Beach and Dune Monitoring on Mustang Island

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The Texas High School Coastal Monitoring Program (THSCMP) engages people who live along the Texas coast in the study of their natural environment. High school students, teachers, and professional scientists work together to gain a better understanding of dune and beach dynamics in their own locales. Scientists from The University of Texas at Austin (UT) provide the tools and training needed for scientific investigation. Students and teachers learn how to measure the topography, map the vegetation line and shoreline, and observe weather and wave conditions. By participating in an actual research project, the students obtain an enhanced science education. Public awareness of coastal processes and the Texas Coastal Management Program is increased through this program. The students' efforts also provide coastal communities with valuable data on their changing shoreline. There are currently seven schools participating in THSCMP: Ball, High Island, Palacios, Port Aransas, Port Isabel, and Van Vleck High Schools and Cunningham Middle School.

Port Aransas High School students have been collecting data at three locations on Mustang Island (**fig. 5-1**) since they joined the THSCMP in 1999. The central element in the high school monitoring program is at least three class field trips during the academic year, weather permitting. During each trip, students apply scientific procedures to measuring beach morphology and making observations on beach, weather, and wave conditions. Students use a pair of Emery rods, a metric tape, and a hand level to accurately survey a shore-normal beach profile from behind the foredunes to the waterline (**fig. 5-2).** Using handheld GPS units, students walk along the shoreline and vegetation line (**fig. 5-3**) mapping these features for change analysis. Students record wind speed and direction; estimate the width of the surf zone; observe breaker type; record wave direction, height, and period; take readings of shoreline and foredune orientation; and estimate longshore current speed and direction using a float, stopwatch, and tape measure (**fig. 5-4**).

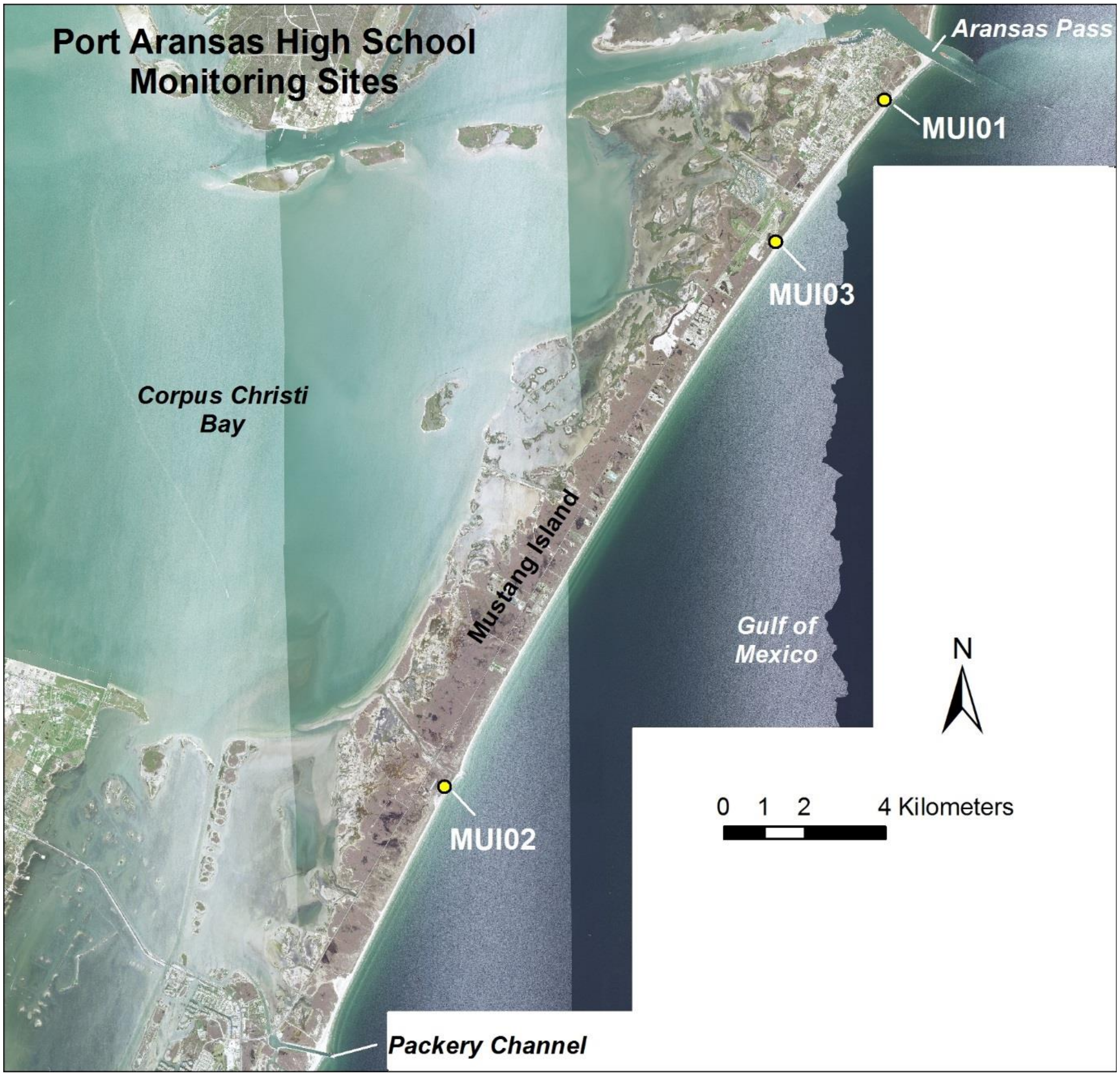

Figure 5-1. Location map of Port Aransas High School monitoring sites.

Figure 5-2. Students using (A) a sighting level to determine vertical offset between Emery rods, and (B) a metric tape to measure horizontal distance.

Figure 5-3. Students mapping (A) the vegetation line and (B) shoreline (wet/dry line) using handheld GPS units.

