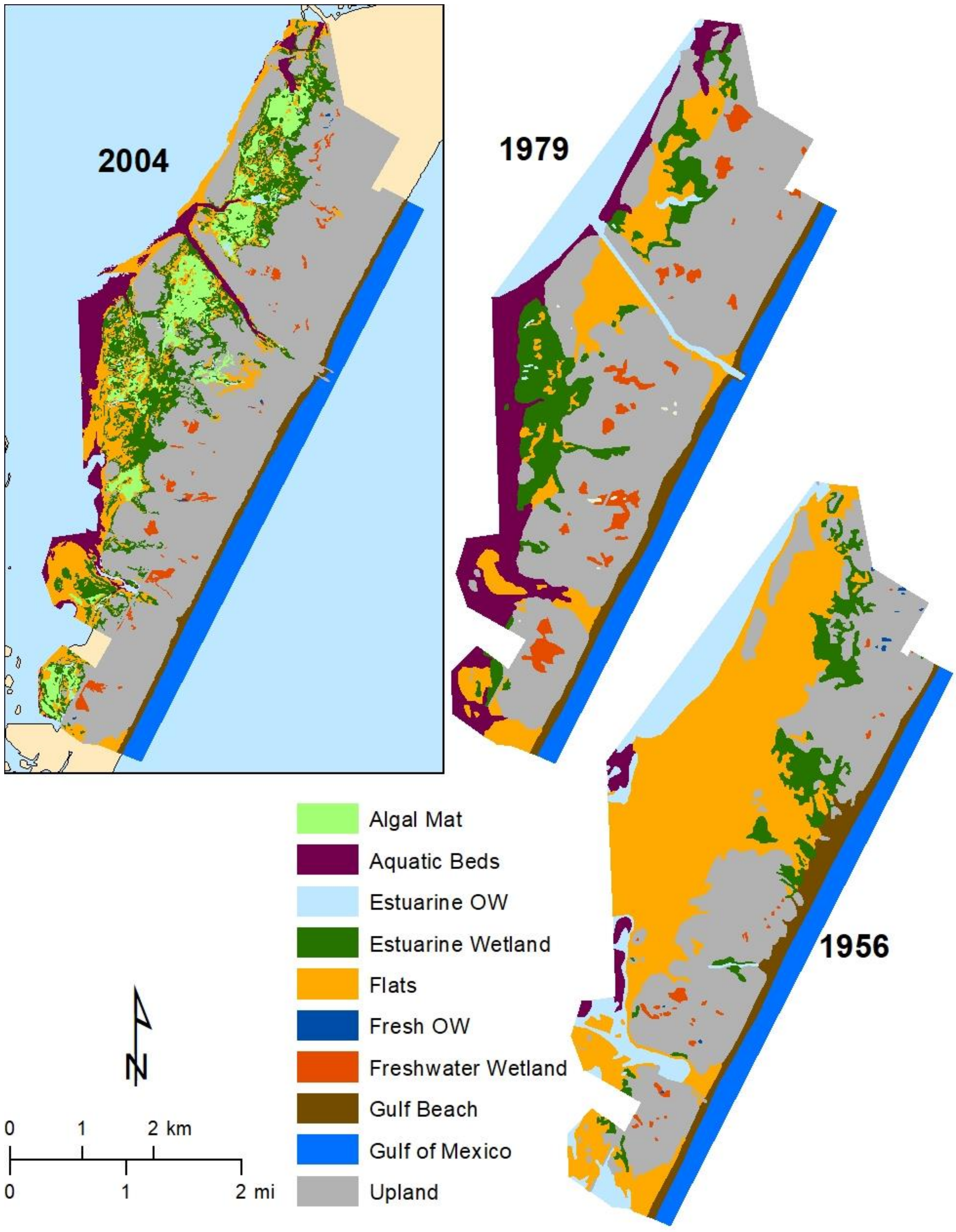

Figure 20. Maps showing distribution of major wetland and aquatic habitats in 2004, 1979, and 1956 in Mustang Island State Park. Modified from White and others, 2006.

