FINAL REPORT

Texas High School Coastal Monitoring Program: 2021–2022

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The University of Texas at Austin, Austin, Texas 78713-8924

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INTRODUCTION

The Texas High School Coastal Monitoring Program (THSCMP) is designed to help students and communities living on the Texas coast develop a better understanding of their natural environment. Students, teachers, and scientists work together to gain a better understanding of dune and beach dynamics in their regions. Scientists from The University of Texas at Austin's Bureau of Economic Geology (the Bureau) lead the research and outreach program by providing the tools and training needed for scientific investigation. Students and teachers learn how to measure topography, map vegetation lines and shorelines, and observe weather and wave conditions. Coastal processes, the beach and dune environment, and public access and private property rights provide an ideal setting for teaching middle school and high school students basic and applied science and for illustrating the roles that science and good data-collection practices play in public policy decision-making.

By participating in an actual research project, the students obtain an enhanced science education and provide coastal decision-makers with valuable data about the Texas shoreline. Students monitor changes in beaches, dunes, and vegetation-line position on Bolivar Peninsula, Galveston Island, Follets Island, Matagorda Peninsula, Mustang Island, North Padre Island, and South Padre Island (**Fig. 1**). In support of coastal-management issues, data collected by students are useful in explaining beach cycles and defining short-term versus long-term trends. Defining these trends is important in decision-making regarding coastal development, beach nourishment, and dune restoration projects. The THSCMP observes beaches in several coastal parks: Mustang Island and Galveston Island State Parks, overseen by the Texas Parks & Wildlife Department (TPWD); the Lower Colorado River Authority's Matagorda Bay Nature Park; Cameron County's Isla Blanca Park; Brazoria County's Quintana Beach County Park, and the City of Galveston's Dellanera RV Park. The data collected within these park systems help managers develop a better understanding of their local coastal environments, which allows managers to make wise decisions in long-term management and future park development.

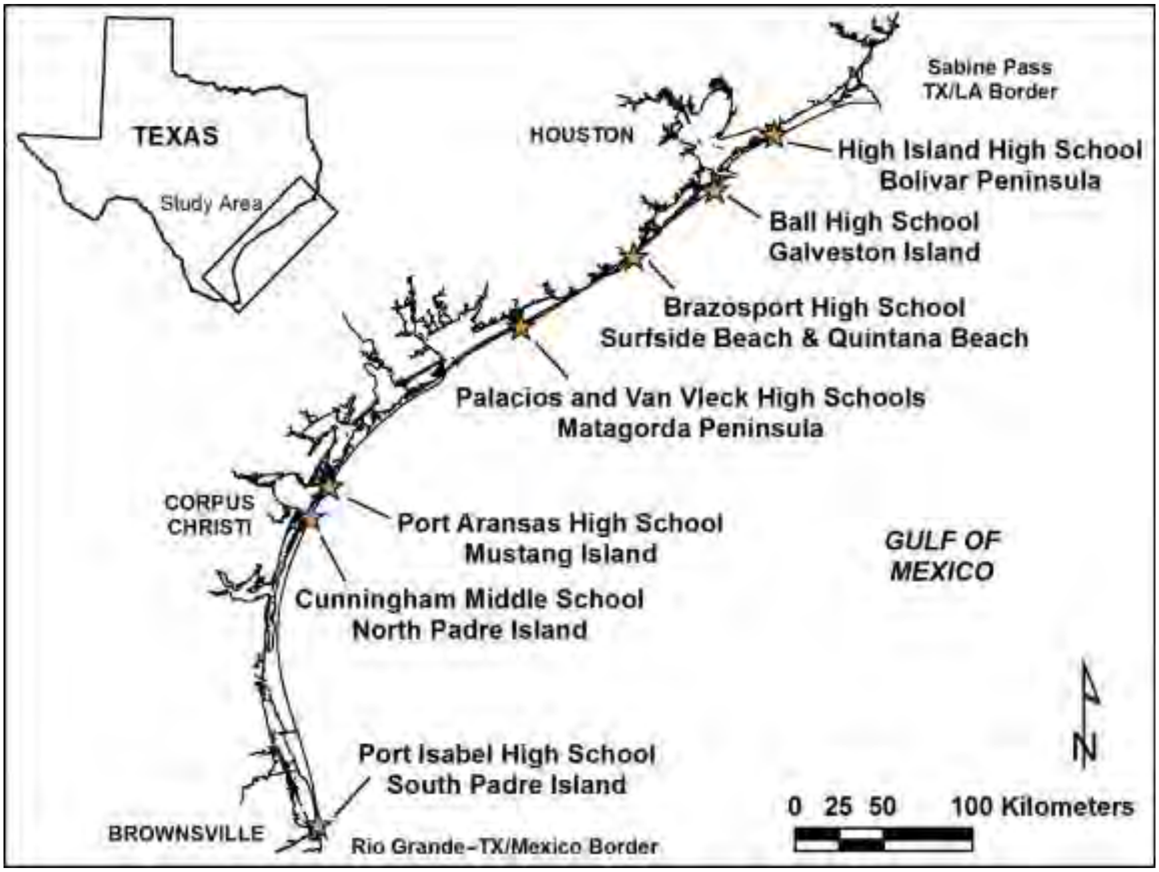

Figure 1. Location map of participating schools.

This report describes the program and our experiences at the eight participating schools during the 2021–2022 academic year. Field trips resumed during this academic year but were complicated in all of the school districts due to the on-going COVID-19 pandemic, shortages of substitute teachers and school bus drivers, the September landfall of Hurricane Nicholas, and general scheduling issues. During the 2021–2022 academic year, Ball High School on Galveston Island completed its 23rd year in the program, and Port Aransas and Port Isabel High Schools completed their 22nd year. Through collaboration with the Lower Colorado River Authority, the program works with two schools in the Matagorda area: Van Vleck High School completed their 17th year in the program and Palacios High School completed its 15th year. Cunningham Middle School in the Corpus Christi Independent School District marked its 13th year in the program. High Island High School on Bolivar Peninsula completed their 6th year in THSCMP. Brazosport High School in Freeport completed their 3rd year in THSCMP monitoring beaches in Quintana and Surfside Beach.

The eight schools participating in THSCMP collect data along the easily accessible developed sections of the Texas coast. During the 2021–2022 academic year we had 21 field trips with approximately 215 students participating. Since the program began in 1997, a total of 369 field trips have been completed. An analysis of data collected by the students is included in this report. The program is also enhanced by a continuously updated website (http://www.beg.utexas.edu/thscmp/).

PROGRAM DESCRIPTION

Goals

The coastal monitoring program has three major goals:

(1) Provide students with an inquiry-based learning experience. Students make several field trips to their study sites during the school year. Working in teams, they conduct topographic surveys (beach profiles) of the foredune and beach, map the vegetation line and shoreline, collect sediment samples, and observe weather and wave conditions. Back in the classroom, students analyze their data and look for relationships among the observed phenomena. Bureau scientists provide background information and guide inquiries about the data, but students are encouraged to form and test their own hypotheses. Through their collaboration with working scientists on an actual research project, the students gain an enhanced science education.

(2) Increase public awareness and understanding of coastal processes and hazards. All data collected by the students and analyses made by Bureau scientists are publicly available for use by coastal managers, scientists, decision-makers, and the general public. The THSCMP website (http://www.beg.utexas.edu/thscmp/) containing the latest data, analysis, photos, and educational resources is central to the project's community outreach aspect. Further aspects of the program conducted to improve public awareness include presentations at conferences by Bureau

scientists, student presentations and data-collection demonstrations at community outreach events, the annual report, and scientific journal articles.

(3) *Achieve a better understanding of the relationship between coastal processes, beach morphology, and shoreline change, and make data and findings available for solving coastal management problems*. The Bureau has conducted a 40-year research program to monitor shorelines and investigate coastal processes. An important part of this program is repeated shoreline mapping and beach profile measuring. Over time, these data are used to determine the rate of shoreline change. A problem we face is the limited temporal resolution of 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 secular changes. 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.

Methods

The central element of the monitoring program is at least three class field trips during the academic year, weather permitting. During each trip, students visit several locations and apply scientific procedures to measure beach morphology and to make observations on beach, weather, and wave conditions. These procedures were developed during the program's pilot year (1997–1998) and are available on our website, which also includes field forms. A general discussion of the field measurements follows.

Beach profile: 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. 2**; Emery, 1961; Krause, 2004; O'Connell, 2001). The students begin the profile at a pre-surveyed datum stake so that they can compare each new profile with earlier profiles. Consistently oriented photographs are taken with a digital camera. The beach profiles provide detailed data on the volume of sand and the shape of the beach.

Shoreline and vegetation-line mapping: Using handheld Global Positioning System (GPS) units, students walk along the shoreline and vegetation line, mapping these features for display on Geographic Information System (GIS) software (**Fig. 3**). GPS mapping can be used to measure the rates of change to these features. By comparing positions determined through GPS mapping over time, students are able to visualize shoreline and vegetation-line changes.

Beach processes observations: Students measure wind speed and direction, estimate the width of the surf zone, and observe breaker type. They note wave direction, height, and period and they estimate longshore current speed and direction using a float, stopwatch, and tape measure (**Fig. 4**). Students also take readings of shoreline and foredune orientation (**Fig. 4**). From these measurements, they can infer relationships between physical processes and beach changes in time and space. Students also learn to obtain weather and oceanographic data from online resources.

Bureau scientists provide teachers and students with all the training, information, field forms, and equipment needed to conduct the field measurements. During the academic year, Bureau scientists accompany students on at least one field trip. The scientists and students discuss general and theoretical issues regarding scientific research, as well as coastal issues relevant to their community and the State of Texas. These visits also provide scientists with an opportunity to ensure the quality of the data.

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

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

Figure 4. Students (A) using a sighting compass to measure dune orientation and (B) measuring how far along the shoreline the float (an orange) drifted to determine longshore current.

Data Management, Data Analysis, and Dissemination of Information

All THSCMP data since the inception of the program have been analyzed and archived by Bureau scientists. The THSCMP produces several data products: topographic profiles representing the beach and dune system; GIS shapefiles mapping shorelines and vegetation lines; and photographs of shorelines, vegetation lines, and foredune crests from each data collection site. All scientific data, analyses, and results from the THSCMP are publicly available either through the THSCMP website or by request to Bureau staff.

The THSCMP website (http://www.beg.utexas.edu/thscmp/), housed and maintained on a Bureau server, is central to the dissemination of data collected for this program. The website was implemented toward the end of the 1998–1999 academic year. It provides all the information needed to begin a beach-monitoring program and curriculum materials for high school teachers. Each school in the program has a page on the website dedicated to data, observations, and photos related to their study area. Numerous educational resources are curated on the website that have been developed for use by students and teachers to enhance learning about coastal environments, processes, issues, and hazards. The website also hosts the 3D coastal visualization model to supplement in-class or at-home learning about coastal change.

STUDENT, TEACHER, AND SCIENTIST INTERACTIONS

In 1997, Bureau researchers developed a pilot beach-monitoring program with Ball High School on Galveston Island (Caudle and Paine, 2012; Hepner and Gibeaut, 2004). The THSCMP has since expanded several times to now include a total of eight schools (**Fig. 1, Table 1**). Expansion of the program has not only increased the number of schools in the THSCMP but also included middle school students. Students in the program are enrolled in classes such as physics, environmental science, biology, aquatic science, and general science.

Table 1. Schools involved in the THSCMP.

School	**Location**	**Year Started**
Ball HS	Galveston Island	1997
Brazosport HS	Surfside & Quintana	2018
Cunningham MS	North Padre Island	2009
High Island HS	Bolivar Peninsula	2016
Palacios HS	Matagorda Peninsula	2006
Port Aransas HS	Mustang Island	1999
Port Isabel HS	South Padre Island	1999
Tidehaven MS	Matagorda Peninsula	2005
Van Vleck HS	Matagorda Peninsula	2005

Bureau researchers work with the same teachers each academic year unless changes occur such as a teacher's retirement or reassignment. Researchers communicate directly with teachers to schedule field trips in the fall (September, October, or November), winter (January or February), and spring (April or May). The teacher arranges transportation to the study sites (via bus or SUV, depending on class size) and a substitute teacher to cover their classroom for the day. To encourage school districts to continue participating in the THSCMP, project support provides funding to cover the cost of student transportation and substitute teachers. A stipend is also provided to the participating teachers.

The most heavily used segments of the Texas coast are monitored two or three times a year (**Fig. 1**). Students monitor beaches, dunes, and vegetation lines on the following sandy barrier islands and peninsulas: Bolivar Peninsula, Galveston Island, Follets Island, Quintana Beach, Matagorda Peninsula, Mustang Island, and North and South Padre Islands. Staff from the Lower Colorado River Authority (LCRA) at Matagorda Bay Nature Park help facilitate field trips on Matagorda Peninsula, and occasionally graduate students from the Harte Research Institute, Texas A&M University–Corpus Christi help with the Cunningham Middle School field trips.

A Bureau scientist visits each school at least once, usually coinciding with the first field trip of the academic year. During field trips, scientists discuss coastal issues pertaining to the area that the students are visiting, coastal issues concerning the entire State of Texas, and careers in science. These visits serve not only to enhance scientific instruction but also to give students insight into science as a career and the chance to discuss coastal community concerns.

During field trips, students are divided into two or three teams of five to eight, depending on the size of the class. One team measures the beach profile while the others collect data on weather and waves or conduct a GPS survey of the shoreline and vegetation line. Team members have specific tasks, and after each team completes its tasks at the first location, the teams switch roles so that everyone has an opportunity to collect each type of measurement. Aside from conducting the beach profile and measuring processes and the shoreline, additional tasks can be assigned to the team that finishes first. It is important to assign each student a job to keep them focused and interested, although time for a little fun is also allowed. People normally think of the beach as a place of recreation, and participation in this project should not change that. In fact, it is hoped that program participants will enjoy going to the beach even more because of their newly acquired knowledge and observation skills.

The day of the field trip, students meet in their teacher’s classroom to organize equipment and gather additional materials that they may need for the day (coolers with ice and water, lunches, and so on). Throughout the day, data are collected from one to three locations, with sufficient time allotted for lunch. All trips allow ample time for careful data collection while ensuring that students are back at school about 1 hour before the end of the school day. During this hour, equipment is cleaned and stored, and datasheets are copied, and GPS files are transferred to a computer.

Schools participating in the THSCMP face challenges that sometimes hinder the data collection process. Access to sites is sometimes prohibited because of elevated water levels, flooded access roads, beach nourishment activities and equipment, or coastal construction such as dune walkover replacement. Even roadway construction can hinder access to sites. Weather conditions (such as heat, cold, or rain) or wildlife sightings (rattlesnakes) can present challenges to the data collection process. All possible attempts are made to overcome challenges, but the safety of students, teachers, and staff is always the highest priority, and sometimes a dataset must be missed.

High Island High School

High Island High School joined the THSCMP during the 2015–2016 academic year. Ms. Caudle works with High Island High School science teacher Maria Skewis. Science students collected data from three Bolivar Peninsula sites on November 16, 2021; February 1, 2022; and April 7, 2022. Two of the monitoring sites are adjacent to Rollover Pass—BOL02 to the west of the pass and BOL03 to the east (**Fig. 5**). A third site (HIB01), seaward of High Island, is located just past the eastern end of Highway 87 (**Fig. 5**). The original HIB01 datum point was lost due to erosion. A new datum point was established 38 meters landward from the original point. Students began collecting shoreline positions across the mouth of the now closed Rollover Pass.

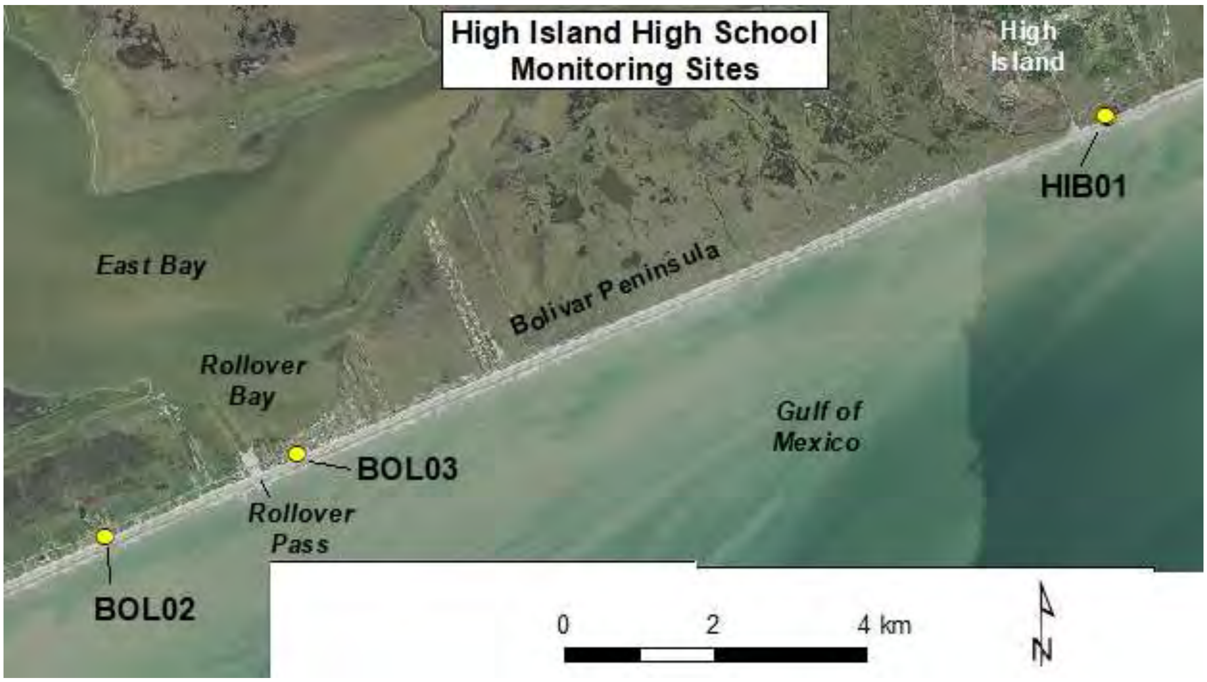

Figure 5. Location map of High Island High School monitoring sites.

Ball High School

Dr. Daniel Hochman's Advanced Placement (AP) Environmental Science classes at Ball High School conduct surveys at site BEG02 in Galveston Island State Park (**Fig. 6**), a profile that the Bureau has been measuring since the 1980's. Ball High School students also collect data at JAM02 in Jamaica Beach and DEL01 in the Dellanera RV Park (**Fig. 6**). Both of these sites monitor beach nourishment and Coastal Erosion Planning and Response Act (CEPRA) beach and dune restoration activities. GPS mapped shoreline positions are collected along the Babe's Beach section of Galveston Island (west of 61st Street) as well. Ball High School students collected data on November 17, 2021 and February 2, 2022. A third field trip was schedule for mid-May but was cancelled due to conflicts with the Senior testing scheduling. Unfortunately, the trip was unable to be rescheduled so close to the end of the academic year and graduation.

Figure 6. Location map of Ball High School monitoring sites.

Brazosport High School

Brazosport High School in Freeport, Texas, joined THSCMP during the 2018–2019 academic year. Ms. Caudle works with high school Science Content Specialist Mary Armstrong and senior AP Environmental Science students to collect data from sites at Surfside Beach and Quintana Beach. Field trips took place on February 6, 2022 and May 17, 2022. Three of the monitoring sites (SURF2, SURF4, and jetty park) are located in Surfside Beach on the southern end of Follets Island (**Fig. 7**). A fourth site (QUIN1) was established in Brazoria County's Quintana Beach County Park (**Fig. 7**). The QUIN1 and SURF1 datum points were lost due to erosion during the

2020 and 2021 storm seasons and we were unable to visit Quintana Beach County Park (QUIN1) during the winter field trip because it was still closed to the public for repairs due to storm damage. During the spring field trip a new QUIN1 datum point was not established in a more landward position due to a thick stand of salt cedar trees at the vegetation line. Students will continue to map the vegetation line and shoreline at this site and a beach profile datum may be reestablished in the future. SURF4 at Stahlman Park, was established in 2022 to replace the SURF1 profile.

Figure 7. Location map of Brazosport High School monitoring sites.

Matagorda Area Schools

Van Vleck High School environmental science students participated in field trips on October 7, 2021; February 24, 2022; and May 18, 2022. Sherry Martinez's class collected data at MAT01 (**Fig. 8**). Physics students from Palacios High School participated in field trips on October 6, 2021; February 25, 2022; and April 8, 2022. McKaylie Reamy's students collected data at MAT02 (**Fig. 8**). The MAT03 profile location (**Fig. 8**) has seen a significant increase in beach width, including a coppice mound field with intermittent swales that usually contain water, marsh plants, and venomous snakes. It has become dangerous for students, teachers, and staff to collect profile data at this location without the proper protective gear. Though beach profile data is no longer collected at MAT03, Van Vleck and Palacios High Schools continue mapping via GPS of the shoreline and vegetation line positions at this site.

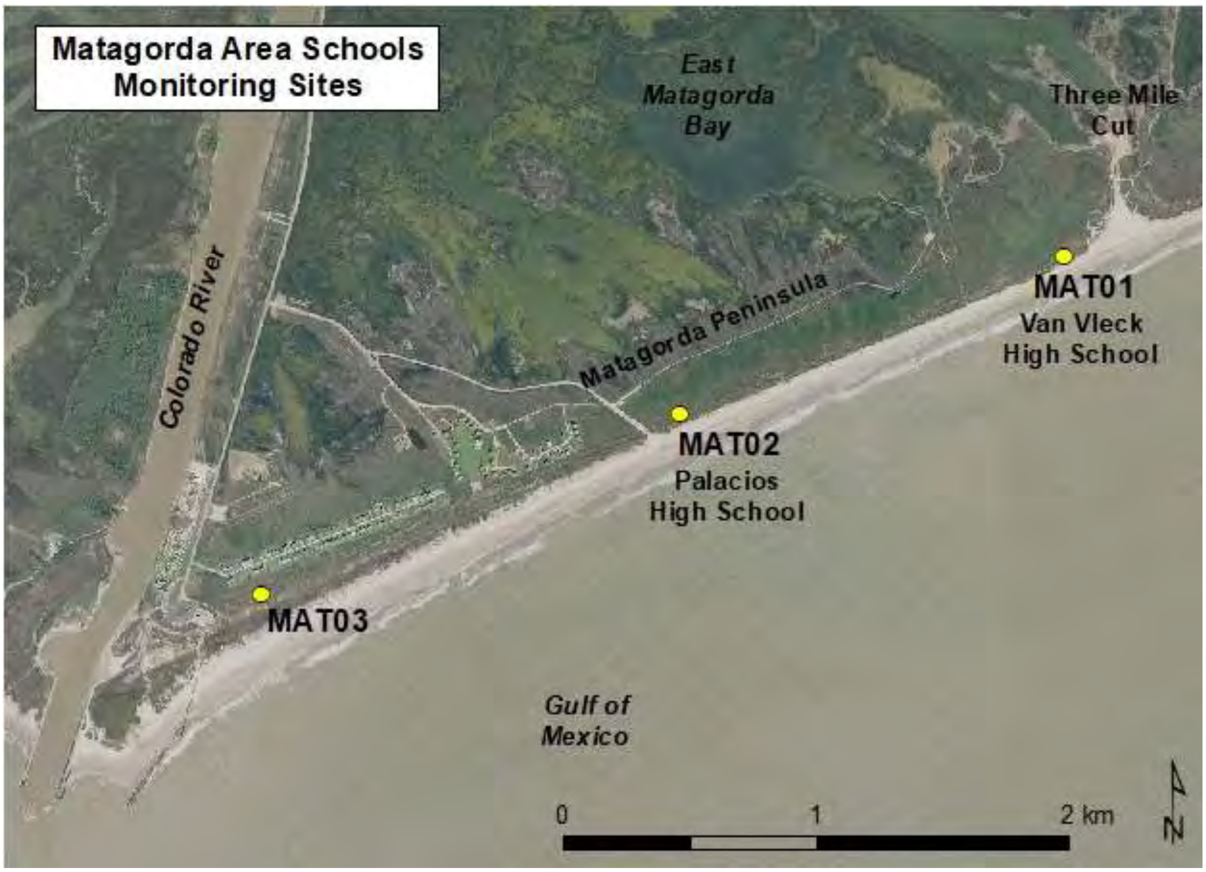

Figure 8. Location map of sites monitored by Matagorda-area schools.

Port Aransas High School

Port Aransas students participated in field trips on November 15, 2021; January 19, 2022; and April 20, 2022. Ryan Piwetz's Aquatic Science class collected data at three profile locations on Mustang Island: MUI01 near Horace Caldwell Pier, MUI02 in Mustang Island State Park, and MUI03 at Beach Access Road 1 at the Palmilla

Beach Golf Club (**Fig. 9**). Port Aransas High School has been measuring these profiles since 1999.

Figure 9. Location map of Port Aransas High School monitoring sites.

Cunningham Middle School

The Bureau worked with 8th grade students from Cunningham Middle School at South Park (Corpus Christi Independent School District) on January 27, 2022 and April 21, 2022. The Corpus Christi Indepentent School District did not allow field trips to take place during the fall semester of 2021 due to the ongoing pandemic.

Teacher Eunice Silva's students collected data at NPI08 on North Padre Island and NPC06 on the North Padre Island seawall (**Fig. 10**). Both sites monitor the impacts of beach restoration and maintenance activities. Cunningham students also began to map the shoreline position in front of the north end of the Padre seawall during the spring field trip. Water levels during this trip were extremely high.

Figure 10. Location map of Cunningham Middle School monitoring sites.

Port Isabel High School

Port Isabel students participated in field trips on October 14, 2021; January 26, 2022; and May 13, 2022. Students from Dr. Michelle Zacher's AP Environmental Science class collected data at three profile locations on South Padre Island: SPI01 in Isla Blanca Park, SPI02 at Beach Access #13, and SPI08 at the Tiki Condominiums (E. White Sands Street) (**Fig. 11**). Because of construction of a promenade and new beach pavilion within Isla Blanca Park, the SPI01 datum point was reestablished. Port Isabel High School has been measuring SPI01 and SPI02 since 1999 and SPI08 since 2007.

Figure 11. Location map of Port Isabel High School monitoring sites.

EFFECTS ON SCIENTIFIC RESEARCH, COASTAL MANAGEMENT, AND PUBLIC AWARENESS

The first goal of the THSCMP is to provide high school students with an inquiry-based learning experience, which is achieved by involving students in real-world research projects. We emphasize to students that they are collecting critical scientific data that will help scientists address coastal issues affecting their communities. The student-collected beach data can be and have been used by researchers at the Bureau to help respond to several beach-related issues. Data are available for coastal managers, decision-makers, scientists, students, and the public.

Long-term data collection is 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, beach nourishment, and dune restoration projects. The data collected within city, county, and state parks helps to develop a better understanding of the local coastal environment, which in turn allows managers to make wise decisions regarding long-term management and future park development. Coastal communities and managers throughout Texas—especially our partners at GLO, TPWD, and other coastal parks—benefit from having access to the beach monitoring data collected by this project for use in public-policy and coastal-management decision-making.

THSCMP-collected data has played a large role in important Bureau studies. In one study, site BEG02 has been used by Bureau scientists to investigate the effects of geotextile tubes installed along the upper Texas coast. BEG02, located in Galveston Island State Park (**Fig. 6**), is adjacent to a subdivision where these erosion-control devices have been installed. The study compared beach width (distance from the vegetation line or dune base to the waterline) in front of the geotextile tubes versus at a natural beach area in the adjacent state park. Beach width in the natural beach area was observed to be wider than in the subdivision—45.7 m on average compared to 20.4 m in the subdivision (Gibeaut and others, 2003; **Fig. 12**). The natural area allowed for the landward migration of the dunes as the shoreline retreated, whereas the geotextile tube created a fixed dune line (Caudle and Paine, 2017).

Data collected by THSCMP students are invaluable in verifying shoreline position for updates to Texas' long-term shoreline-change rates, which are widely used by public officials, corporations, and private citizens. These comparisons—in some cases from ground-based GPS data acquired within a few days to weeks of the imagery or lidar survey date—generally show good agreement (within a few meters) between boundaries interpreted from ground-based data and imagery and those extracted from lidar data. Small discrepancies in the position of the lidar-derived shorelines, imagery-derived shorelines, and the wet-beach/dry-beach boundary are likely to reflect real differences in beach morphology between the dates of the lidar surveys, imagery acquisitions, and ground-based GPS surveys in these dynamic environments.

Figure 12. Lidar topographic-relief image of Galveston Island State Park and Pirates Beach subdivision. Note the difference in beach width between the natural beach and the area in front of the subdivision. From Gibeaut and others (2003).

Beach profiles and GPS-mapped shorelines (wet-beach/dry-beach boundaries) collected by THSCMP students were used to confirm the shoreline position digitized in 2007 aerial photography (Paine and others, 2011, 2012) and the shoreline positions extracted from aerial lidar data collected in 2012 (Paine and others, 2014), 2016 (Paine and Caudle, 2018), and 2019 (Paine and Caudle, 2020). The student-collected data proved vital in validating interpretations of the shoreline positions on Bolivar Peninsula, Galveston Island, Follets Island, Matagorda Peninsula, Mustang Island, and South Padre Island.

For the 2007 shoreline position, georeferencing of the photographs and interpretation of the position of the wet-beach/dry-beach boundary was checked by superimposing GPS-based wet-beach/dry-beach boundary data acquired in 2007 by the THSCMP and the 2007 photo-interpreted wet-beach/dry-beach boundary used for change-rate calculations (Paine and others, 2011, 2012). GPS-mapped shorelines collected by THSCMP students were used to confirm the elevation of the 2012 shoreline position proxy that was used for shoreline change calculations. For example, on South Padre Island (**Fig. 13**; Paine and others, 2014), there is positional agreement between the 2012 lidar-extracted shoreline; the wet-beach/dry-beach boundary as interpreted using National Agriculture Imagery Program (NAIP) aerial imagery acquired on April 23, 2012; and the wet-beach/dry-beach boundary surveyed via GPS by THSCMP students on September 26, 2012. The 2016 shoreline was determined from 2016 NAIP aerial imagery and a lidar survey conducted by the U.S. Army Corps of Engineers (USACE) between September 9 and October 10, 2016, using the CZMIL airborne lidar system (USACE, 2017). A shoreline positional check, which addressed the relative position of the shoreline proxy and the wet-beach/dry-beach boundary, was accomplished by superimposing the lidar-derived shoreline proxy and GPS-based, wet-beach/dry-beach boundary data acquired in fall 2016 by the THSCMP on georeferenced 2016 NAIP imagery (Paine and Caudle, 2018).

The long-term rates of Gulf shoreline movement along the Texas coast have been updated through 2019. The shoreline position extracted from 2019 lidar data was verified by visually comparing the shoreline proxy contour elevation with the wet-beach/dry-beach boundary as shown on georeferenced 2016 and 2018 NAIP aerial photographs and imagery acquired during the airborne survey. We used beach profiles and GPS-mapped shorelines acquired by the THSCMP near the dates of the lidar survey to compare the observed wet- and dry-beach positions. The Surfside Beach profile site SURF2 on Follets Island (**Fig. 14**; Paine and others, 2021) is representative of data comparison all along the Texas coast. At this site, there is excellent positional agreement between the 2019 lidar-derived shoreline proxy; the wet-beach/dry-beach boundary mapped on April 24, 2019, by THSCMP participants and Bureau staff; 2018 NAIP imagery, and 2019 aerial imagery.

Figure 13. Shoreline position comparison at South Padre Island site SPI08. Shorelines include the wet-beach/dry-beach boundary mapped on September 27, 2011, and September 26, 2012, by THSCMP students using GPS and the shoreline proxy extracted from airborne lidar data acquired in February 2012. Shorelines are superimposed on NAIP imagery acquired on April 23, 2012. From Paine and other (2014).

Posters were created from these updated long-term rates (1930s-2019) of shoreline movement along the Texas Gulf of Mexico coast. A poster for the island or shoreline segment studied was provided to all of the participating schools on their first field trip of the 2021–2022 academic year. Posters were also provided to Matagorda Bay Nature Park, Mustang Island State Park, and the Texas General Land Office.

Figure 14. Shoreline position comparison at Surfside Beach site SURF2. Shorelines include the wet-beach/dry-beach boundary mapped on April 24, 2019, by THSCMP students and Bureau staff using ground GPS and the 1 m (3.3 ft) above mean sea level shoreline proxy extracted from airborne lidar data acquired in spring 2019, superimposed on 2019 Bureau imagery. From Paine and others (2021).

The THSCMP has increased public awareness of coastal issues through media reports, presentations at conferences, journal articles, and learning tools. The program has been featured in the 2006 and 2009 winter issues of *On the Coast*, a coastal-issues newsletter from the Texas General Land Office. In December 2019, the THSCMP was the featured Research Program Profile on the Bureau's website (http://www.beg.utexas.edu/node/5664). Ms. Caudle has presented the THSCMP at the 2013 American Shore and Beach Preservation Association national coastal conference in South Padre Island, at the 2015 Texas Chapter of the American Shore and Beach Preservation Association Symposium in Corpus Christi, in a panel discussion on coastal outreach activities at the 2015 Texas Beach and Dune Forum in Corpus Christi, and at the 2017 Texas Chapter of the American Shore and Beach

Preservation Association Symposium in Port Aransas. Ms. Caudle also presented THSCMP to the Bureau of Economic Geology during the Summer Seminar Series on July 30, 2021. The presentation was recorded and can be viewed from the Bureau's YouTube channel: https://www.youtube.com/watch?v=2SLLVBfX_n0.

A paper featuring the program and data collected by the high school students was published in the fall 2004 issue of *Shore & Beach* (vol. 72, no. 4), the journal of the American Shore & Beach Preservation Association (Hepner and Gibeaut, 2004). A paper was written and presented at the 2012 Gulf Coast Association of Geological Societies annual meeting (Caudle and Paine, 2012). A technical communication paper was published in May 2017 in the *Journal of Coastal Research* describing the critical scientific data collected by THSMP students that helps scientists and coastal managers address coastal issues and improve understanding of dune and beach dynamics on the Texas coast (Caudle and Paine, 2017).

The students themselves have also increased public awareness of coastal issues and the program. Port Isabel High School students have presented THSCMP to coastal visitors at the Winter Outdoor Wildlife Expo (WOWE) at the South Padre Island Birding Center since 2017. The 2022 WOWE presentation occurred on February 9. One student presented an overview of the program to the expo attendees while the rest of the students demonstrate THSCMP data collection activities in teams to smaller groups. Ms. Caudle, Dr. Zacher, and two Port Isabel High School students were invited to the annual Coastal States Organization meeting held in South Padre Island in November 2019 to present the THSCMP to meeting attendees.

High Island High School gave three presentations on THSCMP this spring. Student Jordan Grubbs presented the study to the Children's Environmental Literacy Foundation (CELF) Student Symposium on March 11, 2022 (https://www.youtube.com/watch?v=r21uMDcGkM4) and to the High Island School Board on March 28, 2022 (**Fig. 15**). CELF was a virtual event where students participating in citizen science research across the country shared their projects with their peers, communities, and decision makers. High Island teacher, Ms. Skewis, presented the program to the Bolivar Peninsula Special Utility District (BPSUD) on April 12, 2022.

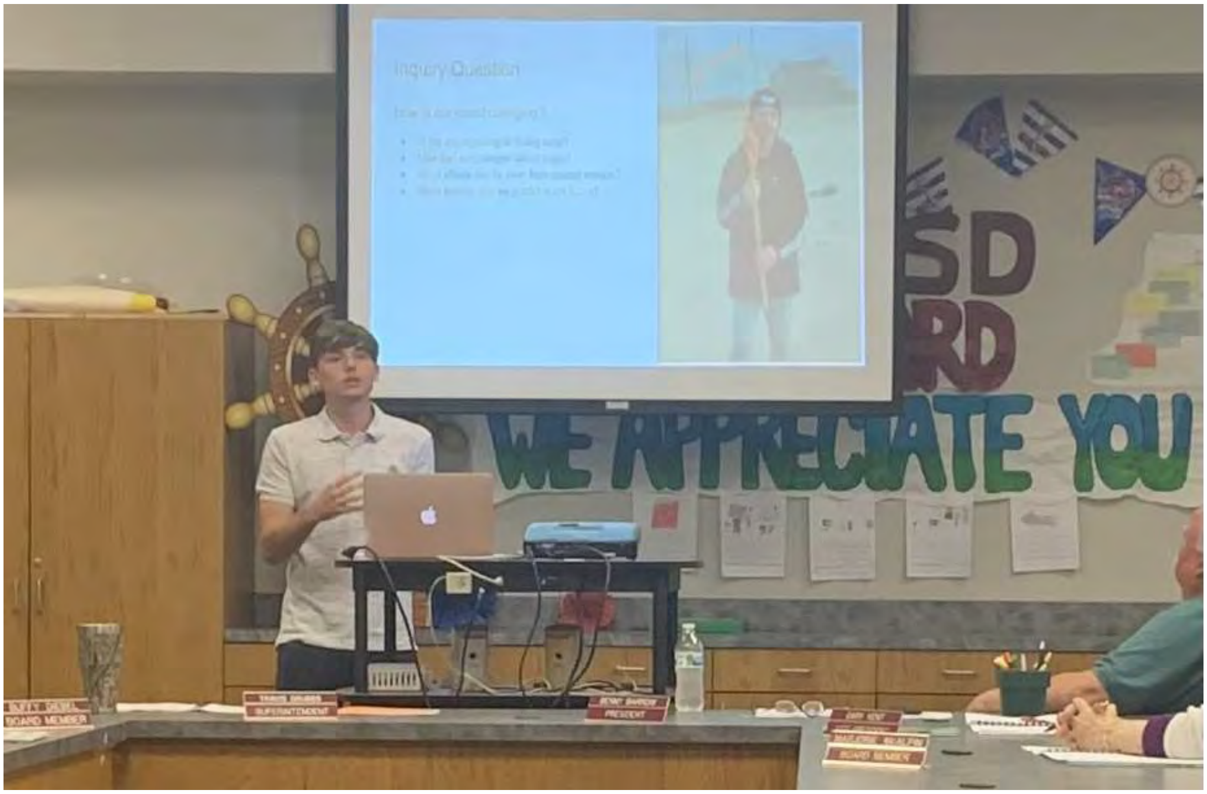

Figure 15. High Island High School student presenting to the School Board.

The THSCMP website also continues to be instrumental in extending the reach of the program and increasing public awareness. The website provides direct access to data, analysis of coastal changes organized by school, field trip photos, and educational resources such as field guides, learning activities, and an interactive 3D model. The web-based 3D model was developed for visualizing beach and dune impacts and recovery from Hurricane Ike in 2008 and Hurricane Harvey 2017 can be accessed from the front page of the website https://www.beg.utexas.edu/thscmp/ or the models direct website https://www.beg.utexas.edu/visualizations/3d-coastal-model/. This visualization project focuses on the geomorphological impacts of the hurricanes on their respective regions of the Texas Gulf Coast. The completed scenes of the model include: general overview of the Gulf of Mexico, Hurricanes Ike and Harvey overviews, and two detailed looks each at the beach and dune impacts produced by both storms. The Hurricane Ike focused scenes are located at High Island and Galveston Island State Park. The Harvey scenes are focused on Port Aransas and a segment of San Jose Island.

SCIENTIFIC RESULTS AND TEXAS COASTAL CHANGES: 1997–2022

Profile data collected by the students are entered into CEDAS v. 4.0 (Coastal Engineering Design and Analysis System)—a system originally developed by the U.S. Army Corp of Engineers and commonly used by coastal engineers and scientists in beach-profile analysis—using the BMAP (Beach Morphology and Analysis Package) module. Beach-volume calculations are then made using BMAP, and shoreline and vegetation-line positions are determined from field notes made by students and scientists. The shoreline is designated by the wet-beach/dry-beach boundary or a berm crest (a prominent break in slope between the forebeach and backbeach) for consistency with historical measurements (Gibeaut and Caudle, 2009). Volume, shoreline, and vegetation-line plots for each monitoring site are found in Appendix B. Profile plots that contain all student-collected data for each monitoring site are found in Appendix C. GPS-mapped shoreline and vegetation-line data for each monitoring site are found in Appendix D.

Since the THSCMP began in 1997, data collected by students have been applied by scientists to investigate beach, dune, and vegetation-line recovery following several tropical cyclones, including Hurricanes Ike in 2008 and Harvey in 2017. Student-collected data are also used to monitor the effects of beach nourishment projects on South Padre, North Padre, and Galveston Islands; foredune changes on Mustang Island due to beach-maintenance practices; and jetty construction and vehicular traffic on Matagorda Peninsula. Through these real-world examples of scientific observation, students gain a better understanding of environmental issues affecting their communities.

Measurements by the schools involved in the THSCMP show the change through time at each location and highlight the spatial variation found along the Texas coast.

The scientific observations documented by THSCMP students help scientists, decision-makers, coastal managers, and the students themselves gain a better understanding of relationships between coastal processes, beach morphology, and shoreline change affecting their local coastal communities. Key research results and coastal issues are presented within this report by region.

Bolivar Peninsula

The beach at HIB01 (**Fig. 5**) has seen significant changes during High Island High School's short monitoring period (**Fig. 16**). On the first field trip, the beach had a steep forebeach, high berm, and a backbeach wide enough for vehicles to travel up and down the beach. Large pieces of pavement that are remnants of Highway 87 were at the upper reach of the swash zone. The October 2017 field trip took place about a month after Hurricane Harvey impacted the Texas Gulf coast. The beach had experienced significant erosion, pavement debris was deposited at the vegetation line, and the elevated berm and backbeach that had once allowed vehicular access to the north was gone. The beach width had recovered by spring 2018.

Between the fall of 2018 and spring of 2021, HIHS students were unable to access the site at High Island Beach because of roadway construction at the intersection of Highway 87 and Texas 124. During that time, the shoreline and vegetation line positions moved landward due to the impacts of the 2020 hurricane season. The original profile site datum was lost due to the erosion of the beach at High Island and reset during the fall 2021 field trip. Between May 2018 and April 2022, the shoreline position moved landward 25 meters (just landward of the original profile datum location) and the vegetation line moved 45 meters landward (**Figs. 16 & 17**).

High Island High School students also monitor sites BOL02 and BOL03 adjacent to Rollover Pass (**Fig. 5**). Rollover Pass was cut across Bolivar Peninsula in 1955 with the intention of improving water quality in Rollover Bay and Galveston East Bay. The opening of the pass caused significant erosion to the adjacent beaches and caused sand and sediment to be deposited in the Gulf Intracoastal Waterway (ICW). For years, the U.S. Army Corps of Engineers were required to dredge and remove sediment from the ICW adjacent to Rollover Bay annually at significant cost. Due to the issues caused by Rollover Pass, the Texas Legislature authorized the General Land Office to close the pass. Construction began at the end of September 2019 and was completed in the spring of 2020. High Island students are monitoring how the closure of Rollover Pass impacts the beaches adjacent to the site as well as mapping the position of the shoreline where the pass has been closed.