Figure 5-4. Students (A) using a sighting compass to measure wind and wave direction, and (B) measuring how far along the shoreline the float (an orange) drifted to determine longshore current.

An important part of this program is the repeated mapping of the shoreline and measurement of beach profiles. A problem we face is the limited temporal resolution in our shoreline data. The beach is a dynamic environment where significant changes in shape and sand volume can occur over periods of days or even hours. Tides, storms, and seasonal wind patterns cause large, periodic or quasiperiodic changes in the shape of the beach. If coastal data are not collected often enough, periodic variations in beach morphology could be misinterpreted as changes that have occurred over a long period of time. The THSCMP helps address this problem by providing scientific data at key locations along the Texas coast. These data are integrated into the ongoing coastal research program at the Bureau and are made available to other researchers and coastal managers.

The beach data collected by students on Bolivar Peninsula, Galveston Island, Matagorda Peninsula, northern Padre Island, South Padre Island and here on Mustang Island have been used by researchers at the Bureau to help respond to several beach-related issues (Caudle, 2017; Caudle and Paine, 2012, 2017; Hepner and Gibeaut, 2004). Profile and process data that the students collect have been incorporated into the beach-profile database at the Bureau, and scientists are using these data to investigate beach-erosion patterns. In support of coastal-management issues, data collected by students are clearly useful in explaining beach cycles and defining short-term versus long-term trends. Defining these trends is important in decision-making regarding coastal development and beach nourishment. We emphasize to students that they are collecting critical scientific data that will help scientists address coastal issues affecting their community.

Beach and Dune Monitoring

The beach-monitoring activities of Port Aransas High School students have provided beneficial information about the beach and dune system on Mustang Island at three profiling sites. Beach maintenance practices vary along the island and have changed over time which the students have documented through their data. Several beaches on Mustang Island, particularly within the Port Aransas boundaries, are regularly scraped to remove seaweed (*Sargassum*) from the forebeach. When the monitoring program began on Mustang Island in 1999, the sand and seaweed removed from the berm and forebeach were regularly placed at the seaward base of the foredune causing the foredune complex to expand seaward. **Figure 5-5** is an example of expansion of the foredune at MUI01 (**fig. 5-1**) near Horace Caldwell Pier in Port Aransas. Note that the width of the dunes increased between 2001 and early 2012, although the shoreline remained relatively stable.

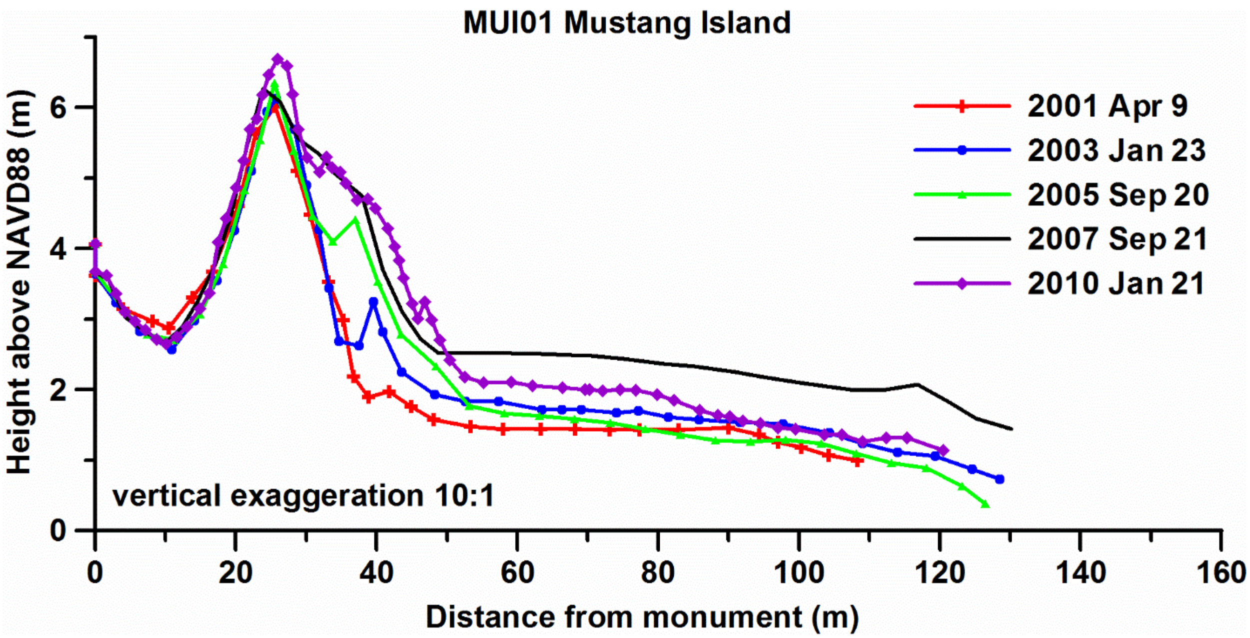

Figure 5-5. Foredune expansion at MUI01 on Mustang Island between 2001 and 2010.

When Port Aransas students arrived at this location to collect profile data in October 2012, a large part of the dune face had been excavated (**figs. 5-6, 5-7**) for beach-maintenance purposes. The City of Port Aransas uses the notch-and-fill method, where a notch is cut out of the foredune and refilled over time with *Sargassum* and sand that is scraped from the beach. The sand that is removed from the dune notch is spread near the waterline for re-distribution by waves and currents. Students documented that sand was replaced in the foredune by May 2013 and that the vegetation line has been re-established at the toe of the dune. The dune has again been notched since the 2014–2015 academic year. The current width of the foredune is narrower and the volume of sand in the profile is significantly less than when THSCMP began monitoring in 1999. Also the crest of the foredune is lower in elevation because of a lack of vegetation on the crest. The dune crest is no longer stabilized at this location and sand is being carried away by the wind. The notched area is slowly being filled. Notice the increase in sand at the base of the dune face on the May 2017 profile plot (**fig. 5-6**). This location has shore-parallel bollards that have been installed on the backbeach to confine vehicles to the upper portion of the backbeach. They also restrict further seaward expansion of the foredune complex at MUI01 by maintaining a fixed location of the beach road starting at the toe of the dune.