Analysis of trends in wetlands and aquatic habitats in the Mustang Island State Park area show that there was a net increase in marshes from 1956 through 2002-04. Emergent wetlands (both estuarine and palustrine) increased from 179 to 353 ha (443 to 872 ac), a gain of almost double the area of emergent marshes (174 ha, 430 ac, Table 5, Fig. 19). The majority of the emergent marsh gain occurred between 1956 to 1979 at a rate of 6.5 ha/yr gain (16 ac/yr). The trend of increased marsh continued between 1979 and 2002-04, but at a much-reduced rate (< 1ha/yr). A recurring trend in wetland habitat studies along the entire Texas coast is the significant loss of tidal flats (White and others 2006). Between 1956 and 1979, tidal flat area decreased at a rate of 32.5 ha/yr (80 ac/yr, Table 5, Figs. 19 and 20). A probable cause for the loss of tidal flats since the 1950s is relative sea level rise (White and others, 2006). Much of the area mapped as wind tidal flat in 1956 converted to aquatic beds (seagrass), open water, or marsh, as low-lying flats were submerged and slightly higher flats were more frequently flooded (Fig. 20, White and others, 2006).

Environmental Geologic Atlas

The interactive viewer for Mustang Island State Park includes digitized maps detailing environmental geology, physical properties, environments & biologic assemblages, and active processes from the Bureau's Environmental Geologic Atlas of the Texas Coastal Zone series for the Corpus Christi area (Brown and others, 1976). This historical publication series provides information that is still relevant for developing and managing the Texas coastal zone. As evidenced from the shoreline movement and wetland data layers, the boundaries for bayside units have moved since these maps were published in 1970s.

<u>Environmental Geology Map:</u> This layer delineates environmental geologic units found in Galveston Island State Park. The depositional units represented within the park formed during the Modern-Holocene period (last 10,000 years) in a barrier-strandplain or offshore setting. The units represented by this map include beach (sand and shell), beach ridge and barrier flat (sand and shell, grass-covered), Marsh (salt-water, mud and locally sand substrate), tidal flat (sand), grass flat (muddy sand with shell), and bay

(mud with oyster shell). The environmental geologic maps in this series is the basic map from which the special-use maps presented below were derived.

Physical Properties Map: This layer groups geologic, biologic, active processes, and man-made map units into groups that have common physical features and properties. Within Mustang Island State Park, four groups are represented.

Group II: Is made of the following modern barrier island sandy geologic units: beach, foredunes, stabilized eolian blowouts, barrier vegetated flats, and washover channels. This group is dominantly sand with high to very high permeability, low water-holding capacity, low compressibility, low shrink-swell potential, good drainage, low ridge and depressed relief, high shear strength, and low plasticity.

Group VI: Includes the following geologic units on Mustang Island; wind-tidal flats, salt marsh, and washover distributary channel and distal fan facies. This group is composed of sand with minor amounts of mud and algal mat laminations, subject to frequent tidal and wind-tidal inundations, eolian transport of sand on the bayside of the barrier island. The group is also characterized by a permanently high-water table, very low permeability, high water-holding capacity, very poor drainage, and very poor load-bearing strength

Group VII: Is made of subaerial spoil heaps or mounds, subaerial reworked spoil, and made land. The properties of this group are highly variable with mixed mud, silt, sand, and shell or reworked spoil that is commonly sandy and shelly with moderate sorting.

Group XI: Includes the back-island dune field, fore-island blowout dunes, coppice dunes and sandflats. This group is composed of friable sand with very high permeability, low water-holding capacity, low compressibility, low shrink-swell potential, good drainage, high shear strength, and low plasticity. Active dunes are unstable due to migration and have relief up to 9 m (30 ft).

Environments and Biologic Assemblages Map: This layer characterizes the dominant collections of bottom-living plants and animals found in Corpus Christi Bay and in the principal plant communities within the park. The collections are grouped by subaqueous environments of the bay and shoreface (grass flats, bay, and upper shoreface) and subaerial environments (beach, barrier flat and foredune ridge, washover, active dunes, sand flats, bay margin, and spoil) defined by land vegetation.

Upper shoreface: Gulf of Mexico nearshore characterized by strong wave action in the surf zone, shifting sands, and normal salinity. Mollusks, sand dollars, starfish, and crustaceans can be found in this environment. Water depths extend from low tide line to 4.6 m (15 ft).