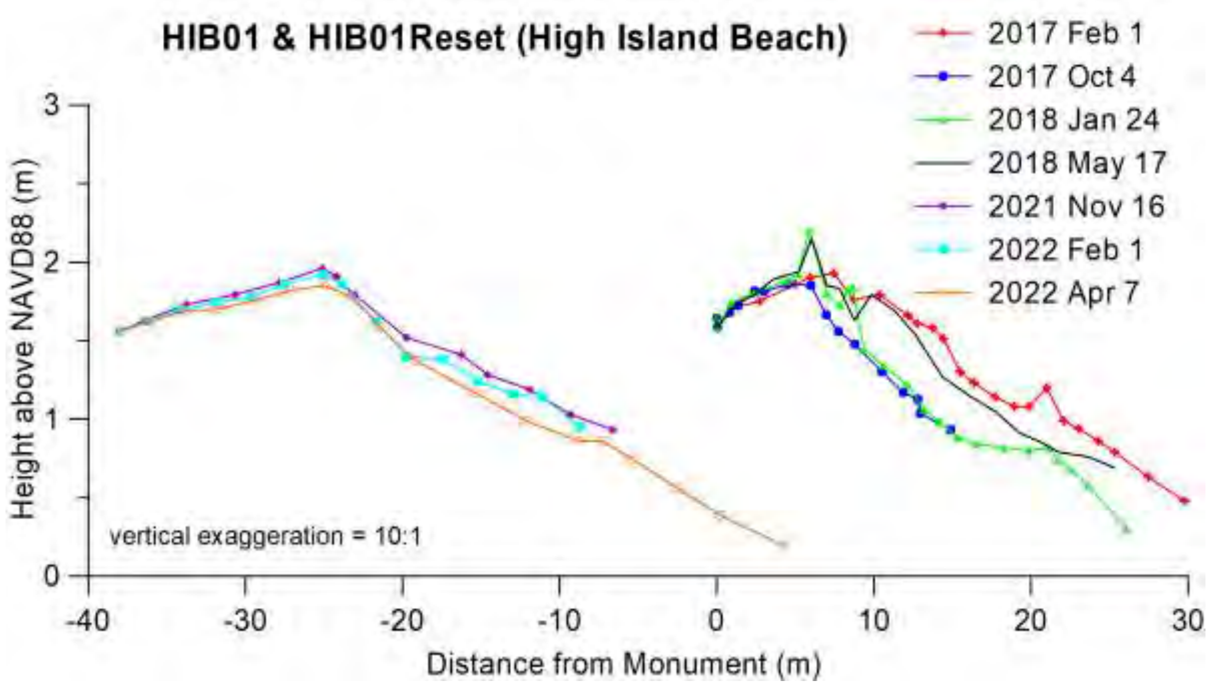

Figure 16. Changes at HIB01 and HIB01 Reset monitored by High Island High School students.

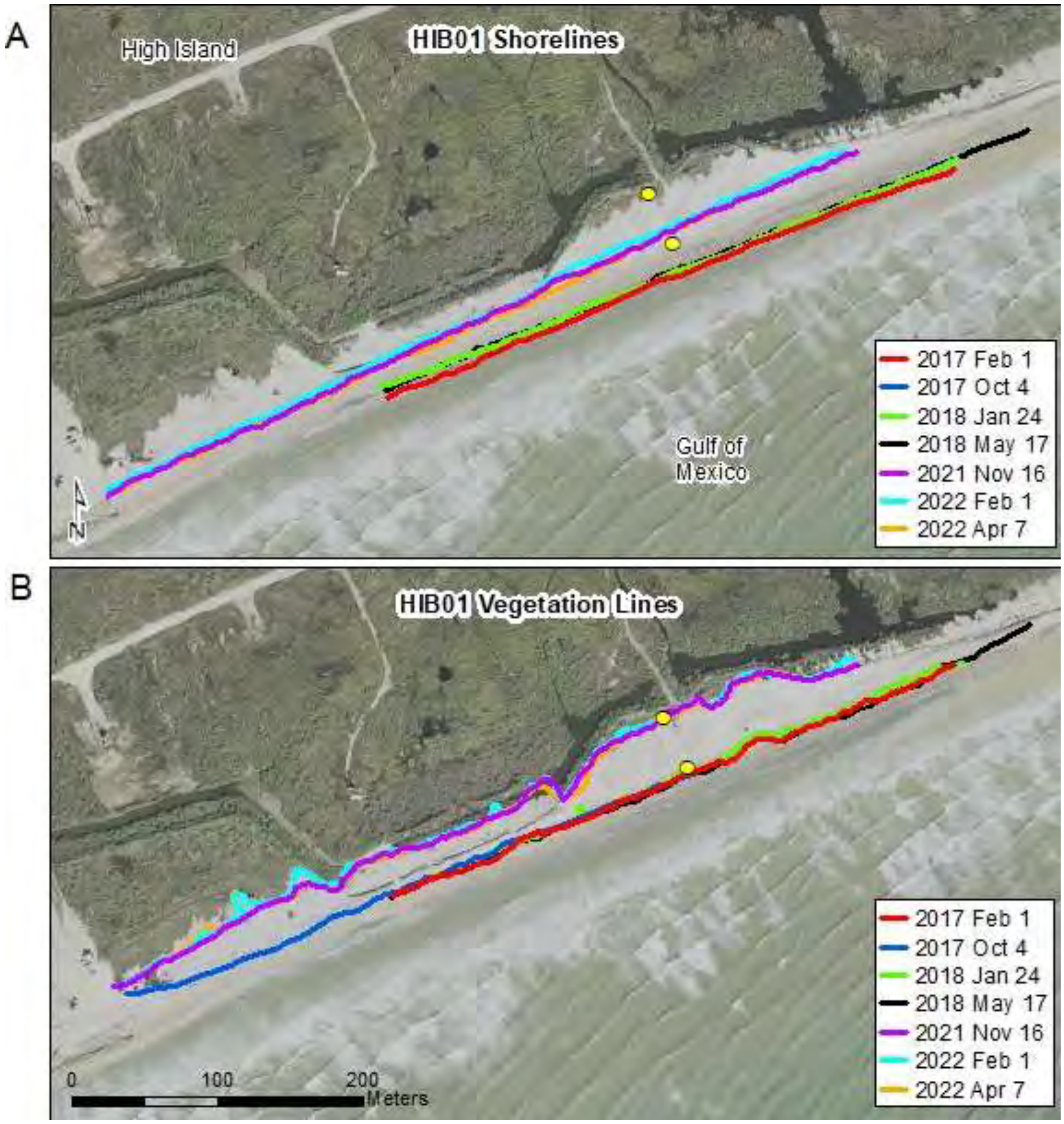

Figure 17. Changes to the position of the (A) shoreline and (B) vegetation line at HIB01 between February 2016 and April 2022.

Galveston Island

Since 1997, Ball High School students participating in the THSCMP have been collecting critical data that is used by scientists at the Bureau to increase understanding of beach and dune recovery stages following major storms. Storm damage to beaches and dunes are indicated by the landward movement of shoreline and vegetation-line positions and a decrease in sediment volume in the beach profile immediately after storms (**Fig. 18**). The gradual seaward migration of the shore and vegetation lines plus sediment volume increases track beach and dune recovery in the years following storms.

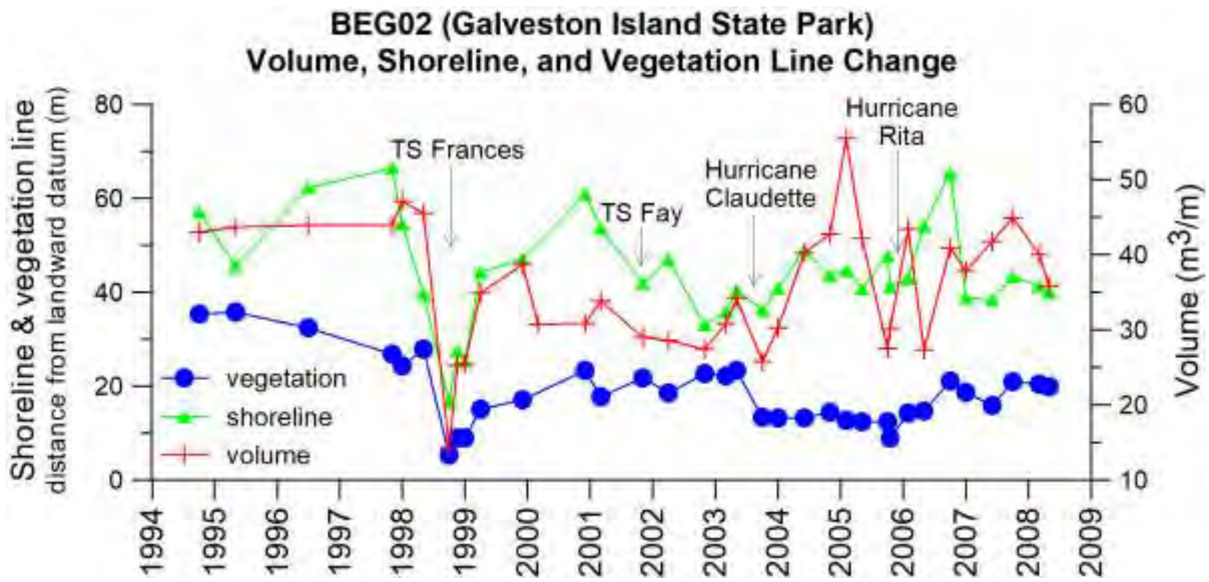

Figure 18. Profile volume, shoreline, and vegetation-line changes at Galveston Island State Park, September 1994–April 2008.

Tropical Storm Frances (September 1998) played a major role in reshaping the beaches on the upper Texas coast. Data collected by Ball High School students on Galveston and Follets Islands documented that Frances caused significant damage to beaches along the southeast coast of Texas. The storm's damage was comparable to damage caused in 1983 by Hurricane Alicia (Gibeaut and others, 2002; Hepner and Gibeaut, 2004; Morton and Paine, 1985), a Category 3 hurricane on the Saffir/Simpson scale (Simpson and Riehl, 1981). Several other severe storms have also impacted the Galveston study area. Tropical Storms Allison (June 2001) and Fay (September 2002) and Hurricanes Claudette (July 2003) and Rita (September 2005) have each caused varying degrees of damage to beaches and dunes along the Texas coast (**Fig. 18**).

The upper Texas coast was severely affected by the landfall of Hurricane Ike in September 2008. Galveston Island experienced significant beach and dune erosion, as well as extensive damage to property and infrastructure. Ball High School students were unable to participate in the THSCMP during the 2008–2009 academic year because of safety concerns to accessing their monitoring sites. Bureau and TAMUCC scientists visited Galveston Island in early October 2008 to conduct ground surveys—beach profiles, photography, and observations of beach and dune conditions—of the area impacted by the hurricane. During this reconnaissance trip, scientists visited profile location BEG02 in Galveston Island State Park, where they discovered that the datum marker at BEG02 had been destroyed by the storm. Scientists used GPS techniques to navigate to the horizontal location of the datum marker, which post-storm was on the open beach. Before the storm, the marker had been at the corner of a concrete picnic pavilion landward of the foredunes. BEG02 (**Fig. 6**) was reset approximately 60 m landward of the old datum marker along the same azimuth line. The new marker (a buried metal pipe) is landward of a washover feature. Reestablishing the marker allowed students to continue to monitor activities and storm recovery and to compare pre- and post-storm profiles at this location.

Ball High School students from the 2007–2008 academic year provided extremely valuable pre-storm profile data that have been used to determine how much the beach and dunes changed after Hurricane Ike. **Figure 19** is a profile plot at BEG02 comparing the Ball High School pre-storm profile (April 2008) with the post–Hurricane Ike profile measured on October 7, 2008. The post–Tropical Storm Frances profile from September 16, 1998, is also plotted for comparison. At Galveston Island State Park, the dune system was completely destroyed; the shoreline (wet-beach/dry-beach boundary) moved 53 m landward between April 23, 2008, and October 7, 2008; the vegetation line moved 56 m landward; and the old datum point was 1.14 m above the post-storm surface of the beach (**Fig. 19**; Caudle and Paine, 2017). Data from 1-year post-storm is also included. This profile shows that the elevation of the beach has been restored, the beach width (dunes to waterline) has increased, and incipient dunes are beginning to form (**Fig. 19**).

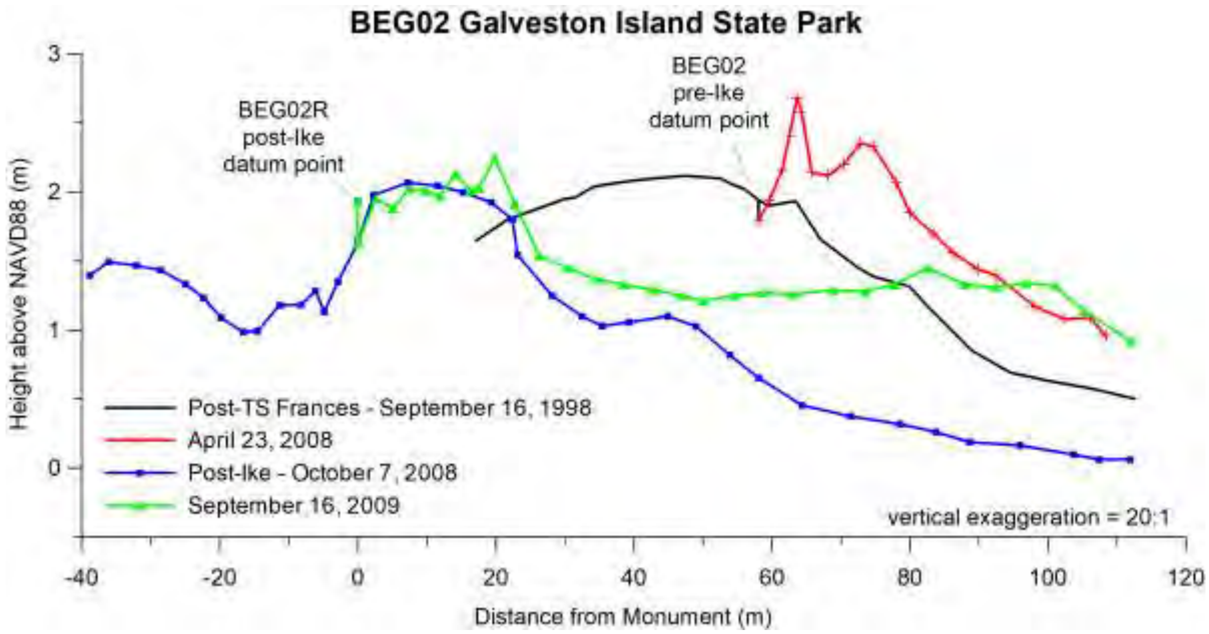

Figure 19. Beach-profile plots from BEG02 in Galveston Island State Park comparing the post–Hurricane Ike profile with a pre-storm profile from early 2008 and the post–Tropical Storm Frances profile from September 1998. Data from September 2009 (1-year post-storm) is also included.

Ball High School students resumed monitoring beaches at the start of the 2009–2010 academic year. Their data collection from BEG02 has documented the recovery of the beach and dune system (**Fig. 20**). Between September 2009 and January 2011, the foredunes at BEG02 had begun to grow. Whether initial growth of the foredunes is due to natural recovery processes or human intervention is unclear. The foredune ridge grew in the intervening years, stabilizing around 2015, and a wide, vegetated zone with expanding coppice dunes developed between the seaward base of the foredunes and the landward extent of wave run-up (**Fig. 20**).

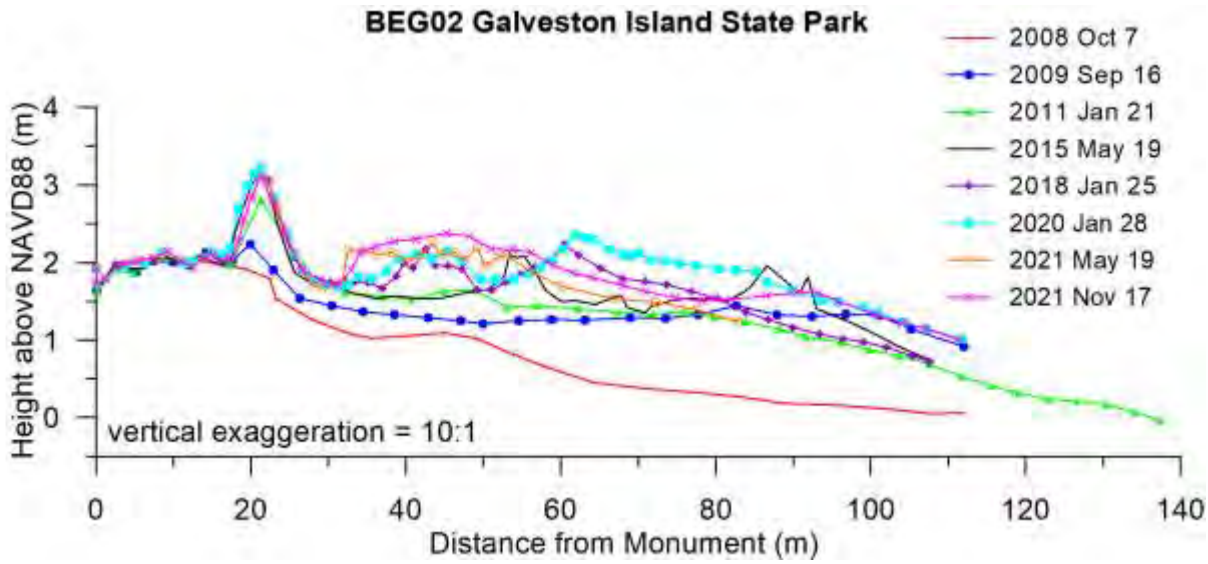

Figure 20. BEG02 datum-reset post–Hurricane Ike profile, plus data collected by Ball High School students. Students are monitoring recovery of the beaches and dunes at this site.

The 2020 hurricane season caused beach and dune erosion at the three sites Ball High School students monitor. At Galveston Island State Park (BEG02), the beach was eroded landward and a washover feature was deposited in the coppice dune area (**Fig. 20**). The dune at the Dellanera RV Park (**Fig. 5**) that was created as part of a large nourishment and dune restoration project that took place in 2015, experienced significant erosion between January 2020 and May 2021 (**Fig. 21**). Over half the volume of sand in the beach/dune system was removed. At the site JAM02 in Jamaica Beach, a community just to the south of the State Park, the 2020 hurricane season caused erosion of the reconstructed dune and landward movement of the vegetation line. Palm fronds have been placed along the vegetation line in Jamaica Beach to trap windblown sand to promote dune growth.

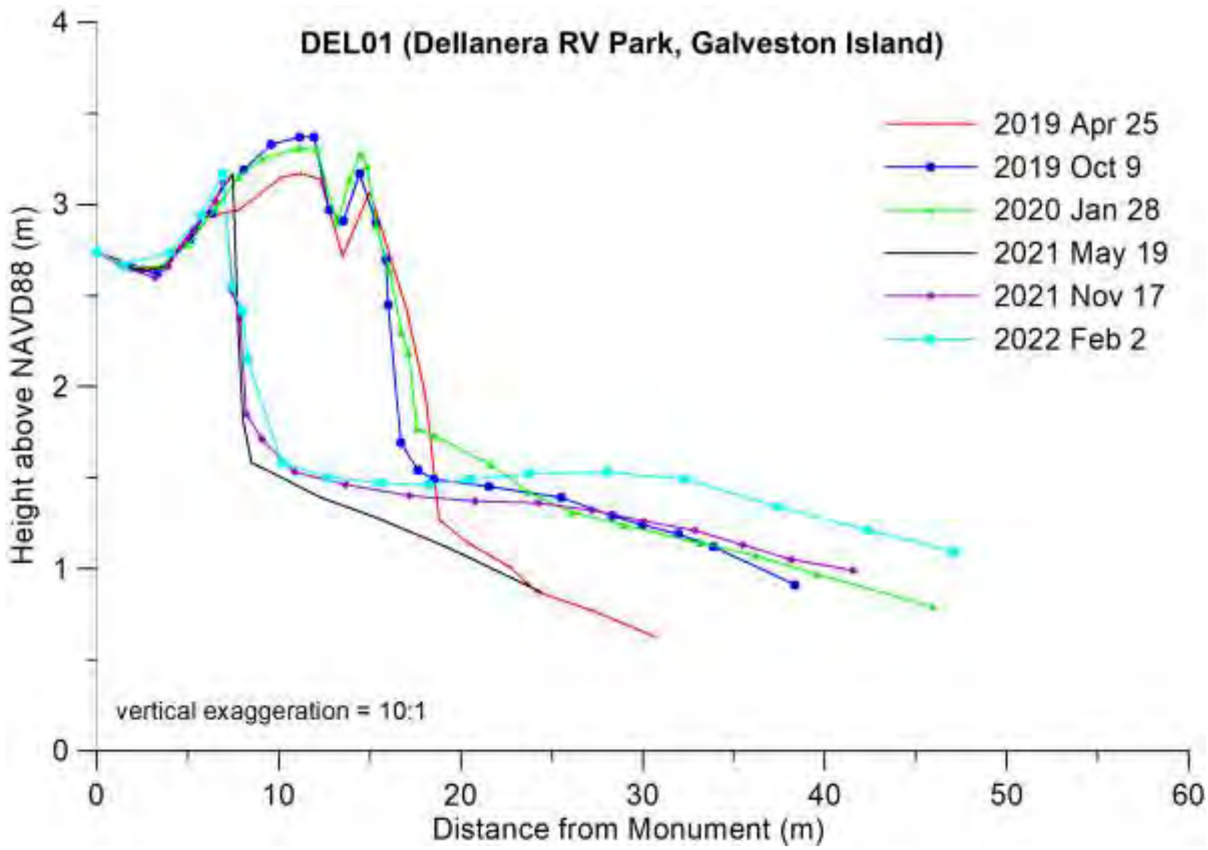

Figure 21. Erosion of the dune at DEL01 in the Dellanera RV Park due to the 2020 hurricane season.

Surfside Beach and Quintana Beach

Brazosport High School in Freeport, Texas, joined the THSCMP during the 2018–2019 academic year, allowing the program to expand to a section of the developed coast that was previously not monitored (**Fig. 7**). Significant changes to the beach and small dune system on Follets Island and Quintana Beach have been documented over the Brazosport's short monitoring period. At the QUIN1 location at Quintana Beach County Park, the small foredune that was present when the profile was established had been destroyed and the vegetation line moved 15 meters landward between January 2020 and May 2021 (**Fig. 22**). At SURF2, the vegetation line also moved landward and the elevation of the profile was lowered at the datum point. Students map the shoreline position of a segment between Surfside Jetty County Park and a rock revetment protecting Beach Drive. At times, the shoreline position (wet/dry line) is beneath or behind structures that are located on the beach (Appendix D). During the 2021—22 academic year, a new site was established at Stahlman Park in Surfside Beach (SURF4) to replace the beach profile lost due to erosion at SURF1. Initial measurements at this new location created a baseline dataset to monitor changes in the beach and dune system into the future (Appendix C).

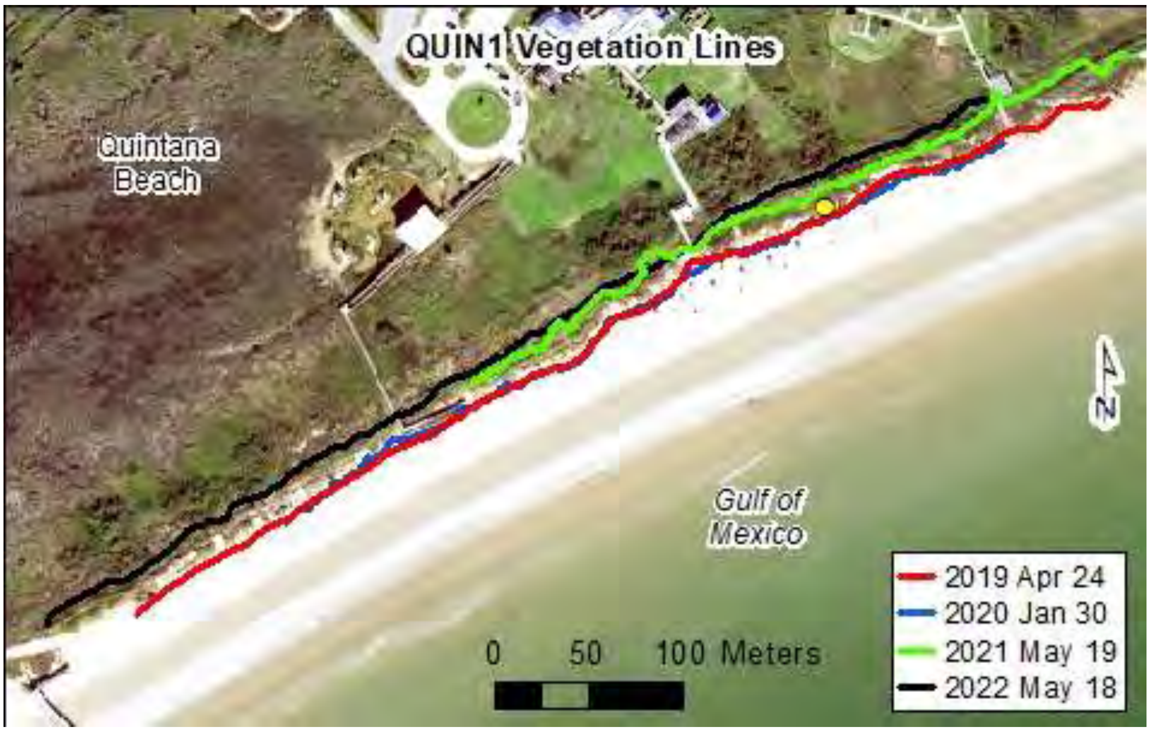

Figure 22. GPS mapping by Brazosport HS students of (A)shoreline positions at SURF2 and (B) vegetation line positions at QUIN1 from April 2019 through May 2022.

Matagorda Peninsula

Van Vleck High School students collect data at MAT01, which is adjacent to a washover channel—Three Mile Cut—that will occasionally open with the passage or landfall of a tropical storm or hurricane (**Fig. 8**). Students from Palacios High School collect data at MAT02, which is northeast of the vehicular beach access point on Matagorda Peninsula (**Fig. 8**). Hurricane Ike made landfall on Galveston Island on September 13, 2008, as a Category 2 hurricane. Owing to the size of the storm, impacts from this hurricane were seen along the entire Texas coast, including on Matagorda Peninsula. The storm surge from Hurricane Ike briefly opened Three Mile Cut and caused vegetation line retreat and dune erosion at MAT01 and MAT02. Over the years since Ike's landfall, students from Van Vleck and Palacios High Schools have been monitoring the recovery and growth of the dunes (**Fig. 23**) and the seaward movement of the vegetation line (Appendix B) post–Hurricane Ike on Matagorda Peninsula.

Palacios and Van Vleck students also measure the shoreline position adjacent to the fishing pier at Matagorda Bay Nature Park (MAT03, **Fig. 8**). The site is on the updrift side of the jetty at the mouth of the Colorado River and has limited vehicular traffic on the beach due to difficult driving conditions. The monitoring of this location is important because understanding the impacts of coastal structures are critical to coastal management. In 2009—2010, the U.S. Army Corps of Engineers constructed a new east jetty at the mouth of the Colorado River. GPS-mapping of shorelines indicates that the shoreline position at MAT03 moved 125-m seaward over a decade, an average rate of 12.8 m per year (**Fig. 24** and Appendix D). The continued mapping has shown that the shoreline position has continued to advance seaward between 2018 and 2022 but at a reduced rate (**Figs. 24 & 25**). Throughout the study period, the vegetation-line position has also been continuously moving seaward and the volume of sediment in the beach profile increasing (**Fig. 25**).

The combination of the new jetty impounding sand on the updrift side and the limited vehicle activity at MAT03 has allowed for coppice dune formation to occur on the expanded backbeach area and for new vegetation to develop without being disturbed. Sediment volume on the beach profile was increasing On field trips during the 2015–2016 and 2016–2017 academic years, it was documented that in the swales between the coppice dunes, salt marsh areas had formed. Due to the increased width of the backbeach, the salt marsh environment in the swales, and the numerous venomous snakes in the area, profile data is no longer collected by students at this site; therefore, profile volume has not been calculated.

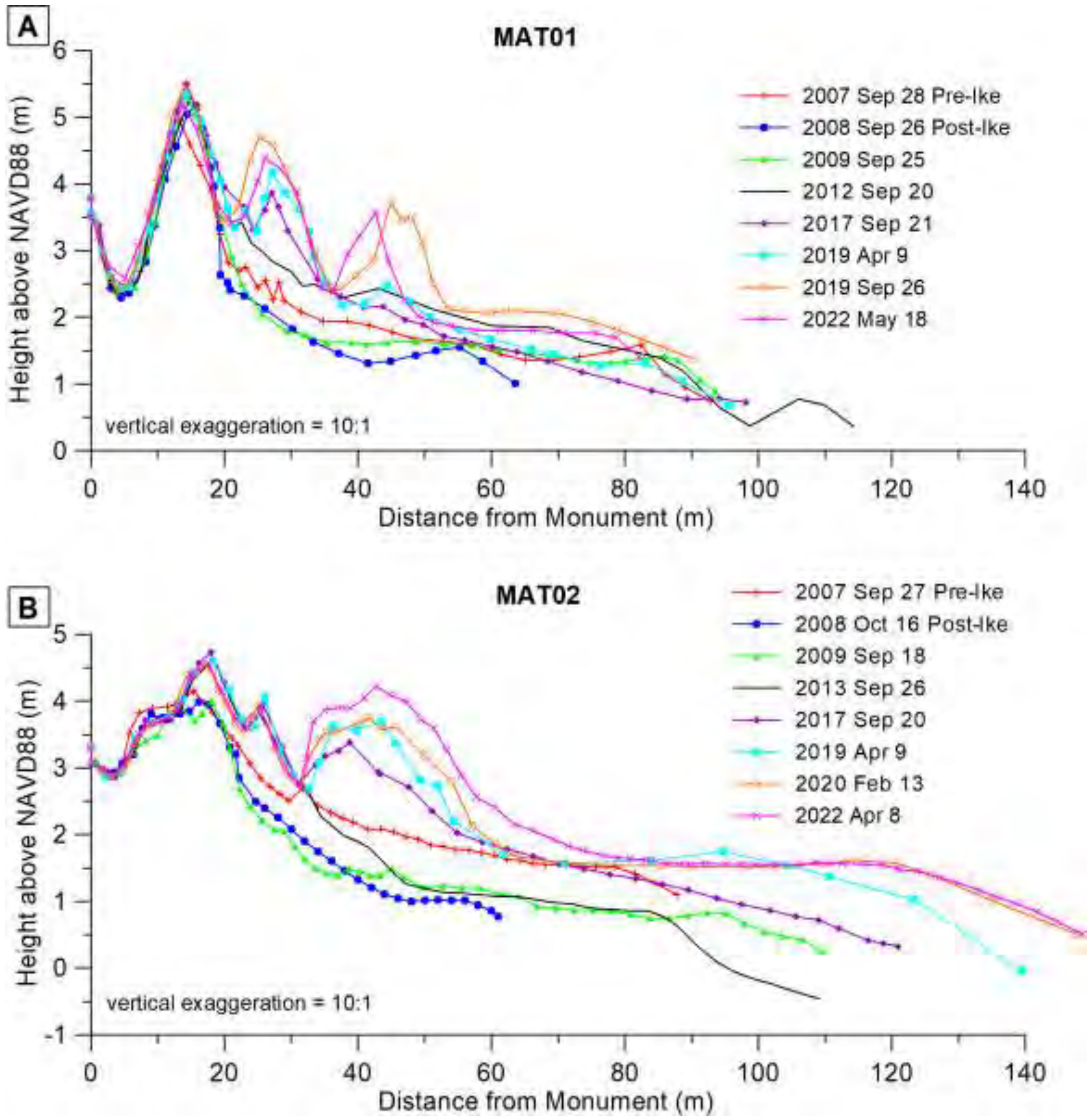

Figure 23. Pre– and post–Hurricane Ike profile data collected by Van Vleck High School students at (A) MAT01 and Palacios High School students at (B) MAT02. Students are monitoring recovery and growth of the foredune at these sites.

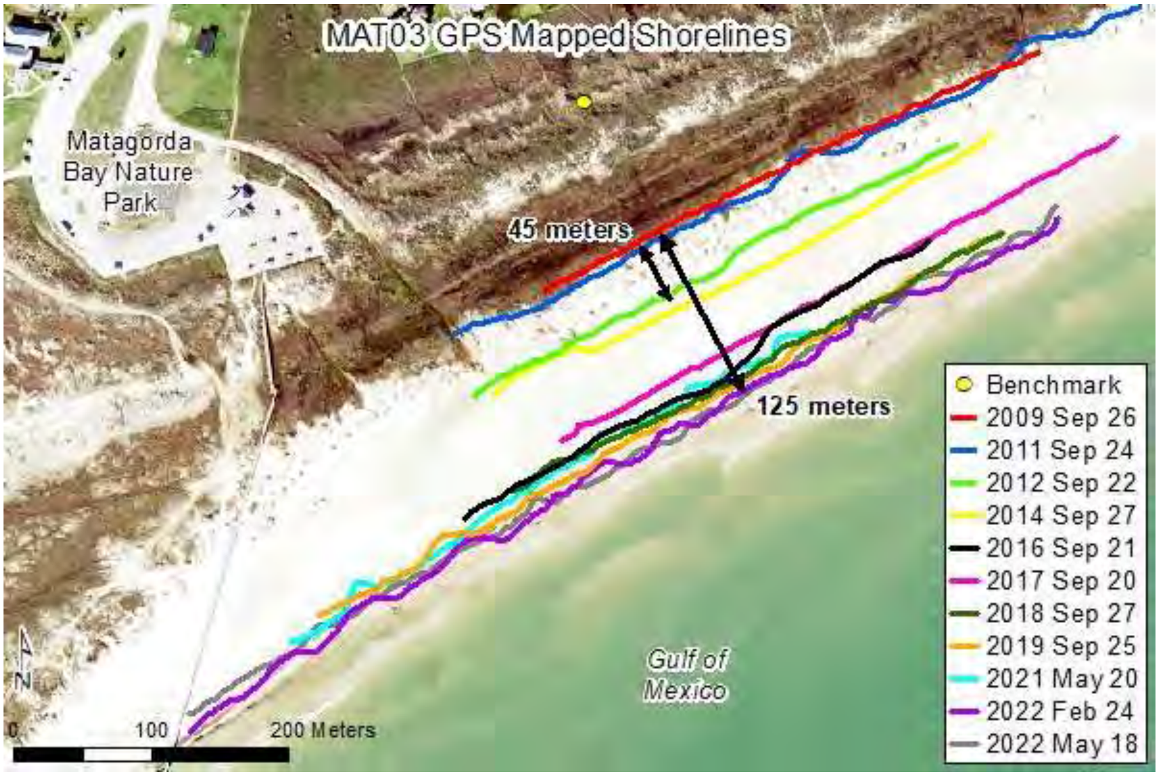

Figure 24. Shoreline position change at Matagorda Peninsula.

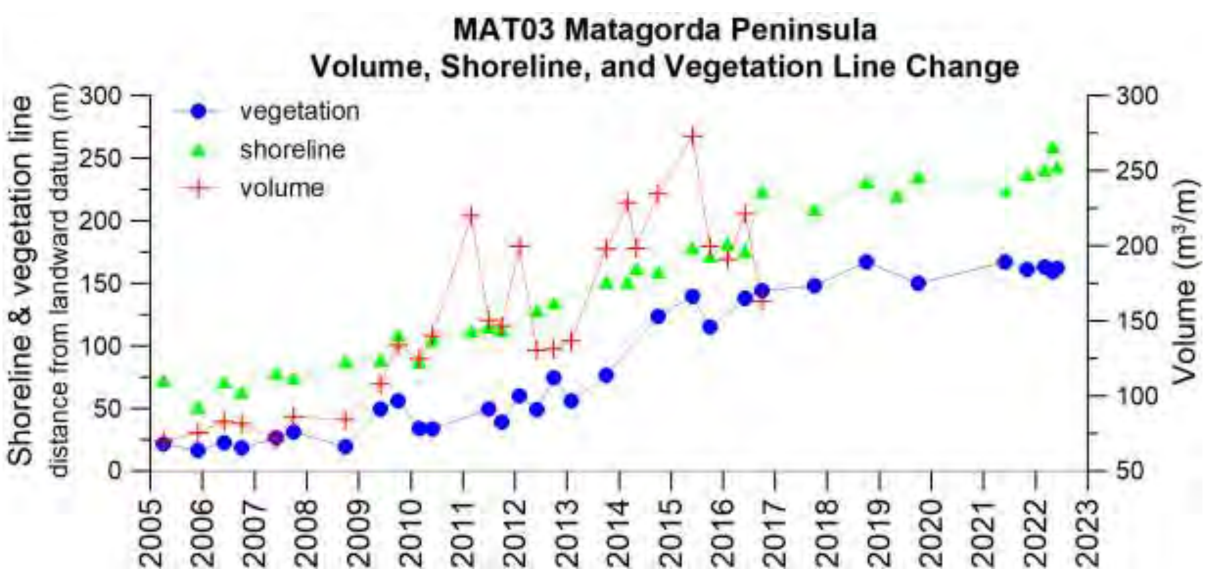

Figure 25. Changes in beach and dune volume, shoreline position, and vegetation-line position at MAT03 on Matagorda Peninsula.

Mustang Island

The beach-monitoring activities of Port Aransas High School students have provided beneficial information about the beach and dune system on Mustang Island (**Fig. 9**). The dune system on Mustang Island is healthy, with tall (> 3 m), 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 have documented 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. Since the beginning of the coastal monitoring program, Port Aransas students have been monitoring the growth of the foredune system at their profiling sites. **Figure 26** is an example of foredune expansion at MUI01 near Horace Caldwell Pier in Port Aransas. Note that the width of the dunes increased between 2001 and early 2010, although the shoreline remained relatively stable.

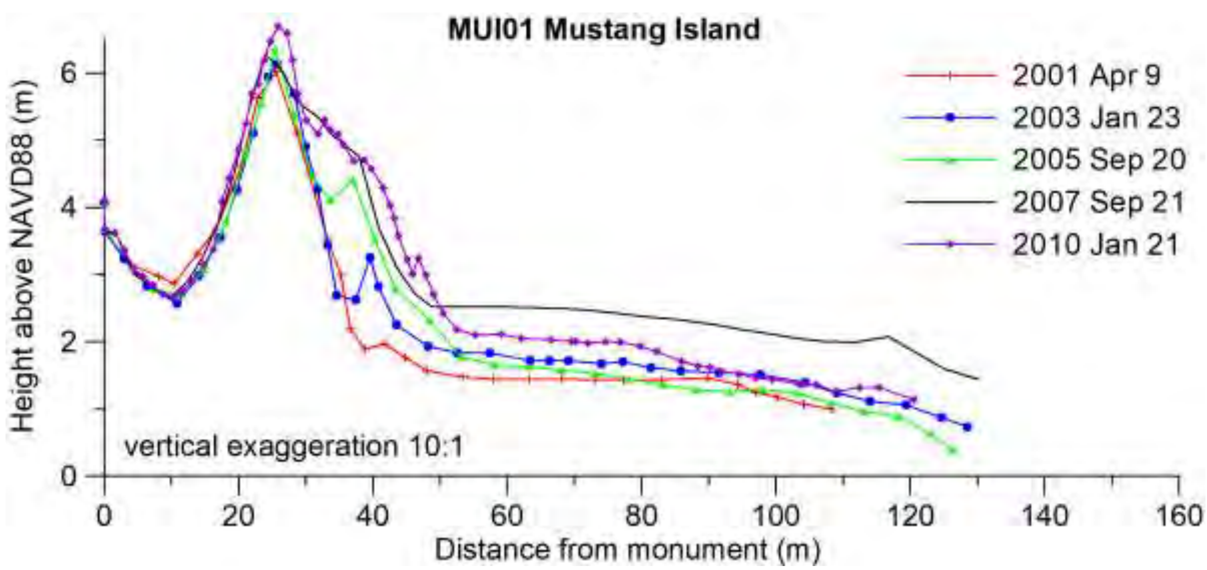

Figure 26. Foredune expansion at MUI01 on Mustang Island.

When Port Aransas students arrived to collect profile data in October 2012, a large part of the dune face had been excavated for a beach-maintenance practice called dune notching (**Figs. 27 & 28**). Students documented that sand was replaced in the foredune by May 2013 and that the vegetation line has been reestablished at the toe of the dune. The dune was notched again during the 2014–2015 academic year. The current width of the foredune is still narrower, and the volume of sand in the profile is less than when the THSCMP began monitoring in 1999 (see change plot in Appendix B). Also, the crest of the foredune is lower in elevation because the dune crest was not stabilized by vegetation for a period of time, resulting in sand being carried away by the wind. The excavated area was slowly filled in between 2016 and 2018 (**Fig. 27**). By the end of the 2018–19 academic year, the foredune was revegetated and stabilized. Between 2019 and 2022, beach profile volume, shoreline position, and vegetation line position has been stable.

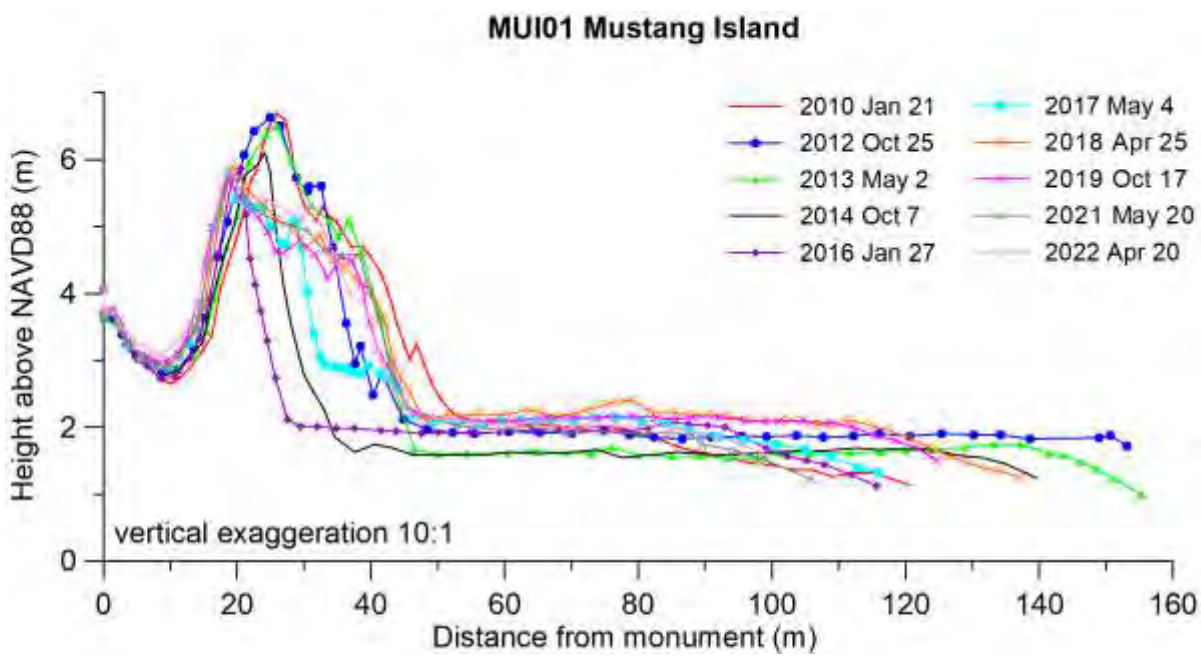

Figure 27. Excavated dune profile at MUI01 on Mustang Island.