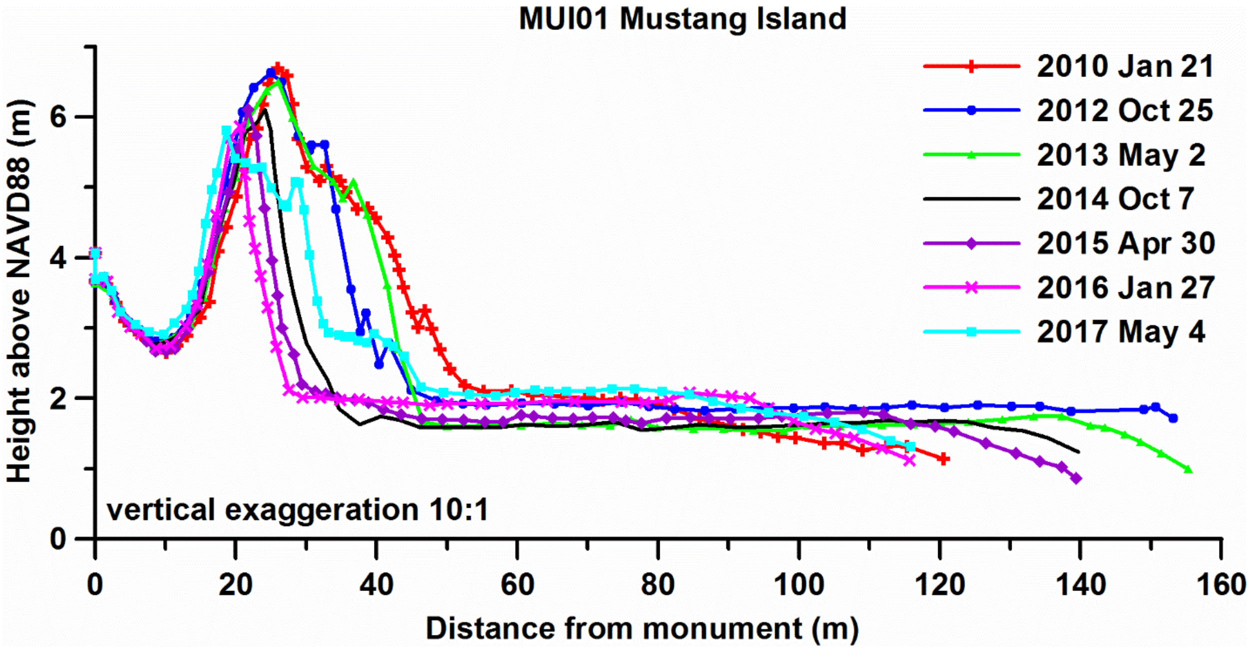

Figure 5-6. Excavated dune profile at MUI01 on Mustang Island.

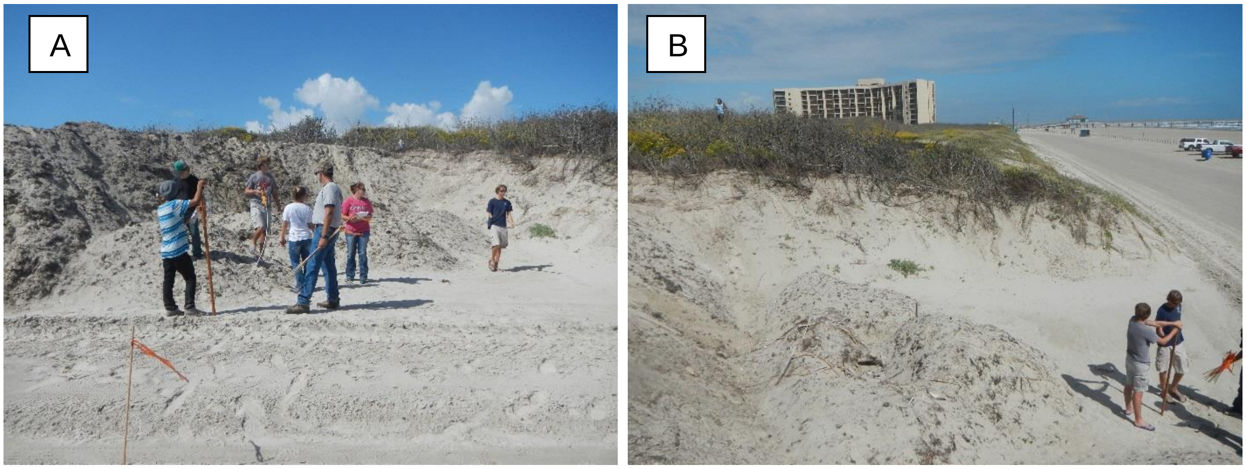

Figure 5-7. Excavated dune at MUI01 on Mustang Island looking (A) north toward Horace Caldwell Pier, and (B) landward.

The MUI03 monitoring site is adjacent to the beach access point at Access Road 1, Palmilla Beach Golf Club (**fig. 5-1**). During the first several years of monitoring at this location, students documented expansion of the foredune complex due to the addition of sediment and sargassum due to beach maintenance practices (**fig. 5-8**). The beach and dune system has been stable since 2007-08. Again the position of the toe of the dune is controlled by the beach road (**fig. 5-9**).