Bay: The Corpus Christi Bay waters are designated as open bay. These waters are away from tidal or river influence and are made of mottled mud, high species diversity, infauna, mollusks, and water depths of 1.8 to 4.6 m (6 to 15 ft).

Grass flats: Occur in the shallow bay margin with dense grasses and a moderate variety of mollusks. Water depths in this environment are less than 1.5 m (5 ft).

Beach: In Mustang Island State Park, the Environmental Geologic Atlas defines the beach as the area lying between low tide to 1.5 m (5 ft) above sea level and includes the swash zone. It is a high energy composed of sand and shell debris where one can find back-beach sea-oats, halophytes, and ghost crabs in the dunes and mollusks and crustacean infauna on the beach.

Barrier flat and foredune ridge: The vegetated barrier flat, foredune ridge, stabilized blowouts are composed of sand and shell and can have relief of 1.5 to 9 m (5 to 30 ft) above sea level. Salt-tolerant grasses, vines, local freshwater marsh, ghost crab, rodents, snakes, and fowl dwell in these environments.

Washover: The washover channel and fan environment is made of sand and localized mud. The surface can have variable collections from being barren or covered by algal mats, to having local ponds and freshwater marsh.

Active dunes: The active dunes, coppice dune, and back island dunes have grasses and other vegetation, while active blowouts tend to be barren. Relief can be from 1 to 9 m (3 to 30 ft) above average sea level, and can contain rodents and snakes.

Sand flats: The tidal flats are an undulatory sand surface -0.3 to 0.61 m (-1 ft to +2 ft) average sea level. They alternate between emergent and submergent depending upon tides and wind. The surface can be covered with blue-green algal mats.

Bay margin: These waters are the shallow (< 1m or 3 ft of depth) in the area between Corpus Christi Bay and Mustang Island. These waters are characterized by sand and mud with shifting sandbars, sparse marine grass, variable salinity and temperature, and home to mollusks.

Spoil: Spoil is land that has been reworked by filling and grading. It is composed of sand, mud, and shell, and can have plants.

Active Processes Map: Outlines the major physical processes that are critical for determining land use. Main map features in Mustang Island State Park include areas inundated by Hurricanes Carla (1961) and Beulah (1967) and by wind tidal flats. Hurricane Carla made landfall as a category 4 hurricane near Port O’Connor, Texas in September 1961. In Port Aransas along the Aransas Pass tidal inlet, storm surge measurements were above 2.7 m (9 ft) during Hurricane Carla. Hurricane Beulah reached category 5 strength while crossing the Gulf of Mexico before making landfall in September 1967 near the mouth of the Rio Grande as a strong category 3 hurricane. Storm surge measurements ranged from 2.4 to 2.9 m (8 to 9.4 ft) along the Mustang Island Gulf of Mexico shoreline and 1.4 m (4.5 ft) at a tide gauge near the Mustang Island State Park bay shoreline. By examining historical hurricanes, coastal managers and planners can have a better understanding of how future storms might impact the coastal zone.

Texas High School Coastal Monitoring Program Data

The Texas High School Coastal Monitoring Program (THSCMP) is a research and outreach project led by the Bureau. The program is designed to help coastal residents develop a better understanding of dune and beach dynamics on the Texas coast. Bureau researchers work with high school and middle school students and teachers training them to measure topography (Fig. 21A), map vegetation lines and shorelines (Fig 21B), and observe weather and wave conditions. As participants in a research project, students enhance their science education and provide coastal communities with valuable data on their changing shoreline. Eight schools participate in THSCMP, monitoring changes in beaches, dunes, and vegetation-line position along the Texas coast. The collected data has been used to investigate beach, dune, and vegetation-line recovery following tropical cyclones; monitor the effects of nourishment projects, beach maintenance practices, and jetty construction; and used in verifying shoreline positions for updates of Texas' long-term shoreline change rates. For more information about THSCMP and to view the data collected by the students, please visit the THSCMP website: https://www.beg.utexas.edu/thscmp/ (Caudle, 2023).

Figure 21. Students from Port Aransas High School A) measuring a beach profile and B) mapping the vegetation line at Mustang Island State Park for the Texas High School Coastal Monitoring Program.