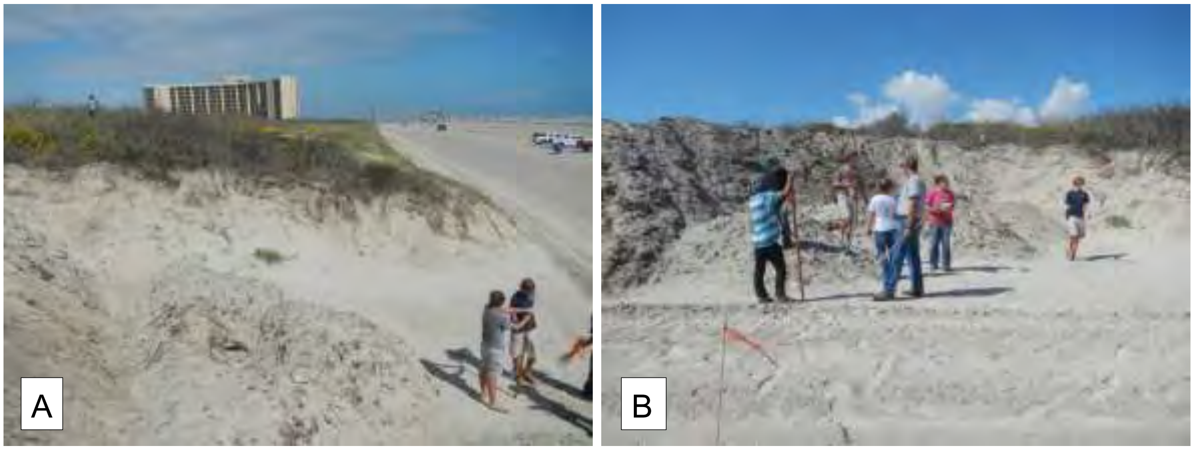

Figure 28. Excavated dune at MUI01 on Mustang Island looking (A) north toward Horace Caldwell Pier and (B) landward.

The MUI01 location also has shore-parallel bollards that have been installed on the backbeach to confine vehicles to the upper portion of the backbeach. The placement of these bollards has restricted further seaward advancement of the foredune complex and the vegetation line by maintaining a fixed location of the Mustang Island beach road starting at the toe of the dune (**Fig. 27** and Appendix B). Beach maintenance practices such as beach grading and dune notching and the impacts of the fixed position of the Mustang Island beach road will continue to be monitored by Port Aransas students at MUI01 and compared with the natural processes that occur at MUI02 in Mustang Island State Park.

The MUI02 monitoring site is located within Mustang Island State Park, 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. 29**). The dune system and vegetation-line position have expanded seaward, and total profile volume has increased at this location (Appendix B). 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. The small, seaward most dune crest present in 2020 was no longer present in the 2021—2022 monitoring.

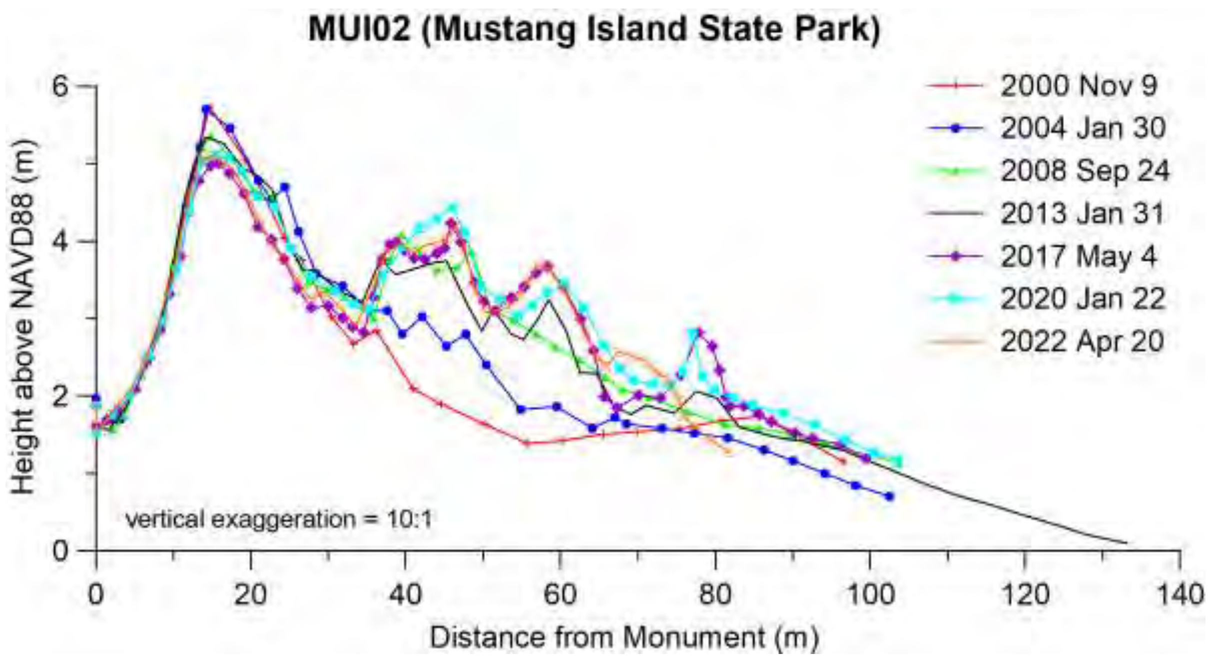

Figure 29. Student monitoring at MUI02 documents an increase in volume of the dune system and seaward migration of the vegetation line.

North Padre Island

Cunningham Middle School at South Park students monitor sites on North Padre Island (**Fig. 10**) that are interesting to compare with the well-vegetated foredunes on Mustang Island to the north. The students have documented many changes at the NPI08 profile location, which is located adjacent to the northern Padre Island seawall. The dune crest at this site is sparsely vegetated which creates an opportunity for prevailing winds to constantly rearrange and alter the shape and height of the dune crest (**Fig. 30**). When the program began at Cunningham in 2009, a new profile marker was established along the profile azimuth directly behind the foredune to shorten the profile for the middle school students. Within the first year of monitoring, sand was transported from the top of the foredune down the back slope of the dune so that the landward toe of the dune buried the new datum pipe.

Students have been using the original datum marker ever since. Until vegetation covers the crest of this dune, it will remain a dynamic site.

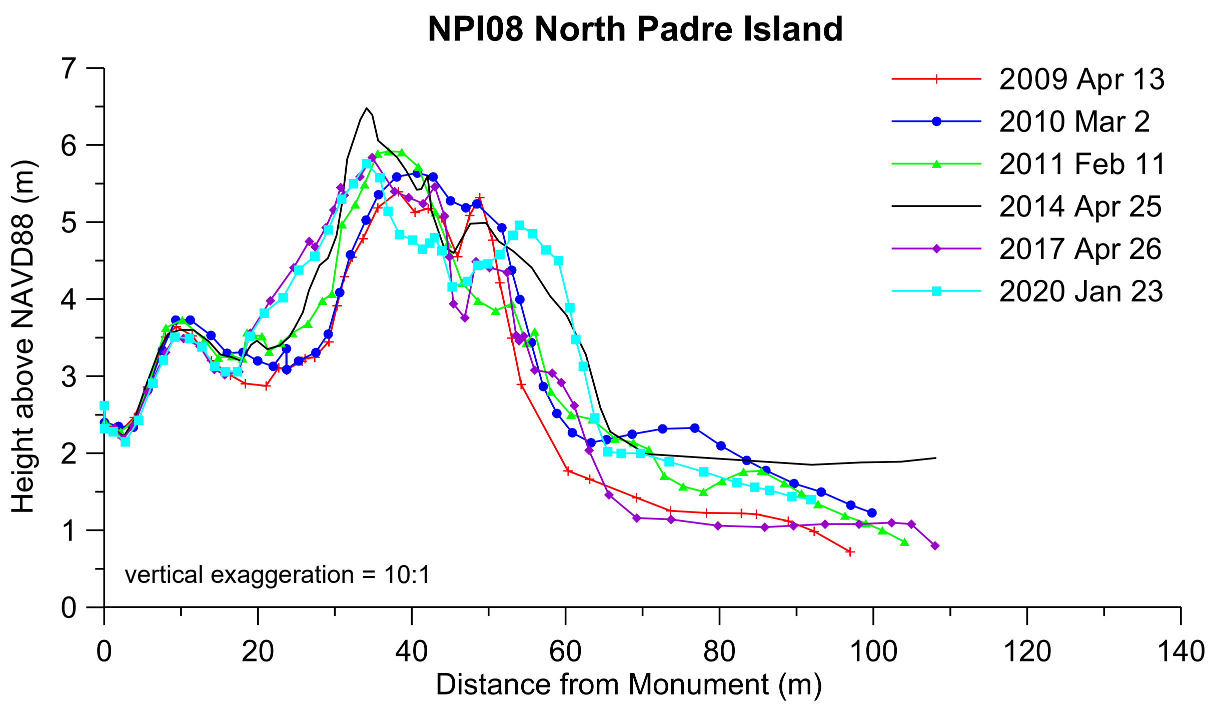

Figure 30. Foredune crest changes at NPI08 monitored by Cunningham Middle School students.

The site NPC06, near the southern end of the North Padre Island seawall (**Fig. 10**), was added in 2015 to track the effects of nourishment projects and maintenance activities on the beach in front of the seawall and the adjacent natural area (NPI08). The beach in front of the seawall is periodically nourished with beneficial use material from maintenance dredging of Packery Channel. Cunningham students have mapped the landward movement of the shoreline position in front of the seawall and the adjacent area with a natural dune system (NPI08) since the last beach nourishment (**Fig. 31**). During the spring 2022 field trip, students were unable to conduct a beach profile or map the shoreline at NPC06 due to elevated water levels which reached the base of the seawall.

Figure 31. Shoreline position change between 2015 and 2022 along southern end of North Padre Island seawall and adjacent beach.

South Padre Island

Brazos Santiago Pass, the southern border of South Padre Island, serves as the southern Gulf of Mexico access to the Gulf Intracoastal Waterway and the Port of Brownsville. Sediment is dredged from the pass biannually and used to nourish the beaches of South Padre Island. The use of sediment dredged from the pass for beach nourishment or other restoration project is called beneficial use of dredged material or BUDM. The three sites monitored by Port Isabel High School students are typically within or adjacent to these nourishment areas.

The SPI02 (**Fig. 11**) monitoring site has been used by students and scientists to monitor the growth of dunes (sand volume) and shoreline movement. When SPI02 was established in August 2000, there were no dunes between the retaining wall and waterline at this location. Since that time, student-collected data has been quantifying the effects of sand fence installations, vegetation planting, beach maintenance practices, and numerous BUDM nourishment projects (**Fig. 32**). Port Isabel student collected data, have documented an overall trend of shoreline advancement and sediment-volume increase throughout the study period (Caudle and others, 2014, 2019). A new dune crossover was construct at this site in 2017. We were concerned the new crossover would interfere with the profile line. Fortunately, the line runs a few feet to the north of the crossover and the only documented impact to the site was a slight flattening of the profile in the dunes and loss of vegetation, which quickly recovered. The position of the shoreline and vegetation line and the volume of sediment in the beach profile has remained stable for the past several years.

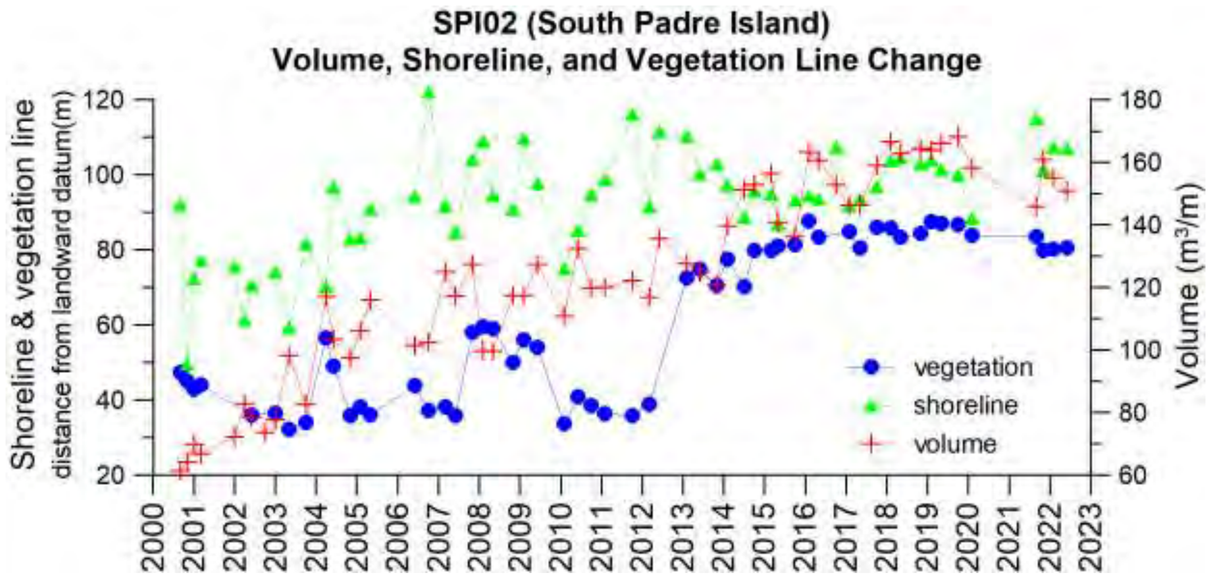

Figure 32. Changes in sand volume and in shoreline and vegetation-line positions at SPI02 on South Padre Island due to beach nourishment projects and the installation of sand fences.

SPI08 is a chronically eroding location in front of the Tiki Condominiums near the north end of the City of South Padre Island (**Fig. 11**). This site has a narrow beach backed by a retaining wall and regularly receives nourishment sand from road maintenance north of the City and from the dredging of Brazos Santiago Pass. The students from Port Isabel have been documenting cycles between beach nourishment, dune creation by beach maintenance practices, and the long-term shoreline erosion trend at this site (**Fig. 33**). The most recent nourishment took place between January 2020 and August 2021. The beach was much wider than had been previously documented. Fencing was installed and vegetation planted before the winter 2022 field trip. Students documented during the May field trip that wind-blown sand was beginning to accumulate around the base of the sand fencing and the vegetation was growing but the beach was narrower. Port Isabel students will continue to monitor this rapidly changing and chronically eroding location.

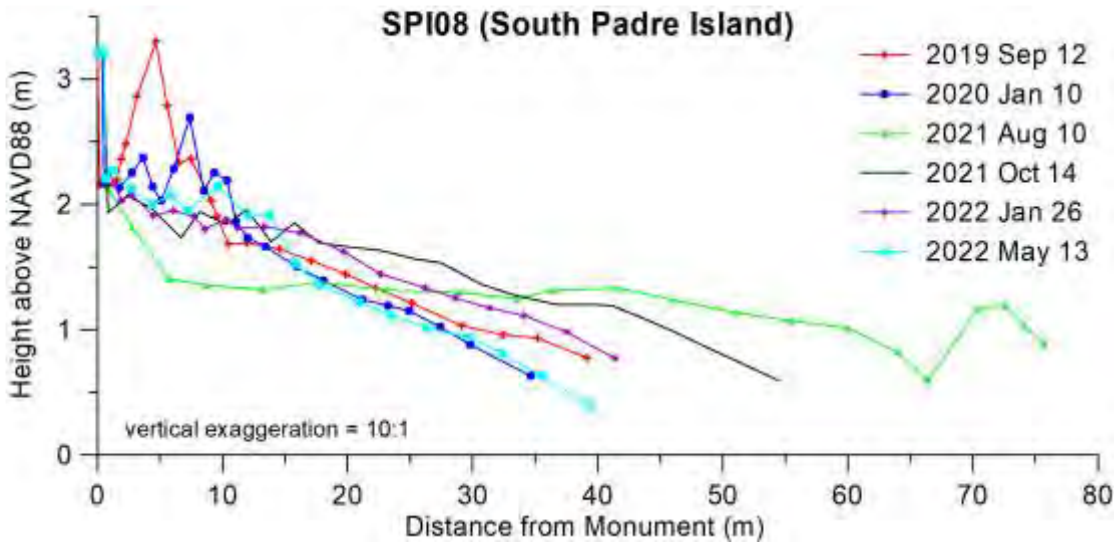

Figure 33. Beach profiles from before and after the latest nourishment project at SPI08.

CONCLUSIONS

The purpose of the Texas High School Coastal Monitoring Program is to provide middle and high school students with a real-world learning experience outside the everyday classroom. The program provides not only hands-on education for students but also valuable data for coastal researchers and decision-makers. During the 2021–2022 academic year, approximately 215 students from Ball, Brazosport, High Island, Palacios, Port Aransas, Port Isabel and Van Vleck High Schools and Cunningham Middle School collected data during 21 field trips.

In the 25 years since the inception of the program, work by students participating in the THSCMP has been beneficial to Bureau researchers and coastal managers in several research projects. Analysis of the data has been used to investigate storm effects and monitor recovery; to measure impacts to the beach and dune system from beach nourishment, construction of jetties, and beach maintenance practices; and to verify shoreline positions for calculating change rates. Through this successful student research program, scientists, students, and the public continue to gain a better understanding of processes and shoreline change along the Texas coast.Historical and future measurements by the eight schools involved in the

THSCMP show change through time at each location, but also highlights the geomorphic differences found along the Texas coast. Data collected from Bolivar Peninsula, Galveston Island, Follets Island, Quintana Beach, Matagorda Peninsula, Mustang Island, and North and South Padre Islands helps scientists better understand the relationships between coastal processes, beach morphology, and shoreline change at these locations. Coastal communities and managers—especially our partners at the Texas General Land Office, Texas Parks and Wildlife Department, and other coastal parks—benefit from having access to the beach monitoring data and analysis for use in public-policy and coastal-management decision-making.

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APPENDIX A: PROFILE INFORMATION

All profile coordinates are in NAD83. Heights above the GRS80 Ellipsoid were converted to North American Vertical Datum 88 (NAVD88) using the Geiod12B ellipsoid model. Profile sites are listed in the order they appear along the Texas coast starting from the northeastern most site closest to the Texas-Louisiana border and traveling south.

Profile	Latitude (deg min)	Longitude (deg min)	Easting (m)	Northing (m)	HAE (m)	NAVD88 (m)	Azimuth (M)
HIB01[1]	29 33.08	94 23.04	365917.69	3269868.01	-25.18	1.64	150
HIB01R	29 33.08	94 23.04	365901.27	3269902.24	-25.26	1.56	150
BOL03	29 30.60	94 29.64	355196.55	3265428.50	-23.26	3.54	150
BOL02	29 30.00	94 31.20	352663.65	3264343.08	-23.62	3.17	150
DEL01	29 14.44	94 52.38	317984.46	3236109.93	-23.84	2.74	150
BEG02[2]	29 11.64	94 57.09	310255.20	3231059.16	-24.75	1.79	139
BEG02R	29 11.67	94 57.11	310228.82	3231110.58	-24.61	1.93	139
GLO06[3]	29 11.12	94 58.05	308696.85	3230117.35	-24.32	2.20	138
JAM02	29 10.87	94 58.39	308128.50	3229670.91	-24.29	2.24	140
BEG08[4]	29 3.22	95 8.90	290838.52	3215830.51	-24.21	2.16	145
SURF4	28 58.29	95 15.68	279648.06	3206930.85	-21.62	4.70	135
SURF1	28 57.47	95 16.59	278154.49	3205457.56	-24.47	1.84	130
SURF2	28 57.08	95 17.03	277426.68	3204737.87	-22.00	4.30	130
QUIN1	28 55.99	95 18.13	275599.85	3202771.80	-24.47	1.82	150
MAT01	28 36.67	95 56.55	212269.73	3168453.74	-22.77	3.79	148
MAT02	28 36.31	95 57.47	210751.39	3167825.80	-23.25	3.32	148
MAT03	28 35.91	95 58.48	209090.26	3167112.23	-21.81	4.78	148
MUI01	27 49.53	97 03.40	691396.24	3079393.46	-22.29	4.07	123
MUI03	27 47.66	97 05.08	688697.38	3075882.46	-22.39	3.91	125
MUI02	27 40.42	97 10.19	680502.6	3062387.97	-24.22	1.88	120
NPC06	27 35.99	97 12.66	676557.71	3054150.56	-21.76	4.19	110
NPI08	27 35.86	97 12.78	676359.73	3053901.89	-23.32	2.62	110
SPI08	26 8.17	97 10.10	683116.29	2892056.38	-18.32	3.22	75
SPI02	26 6.79	97 9.93	683438.99	2889509.24	-18.11	3.39	78
SPI01[5]	26 4.57	97 9.46	684274.71	2885422.83	-18.48	2.97	70
SPI01R	26 4.58	97 9.46	684271.26	2885435.80	-14.94	6.48	70

[1]HIB01 reset in November 2021 after 2020 hurricane season.

[2]BEG02 reset in October 2008 after Hurricane Ike.

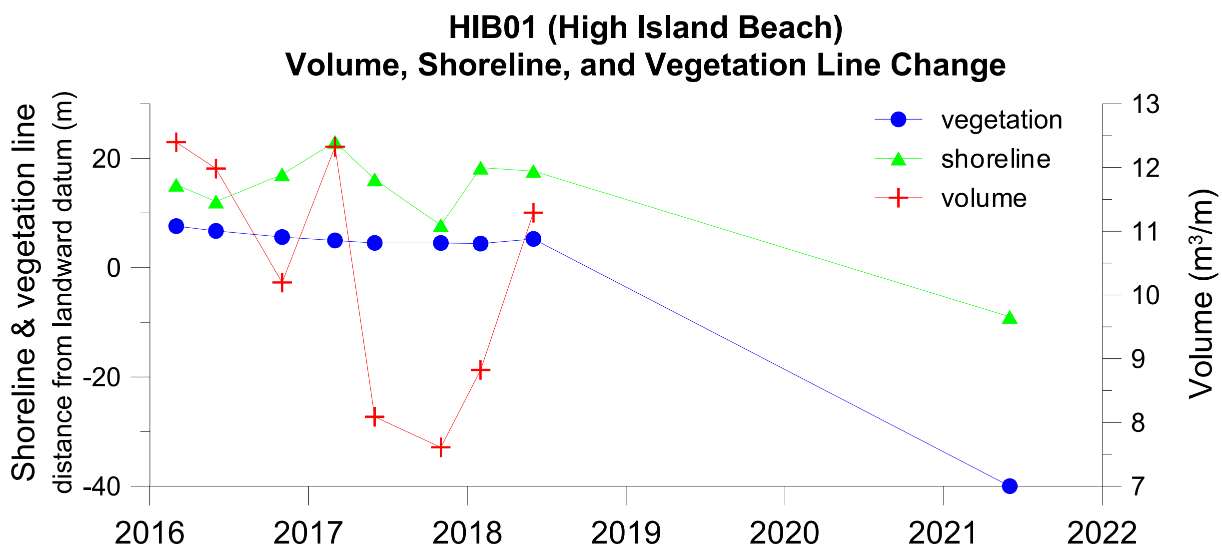
[3]GLO06 was monitored after Hurricane Ike until the Jamaica Beach (JAM02) site was added.

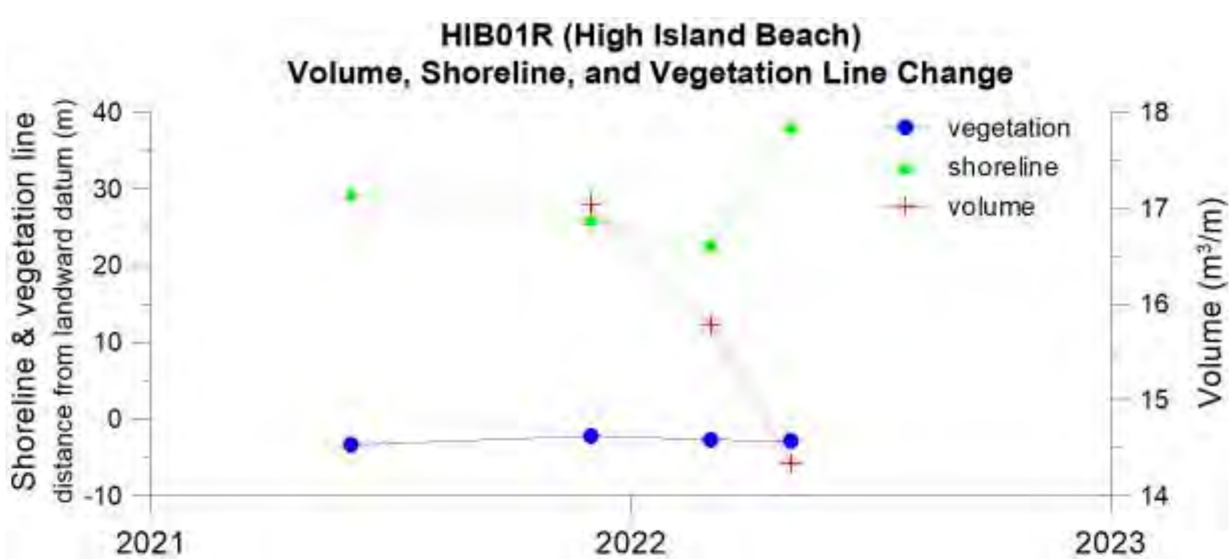
[4]BEG08 was lost due to Hurricane Ike in 2008.

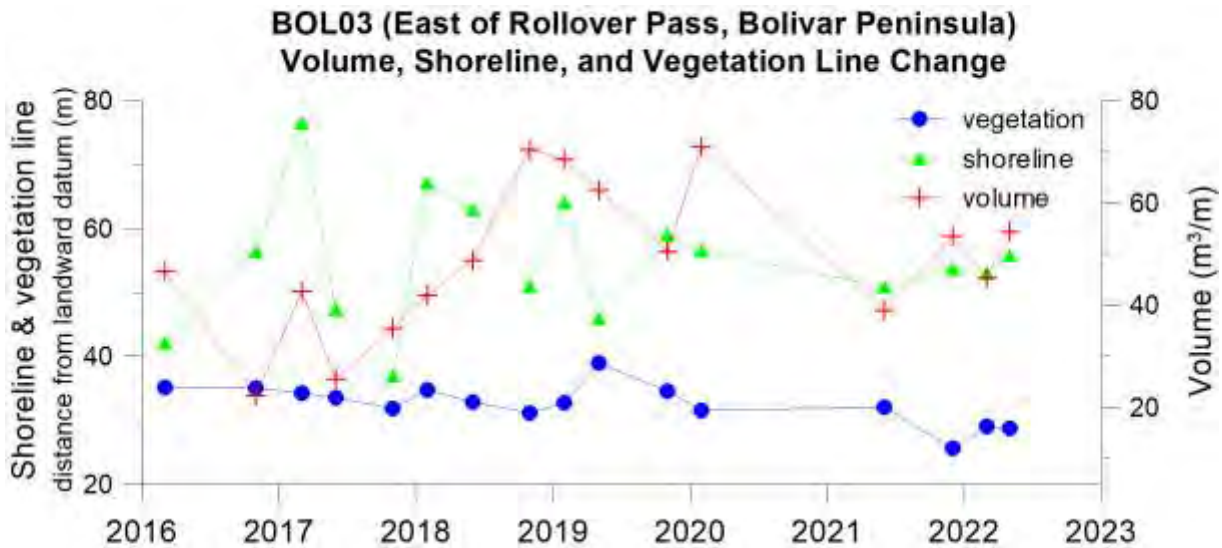
[5]SPI01 was lost due to construction at Isla Blanca Park.

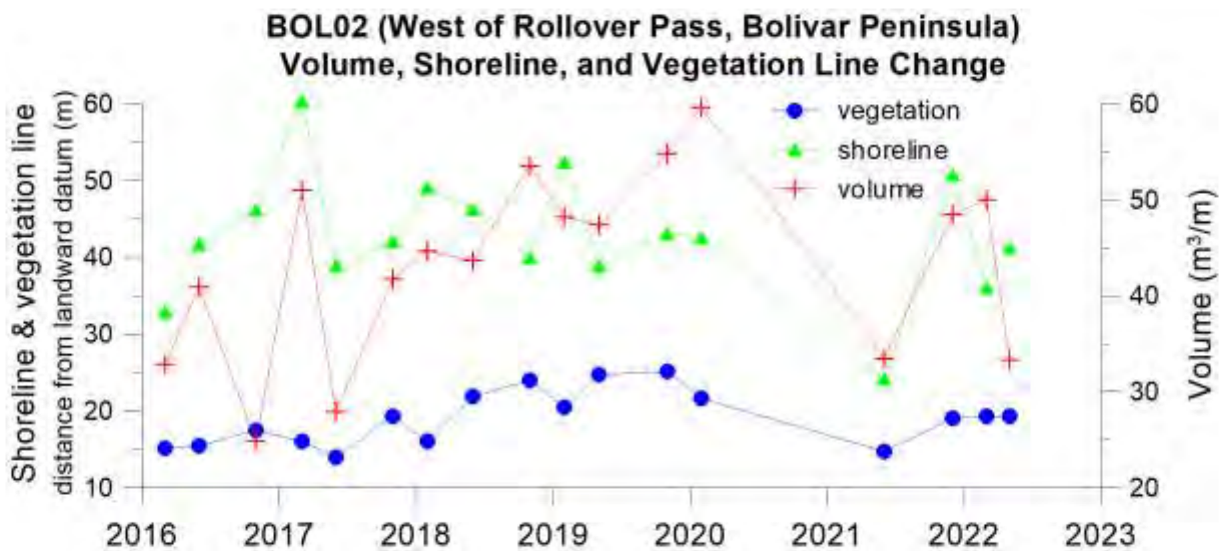
APPENDIX B: GRAPHS OF VOLUME, SHORELINE, AND VEGETATION-LINE CHANGE

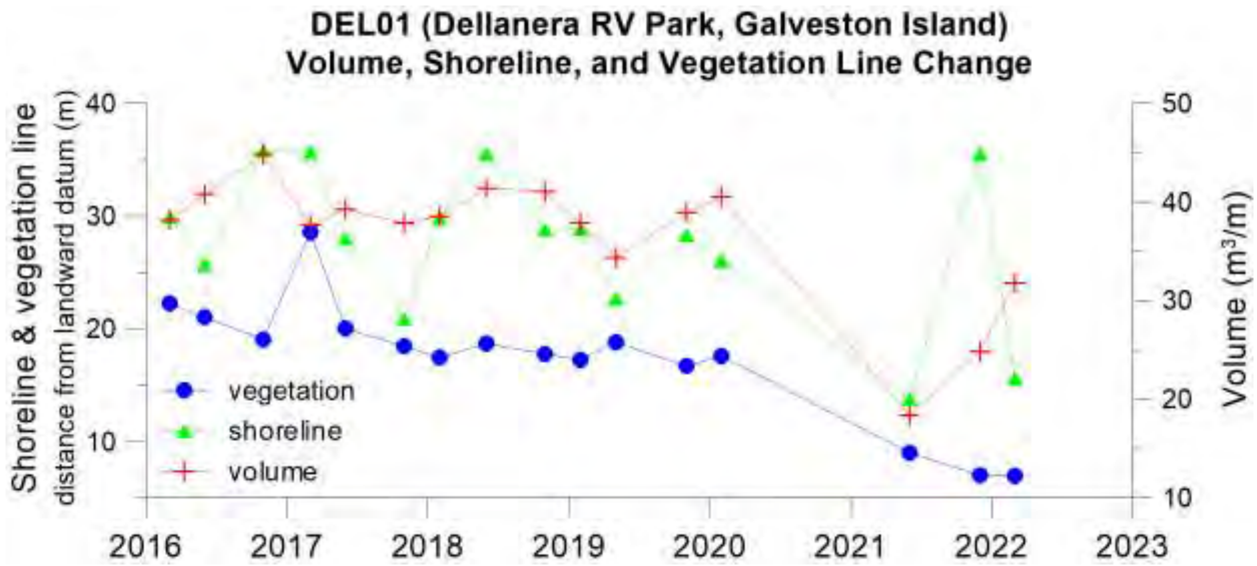
Sediment volume was calculated above 1 meter NAVD88 for all profiles unless otherwise indicated. Profiles that did not extend below the 1 meter NAVD88 elevation were extrapolated.

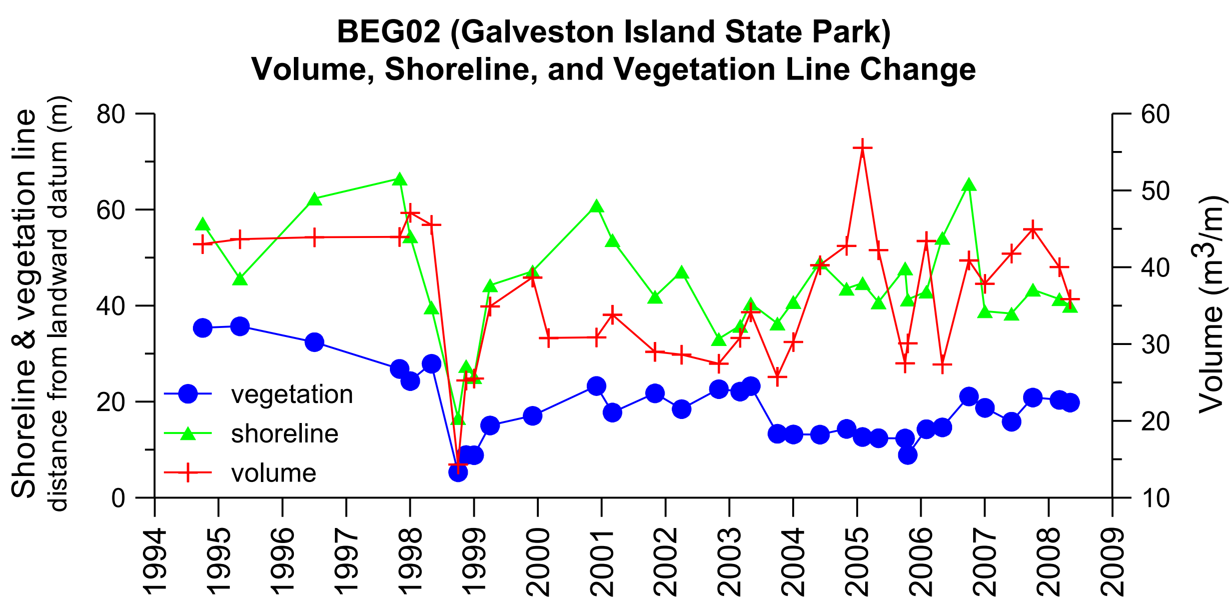


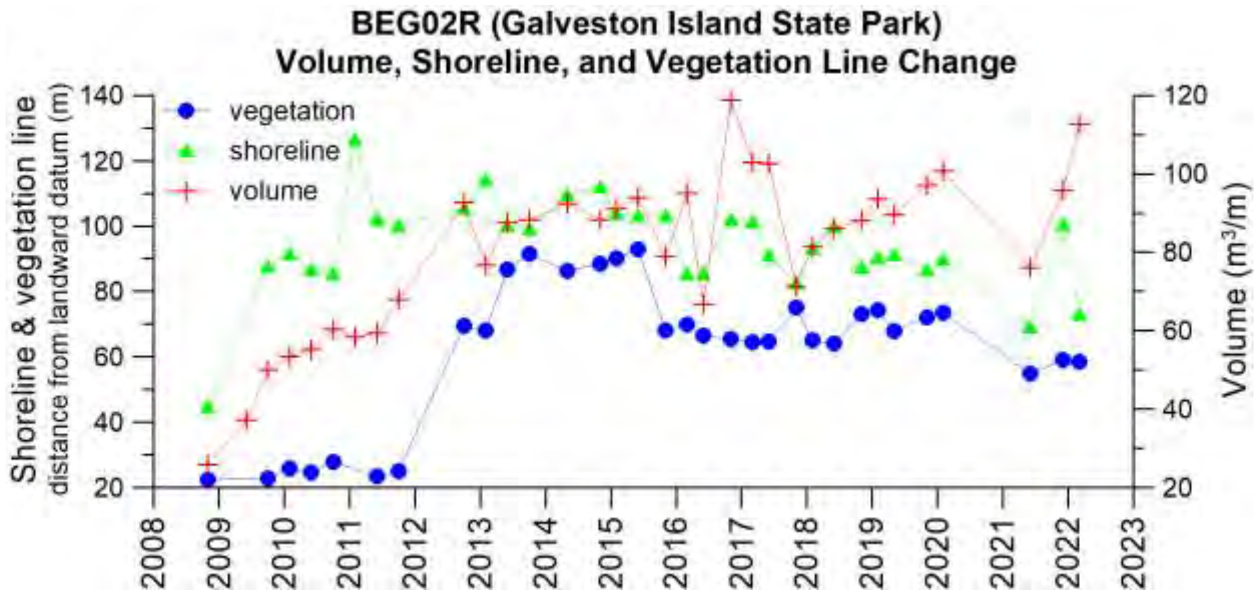


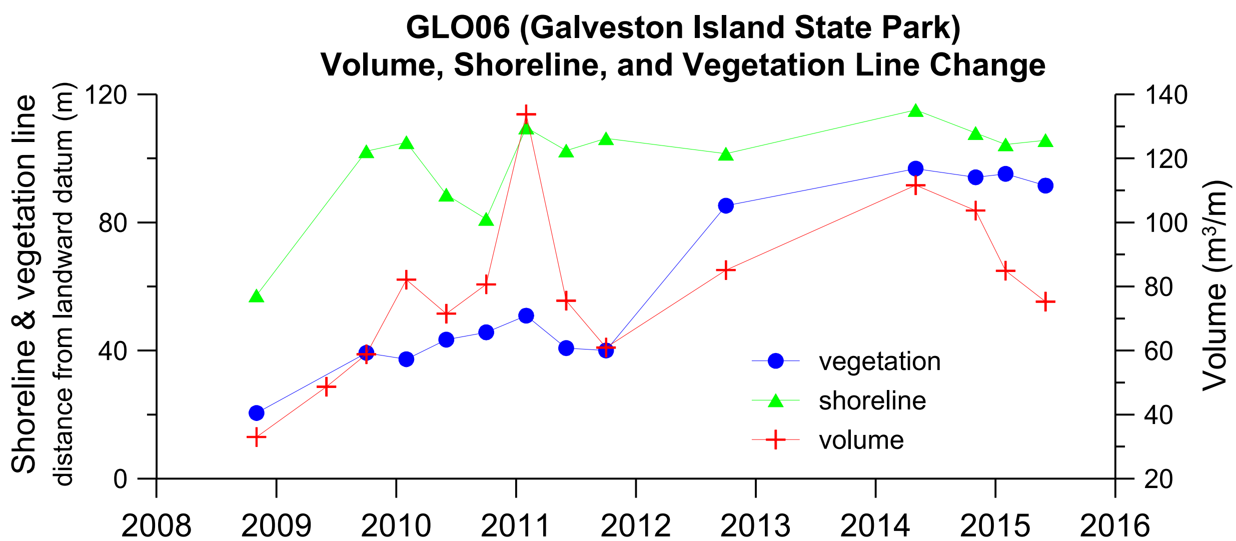

BOL03 (East of Rollover Pass, Bolivar Peninsula)
Volume, Shoreline, and Vegetation Line Change
Shoreline & vegetation line
distance from landward datum (m)
Volume (m³/m)
vegetation
shoreline
volume
20
40
60
80
2016
2017
2018
2019
2020
2021
2022
2023

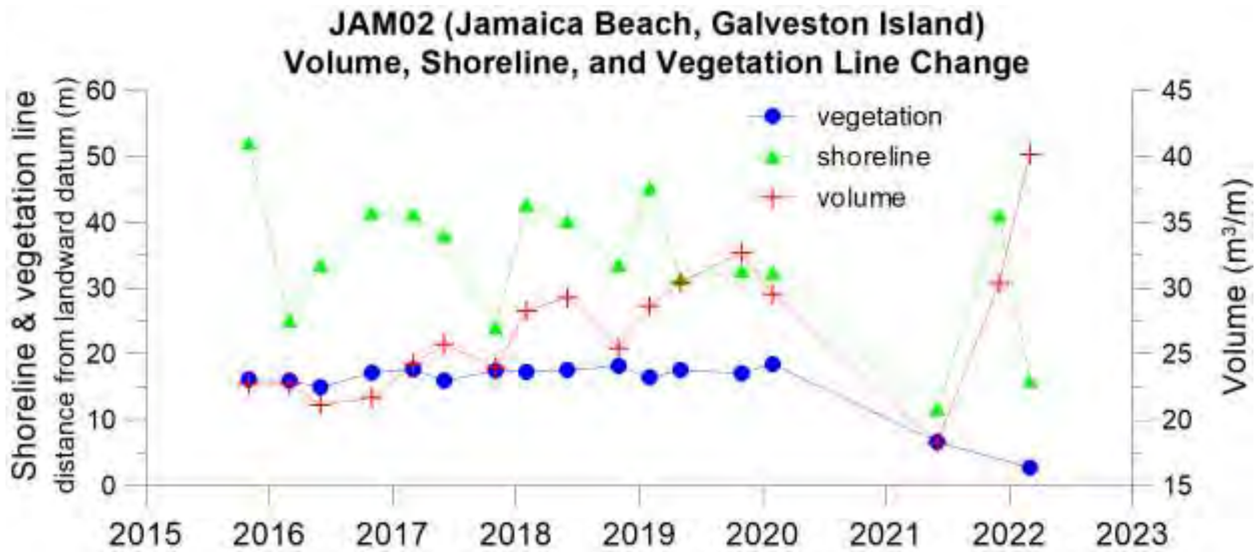

BOL02 (West of Rollover Pass, Bolivar Peninsula)
Volume, Shoreline, and Vegetation Line Change
Shoreline & vegetation line
distance from landward datum (m)
Volume (m³/m)
vegetation
shoreline
volume
10
20
30
40
50
60
2016
2017
2018
2019
2020
2021
2022
2023