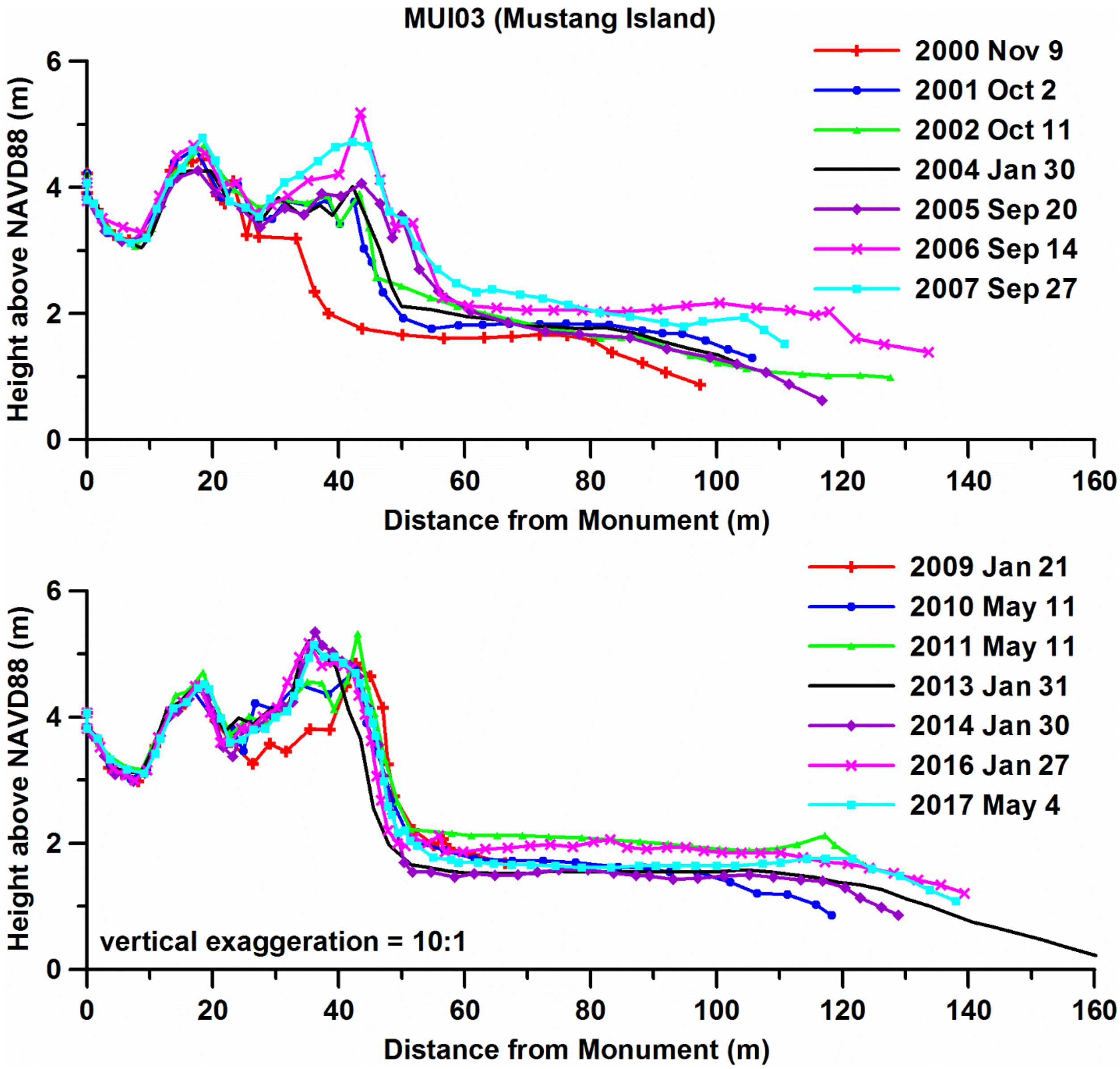

Figure 5-8. Beach profile data from site MUI03 near Access Road 1 on Mustang Island.

Figure 5-9. Dune toe and beach road at site MUI03 on Mustang Island. Notice the tire marks adjacent to the duneface. Vehicular traffic on the beach road has limited the seaward expansion of the foredune at this site.

The final monitoring site for Port Aransas students is MUI02 located within Mustang Island State Park, just to the south of Fish Pass (**fig. 5-1**). This site has seen significant changes since student monitoring began. We have documented several lines of coppice dunes forming and coalescing into continuous dune ridges (**fig. 5-10**). Minimal beach maintenance is performed within the State Park boundaries, mainly to keep the beach access points open.