Students and teachers from Port Aransas High School have been working with Bureau scientists for 24 years collecting valuable data about the beach and dune system on Mustang Island. As previously discussed in this guidebook, the dune system on Mustang Island is healthy, with tall, wide foredunes along most of the island. The only breaks in the foredune system are at beach-access points and washover features. Beach maintenance practices vary along the island and have changed over time, which the students document through their data. Several beaches on Mustang Island, particularly within the City of Port Aransas boundaries, are regularly scraped to remove seaweed (*Sargassum*) from the forebeach.

Port Aransas students monitor the growth of the foredune system at a site in Mustang Island State Park. The monitoring site, called MUI02, is located just to the south of Fish Pass where minimal beach maintenance is performed. This site has seen significant changes since student monitoring began in 2000. Port Aransas students have documented several lines of coppice dunes forming and coalescing into continuous dune ridges (Fig. 22). The dune system and vegetation-line position have expanded seaward, and total profile volume has increased at this location (Fig. 23). The shoreline position has remained stable throughout the monitoring program. The increased dune width and stable shoreline position have caused the beach width (distance between vegetation line and shoreline) to decrease, while the foredune system has increased (Caudle, 2023).

To learn more about Port Aransas High School student participation in THSCMP and the data they collect, visit their webpage at: https://www.beg.utexas.edu/thscmp/schools/port-aransas-high-school. The page includes photo galleries from field trips, information about their monitoring sites on Mustang Island, and a downloadable document that contains data and a summary of field trips from the past academic year. To view beach profiles and vegetation line and shoreline position data collected by Port Aransas High School students, as well as data collected by students all along the Texas coast, please visit the THSCMP interactive data viewer at: https://maps.beg.utexas.edu/thscmp/.

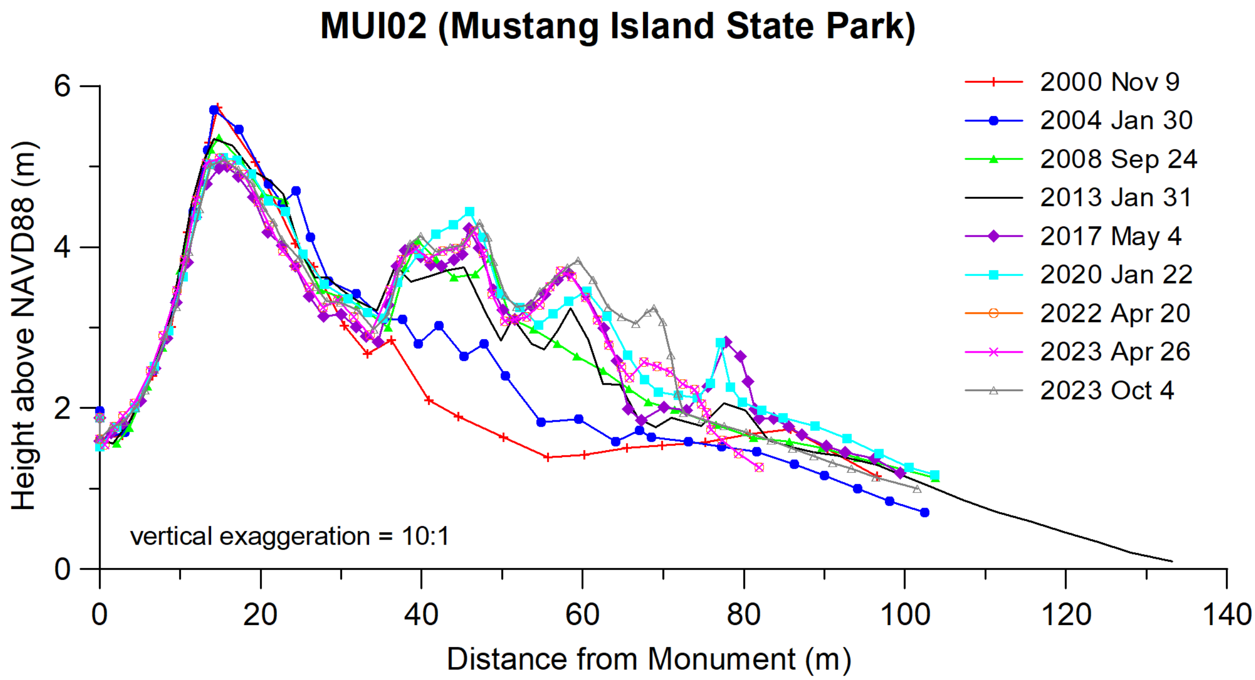

Figure 22. Student monitoring at MUI02 documents the changes in the beach profile between 2000 and 2023 (Caudle, 2023).