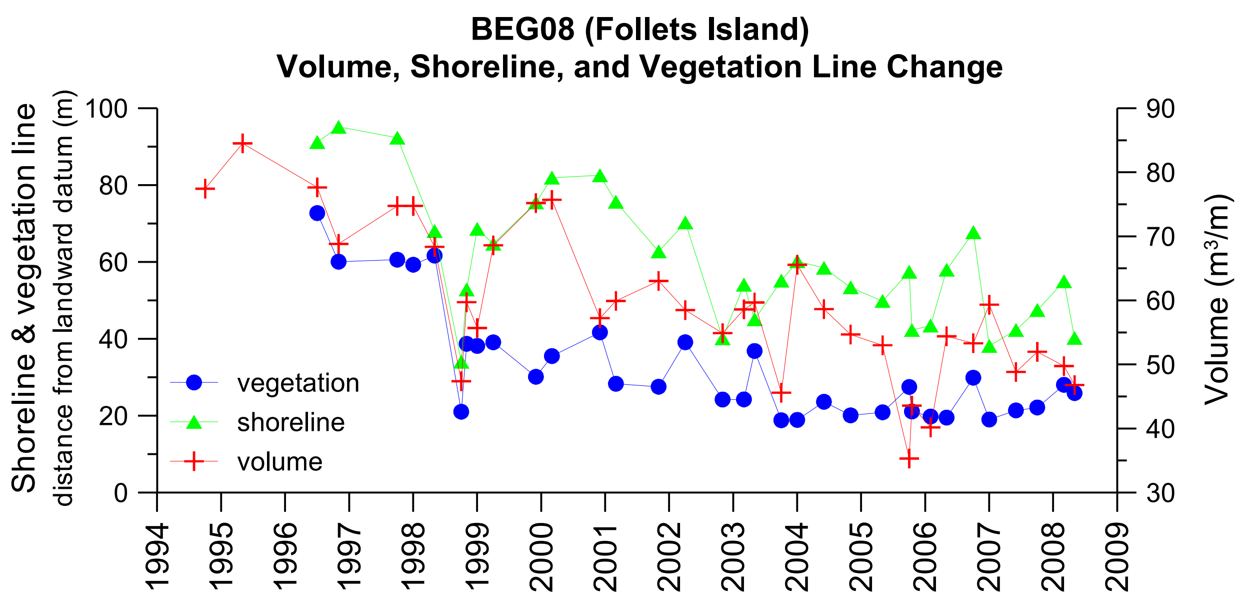

DEL01 (Dellanera RV Park, Galveston Island)
Volume, Shoreline, and Vegetation Line Change
Shoreline & vegetation line
distance from landward datum (m)
Volume (m³/m)
vegetation
shoreline
volume
2016
2017
2018
2019
2020
2021
2022
2023

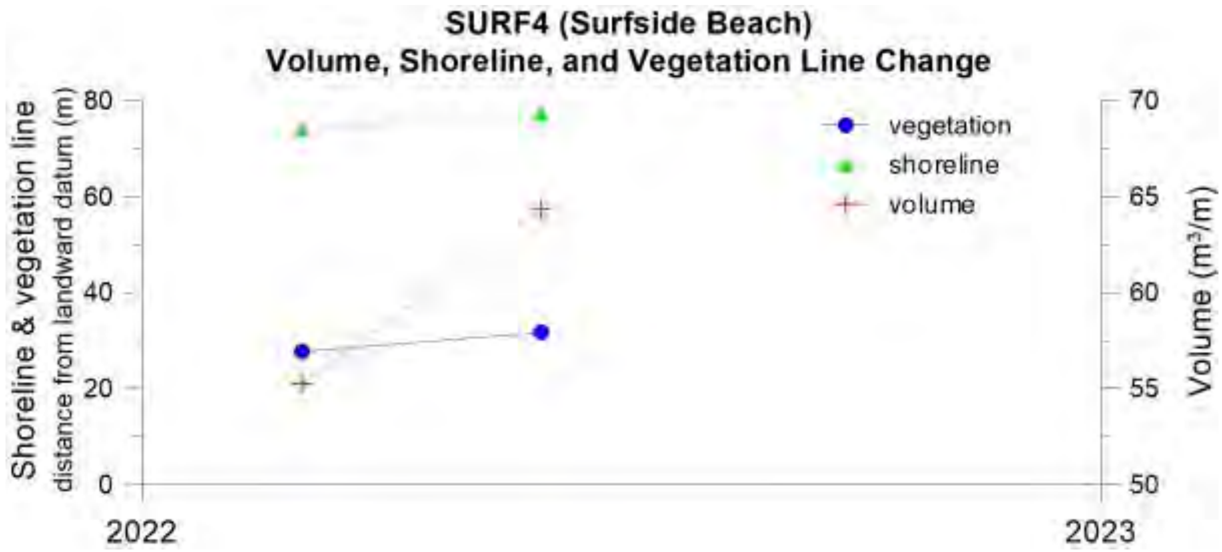

BEG02 (Galveston Island State Park)
Volume, Shoreline, and Vegetation Line Change
Shoreline & vegetation line
distance from landward datum (m)
Volume (m3/m)
vegetation
shoreline
volume

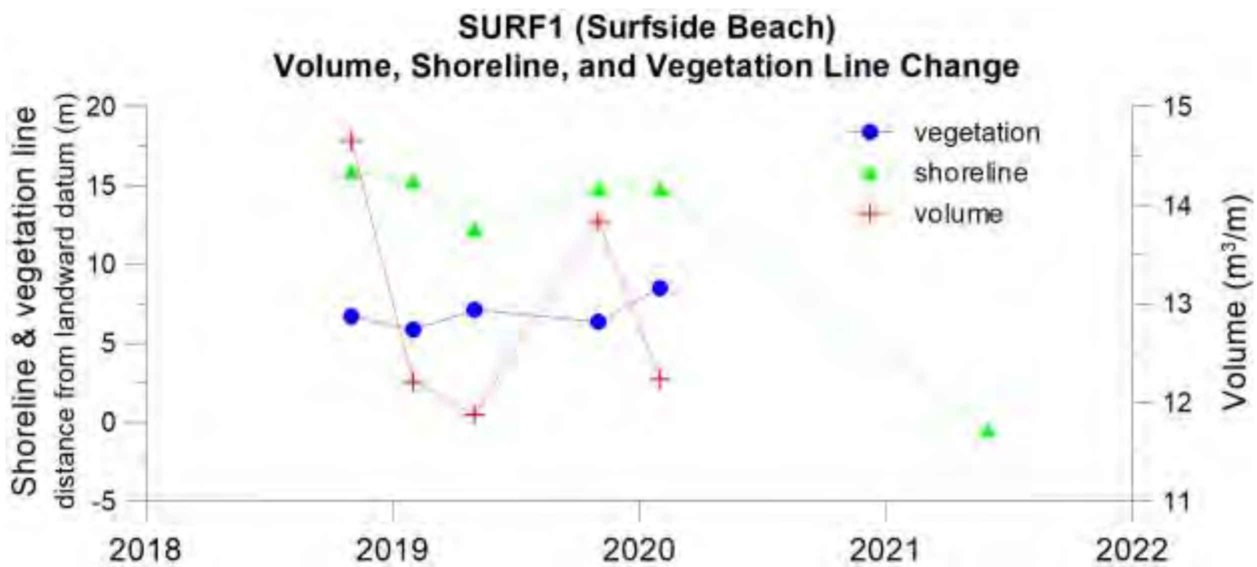

BEG02R (Galveston Island State Park)
Volume, Shoreline, and Vegetation Line Change
Shoreline & vegetation line
distance from landward datum (m)
Volume (m3/m)
vegetation
shoreline
volume
140
120
100
80
60
40
20
2008
2009
2010
2011
2012
2013
2014
2015
2016
2017
2018
2019
2020
2021
2022
2023

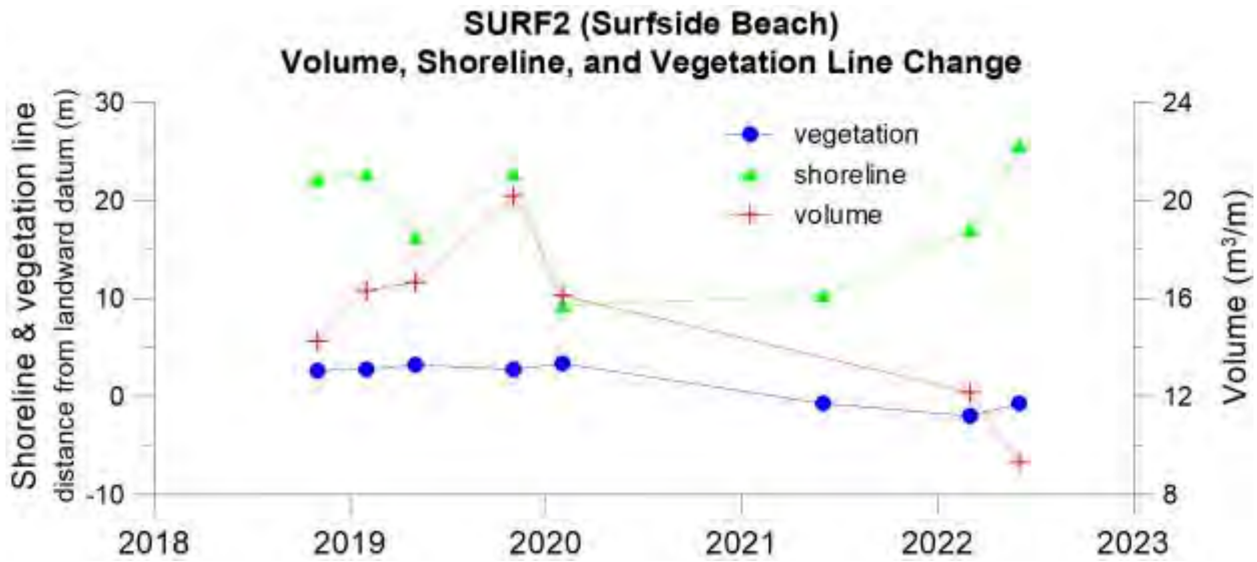

GLO06 (Galveston Island State Park)
Volume, Shoreline, and Vegetation Line Change
Shoreline & vegetation line
distance from landward datum (m)
Volume (m3/m)
vegetation
shoreline
volume
120
80
40
0
140
100
60
20
2008
2009
2010
2011
2012
2013
2014
2015
2016

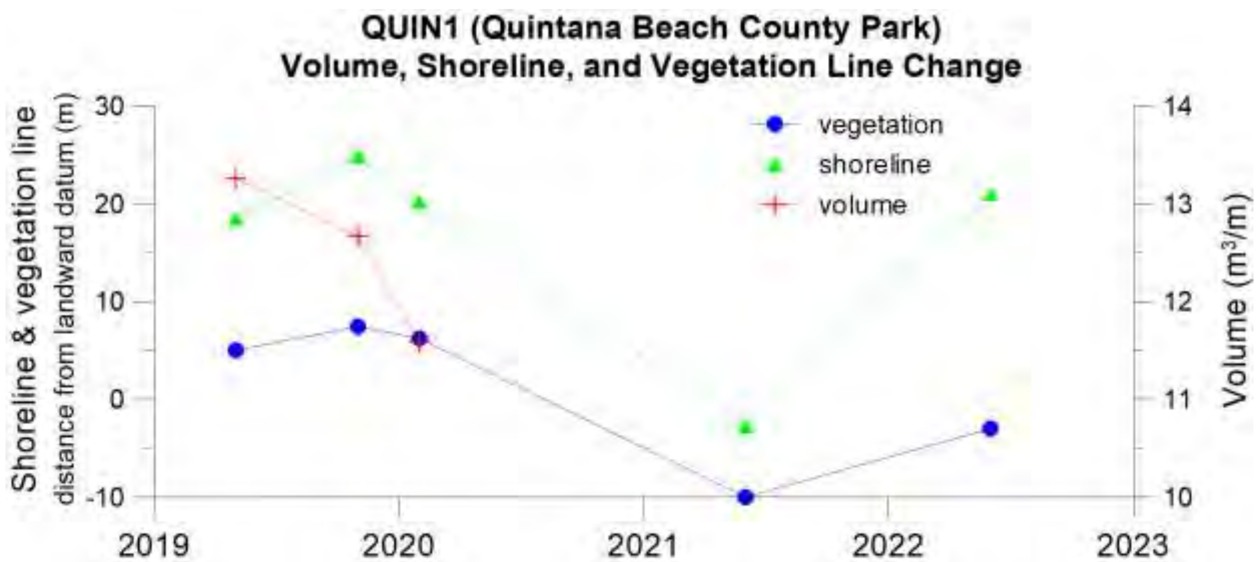

JAM02 (Jamaica Beach, Galveston Island)
Volume, Shoreline, and Vegetation Line Change
Shoreline & vegetation line
distance from landward datum (m)
Volume (m³/m)
vegetation
shoreline
volume
2015
2016
2017
2018
2019
2020
2021
2022
2023

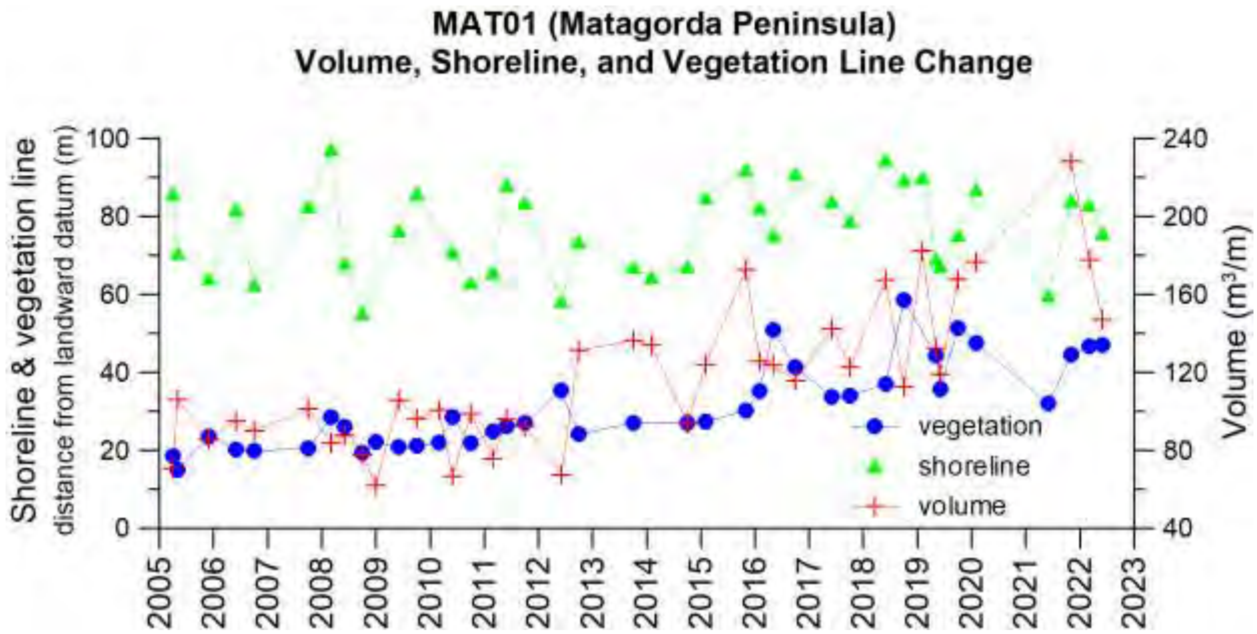

BEG08 (Follets Island)
Volume, Shoreline, and Vegetation Line Change
Shoreline & vegetation line
distance from landward datum (m)
Volume (m³/m)
vegetation
shoreline
volume

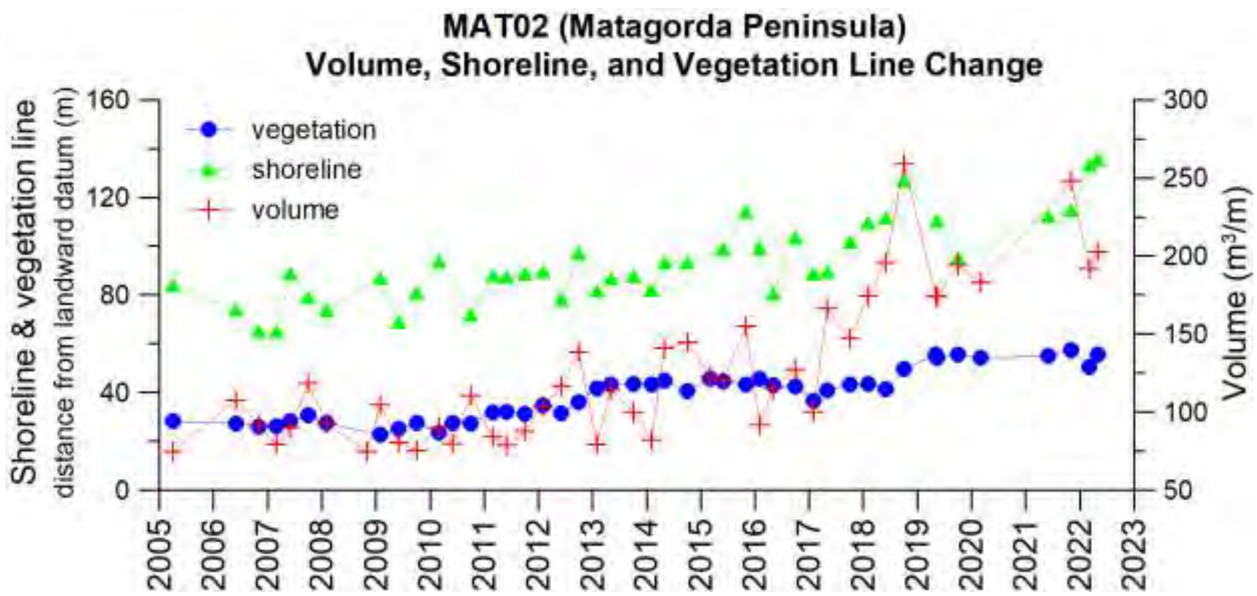

SURF4 (Surfside Beach)
Volume, Shoreline, and Vegetation Line Change
Shoreline & vegetation line
distance from landward datum (m)
Volume (m³/m)
vegetation
shoreline
volume
0
20
40
60
80
50
55
60
65
70
2022
2023

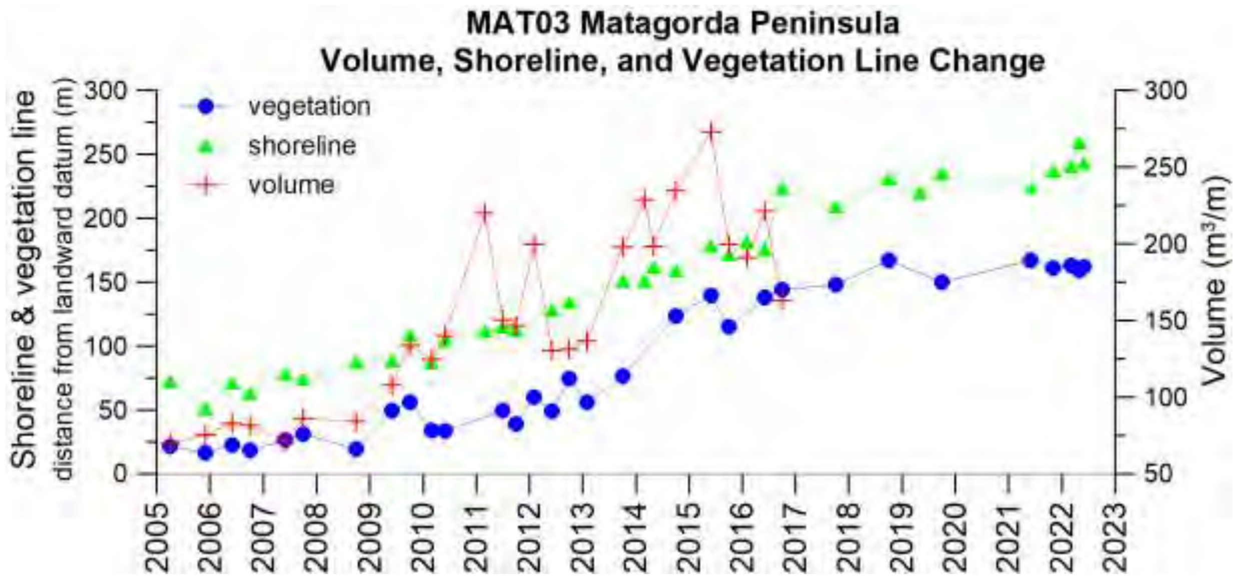

SURF1 (Surfside Beach)
Volume, Shoreline, and Vegetation Line Change
Shoreline & vegetation line
distance from landward datum (m)
Volume (m³/m)
vegetation
shoreline
volume
-5
0
5
10
15
20
11
12
13
14
15
2018
2019
2020
2021
2022


SURF2 (Surfside Beach)
Volume, Shoreline, and Vegetation Line Change
Shoreline & vegetation line
distance from landward datum (m)
Volume (m³/m)
vegetation
shoreline
volume
30
20
10
0
-10
24
20
16
12
8
2018
2019
2020
2021
2022
2023

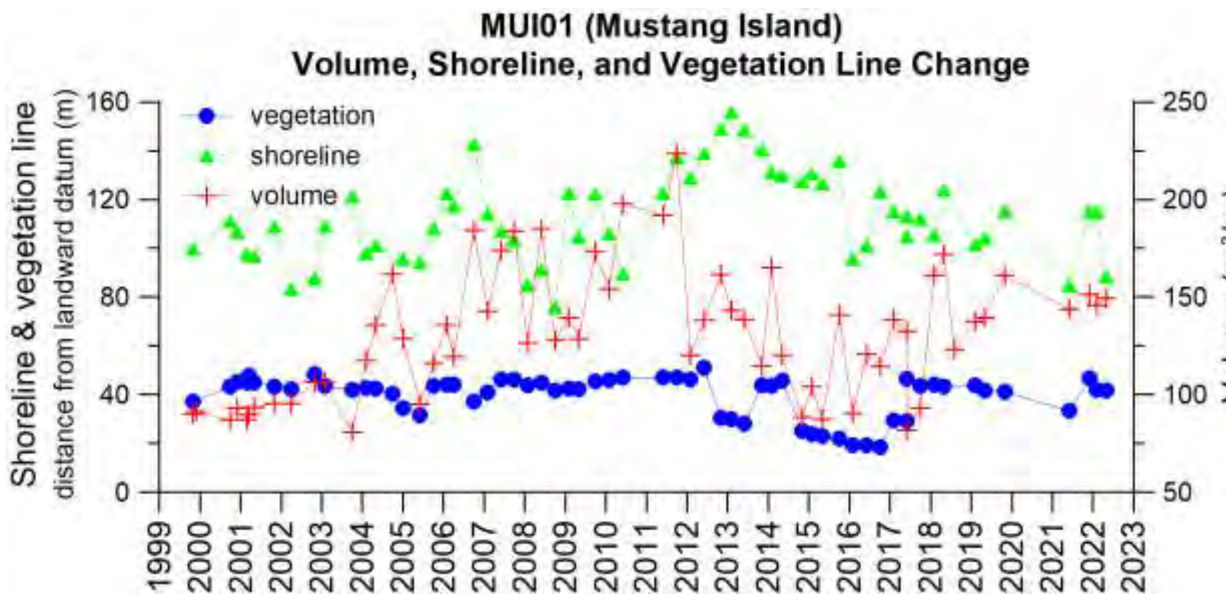

QUIN1 (Quintana Beach County Park)
Volume, Shoreline, and Vegetation Line Change
Shoreline & vegetation line
distance from landward datum (m)
Volume (m³/m)
vegetation
shoreline
volume
30
20
10
0
-10
14
13
12
11
10
2019
2020
2021
2022
2023


MAT01 (Matagorda Peninsula)
Volume, Shoreline, and Vegetation Line Change
Shoreline & vegetation line
distance from landward datum (m)
Volume (m³/m)
vegetation
shoreline
volume
0
20
40
60
80
100
40
80
120
160
200
240
2005
2006
2007
2008
2009
2010
2011
2012
2013
2014
2015
2016
2017
2018
2019
2020
2021
2022
2023

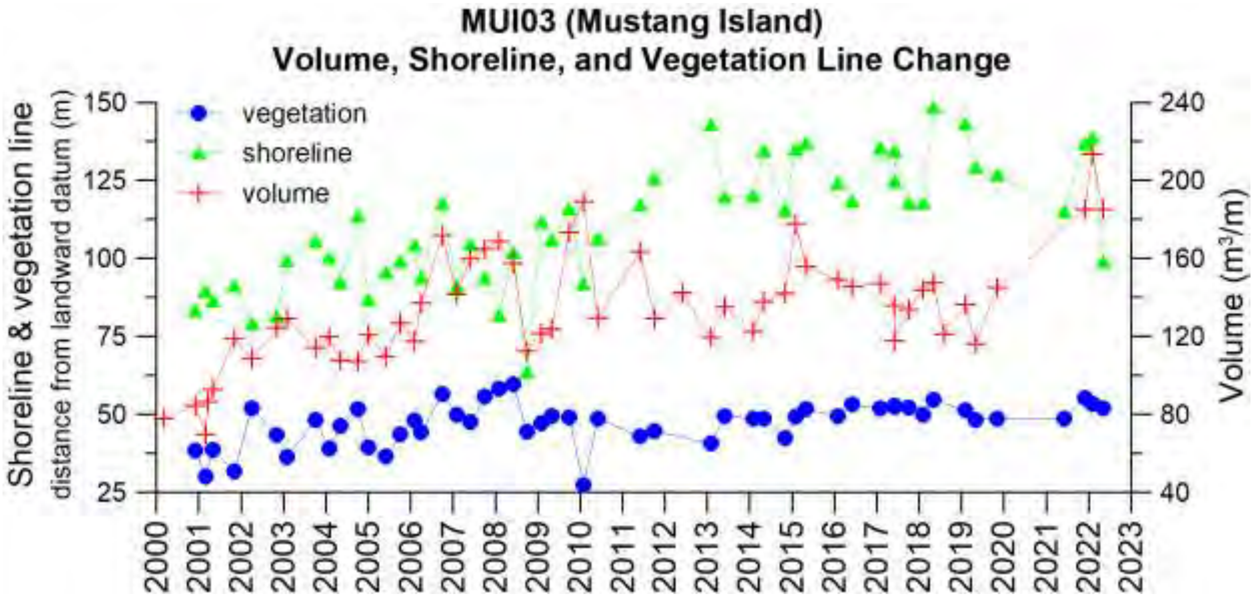

MAT02 (Matagorda Peninsula)
Volume, Shoreline, and Vegetation Line Change
Shoreline & vegetation line
distance from landward datum (m)
Volume (m³/m)
vegetation
shoreline
volume
0
40
80
120
160
50
100
150
200
250
300
2005
2006
2007
2008
2009
2010
2011
2012
2013
2014
2015
2016
2017
2018
2019
2020
2021
2022
2023



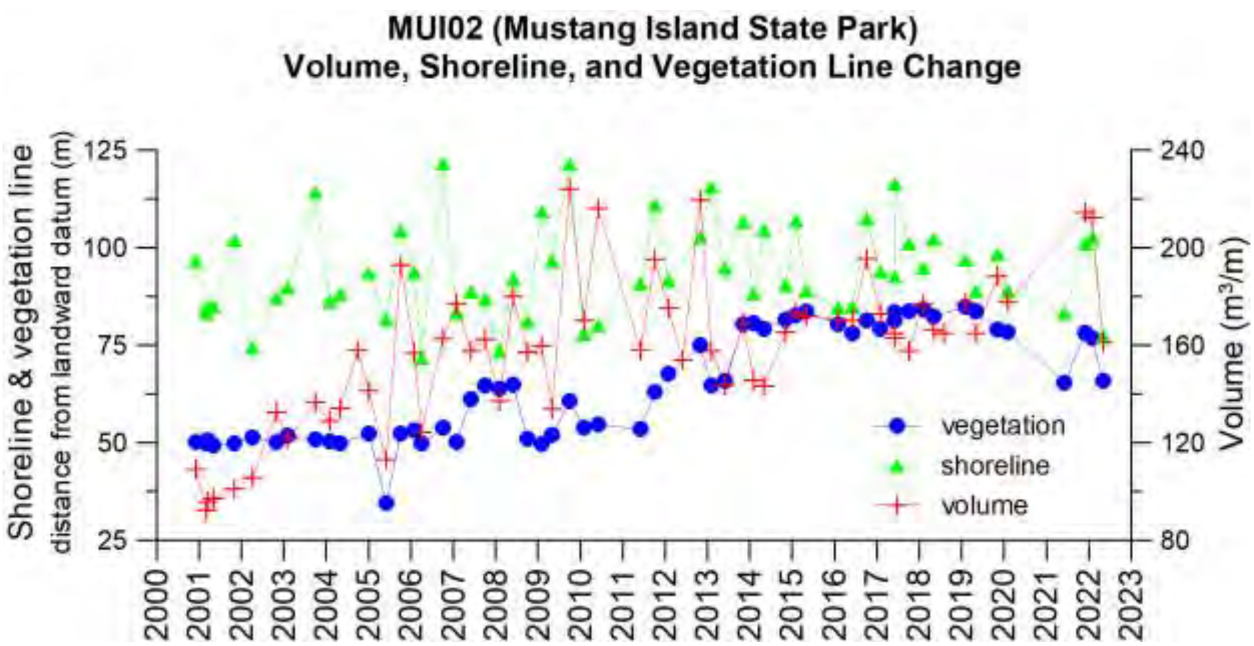
MUI01 volumes were calculated above 1.5 meters NAVD88. Profiles that did not extend below the 1.5-meter NAVD88 elevation were extrapolated.

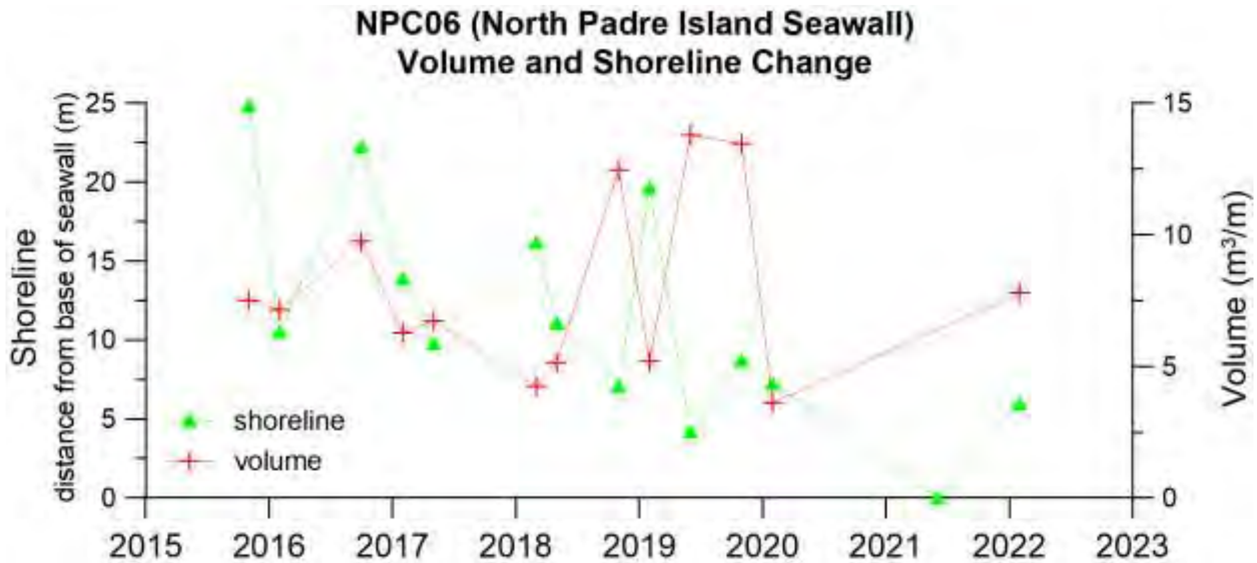


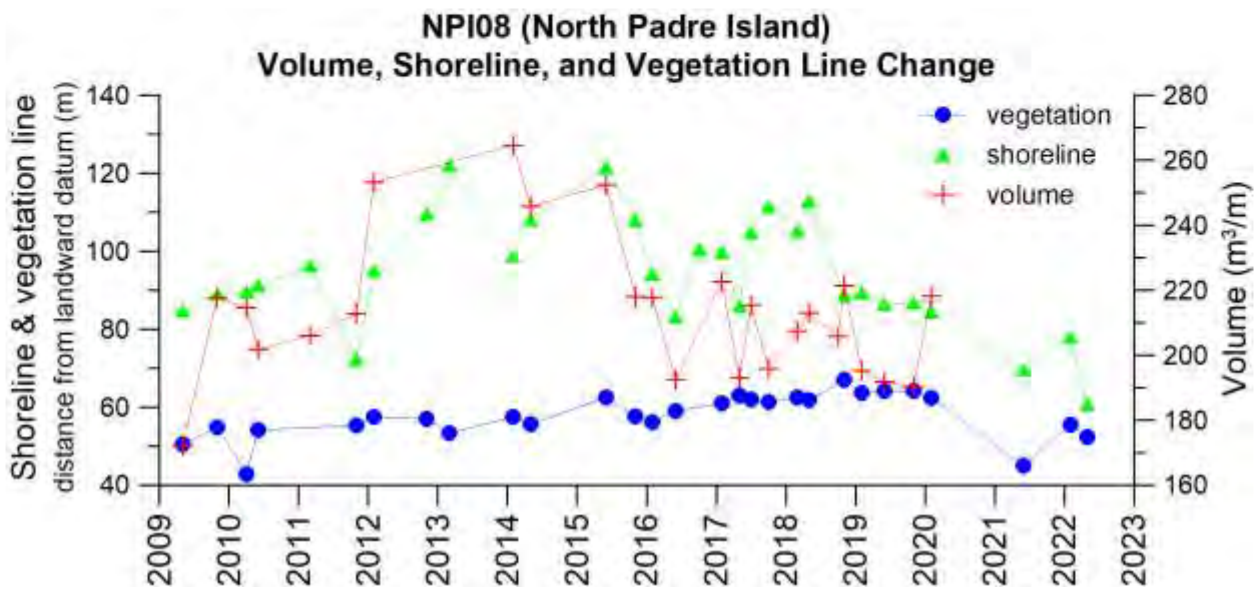
MUI03 volumes were calculated above 1.5 meters NAVD88. Profiles that did not extend below the 1.5-meter NAVD88 elevation were extrapolated.

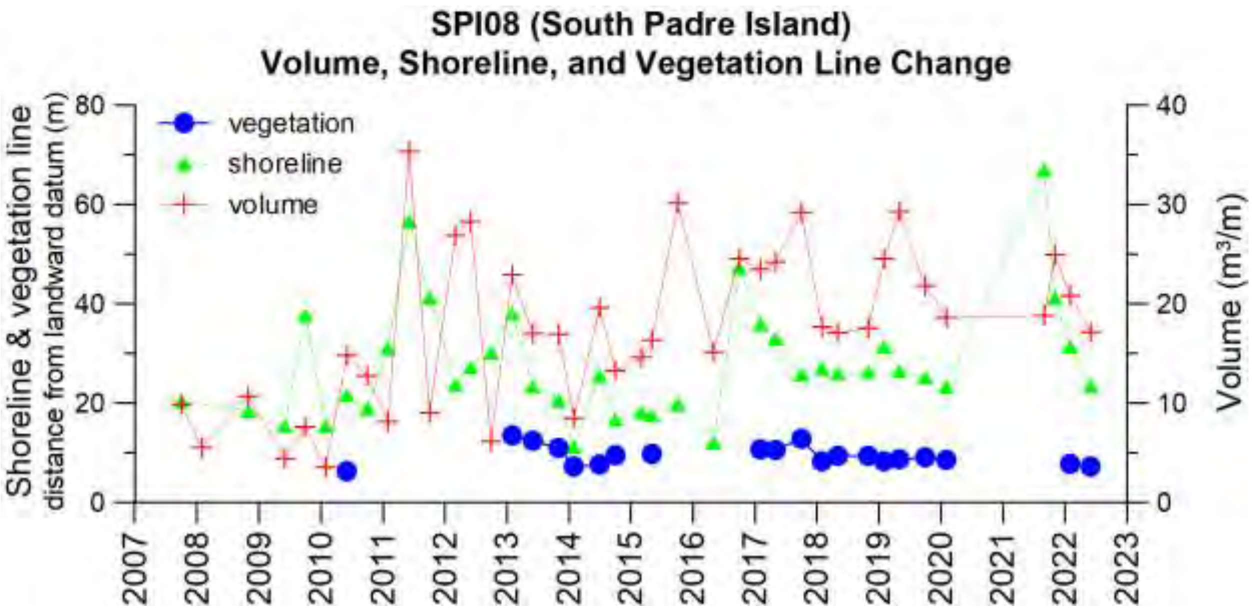


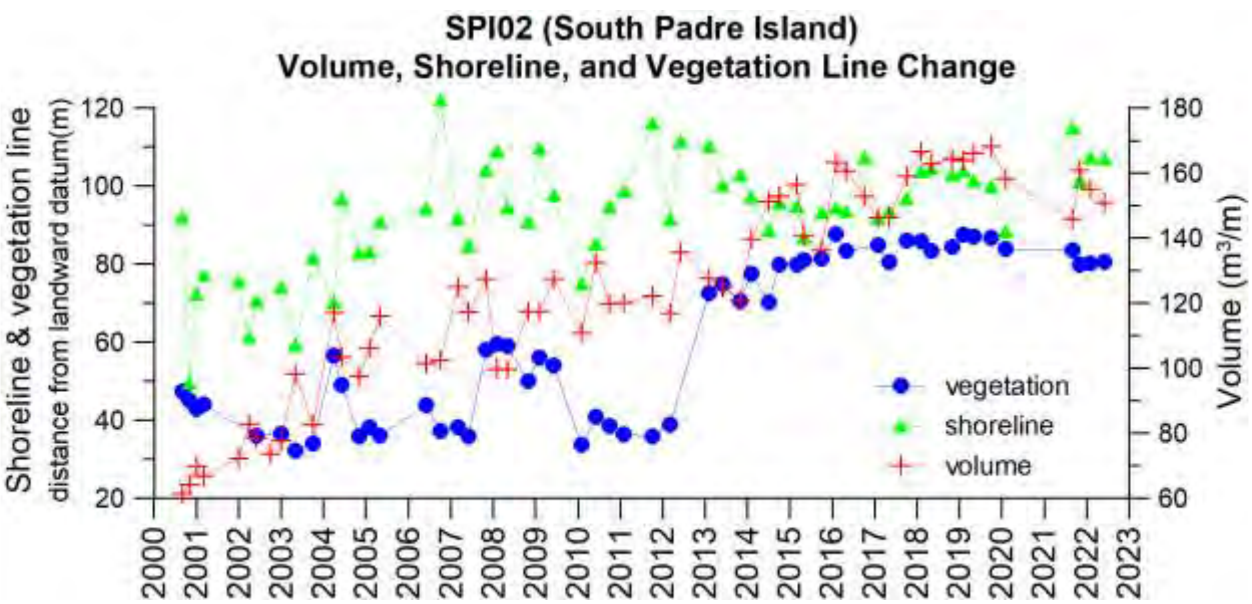
MUI02 volumes were calculated above 1.25 meters NAVD88. Profiles that did not extend below the 1.25-meter NAVD88 elevation were extrapolated.