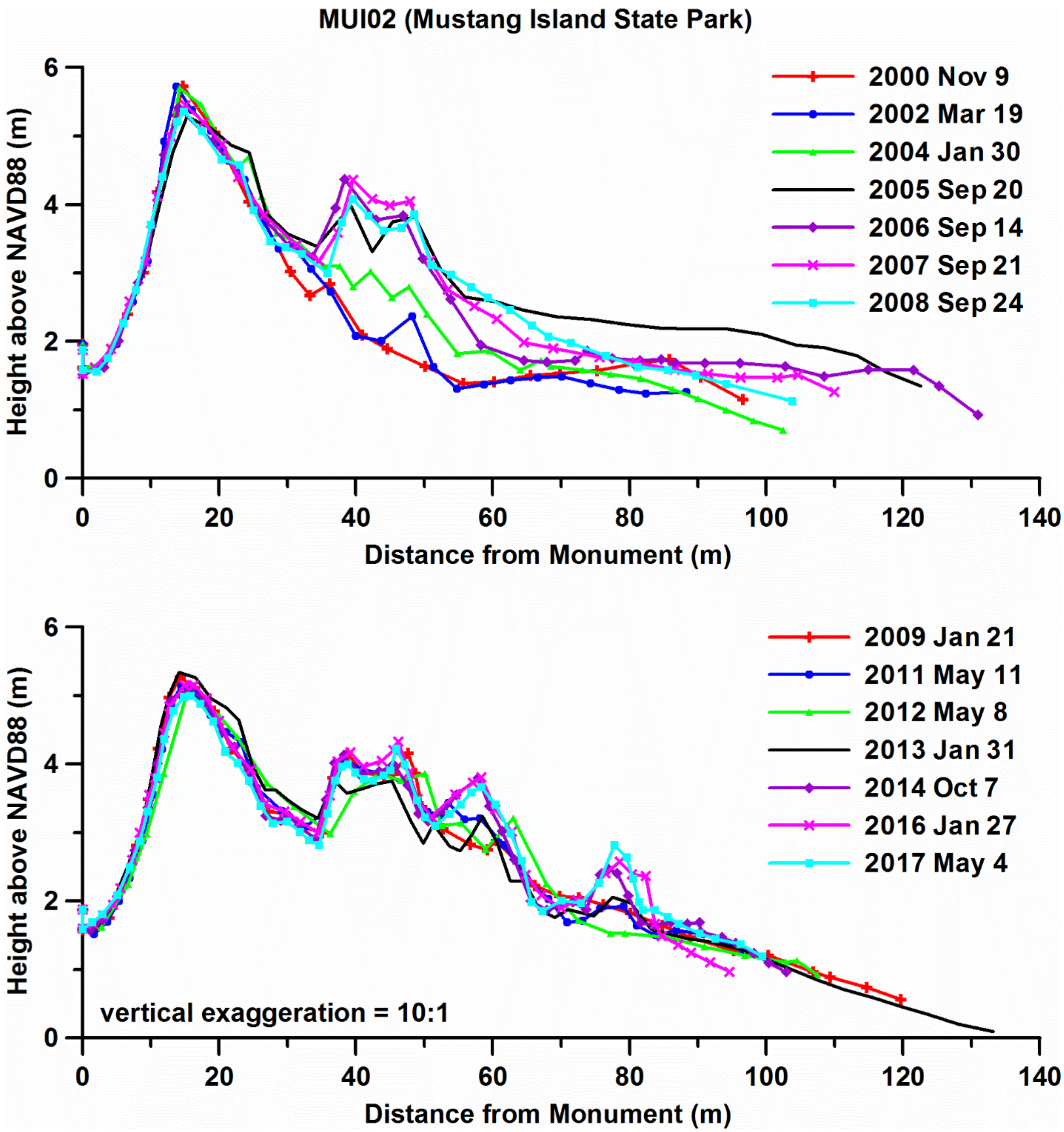

Figure 5-10. Seaward expansion of the foredunes at site MUI02 in Mustang Island State Park.

Shoreline Change

THSCMP-collected data are invaluable in verifying shoreline position for recent updates of Texas' long-term shoreline-change rates (Paine and Caudle, 2018; Paine, Caudle, and Andrews, 2013, 2014; Paine, Mathew, and Caudle, 2011, 2012), which are widely used by public officials, corporations, and private citizens. The Bureau frequently completes projects that require the updating of long-term rates of shoreline change along the entire Texas coast based upon either the mapping of the shoreline position on aerial photographs or extraction of a shoreline proxy (elevation) from airborne LIDAR-derived digital elevation models (DEM's). Beach profiles and GPS-mapped shorelines (wet beach/dry beach boundary) collected by THSCMP students are used to verify the shoreline position digitized on aerial photography or extracted from the LIDAR-derived DEM's. Student-collected data has proven to be invaluable in validating interpretation of the shoreline position on Galveston Island, Follets Island, Matagorda Peninsula, Mustang Island, and South Padre Island. The LIDAR-derived shoreline proxies for the 2012 and 2016 shoreline change updates were superimposed on georeferenced National Agriculture Imagery Program (NAIP) photographs along with GPS-based wet-beach/dry-beach boundary data collected by the THSCMP. In most cases the imagery and ground-based GPS data were acquired within a few days or weeks of the LIDAR survey date. The boundaries interpreted from imagery and ground-based data are generally consistent (within a few meters) with those extracted from LIDAR data.

For example, LIDAR, imagery, and GPS comparisons on Mustang Island (sites MUI02 and MUI03, **figs. 5-11 and 5-12**) show good agreement between the shoreline position extracted from the September-October 2016 LIDAR survey and the wet-beach/dry-beach boundary evident on NAIP imagery acquired on September 30, 2016. GPS surveys of the shoreline acquired by the THSCMP students on September 28, 2016 indicates a shoreline position that coincides with the LIDAR-extracted shoreline (Paine and Caudle, 2018).

The 2016 LIDAR survey did not cover the entire Texas Gulf coast. Where data gaps were present, the shoreline was mapped as the wet-beach/dry-beach boundary on 2016 NAIP imagery. Site MUI02 is located in Mustang Island State Park where one of the 2016 LIDAR coverage gaps begins. The 2016 shoreline was mapped as the web-beach/dry-beach boundary on the September 30, 2016 NAIP imagery (**fig. 5-11**). THSCMP data was used to verify the position of the shoreline mapped on aerial photographs and extracted from LIDAR DEM's for the 2007, 2012, and 2016 long-term shoreline change updates recently completed by the BEG (Paine and Caudle, 2018; Paine, Caudle, and Andrews, 2013, 2014; Paine, Mathew, and Caudle, 2011, 2012).