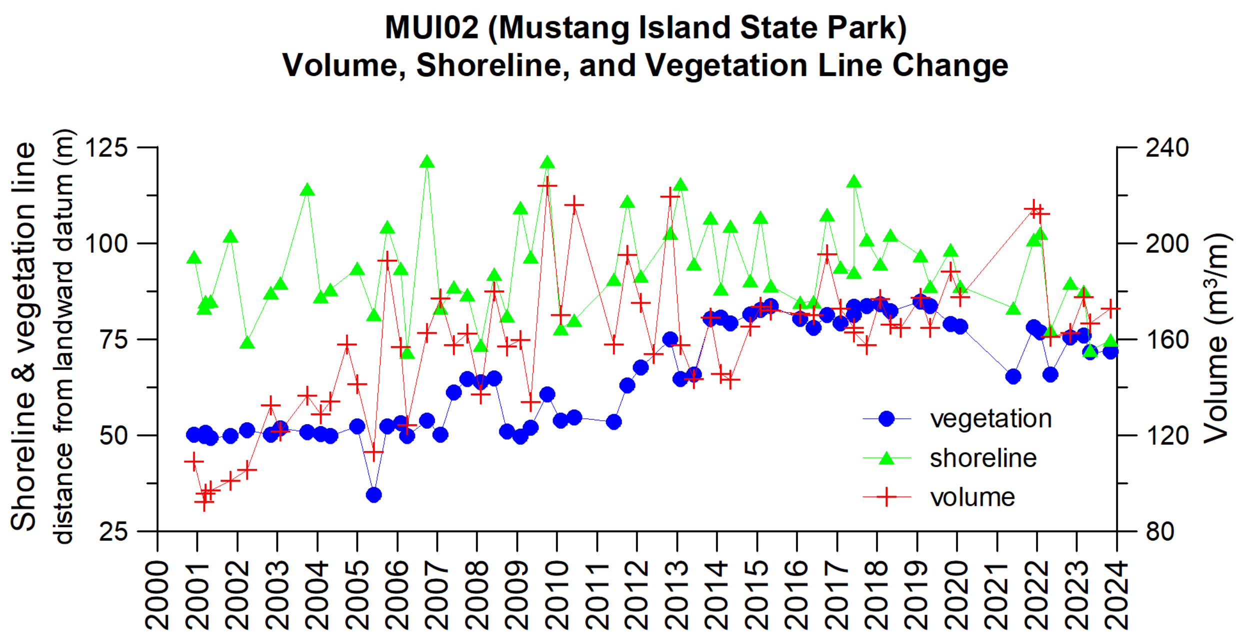

Figure 23. Changes in sand volume and in shoreline and vegetation-line positions at MUI02 in Mustang Island State Park. The volume of sediment (red line) along the beach profile has increased through time with growth of the foredunes. The vegetation line (blue line) has migrated seaward while the shoreline (green) has remained fairly stable (Caudle, 2023).

Acknowledgments

This project was funded in part by a Texas Coastal Management Program grant approved by the Texas Land Commissioner, providing financial assistance under the Coastal Zone Management Act of 1972, as amended, awarded by the National Oceanic and Atmospheric Administration (NOAA), Office for Coastal Management, pursuant to NOAA Award No. NA22NOS4190148. The award was administered through grant no. 23-020-008-D602 from the General Land Office of Texas (GLO) to the Bureau of Economic Geology, The University of Texas at Austin. Jessica Chappell (GLO) served as project manager. Tiffany Caudle served as principal investigator. Bureau staff John Andrews and Aaron Averett created the 3D visualization and data viewer tools. This effort is built on concepts presented in the Padre Island National Seashore guidebook (Weise and White, 1980); Down to Earth at Mustang Island, Texas (Raney and White, 2002) and the Powderhorn Ranch Geoenvironmental Atlas (Paine and others, 2018). The views expressed herein are those of the author(s) and do not necessarily reflect the views of NOAA, the U.S. Department of Commerce, or any of their subagencies.

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