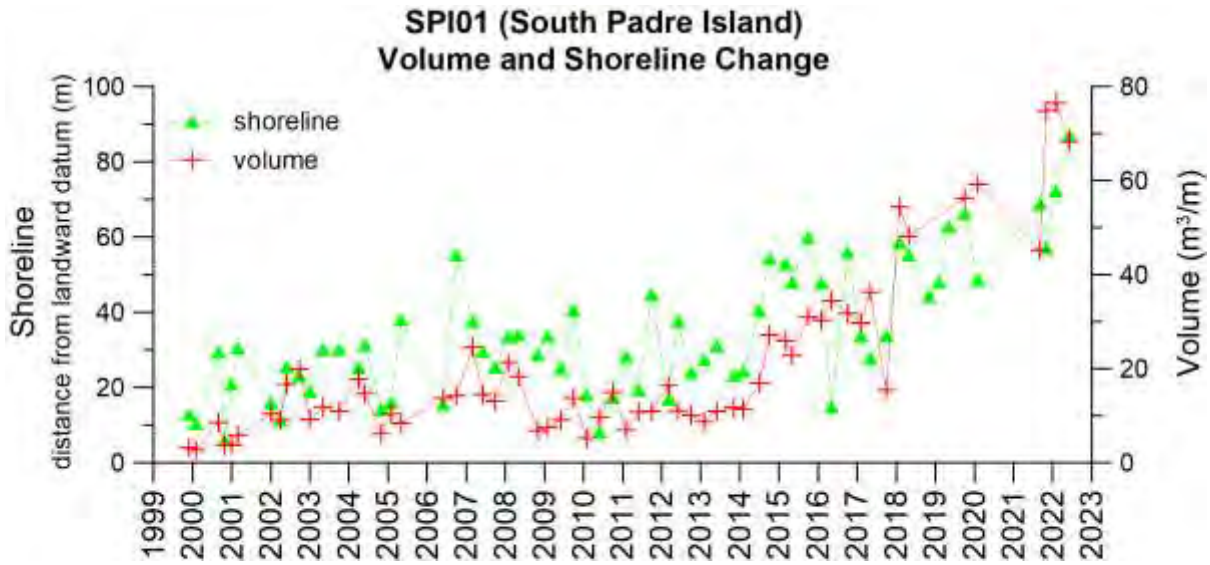



NPC06 (North Padre Island Seawall)
Volume and Shoreline Change
Shoreline
distance from base of seawall (m)
Volume (m³/m)
shoreline
volume
2015
2016
2017
2018
2019
2020
2021
2022
2023


NPI08 (North Padre Island)
Volume, Shoreline, and Vegetation Line Change
Shoreline & vegetation line
distance from landward datum (m)
Volume (m³/m)
vegetation
shoreline
volume

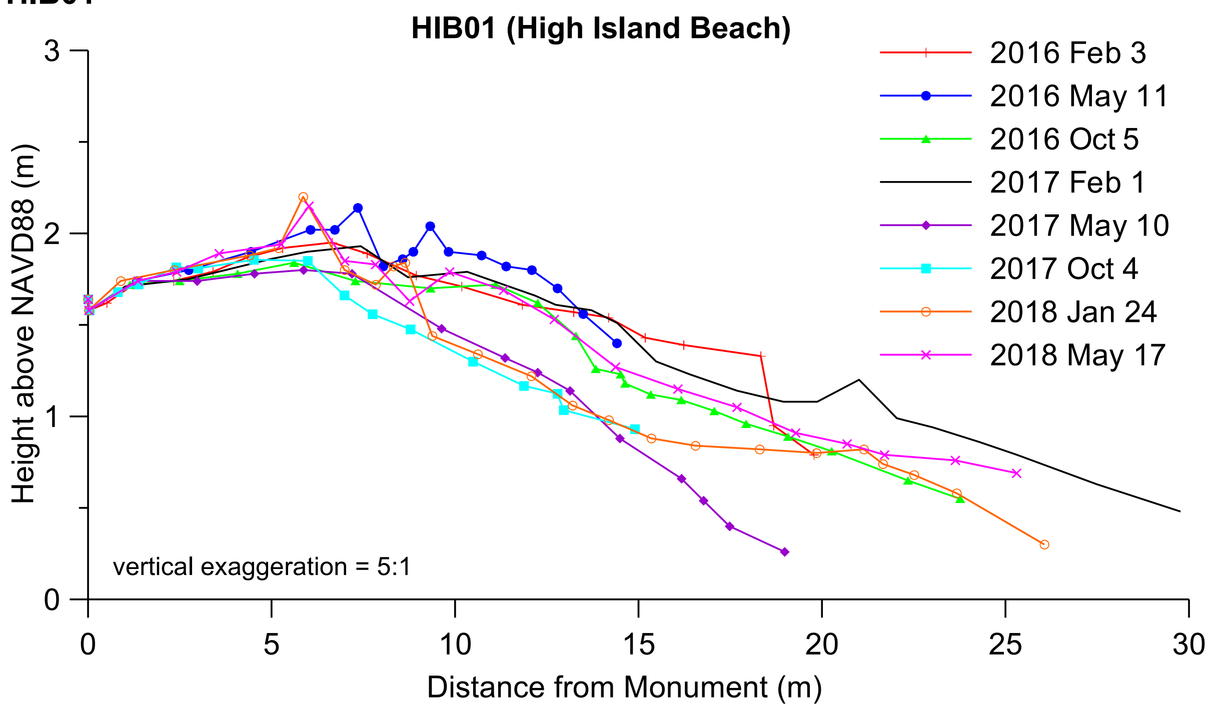

SPI08 (South Padre Island)
Volume, Shoreline, and Vegetation Line Change
Shoreline & vegetation line
distance from landward datum (m)
Volume (m3/m)
vegetation
shoreline
volume
0
20
40
60
80
0
10
20
30
40
2007
2008
2009
2010
2011
2012
2013
2014
2015
2016
2017
2018
2019
2020
2021
2022
2023

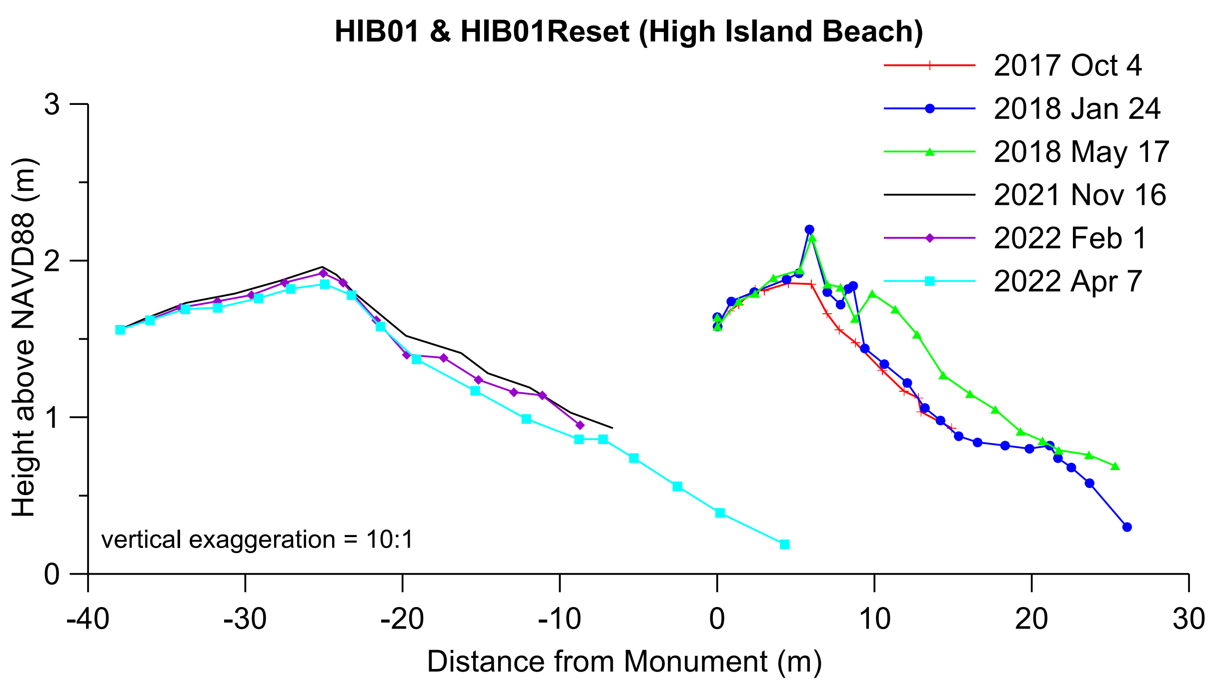

SPI02 (South Padre Island)
Volume, Shoreline, and Vegetation Line Change
Shoreline & vegetation line
distance from landward datum(m)
Volume (m3/m)
vegetation
shoreline
volume
20
40
60
80
100
120
60
80
100
120
140
160
180
2000
2001
2002
2003
2004
2005
2006
2007
2008
2009
2010
2011
2012
2013
2014
2015
2016
2017
2018
2019
2020
2021
2022
2023


SPI01 (South Padre Island)
Volume and Shoreline Change
Shoreline
distance from landward datum (m)
Volume (m³/m)
shoreline
volume

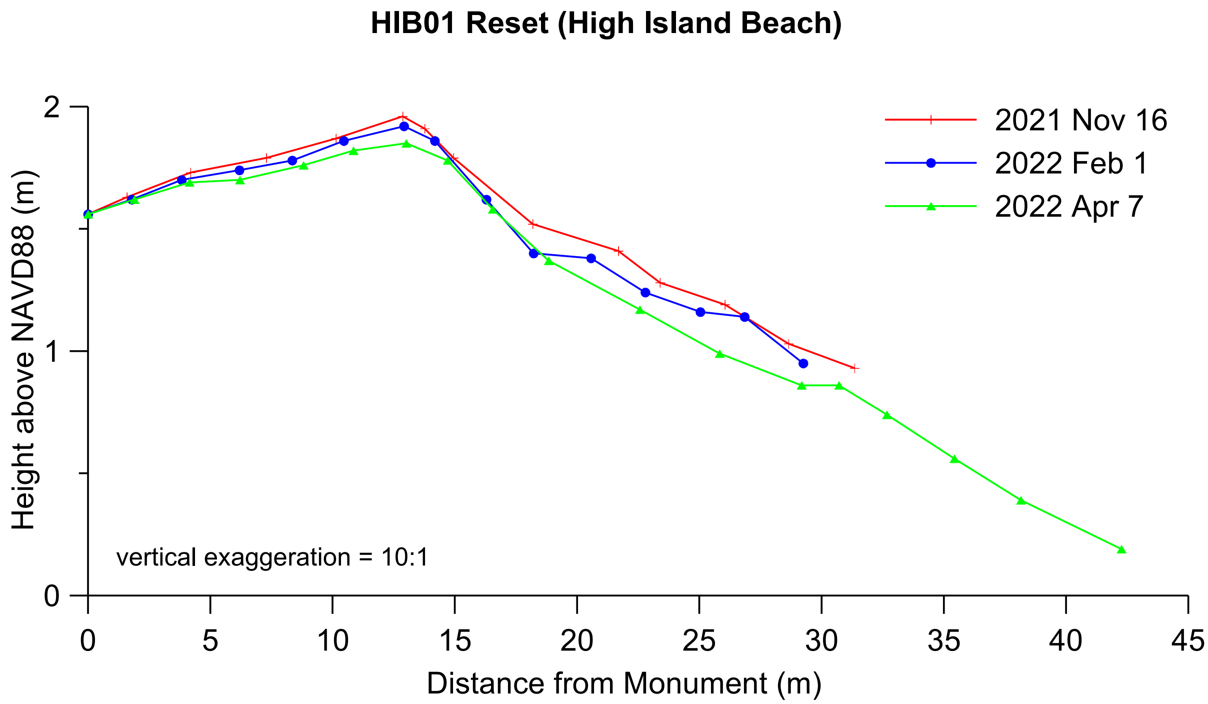
APPENDIX C: GRAPHS OF BEACH PROFILES

HIB01



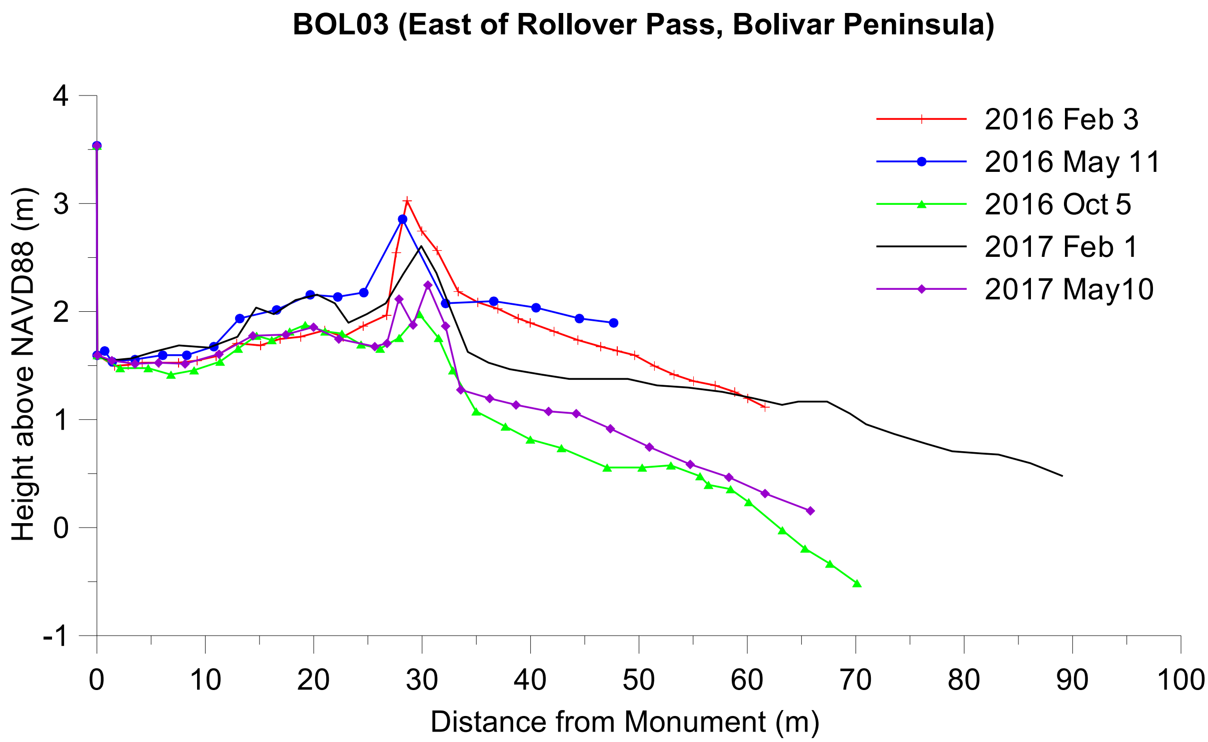


HIB01R

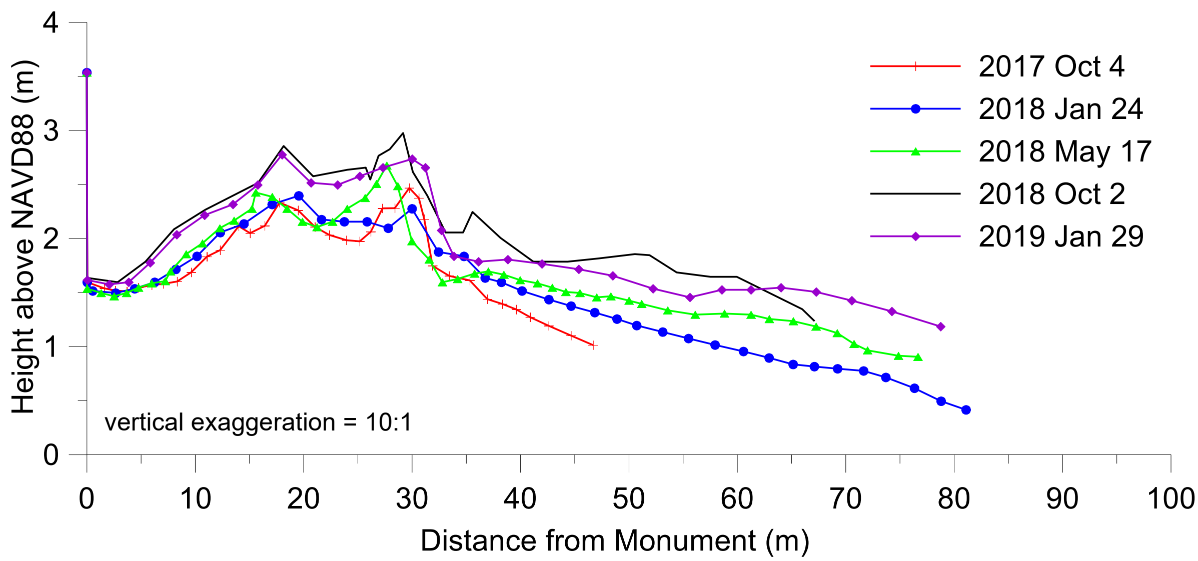


HIB01 Reset (High Island Beach)
2021 Nov 16
2022 Feb 1
2022 Apr 7
Height above NAVD88 (m)
vertical exaggeration = 10:1
0
1
2
0
5
10
15
20
25
30
35
40
45
Distance from Monument (m)

BOL03

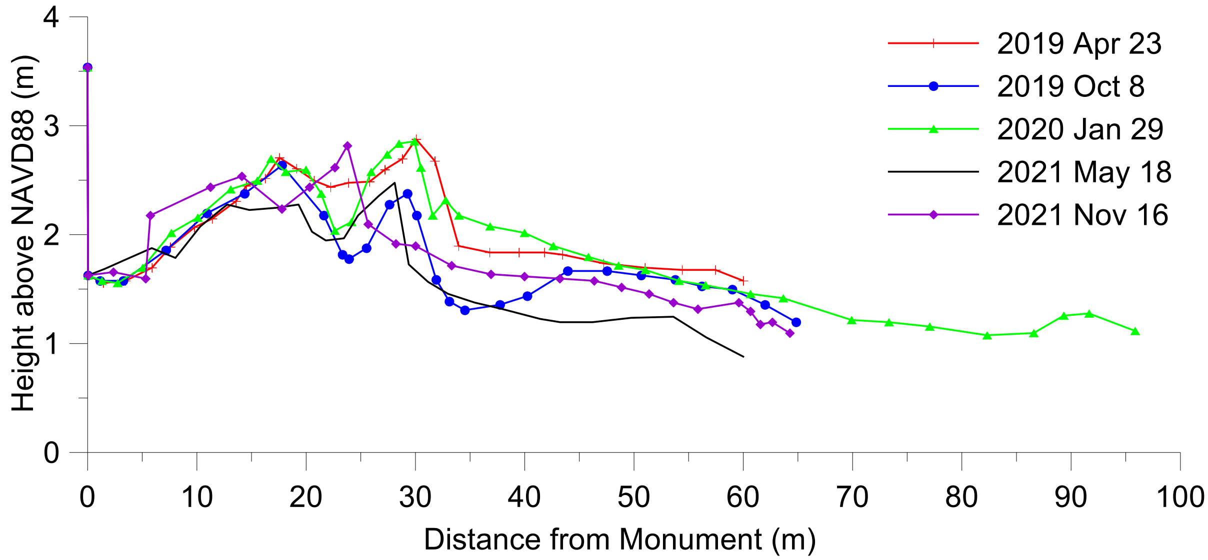


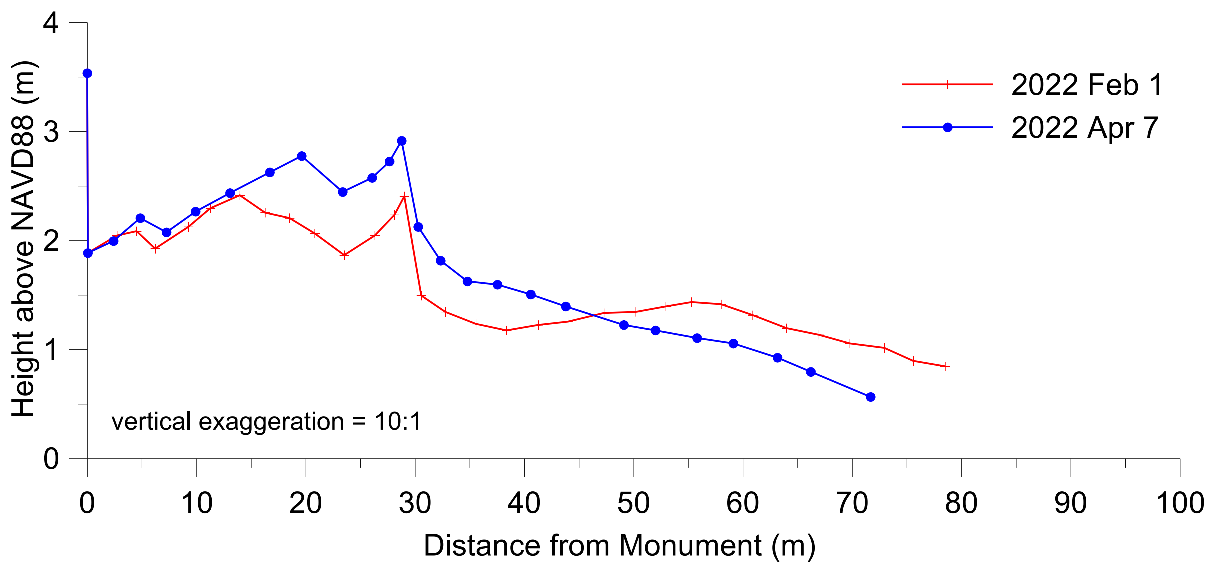
BOL03 (East of Rollover Pass, Bolivar Peninsula)
Height above NAVD88 (m)
Distance from Monument (m)
2016 Feb 3
2016 May 11
2016 Oct 5
2017 Feb 1
2017 May10



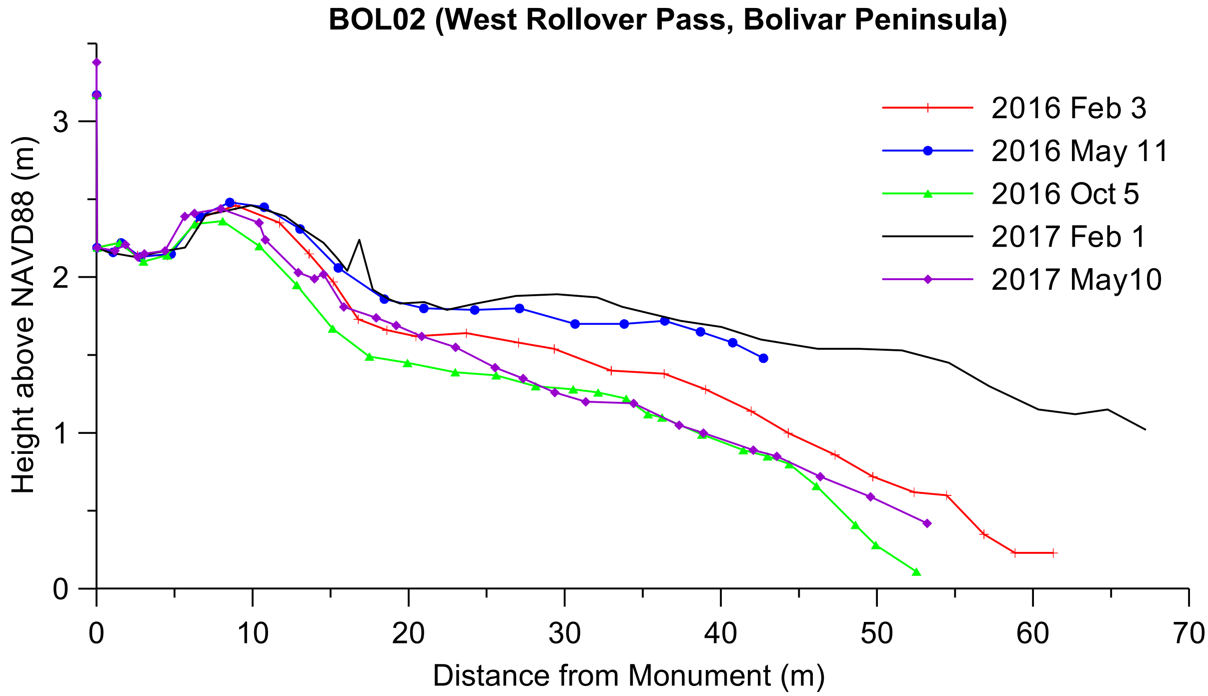
Height above NAVD88 (m)
Distance from Monument (m)
2017 Oct 4
2018 Jan 24
2018 May 17
2018 Oct 2
2019 Jan 29
vertical exaggeration = 10:1

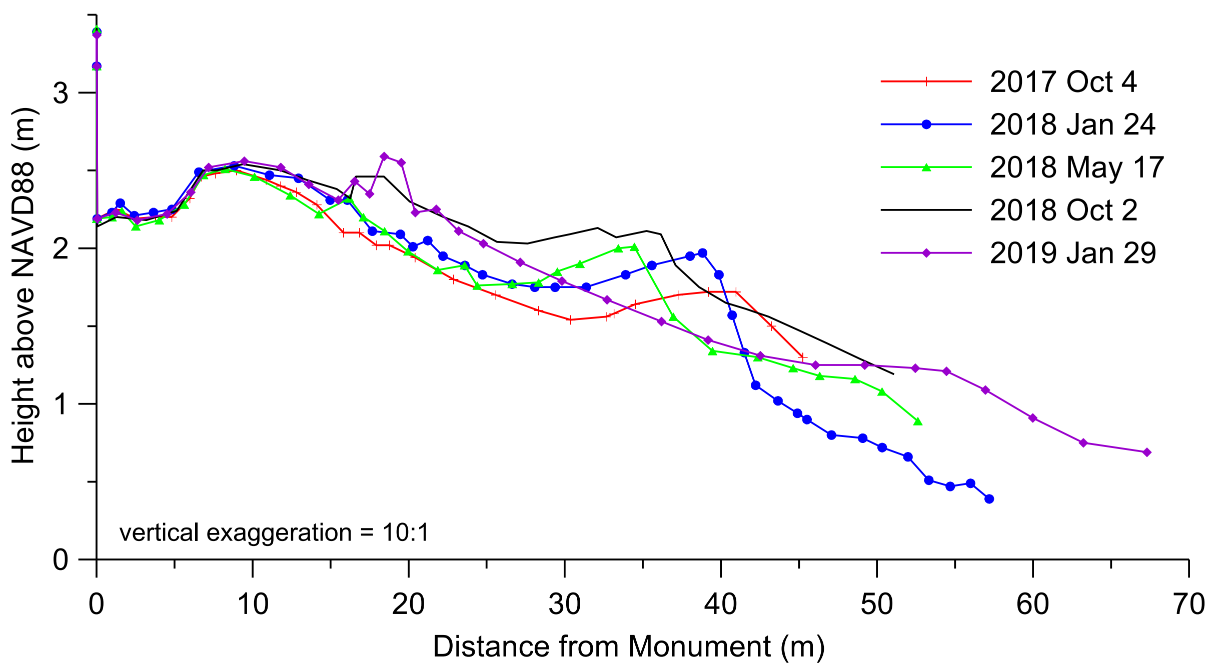
BOL03 (East of Rollover Pass, Bolivar Peninsula)



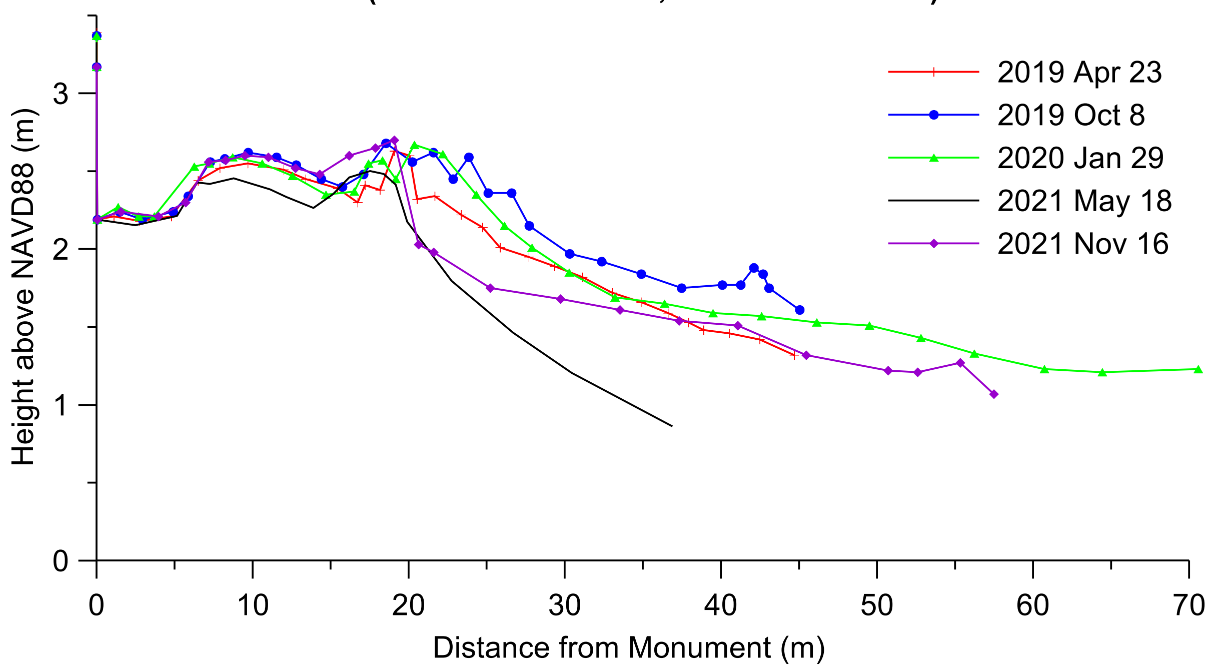


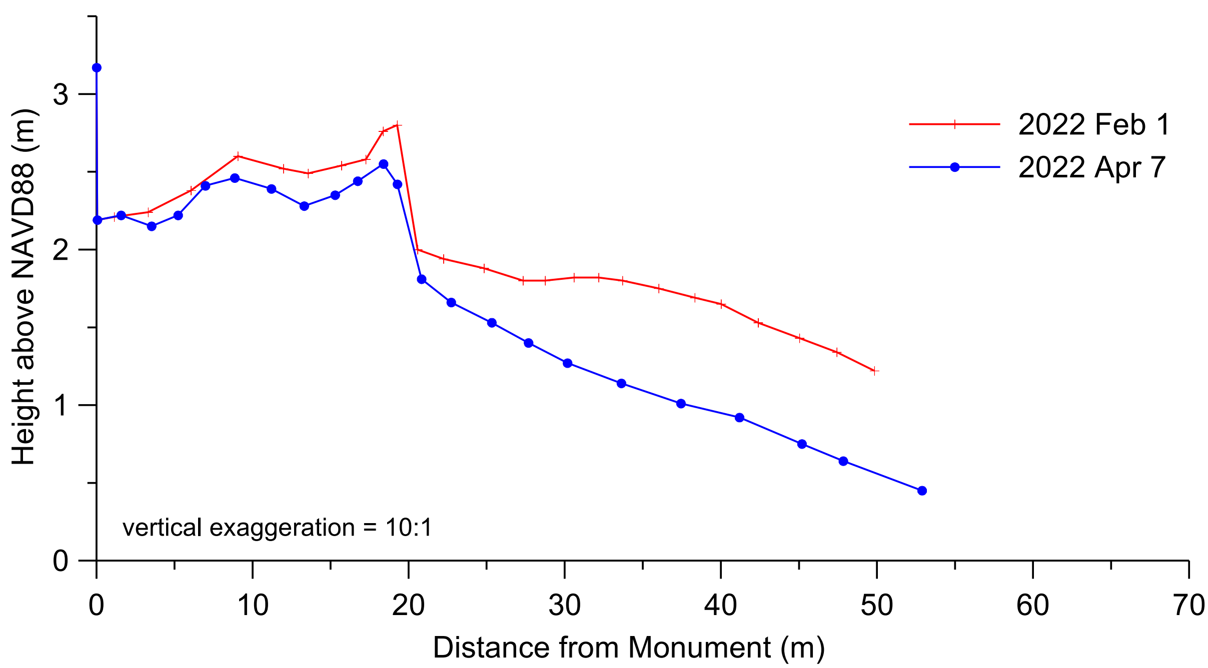
BOL02


BOL02 (West Rollover Pass, Bolivar Peninsula)
Height above NAVD88 (m)
Distance from Monument (m)
0
1
2
3
0
10
20
30
40
50
60
70
2016 Feb 3
2016 May 11
2016 Oct 5
2017 Feb 1
2017 May10

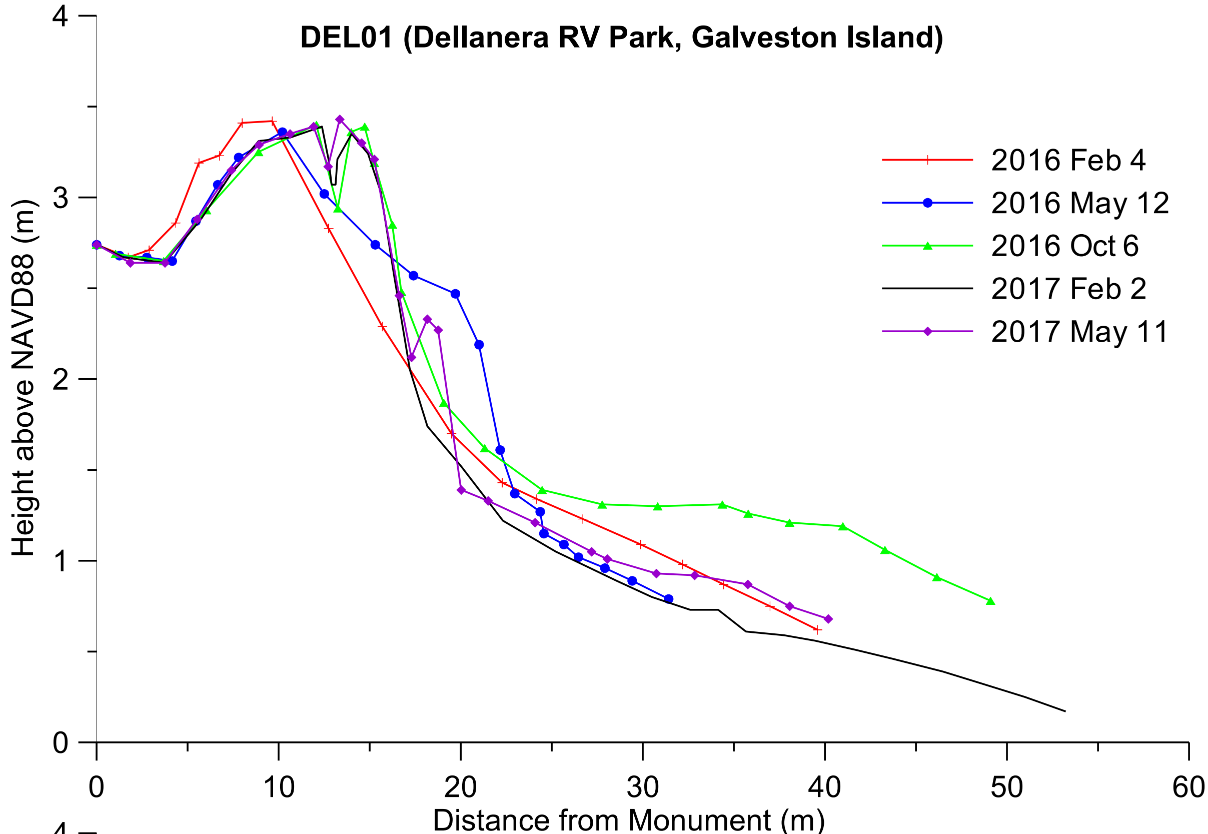

Height above NAVD88 (m)
Distance from Monument (m)
0
1
2
3
0
10
20
30
40
50
60
70
2017 Oct 4
2018 Jan 24
2018 May 17
2018 Oct 2
2019 Jan 29
vertical exaggeration = 10:1

BOL02 (West Rollover Pass, Bolivar Peninsula)

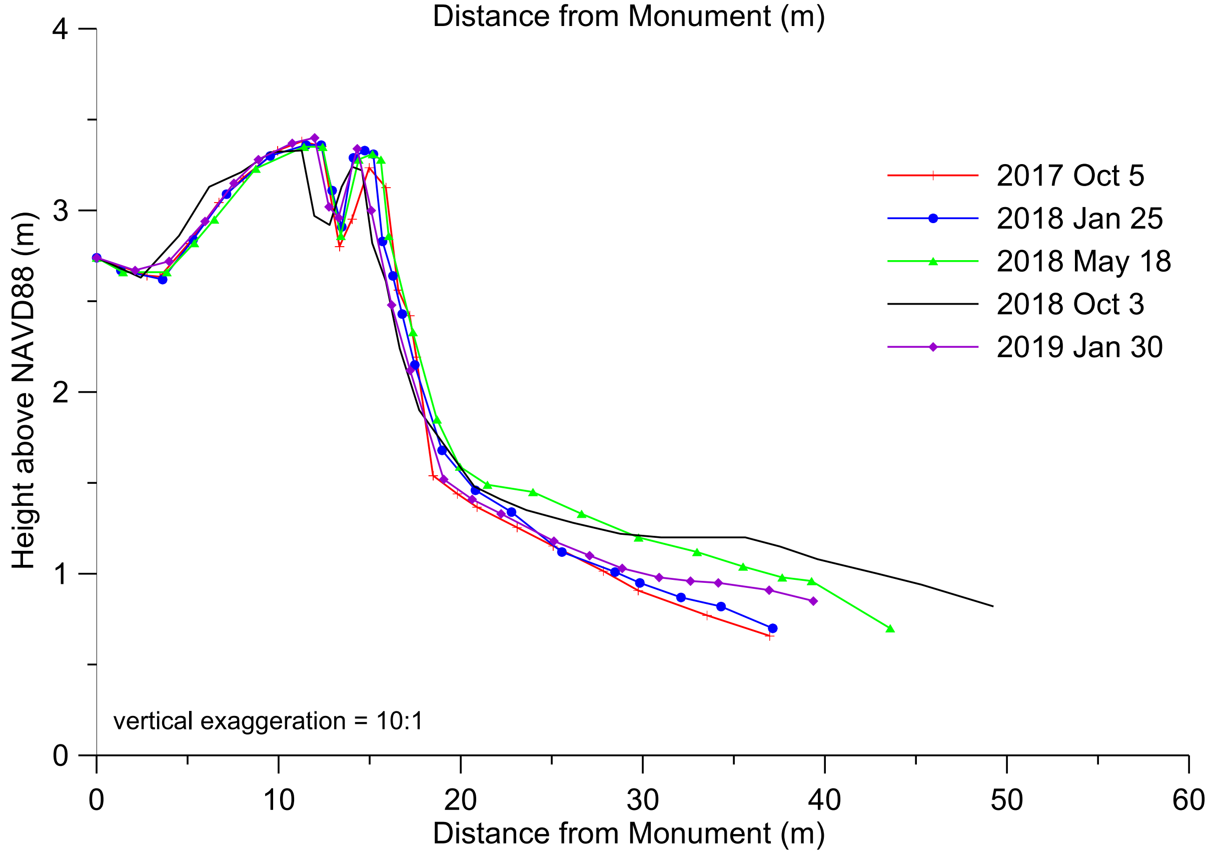




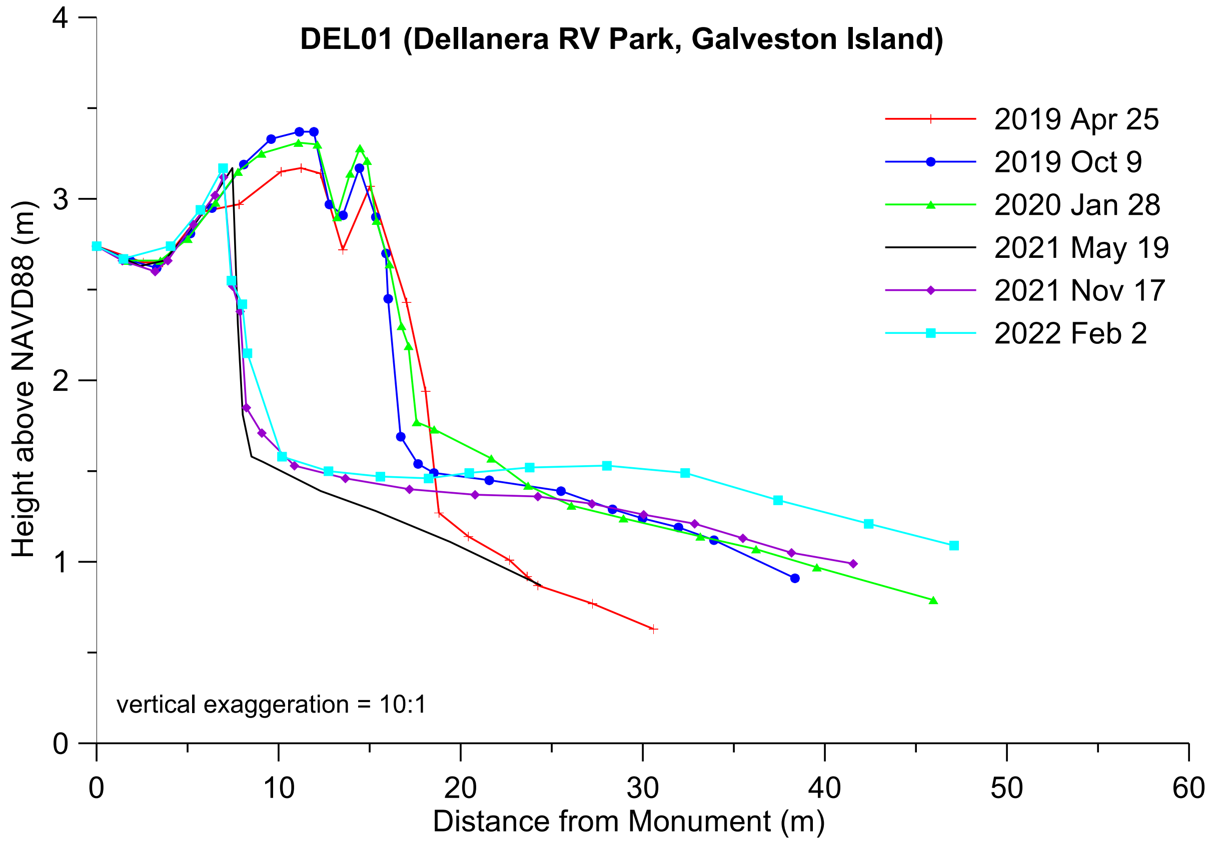
DEL01



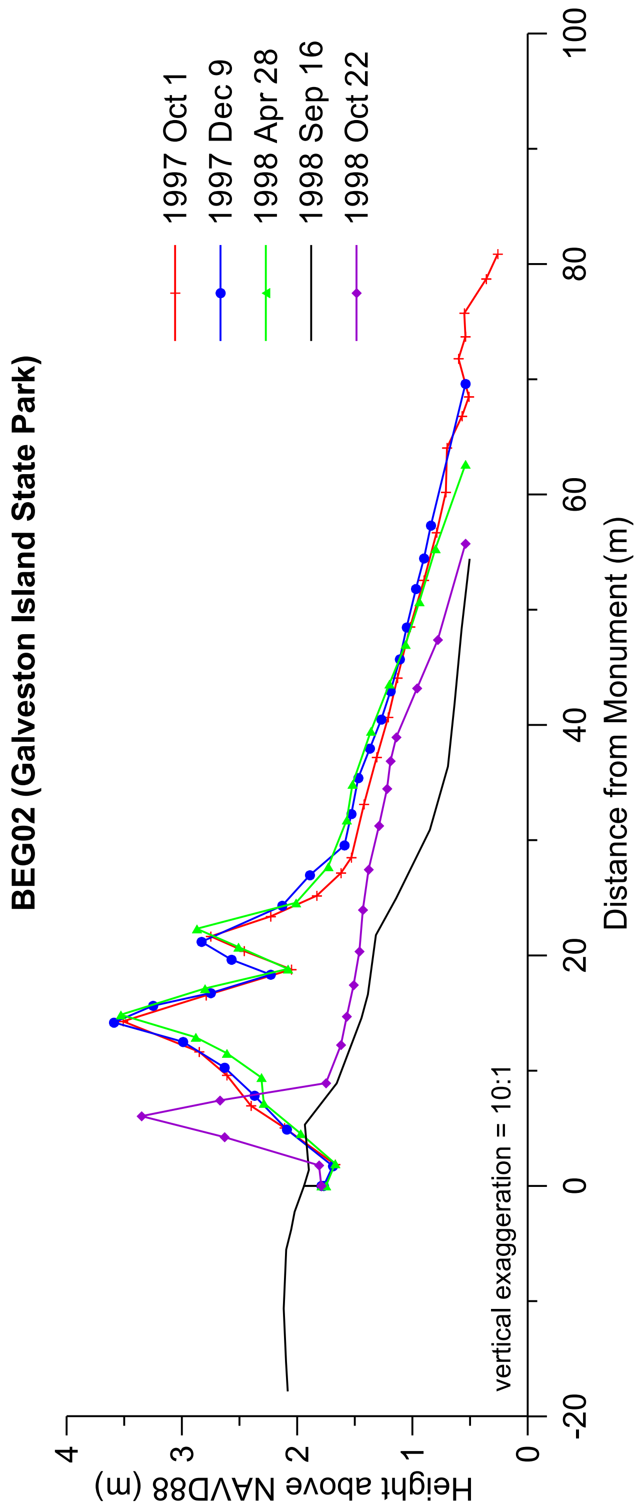
DEL01 (Dellanera RV Park, Galveston Island)
Height above NAVD88 (m)
Distance from Monument (m)
2016 Feb 4
2016 May 12
2016 Oct 6
2017 Feb 2
2017 May 11
0
1
2
3
4
0
10
20
30
40
50
60