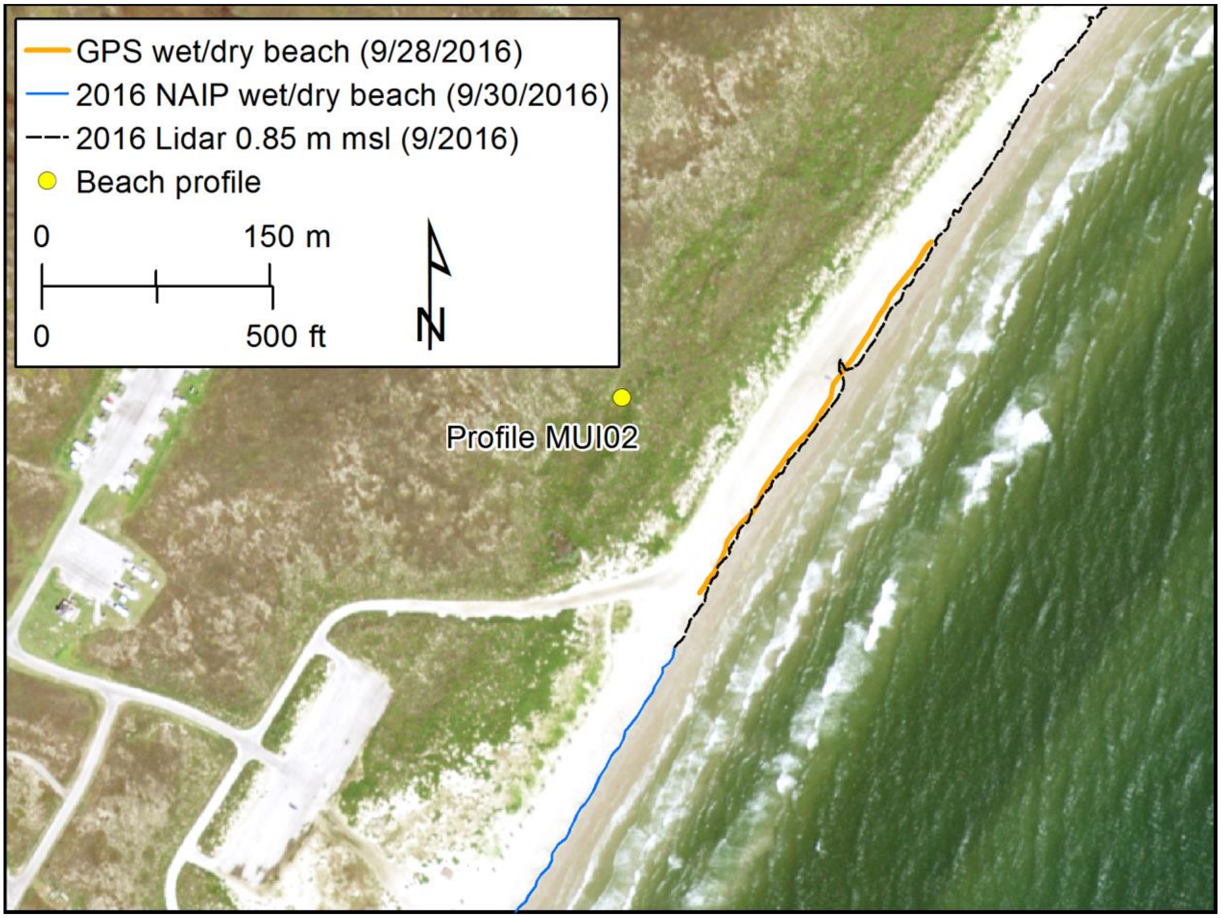

Figure 5-11. Shoreline position comparison at Mustang Island site MUI02 (fig. 4-1). Shorelines include the wet-beach/dry-beach boundary (September 28, 2016) mapped by THSCMP students using ground GPS and the shoreline proxy extracted from airborne LIDAR data acquired September-October 2016 by the U.S. Army Corps of Engineers. Shorelines are superimposed on NAIP imagery acquired on September 30, 2016 (from Paine and Caudle, 2018).