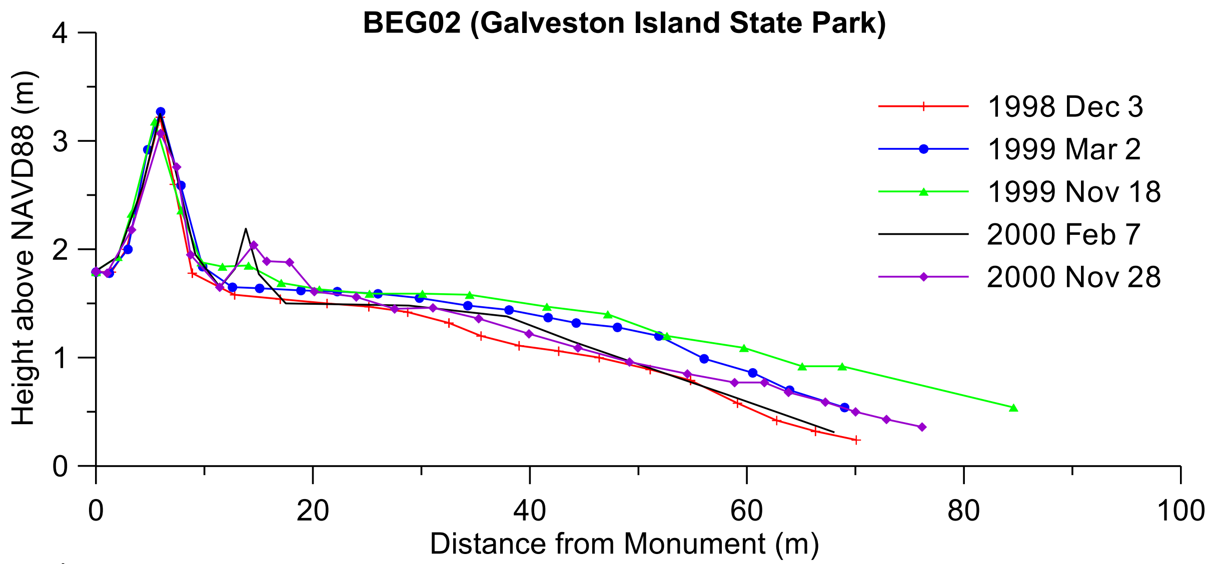
Height above NAVD88 (m)
Distance from Monument (m)
2017 Oct 5
2018 Jan 25
2018 May 18
2018 Oct 3
2019 Jan 30
vertical exaggeration = 10:1
0
1
2
3
4
0
10
20
30
40
50
60

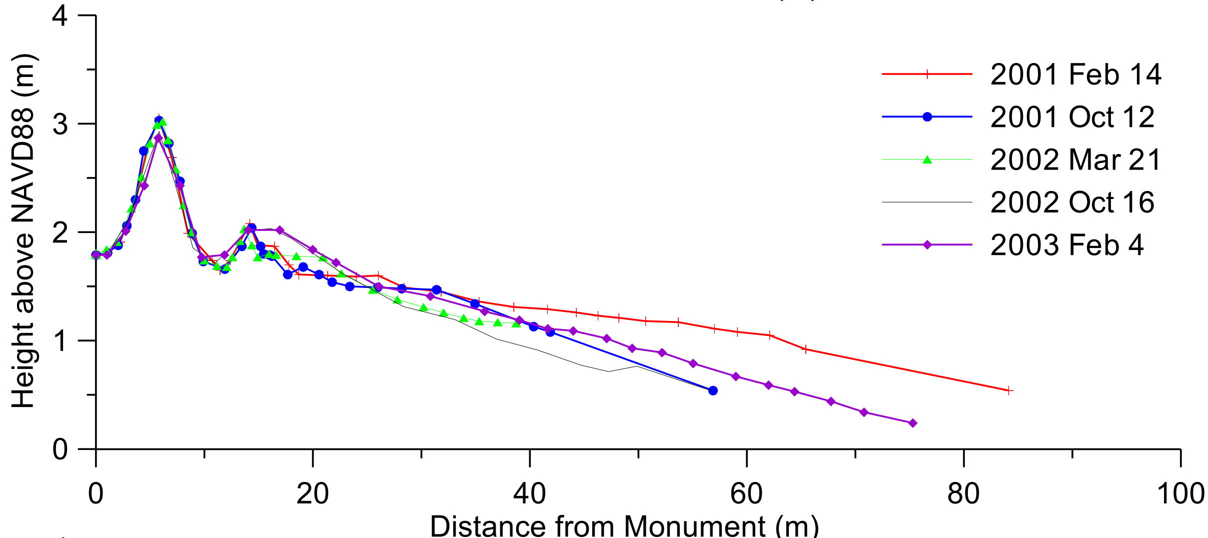

DEL01 (Dellanera RV Park, Galveston Island)
2019 Apr 25
2019 Oct 9
2020 Jan 28
2021 May 19
2021 Nov 17
2022 Feb 2
Height above NAVD88 (m)
Distance from Monument (m)
vertical exaggeration = 10:1
0
1
2
3
4
0
10
20
30
40
50
60

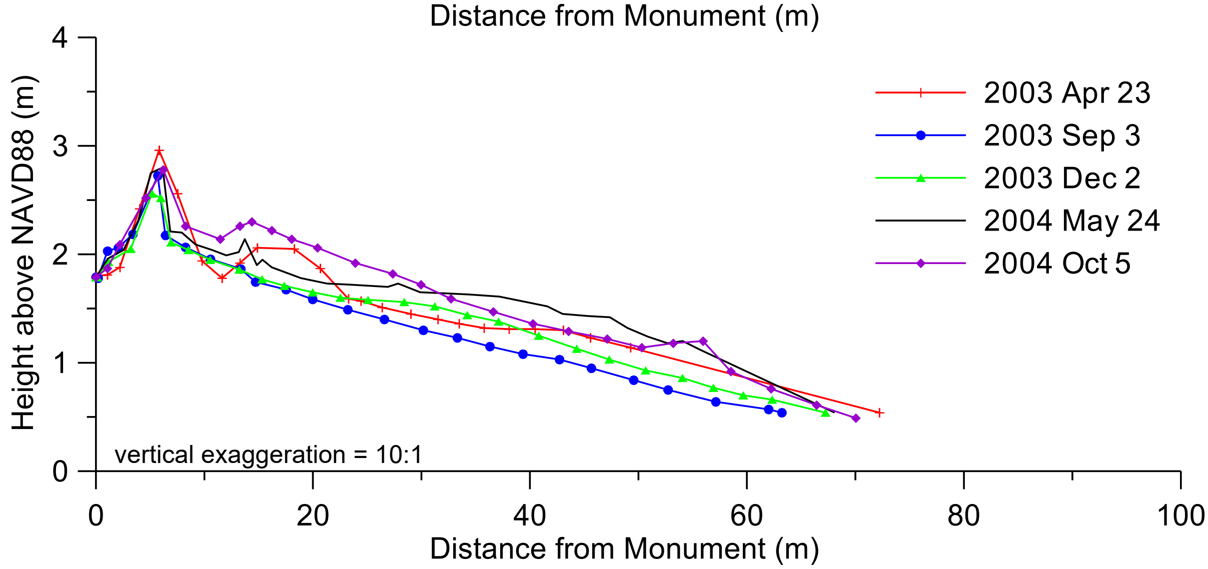
BEG02

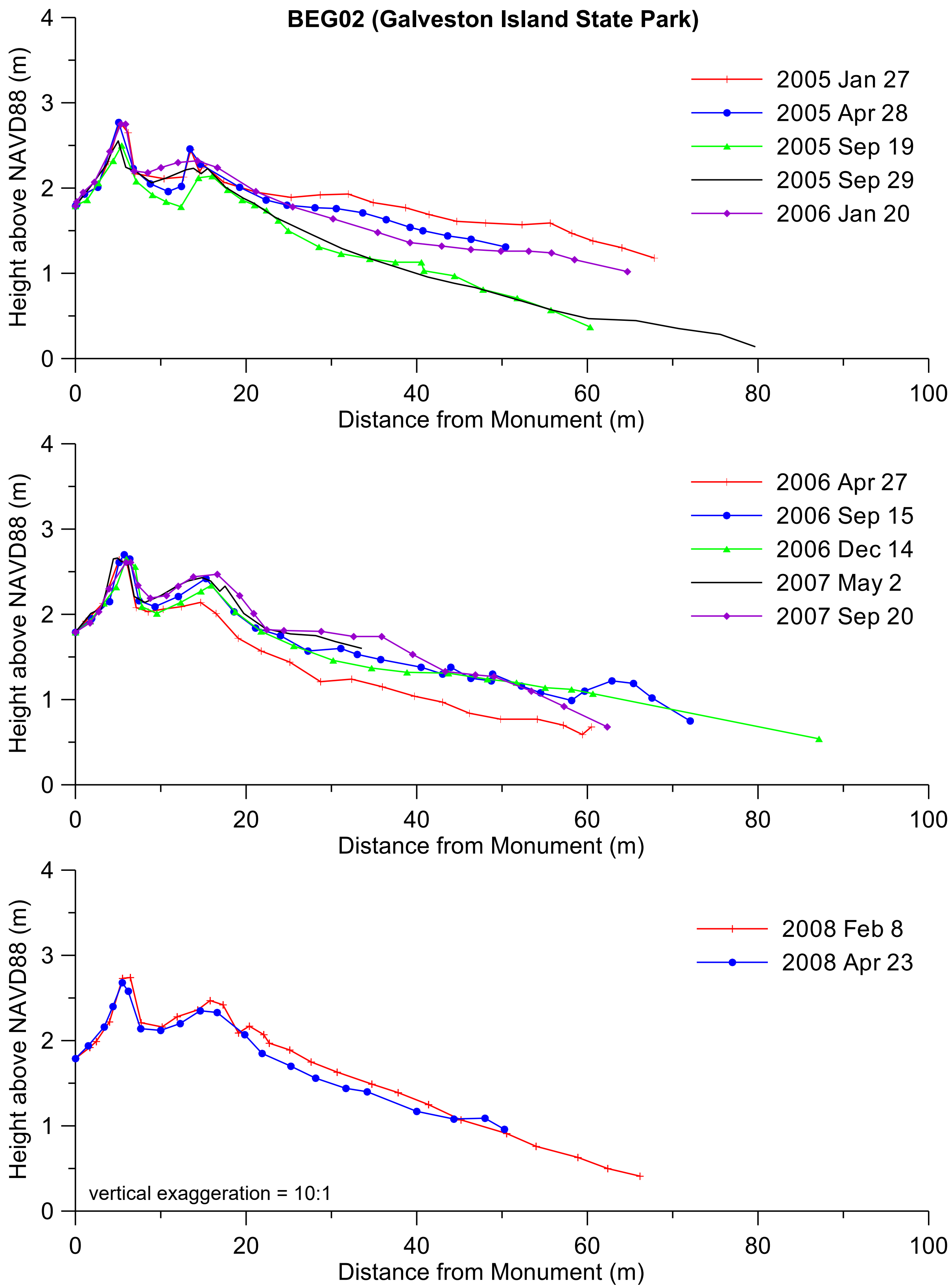


BEG02 (Galveston Island State Park)
1997 Oct 1
1997 Dec 9
1998 Apr 28
1998 Sep 16
1998 Oct 22
vertical exaggeration = 10:1
Height above NAVD88 (m)
Distance from Monument (m)
-20
0
20
40
60
80
100
0
1
2
3
4

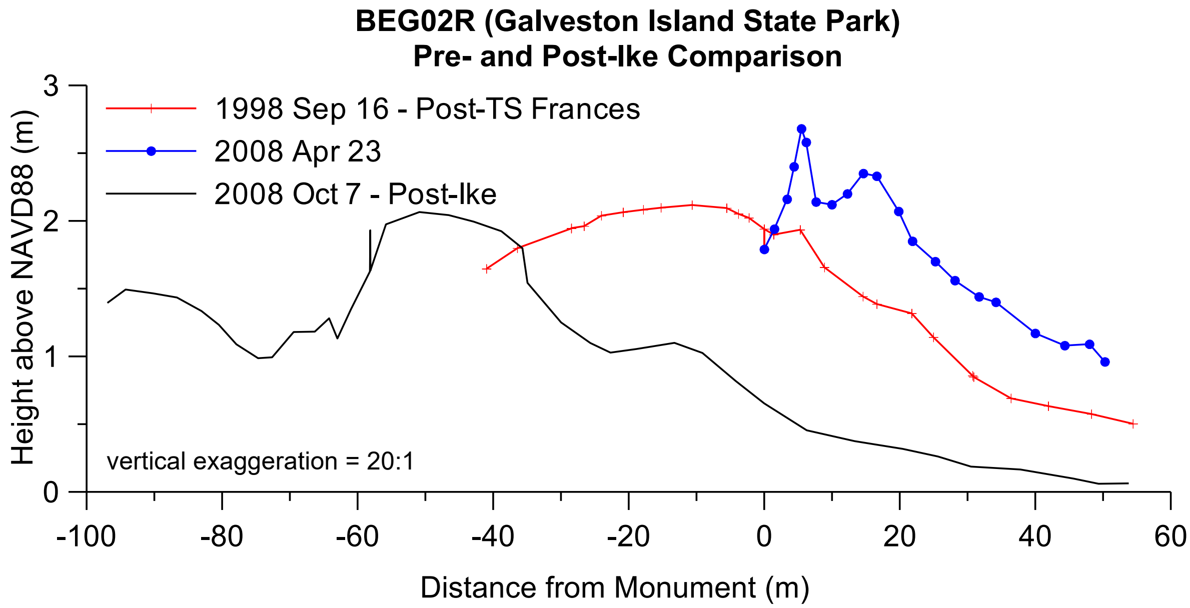

BEG02 (Galveston Island State Park)
Height above NAVD88 (m)
Distance from Monument (m)
1998 Dec 3
1999 Mar 2
1999 Nov 18
2000 Feb 7
2000 Nov 28

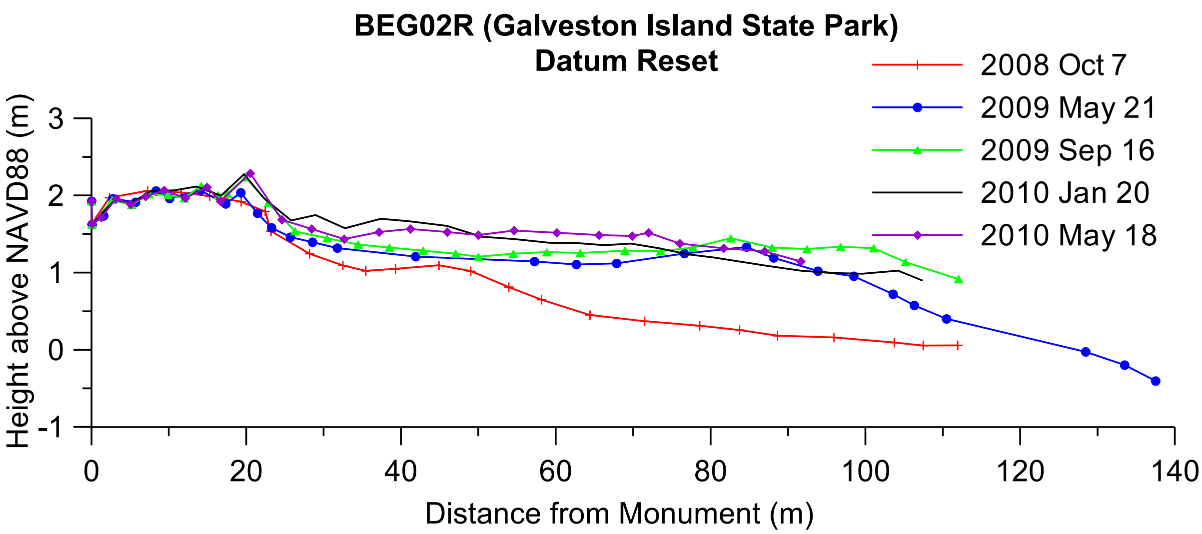

Height above NAVD88 (m)
Distance from Monument (m)
2001 Feb 14
2001 Oct 12
2002 Mar 21
2002 Oct 16
2003 Feb 4

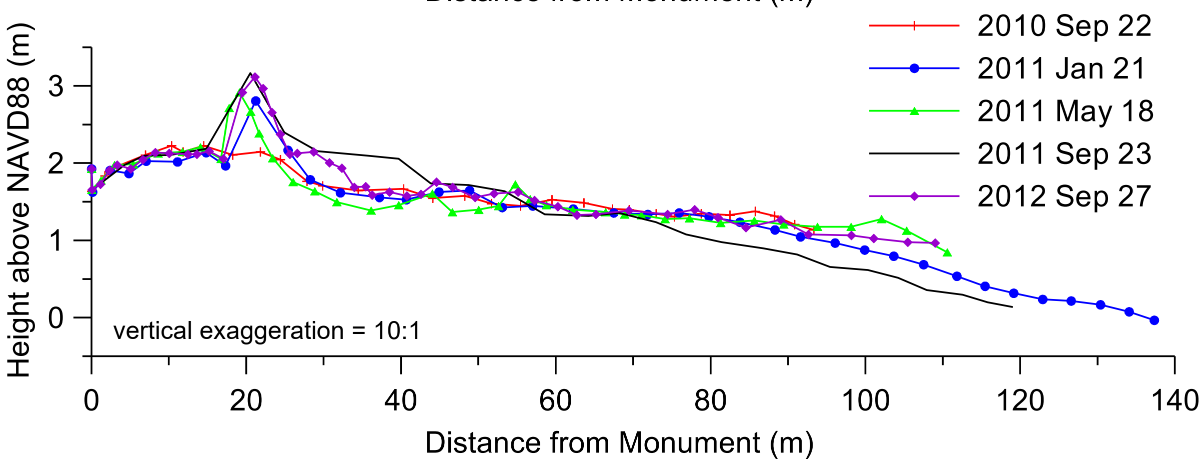

Height above NAVD88 (m)
Distance from Monument (m)
2003 Apr 23
2003 Sep 3
2003 Dec 2
2004 May 24
2004 Oct 5
vertical exaggeration = 10:1


BEG02 (Galveston Island State Park)
Height above NAVD88 (m)
Distance from Monument (m)
2005 Jan 27
2005 Apr 28
2005 Sep 19
2005 Sep 29
2006 Jan 20
2006 Apr 27
2006 Sep 15
2006 Dec 14
2007 May 2
2007 Sep 20
2008 Feb 8
2008 Apr 23
vertical exaggeration = 10:1

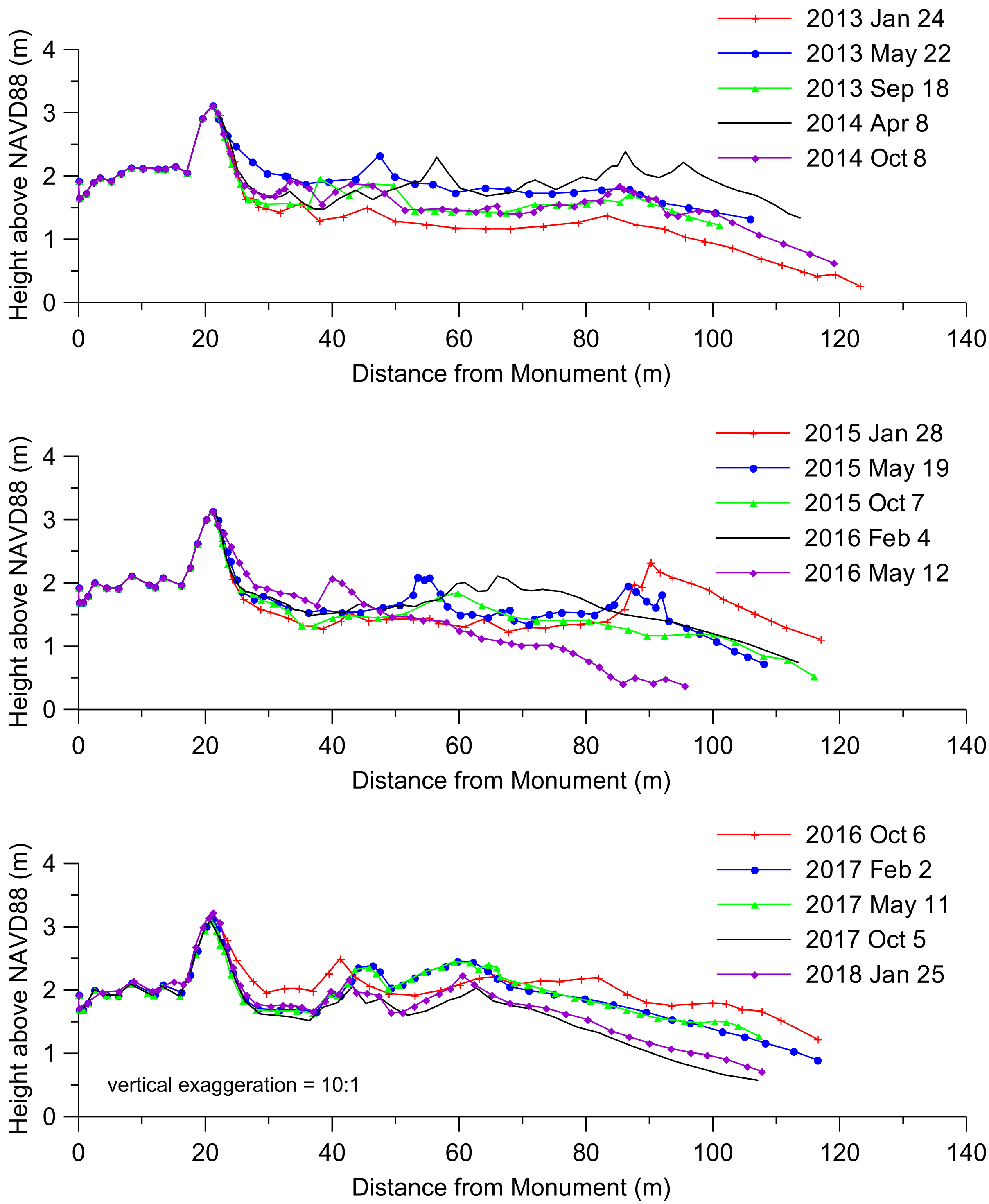
BEG02R

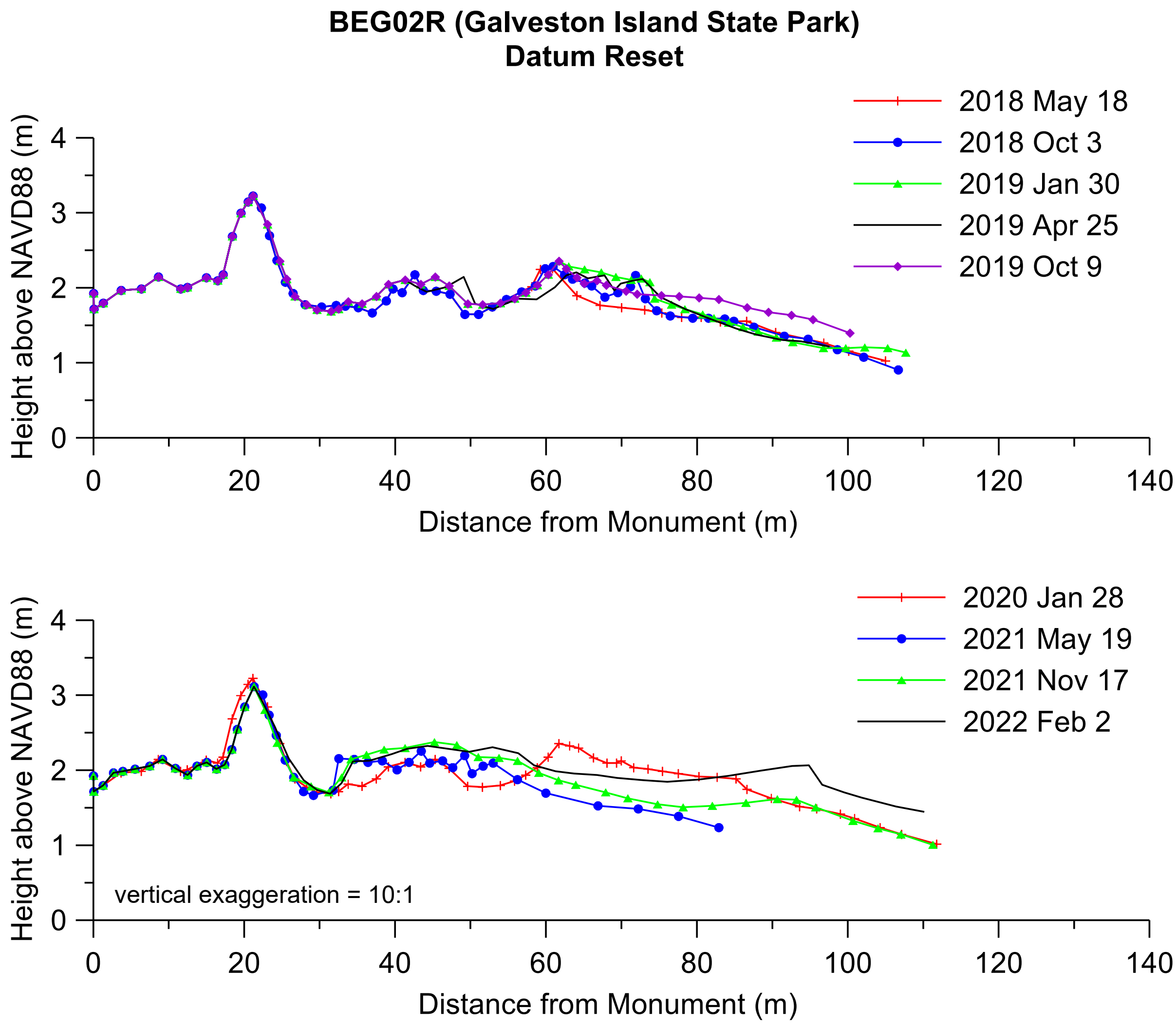

BEG02R (Galveston Island State Park)
Pre- and Post-Ike Comparison
1998 Sep 16 - Post-TS Frances
2008 Apr 23
2008 Oct 7 - Post-Ike
vertical exaggeration = 20:1
Height above NAVD88 (m)
Distance from Monument (m)
3
2
1
0
-100
-80
-60
-40
-20
0
20
40
60


BEG02R (Galveston Island State Park)
Datum Reset
2008 Oct 7
2009 May 21
2009 Sep 16
2010 Jan 20
2010 May 18
Height above NAVD88 (m)
Distance from Monument (m)
3
2
1
0
-1
0
20
40
60
80
100
120
140


2010 Sep 22
2011 Jan 21
2011 May 18
2011 Sep 23
2012 Sep 27
vertical exaggeration = 10:1
Height above NAVD88 (m)
Distance from Monument (m)
3
2
1
0
0
20
40
60
80
100
120
140

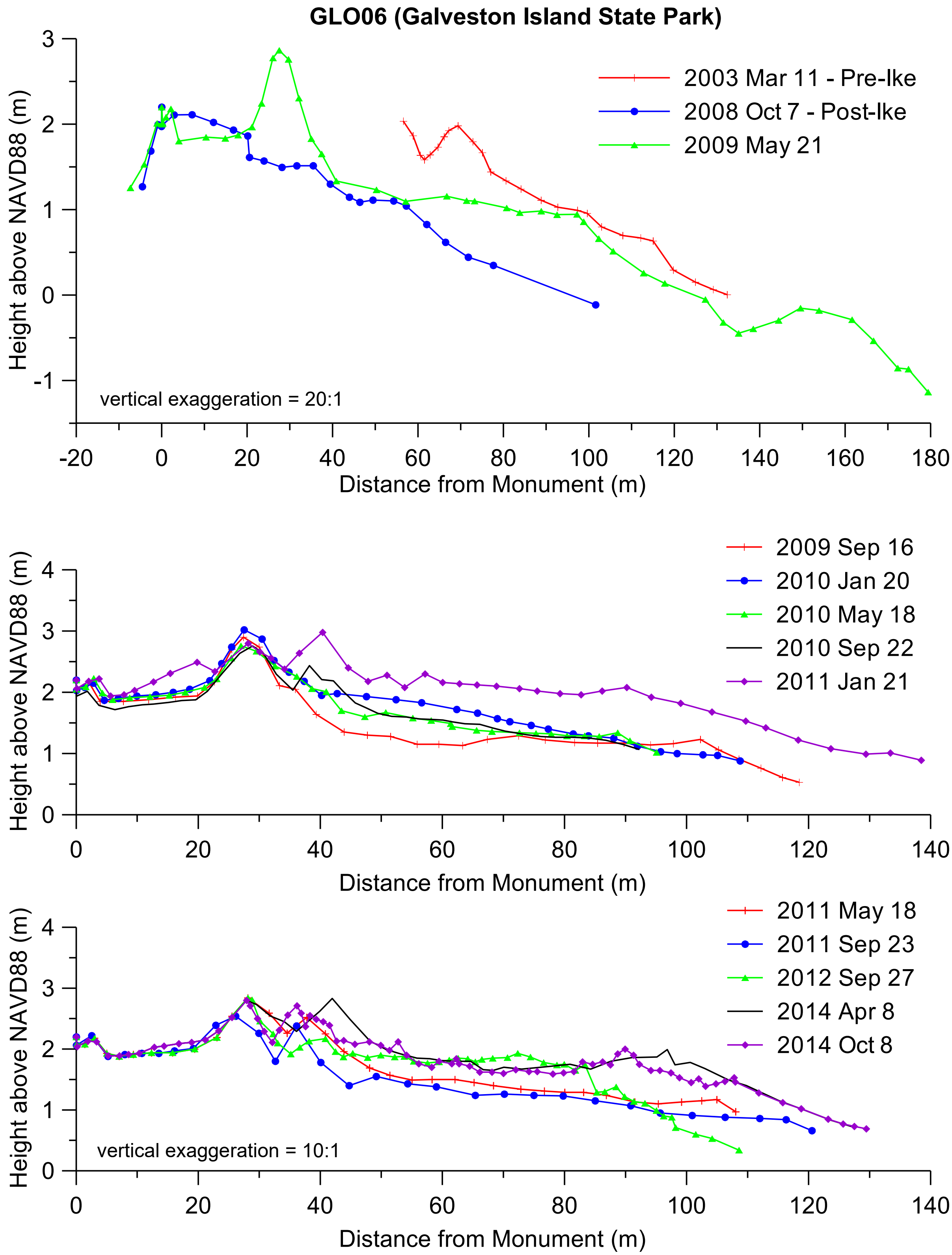
BEG02R (Galveston Island State Park)
Datum Reset

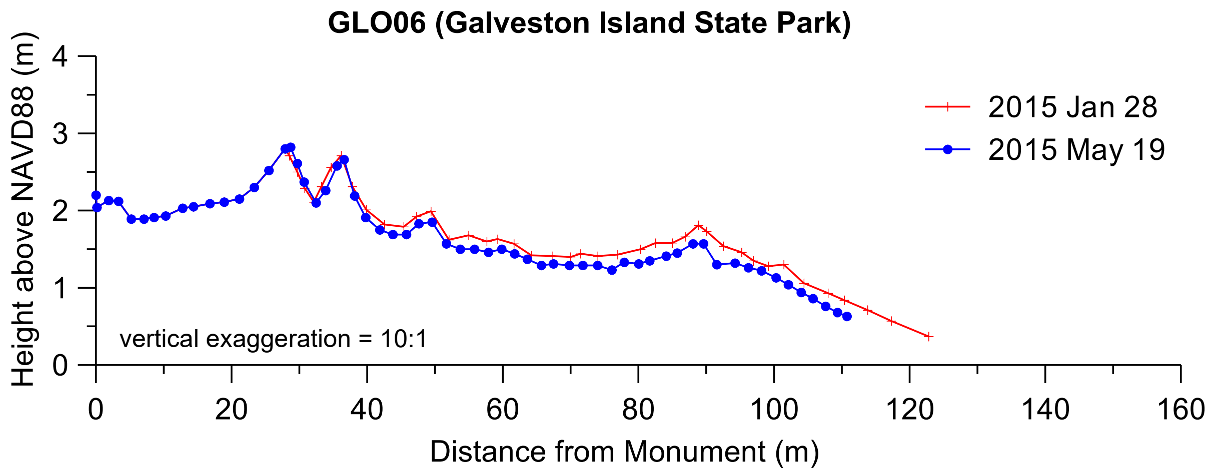




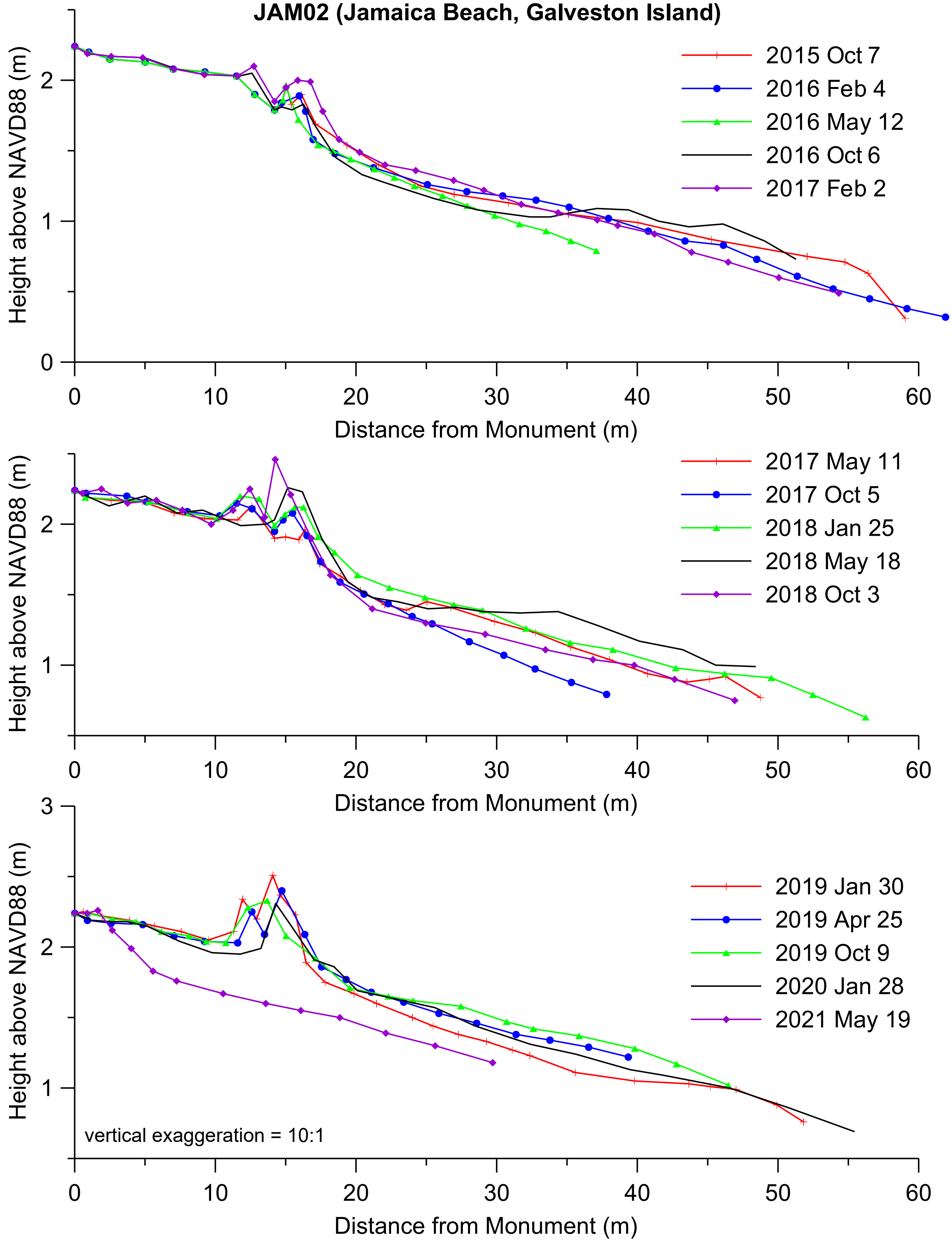
BEG02R (Galveston Island State Park)
Datum Reset
2018 May 18
2018 Oct 3
2019 Jan 30
2019 Apr 25
2019 Oct 9
Height above NAVD88 (m)
Distance from Monument (m)
2020 Jan 28
2021 May 19
2021 Nov 17
2022 Feb 2
vertical exaggeration = 10:1

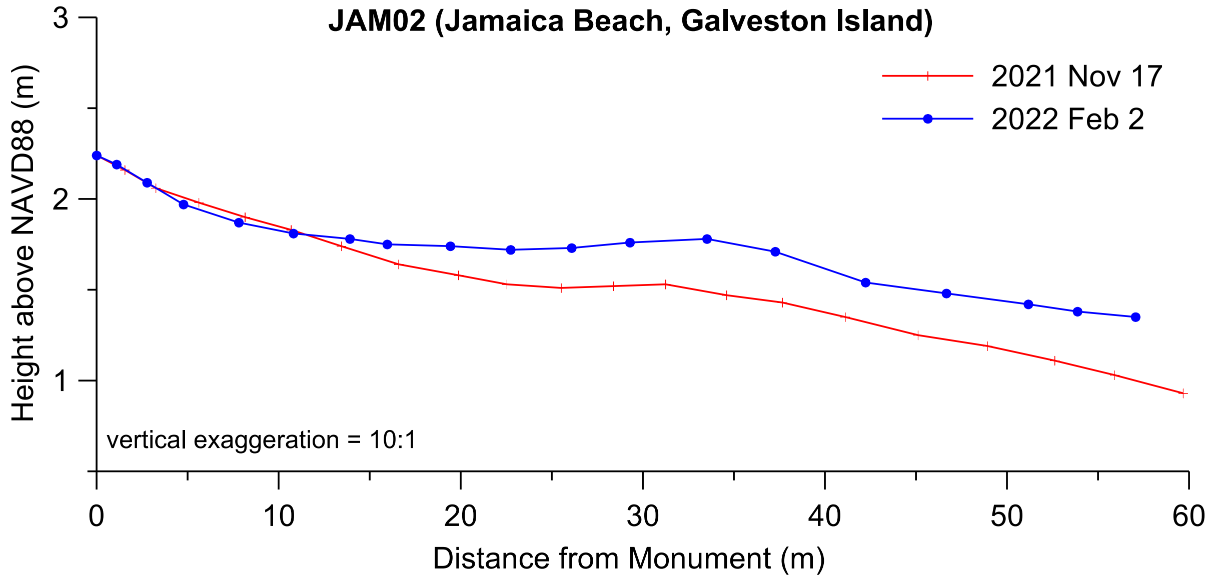
GLO06


GLO06 (Galveston Island State Park)
2003 Mar 11 - Pre-Ike
2008 Oct 7 - Post-Ike
2009 May 21
vertical exaggeration = 20:1
Height above NAVD88 (m)
Distance from Monument (m)
2009 Sep 16
2010 Jan 20
2010 May 18
2010 Sep 22
2011 Jan 21
Height above NAVD88 (m)
Distance from Monument (m)
2011 May 18
2011 Sep 23
2012 Sep 27
2014 Apr 8
2014 Oct 8
vertical exaggeration = 10:1
Height above NAVD88 (m)
Distance from Monument (m)


GLO06 (Galveston Island State Park)
Height above NAVD88 (m)
Distance from Monument (m)
2015 Jan 28
2015 May 19
vertical exaggeration = 10:1
0
1
2
3
4
0
20
40
60
80
100
120
140
160

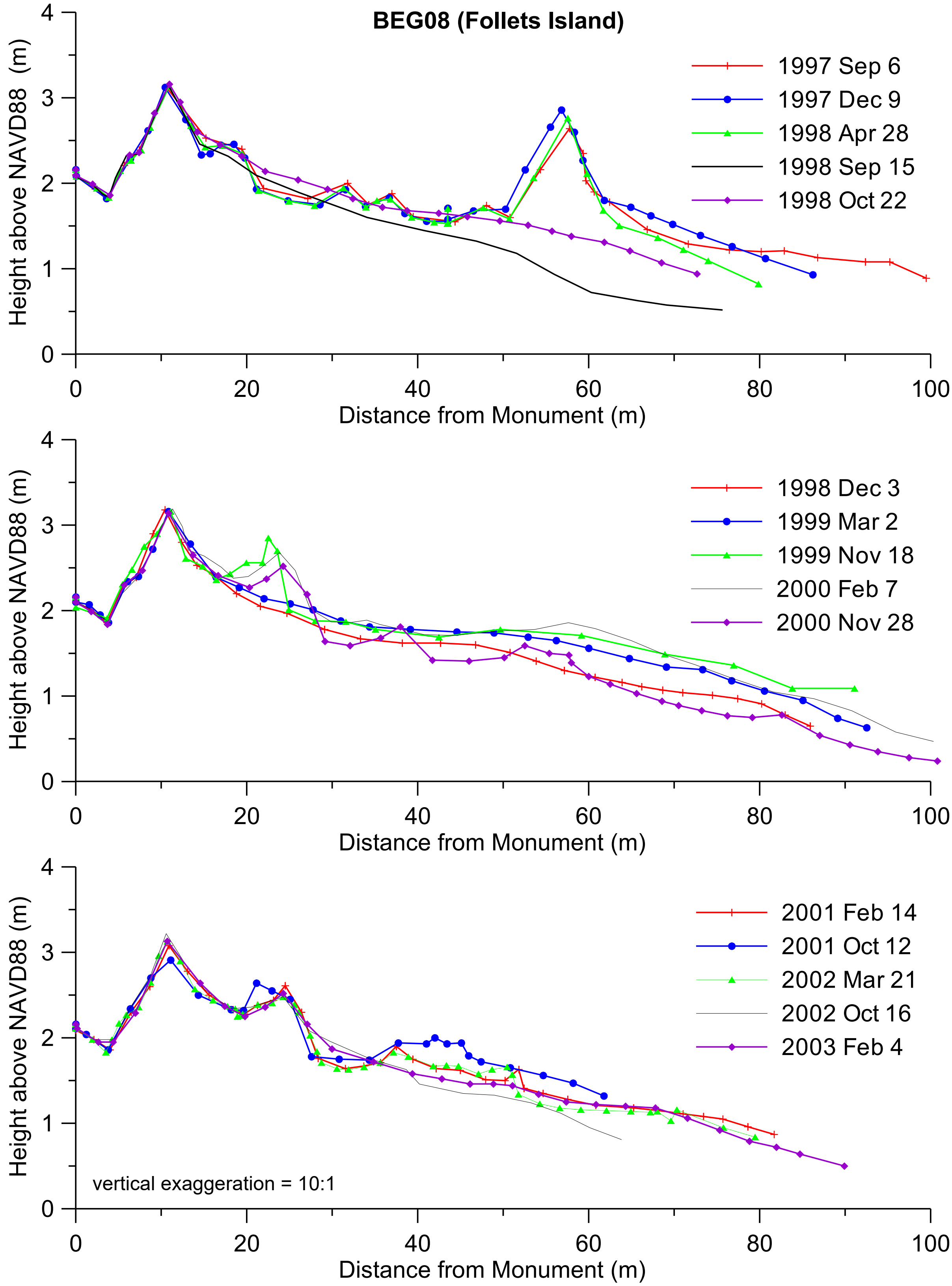
JAM02

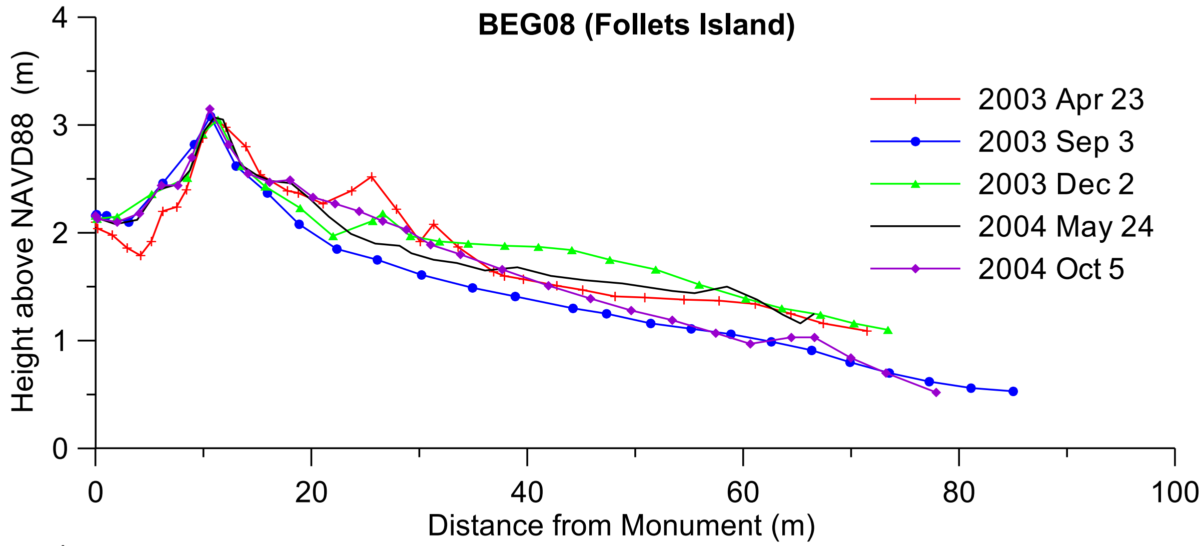

JAM02 (Jamaica Beach, Galveston Island)
2015 Oct 7
2016 Feb 4
2016 May 12
2016 Oct 6
2017 Feb 2
Height above NAVD88 (m)
Distance from Monument (m)
2017 May 11
2017 Oct 5
2018 Jan 25
2018 May 18
2018 Oct 3
2019 Jan 30
2019 Apr 25
2019 Oct 9
2020 Jan 28
2021 May 19
vertical exaggeration = 10:1



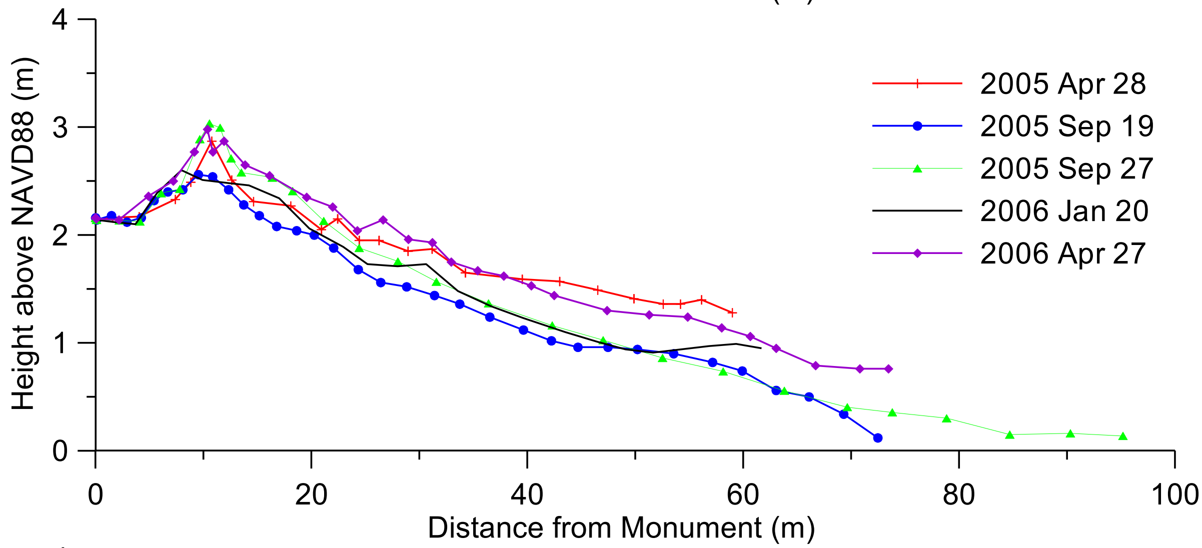
JAM02 (Jamaica Beach, Galveston Island)
2021 Nov 17
2022 Feb 2
Height above NAVD88 (m)
3
2
1
vertical exaggeration = 10:1
0
10
20
30
40
50
60
Distance from Monument (m)

BEG08

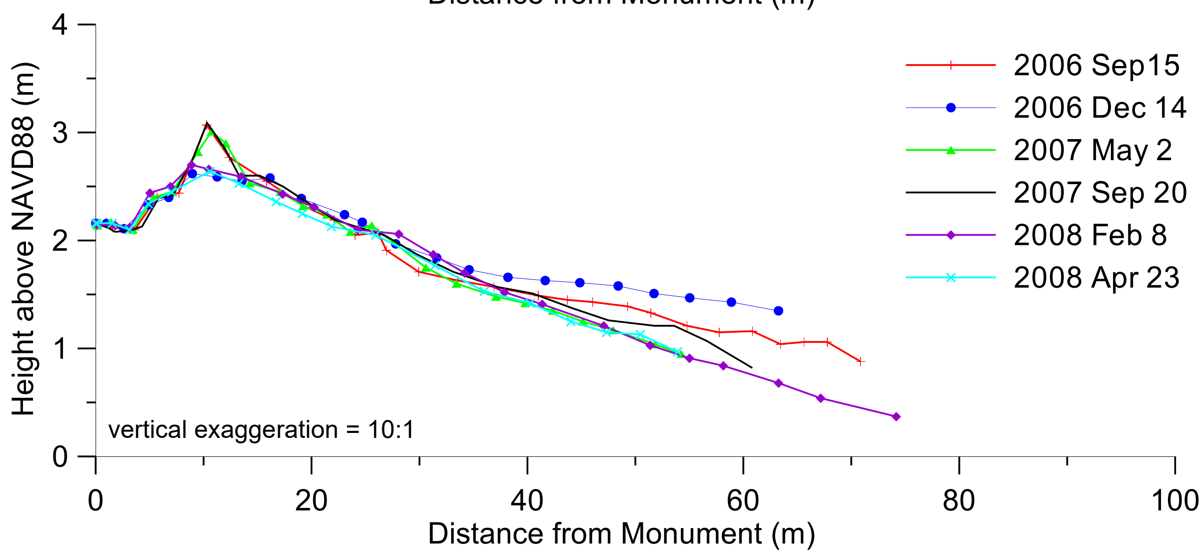

BEG08 (Follets Island)
Height above NAVD88 (m)
Distance from Monument (m)
1997 Sep 6
1997 Dec 9
1998 Apr 28
1998 Sep 15
1998 Oct 22
1998 Dec 3
1999 Mar 2
1999 Nov 18
2000 Feb 7
2000 Nov 28
2001 Feb 14
2001 Oct 12
2002 Mar 21
2002 Oct 16
2003 Feb 4
vertical exaggeration = 10:1
0
1
2
3
4
0
20
40
60
80
100



BEGO8 (Follets Island)
Height above NAVD88 (m)
Distance from Monument (m)
2003 Apr 23
2003 Sep 3
2003 Dec 2
2004 May 24
2004 Oct 5

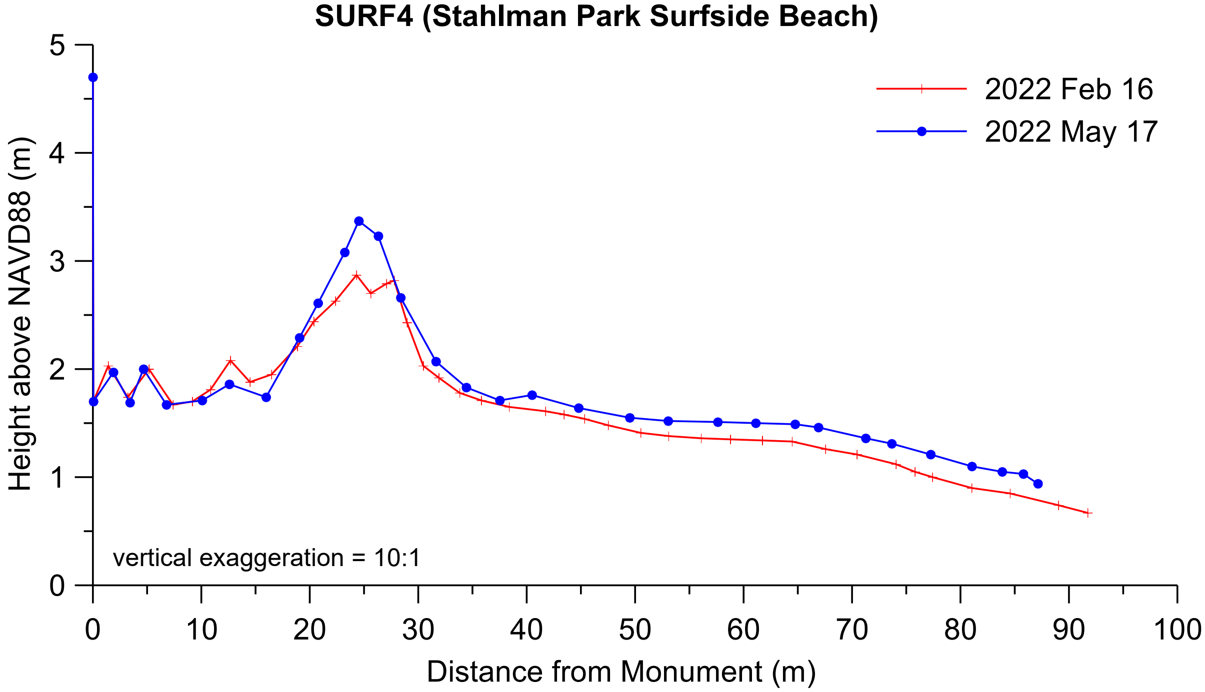


Height above NAVD88 (m)
Distance from Monument (m)
2005 Apr 28
2005 Sep 19
2005 Sep 27
2006 Jan 20
2006 Apr 27



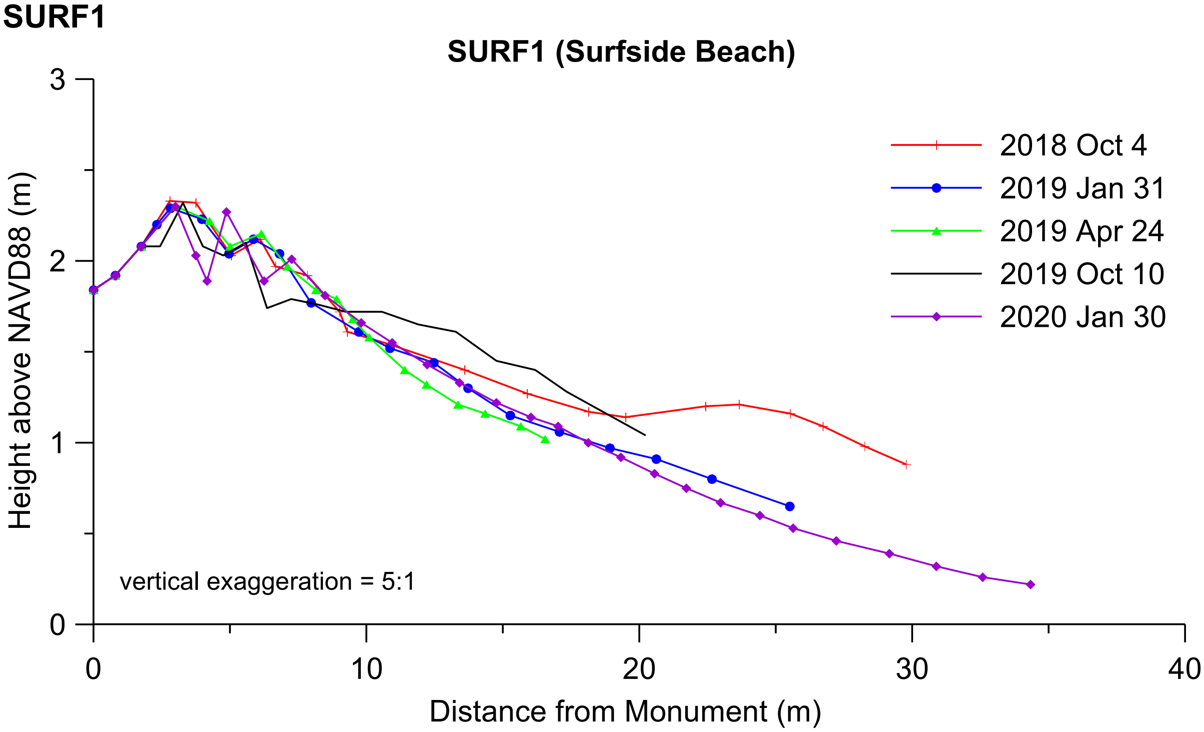
Height above NAVD88 (m)
Distance from Monument (m)
2006 Sep15
2006 Dec 14
2007 May 2
2007 Sep 20
2008 Feb 8
2008 Apr 23
vertical exaggeration = 10:1

SURF4



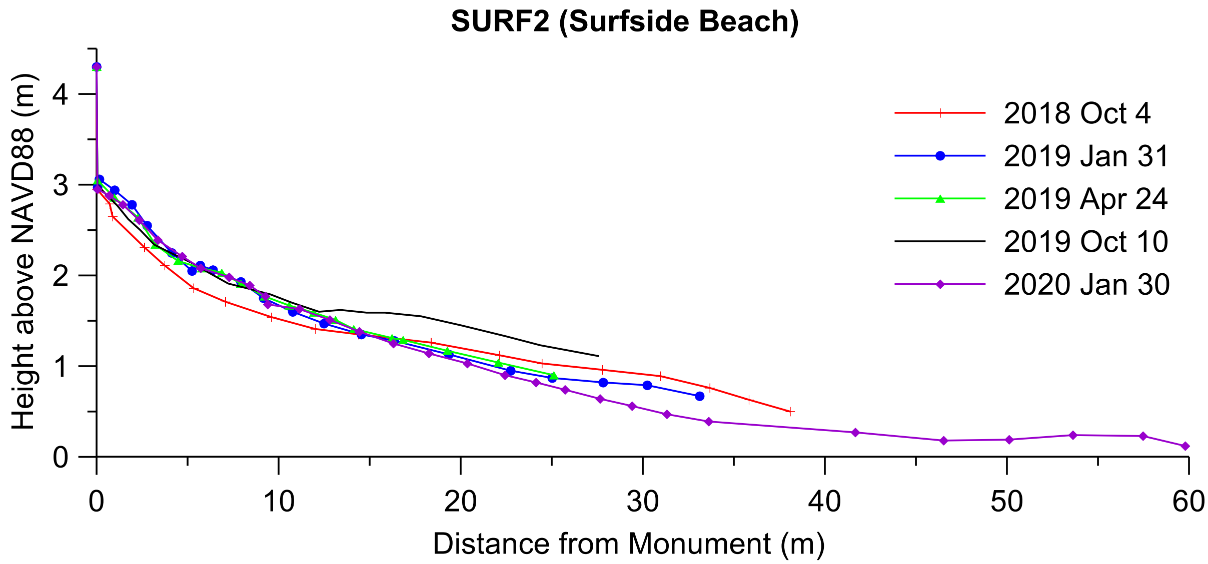
SURF4 (Stahlman Park Surfside Beach)
2022 Feb 16
2022 May 17
Height above NAVD88 (m)
Distance from Monument (m)
vertical exaggeration = 10:1
0
1
2
3
4
5
0
10
20
30
40
50
60
70
80
90
100

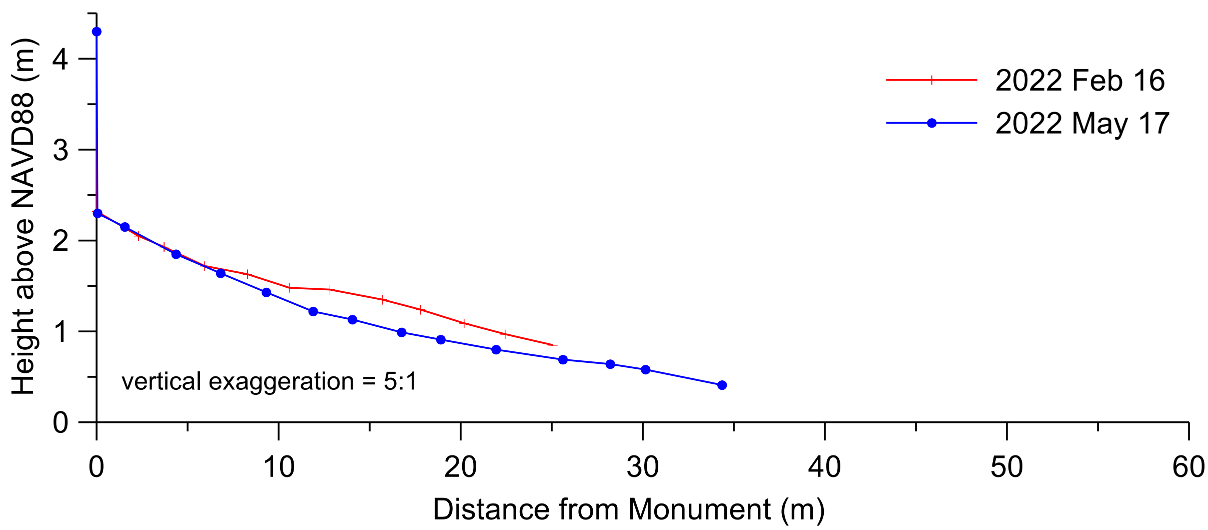
SURF1



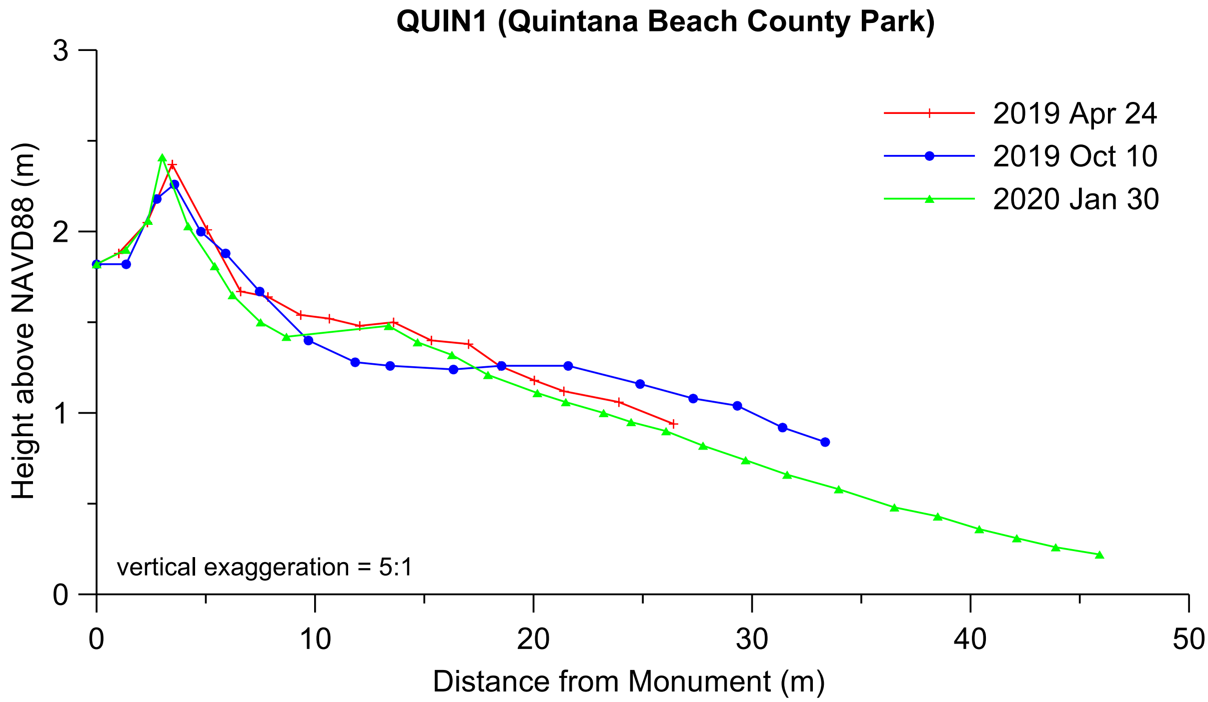
SURF1 (Surfside Beach)
2018 Oct 4
2019 Jan 31
2019 Apr 24
2019 Oct 10
2020 Jan 30
Height above NAVD88 (m)
Distance from Monument (m)
vertical exaggeration = 5:1
0
1
2
3
0
10
20
30
40

SURF2


SURF2 (Surfside Beach)
Height above NAVD88 (m)
Distance from Monument (m)
2018 Oct 4
2019 Jan 31
2019 Apr 24
2019 Oct 10
2020 Jan 30
0
1
2
3
4
0
10
20
30
40
50
60

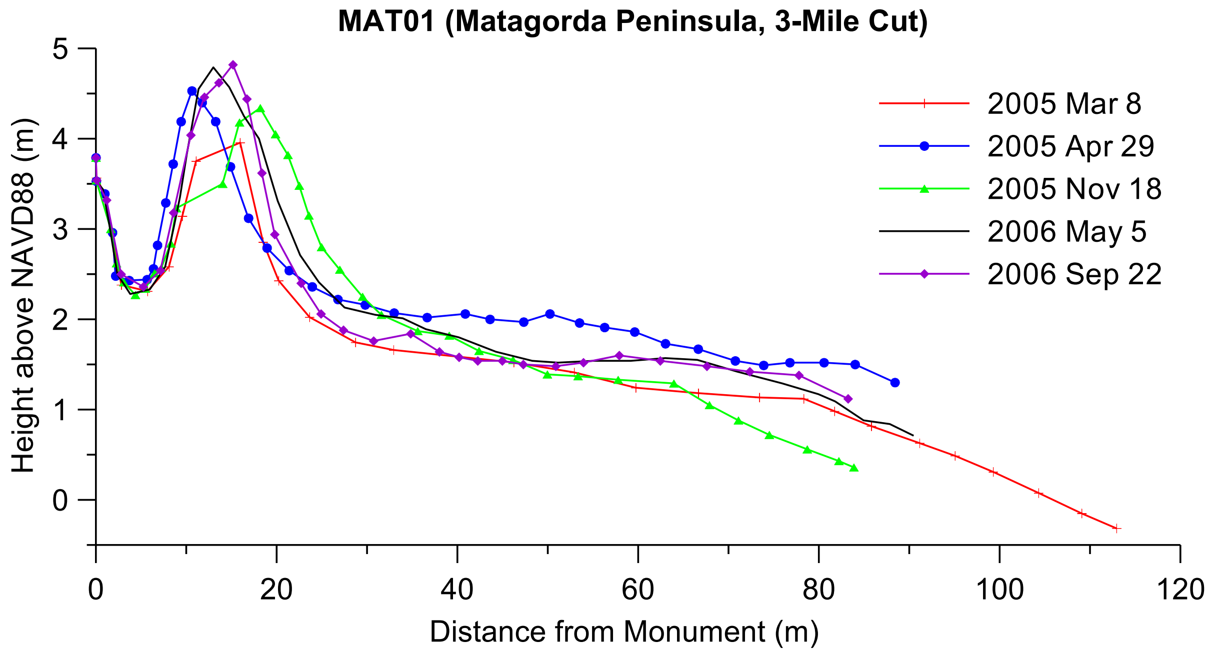

Height above NAVD88 (m)
Distance from Monument (m)
2022 Feb 16
2022 May 17
vertical exaggeration = 5:1
0
1
2
3
4
0
10
20
30
40
50
60

QUIN1

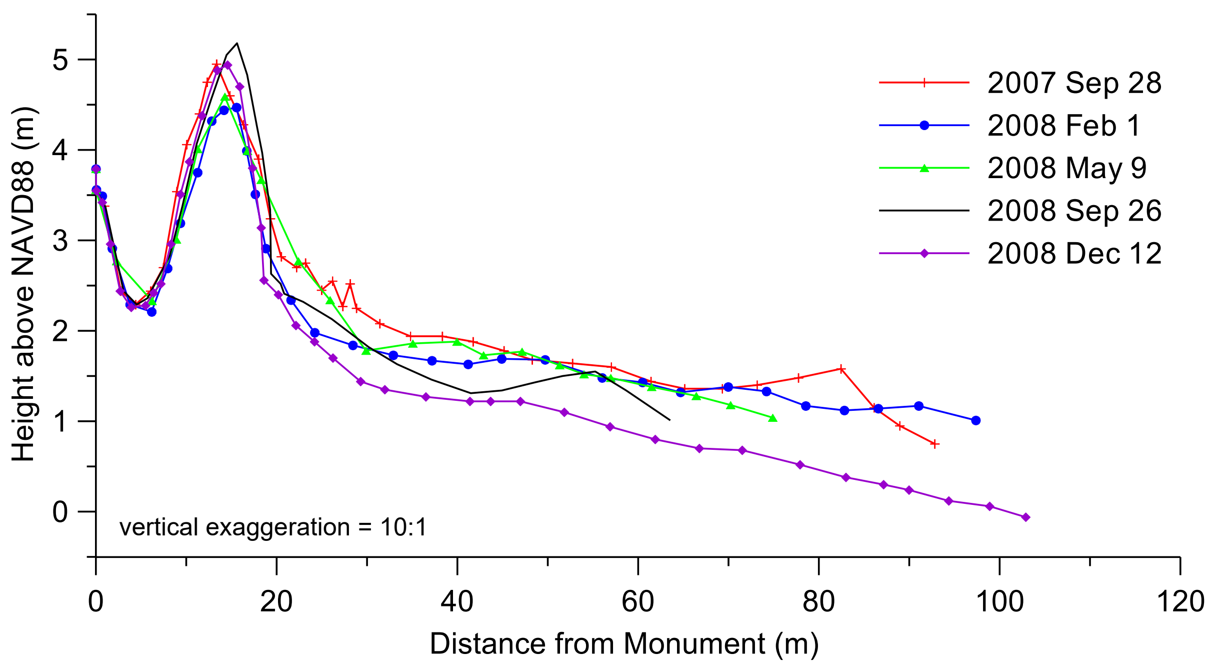


QUIN1 (Quintana Beach County Park)
Height above NAVD88 (m)
Distance from Monument (m)
2019 Apr 24
2019 Oct 10
2020 Jan 30
vertical exaggeration = 5:1
0
1
2
3
0
10
20
30
40
50

MAT01

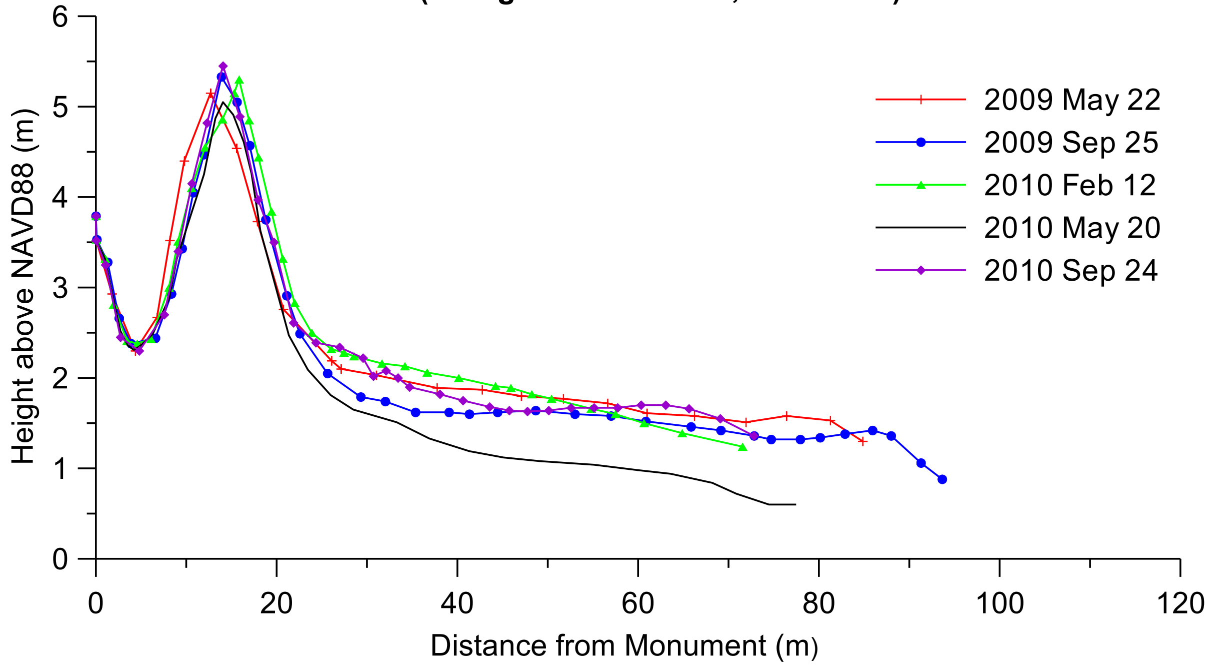


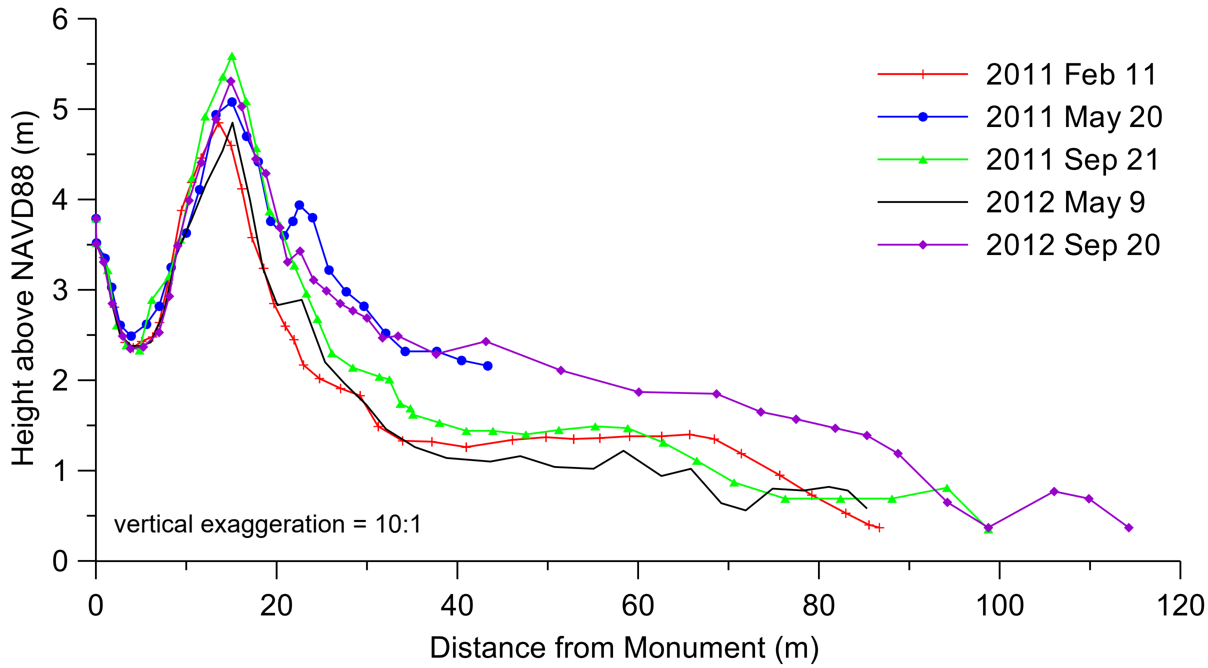
MAT01 (Matagorda Peninsula, 3-Mile Cut)
Height above NAVD88 (m)
Distance from Monument (m)
2005 Mar 8
2005 Apr 29
2005 Nov 18
2006 May 5
2006 Sep 22

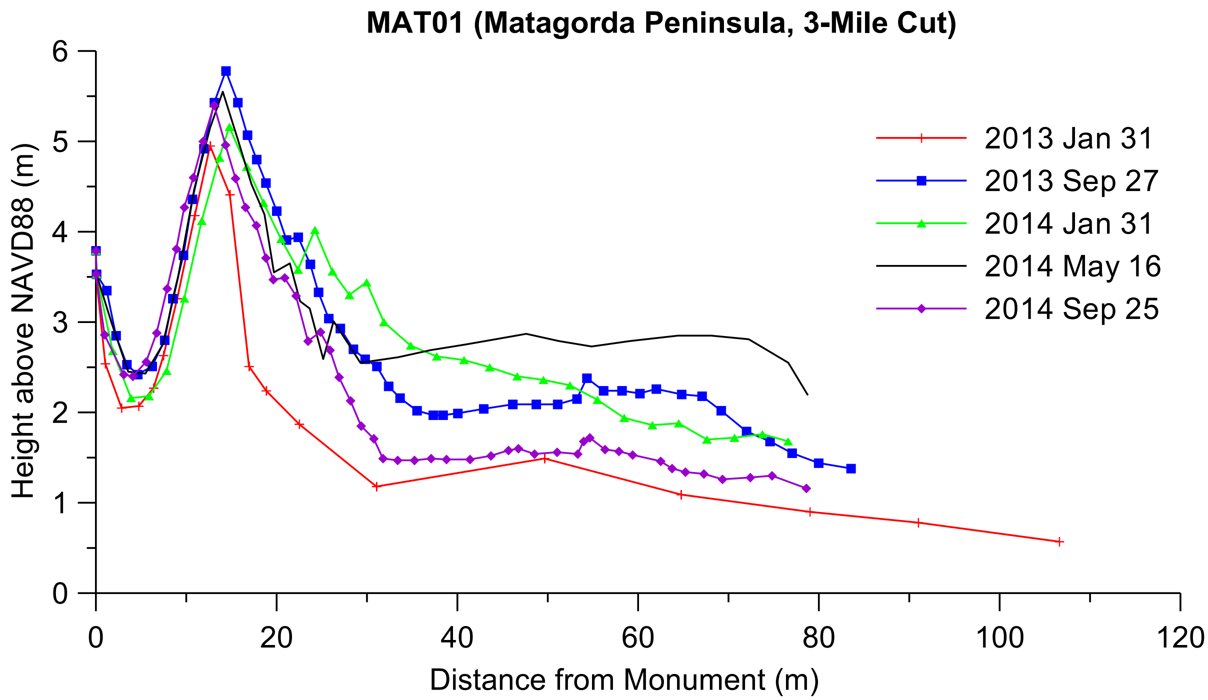


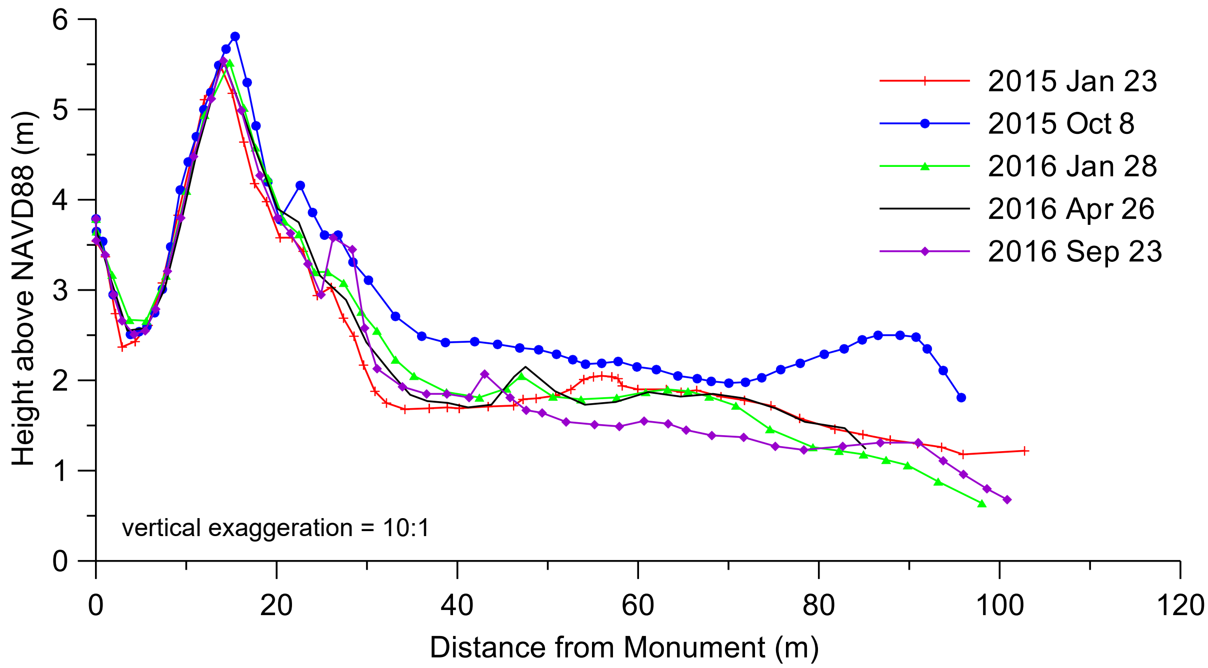
Height above NAVD88 (m)
Distance from Monument (m)
2007 Sep 28
2008 Feb 1
2008 May 9
2008 Sep 26
2008 Dec 12
vertical exaggeration = 10:1

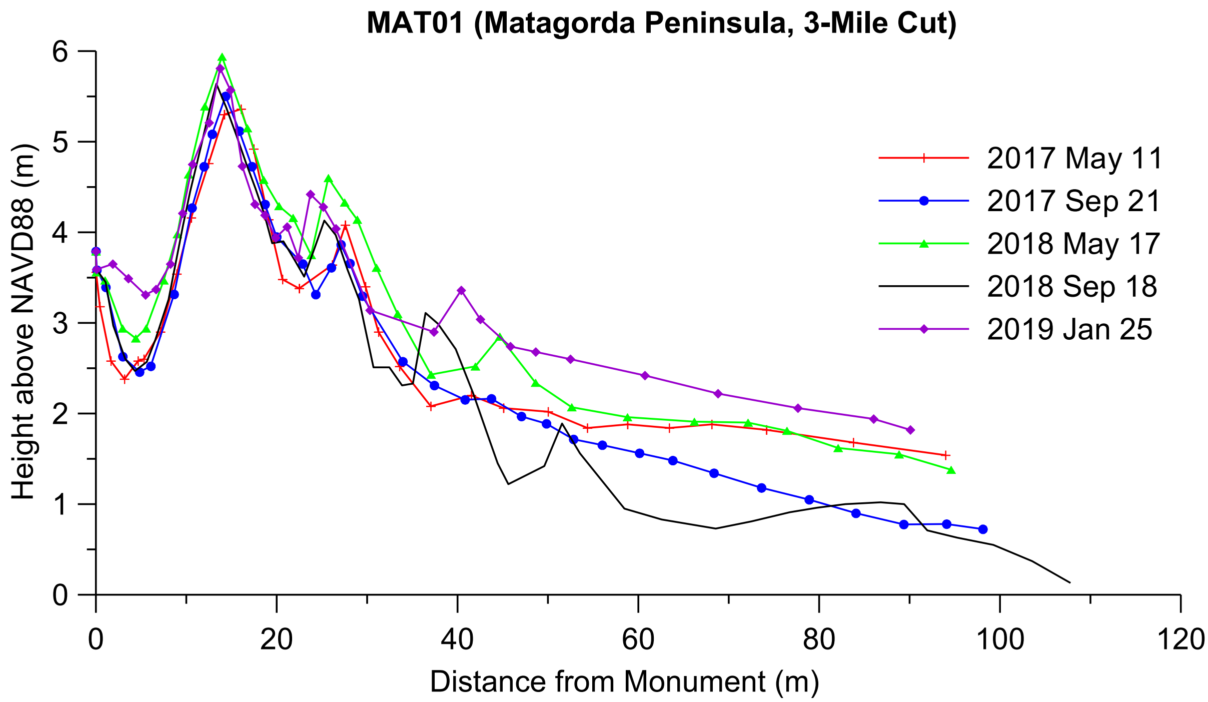
MAT01 (Matagorda Peninsula, 3-Mile Cut)

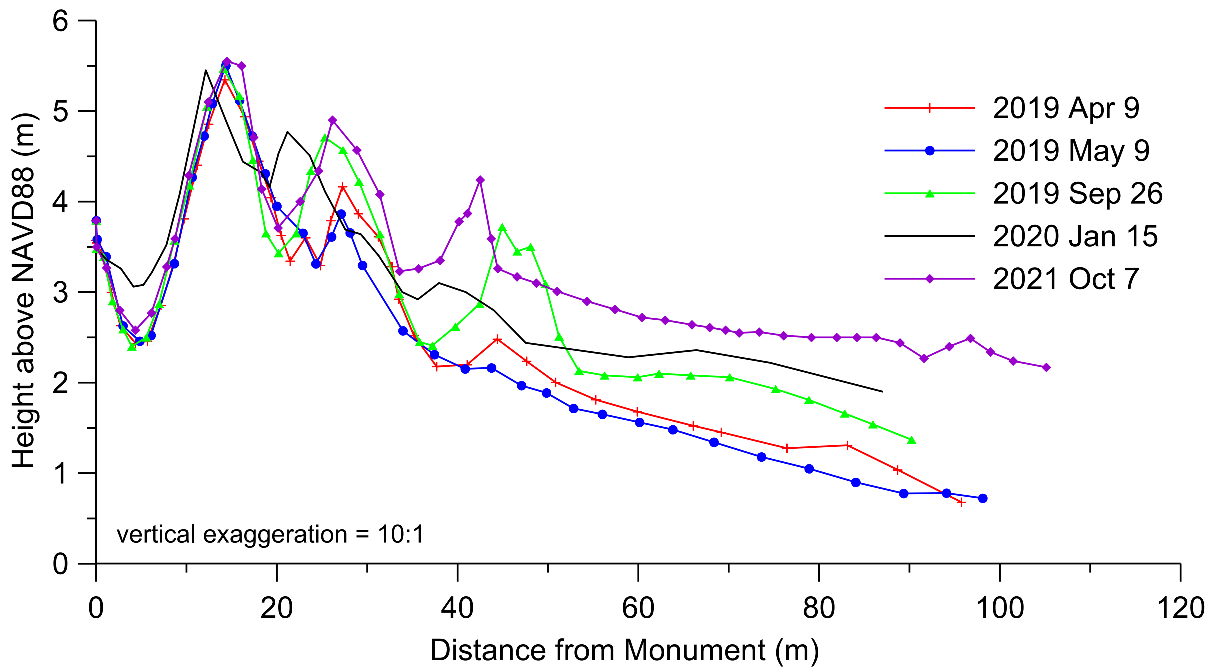


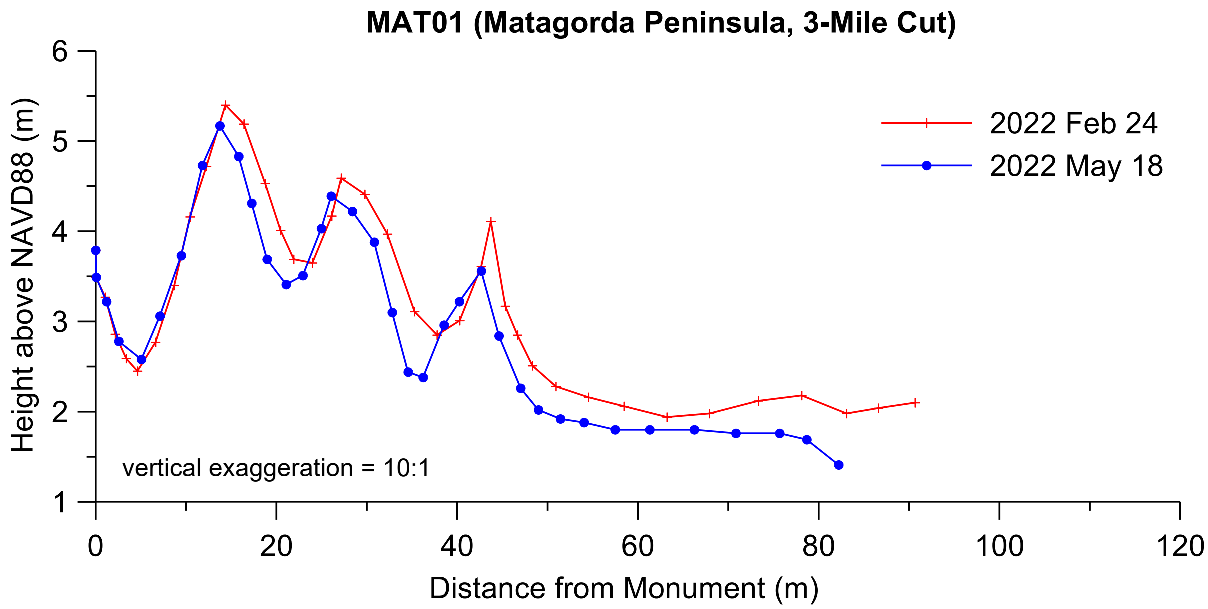



MAT01 (Matagorda Peninsula, 3-Mile Cut)
Height above NAVD88 (m)
Distance from Monument (m)
2013 Jan 31
2013 Sep 27
2014 Jan 31
2014 May 16
2014 Sep 25
0
1
2
3
4
5
6
0
20
40
60
80
100
120