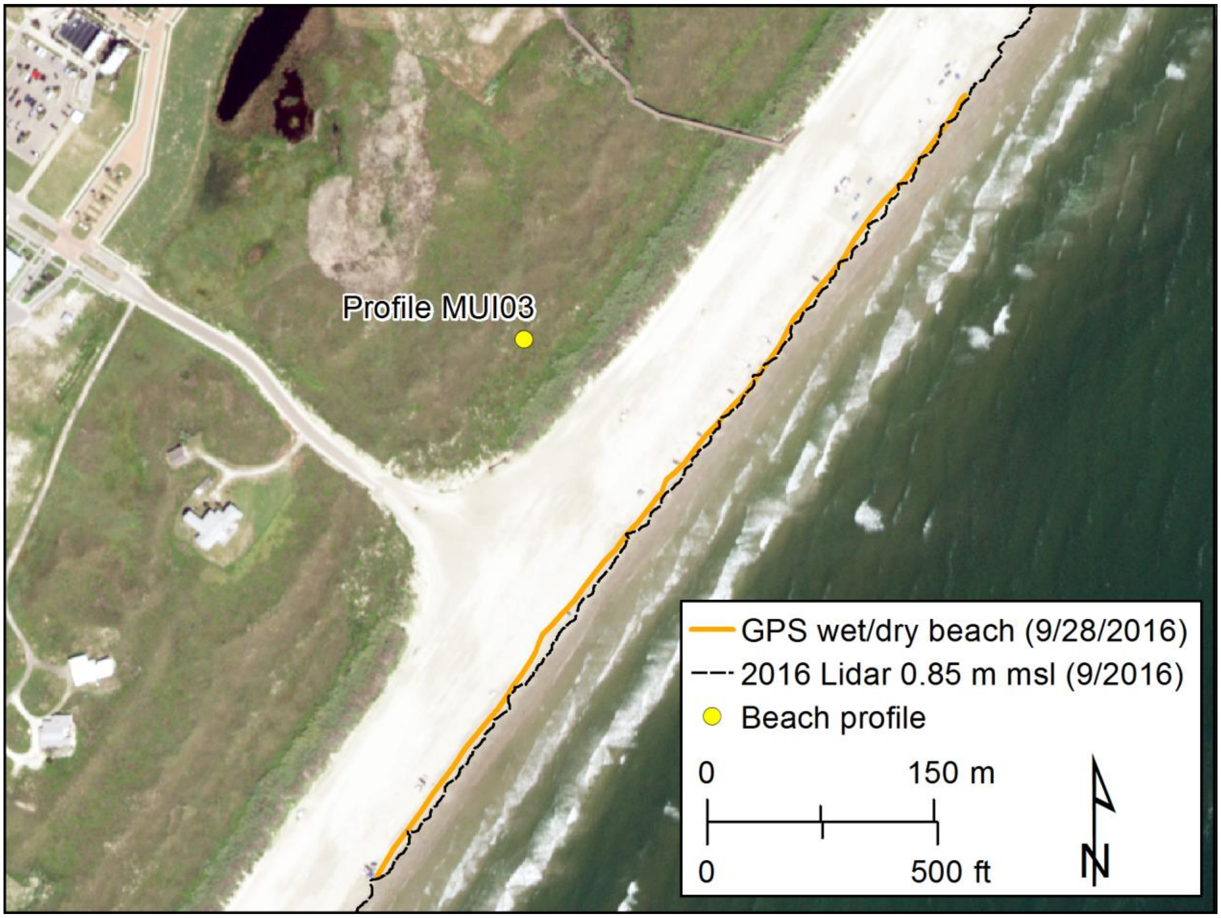

Figure 5-12. Shoreline position comparison at Mustang Island site MUI03 (fig. 4-1). Shorelines include the wet-beach/dry-beach boundary mapped by THSCMP students and the LIDAR-extracted shoreline proxy superimposed on NAIP imagery (from Paine and Caudle, 2018).

Mustang Island has one of the lowest shoreline change rates of the entire Texas Gulf of Mexico coast. Long-term (1930s-2016) Gulf shoreline changes rates for Mustang Island were calculated for 574 sites spaced at 50 m (164 ft) alongshore (Paine and Caudle, 2018). Net shoreline change rates calculated from the 1930's to 2016 averaged retreat at 0.09 m/yr (0.3 ft/yr) on Mustang Island (**fig. 5-13**). Annual rates of land loss estimated from these rates are 0.3 ha/yr (0.6 ac/yr) and estimated total land loss along the Mustang Island Gulf shoreline since 1930 is 22 ha (55 ac). Net rates at individual sites ranged from retreat at 1.3 m/yr (4.3 ft/yr) to advance at 2.0 m/yr (6.6 ft/yr). Sites along a 7.4-km (4.6-mi)-long shoreline segment adjacent to the south jetty at Aransas Pass as well as the area adjacent to the Fish Pass jetties in Mustang Island State Park recorded minor net shoreline advance. A short 2.5-km (1.5-mi)-long segment on the southern part of the island recorded net retreat rates greater than 1 m/yr (3.3 ft/yr). Net retreat rates on most of Mustang Island were less than about 1 m/yr (3 ft/yr).

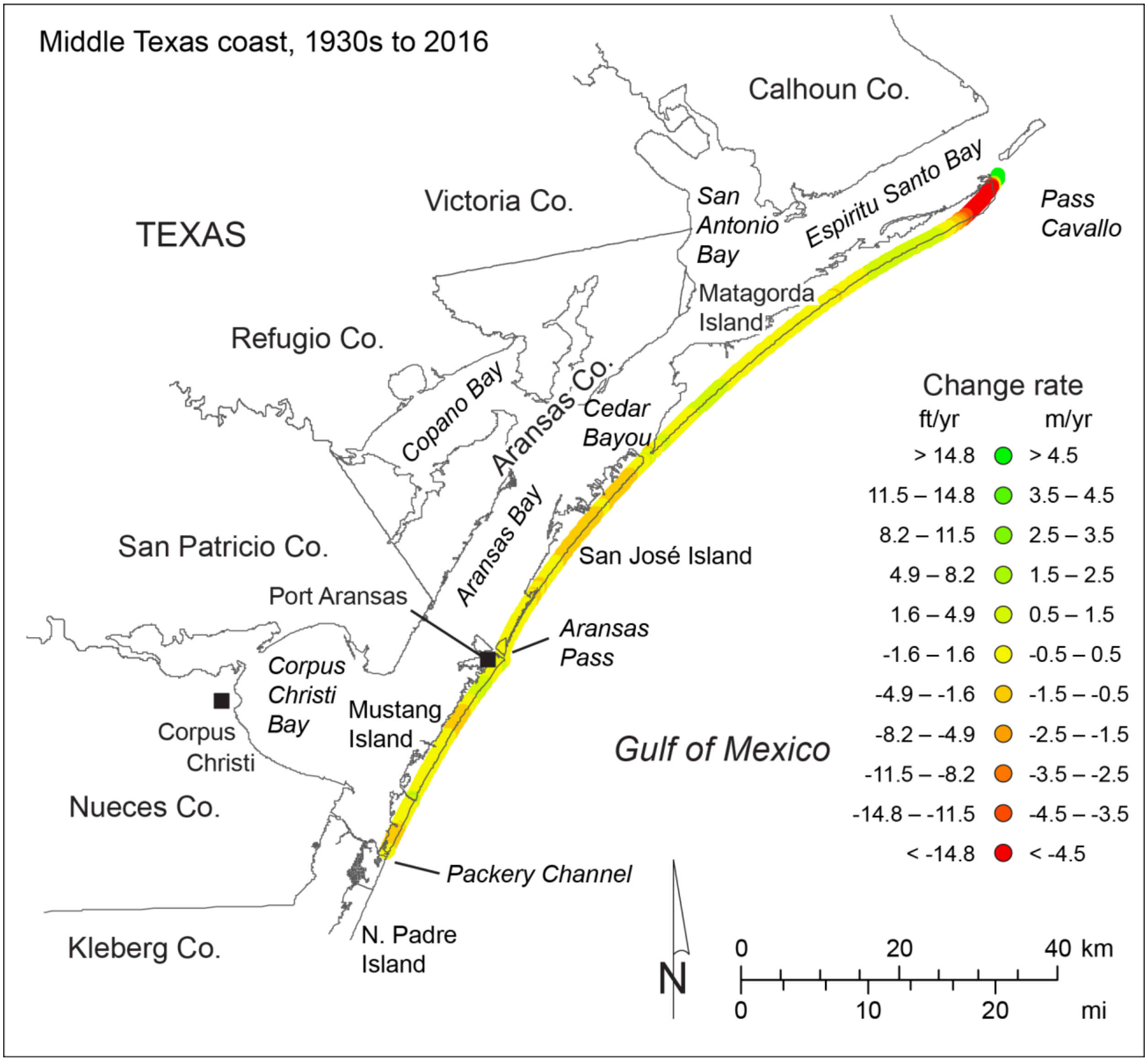

Figure 5-13. Net rates of long-term change for the central Texas Gulf shoreline between Pass Cavallo and the Packery Channel area (including Mustang Island) calculated from shoreline positions between the 1930's and 2016 (from Paine and Caudle, 2018).

The latest Gulf movement update also examined short-term (2000-2016) trends in shoreline change (Paine and Caudle, 2018). On Mustang Island the shoreline movement trend changed to net advance at 1.17 m/yr (3.8 ft/yr) during the most recent monitoring period, one of five major geologic features on the Texas coast having net shoreline advance (**fig. 5-14**). Annual rates of land gained estimated from these rates are 3.4 ha/yr (8.4 ac/yr) and estimated total land gained along the Mustang Island Gulf shoreline since 2000 is 54 ha (133 ac). Net rates at individual sites ranged from retreat at 0.6 m/yr (2.0 ft/yr) to advance at 7.1 m/yr (23.3 ft/yr). A small 2.1-km (1.3-mi)-long segment near Newport Pass is the only stretch of shoreline on Mustang Island recording net shoreline retreat during the recent period (2000-2016).

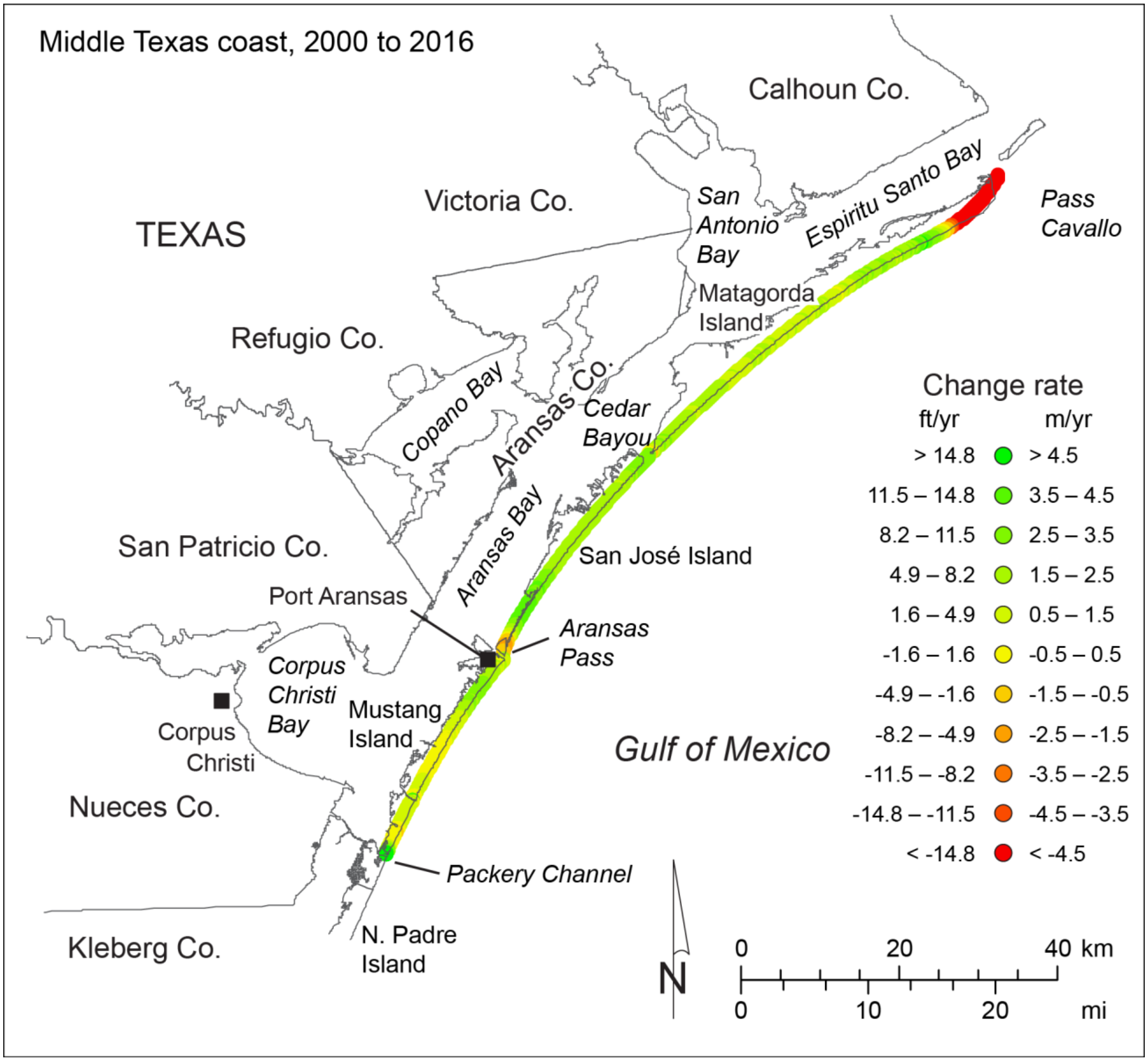

Figure 5-14. Net rates of short-term change for the central Texas Gulf shoreline between Pass Cavallo and Packery Channel (including Mustang Island) calculated from shoreline positions between 200 and 2016 (from Paine and Caudle, 2018).

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