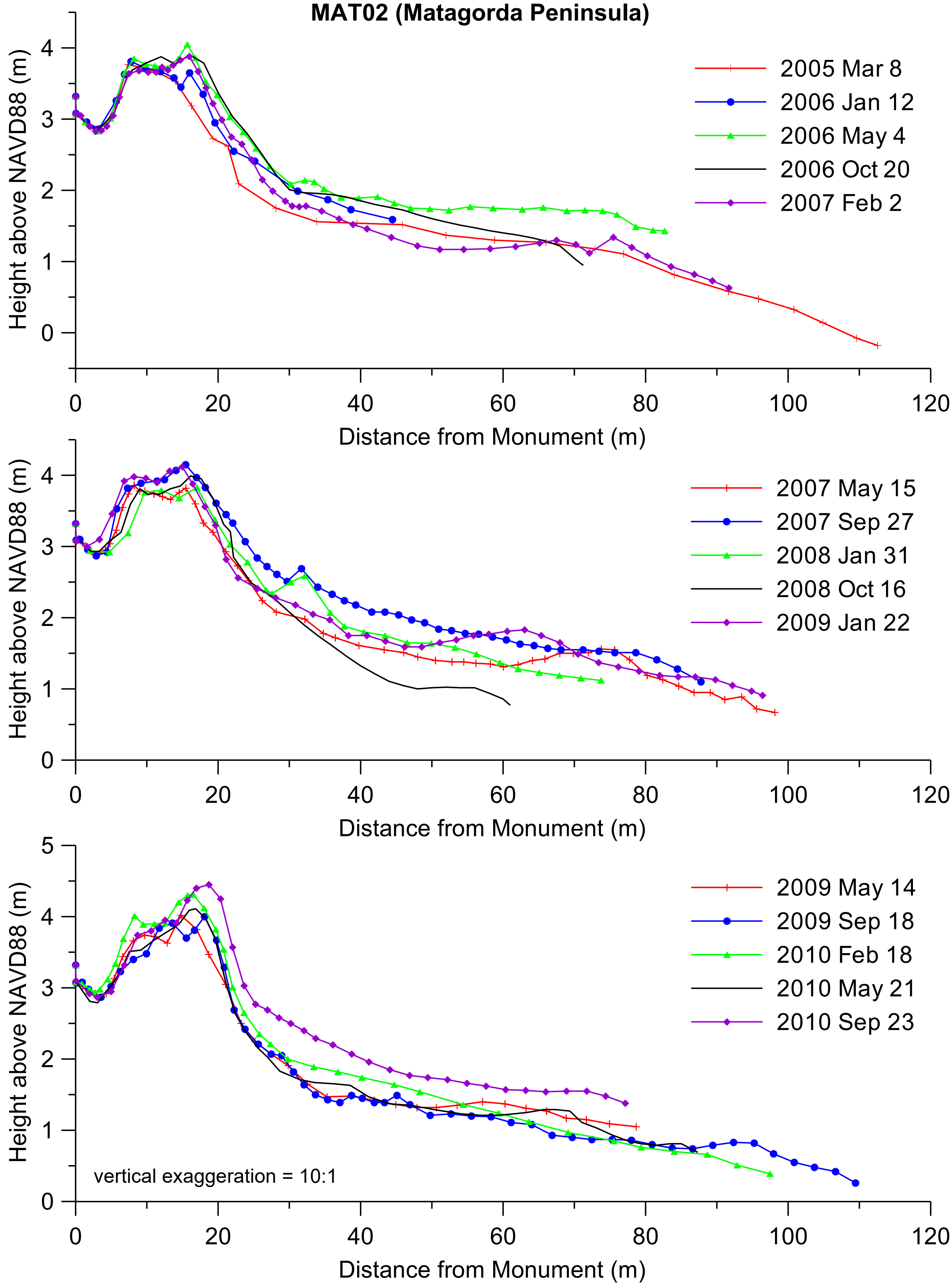

Height above NAVD88 (m)
Distance from Monument (m)
2015 Jan 23
2015 Oct 8
2016 Jan 28
2016 Apr 26
2016 Sep 23
vertical exaggeration = 10:1
0
1
2
3
4
5
6
0
20
40
60
80
100
120

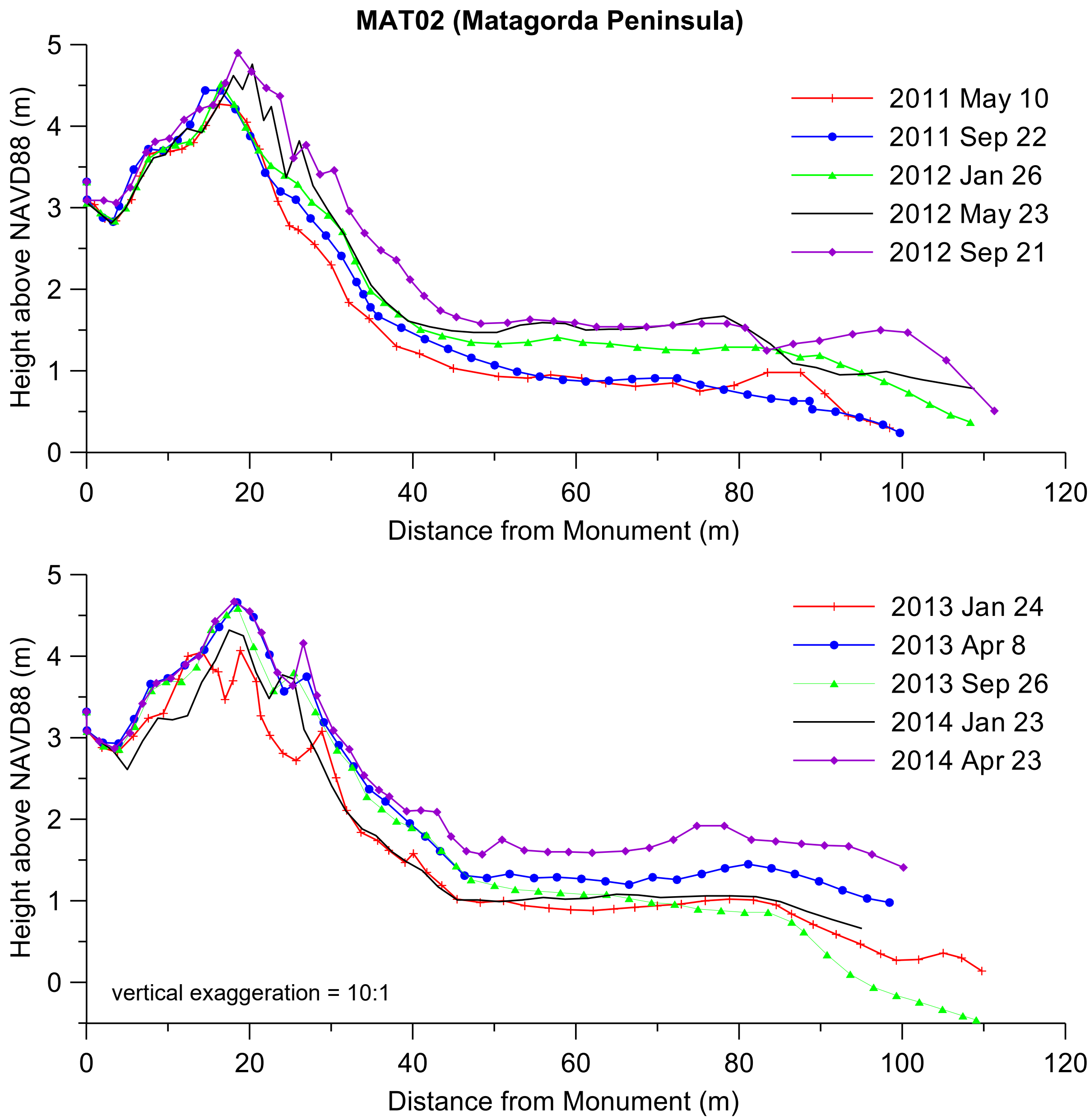

MAT01 (Matagorda Peninsula, 3-Mile Cut)
Height above NAVD88 (m)
Distance from Monument (m)
2017 May 11
2017 Sep 21
2018 May 17
2018 Sep 18
2019 Jan 25
0
1
2
3
4
5
6
0
20
40
60
80
100
120

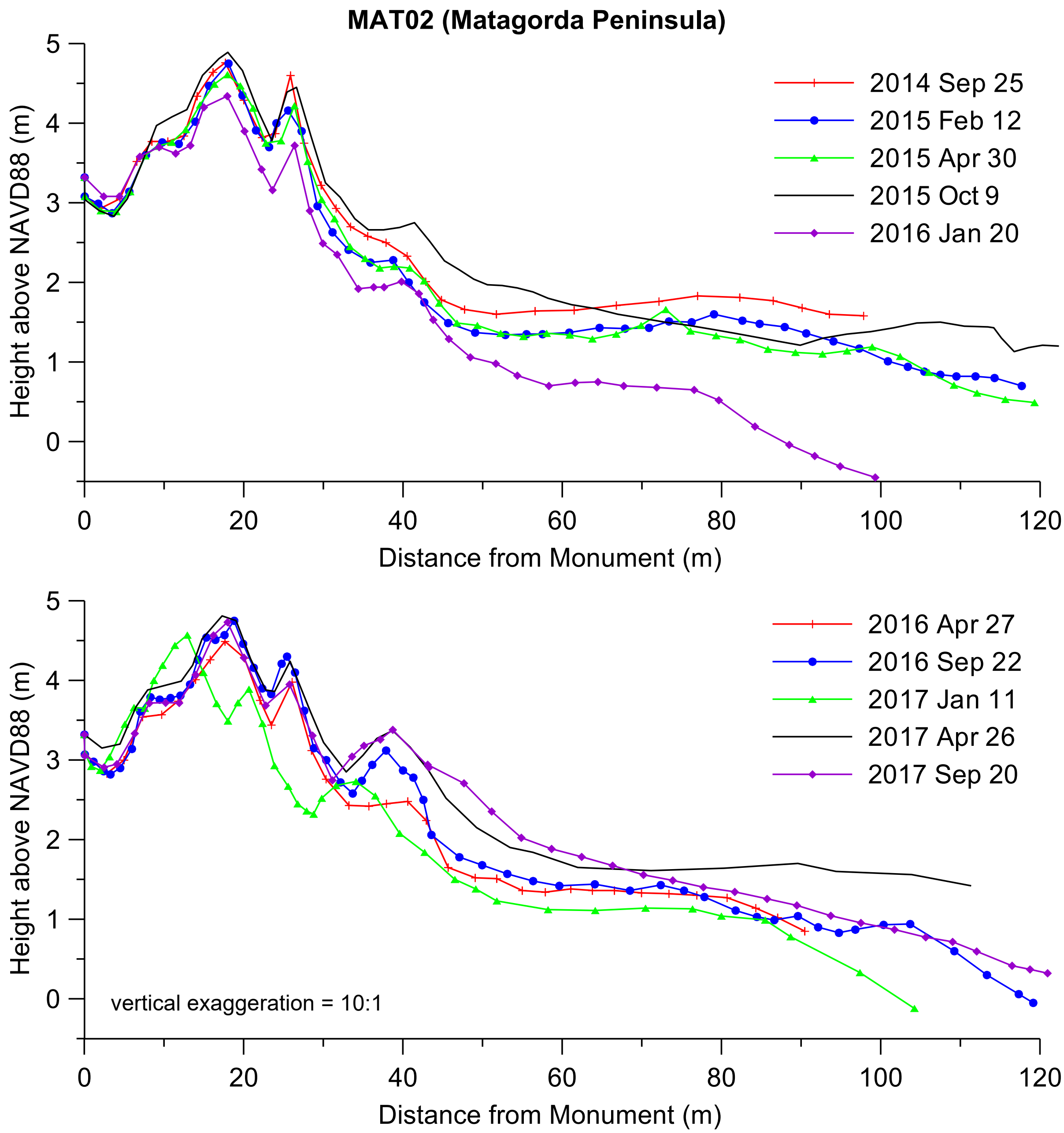

Height above NAVD88 (m)
Distance from Monument (m)
2019 Apr 9
2019 May 9
2019 Sep 26
2020 Jan 15
2021 Oct 7
vertical exaggeration = 10:1
0
1
2
3
4
5
6
0
20
40
60
80
100
120


MAT01 (Matagorda Peninsula, 3-Mile Cut)
Height above NAVD88 (m)
Distance from Monument (m)
2022 Feb 24
2022 May 18
vertical exaggeration = 10:1
0
20
40
60
80
100
120
1
2
3
4
5
6

MAT02

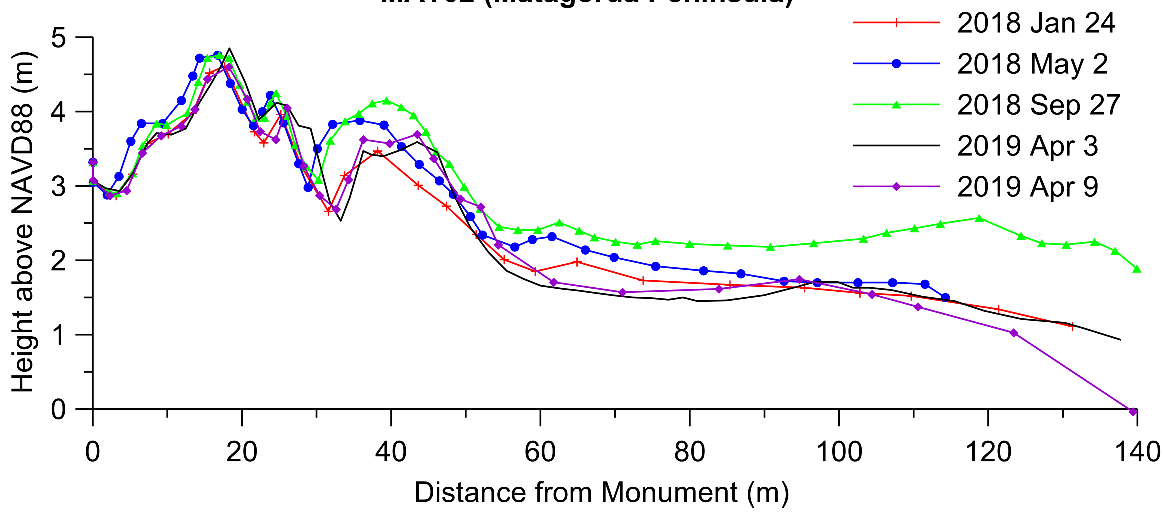

MAT02 (Matagorda Peninsula)
Height above NAVD88 (m)
Distance from Monument (m)
2005 Mar 8
2006 Jan 12
2006 May 4
2006 Oct 20
2007 Feb 2
2007 May 15
2007 Sep 27
2008 Jan 31
2008 Oct 16
2009 Jan 22
2009 May 14
2009 Sep 18
2010 Feb 18
2010 May 21
2010 Sep 23
vertical exaggeration = 10:1

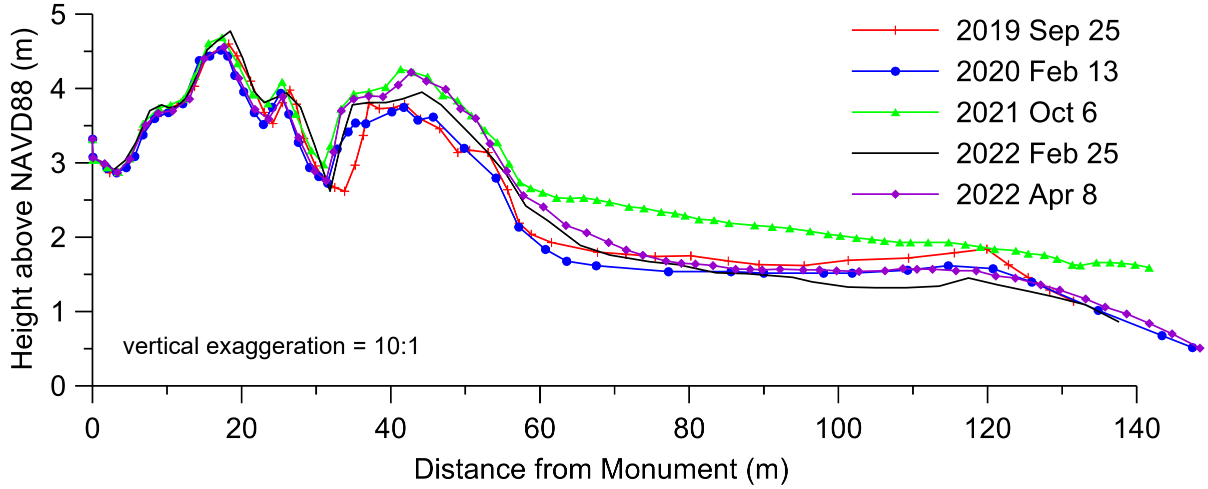

MAT02 (Matagorda Peninsula)
Height above NAVD88 (m)
Distance from Monument (m)
2011 May 10
2011 Sep 22
2012 Jan 26
2012 May 23
2012 Sep 21
Height above NAVD88 (m)
Distance from Monument (m)
2013 Jan 24
2013 Apr 8
2013 Sep 26
2014 Jan 23
2014 Apr 23
vertical exaggeration = 10:1



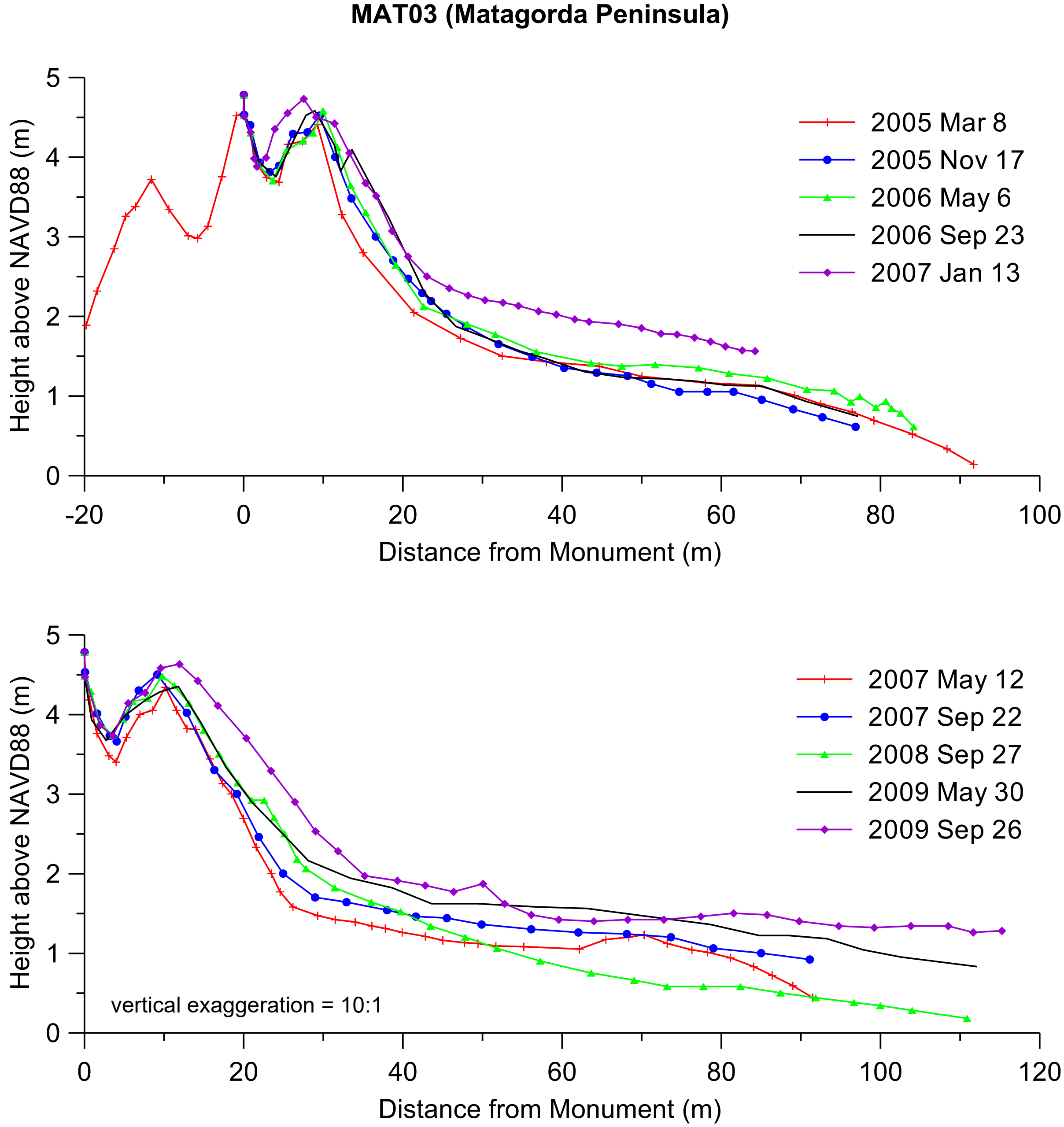
MAT02 (Matagorda Peninsula)
Height above NAVD88 (m)
Distance from Monument (m)
2014 Sep 25
2015 Feb 12
2015 Apr 30
2015 Oct 9
2016 Jan 20
Height above NAVD88 (m)
Distance from Monument (m)
2016 Apr 27
2016 Sep 22
2017 Jan 11
2017 Apr 26
2017 Sep 20
vertical exaggeration = 10:1

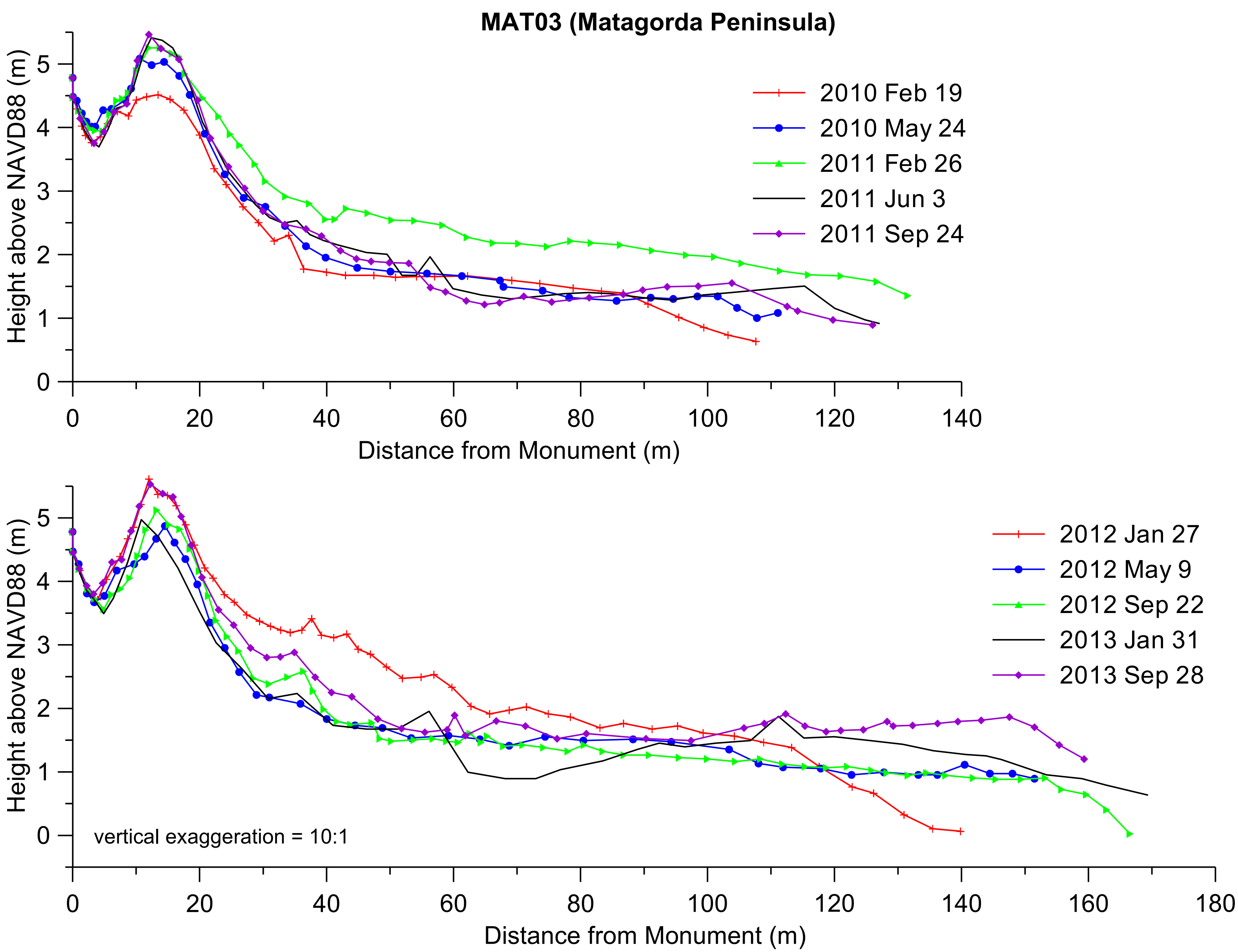
MAT02 (Matagorda Peninsula)



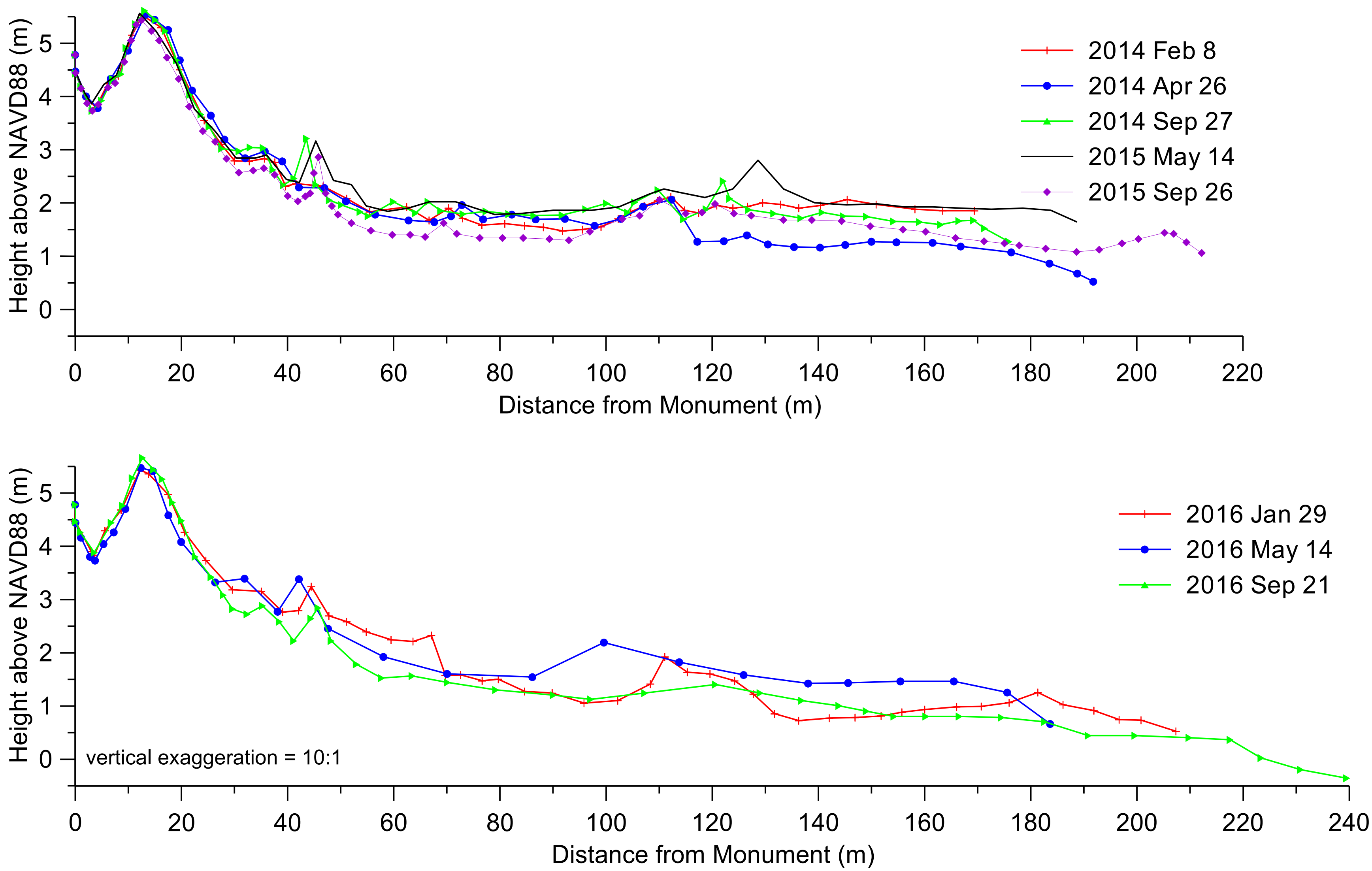


MAT03

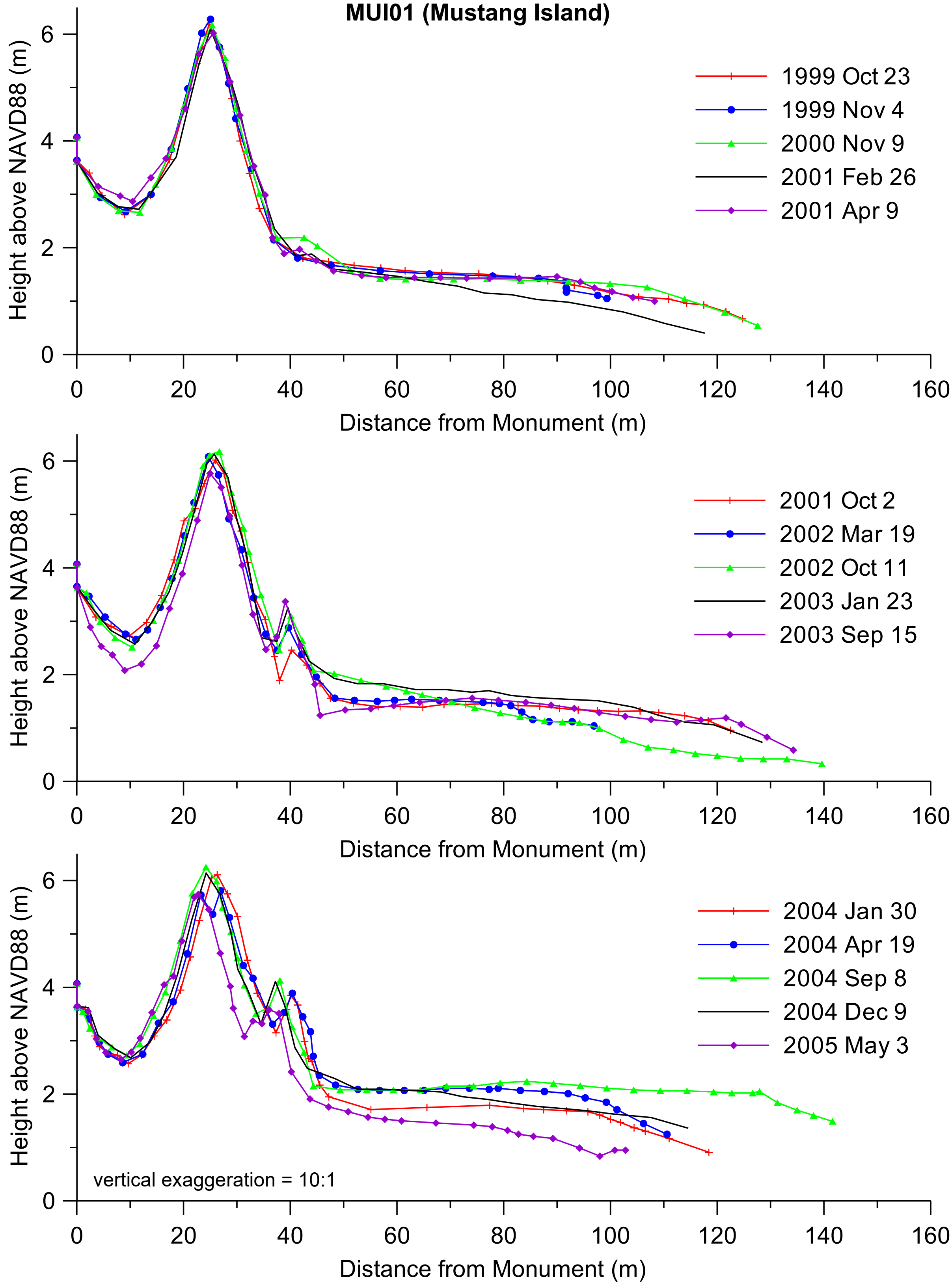

MAT03 (Matagorda Peninsula)
Height above NAVD88 (m)
Distance from Monument (m)
2005 Mar 8
2005 Nov 17
2006 May 6
2006 Sep 23
2007 Jan 13
Height above NAVD88 (m)
Distance from Monument (m)
2007 May 12
2007 Sep 22
2008 Sep 27
2009 May 30
2009 Sep 26
vertical exaggeration = 10:1

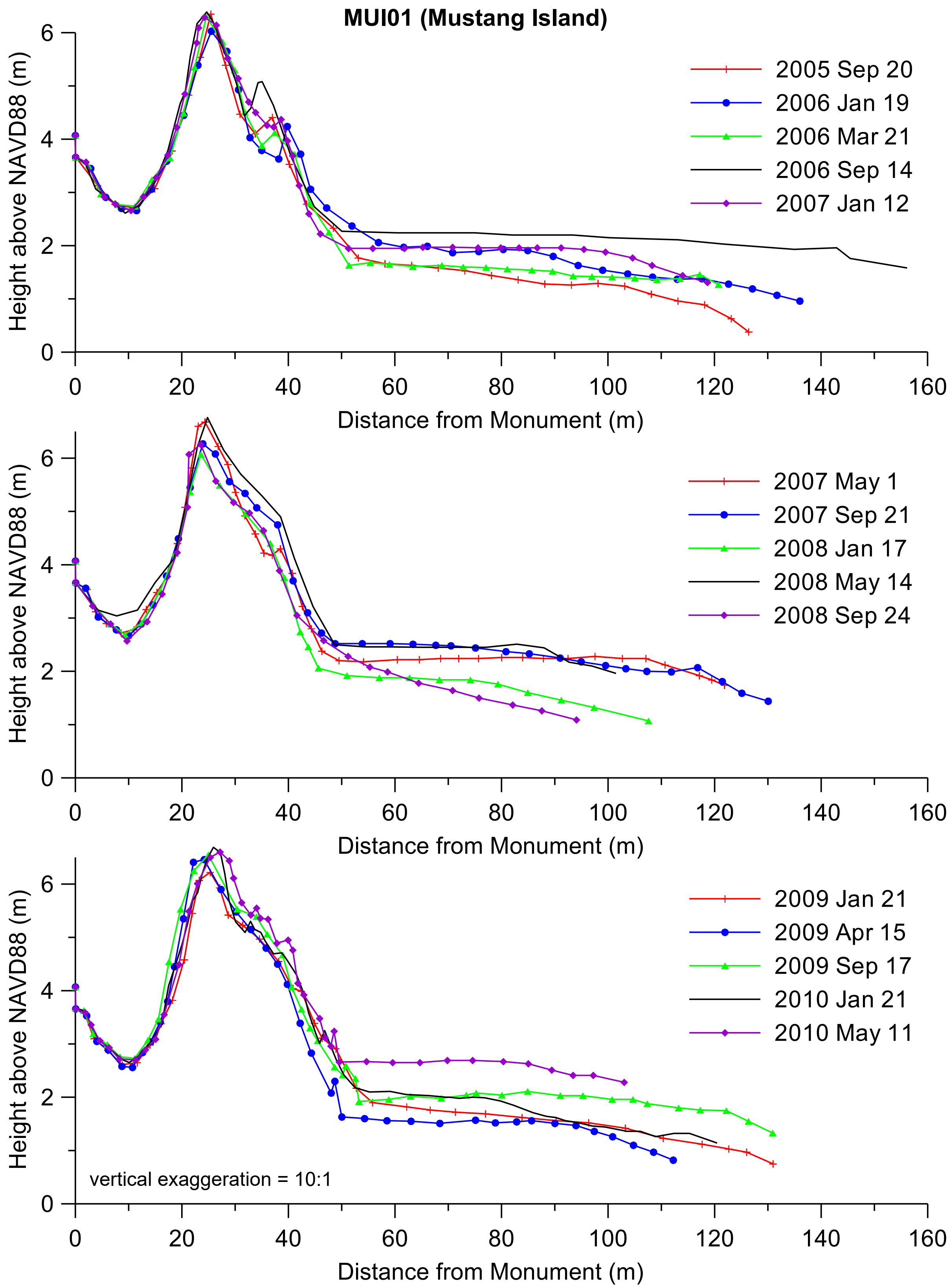

MAT03 (Matagorda Peninsula)
Height above NAVD88 (m)
Distance from Monument (m)
2010 Feb 19
2010 May 24
2011 Feb 26
2011 Jun 3
2011 Sep 24
2012 Jan 27
2012 May 9
2012 Sep 22
2013 Jan 31
2013 Sep 28
vertical exaggeration = 10:1

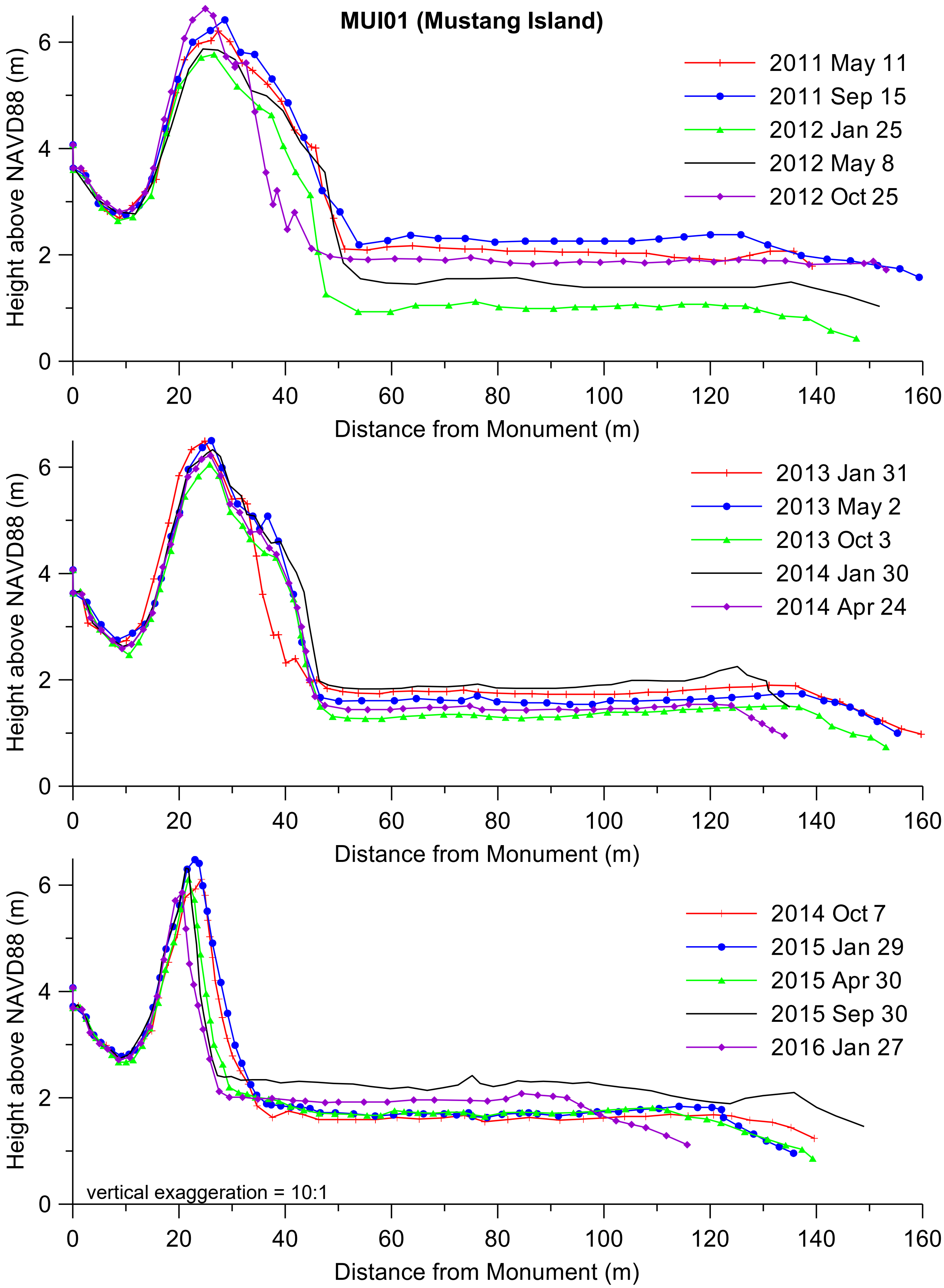
MAT03 (Matagorda Peninsula)

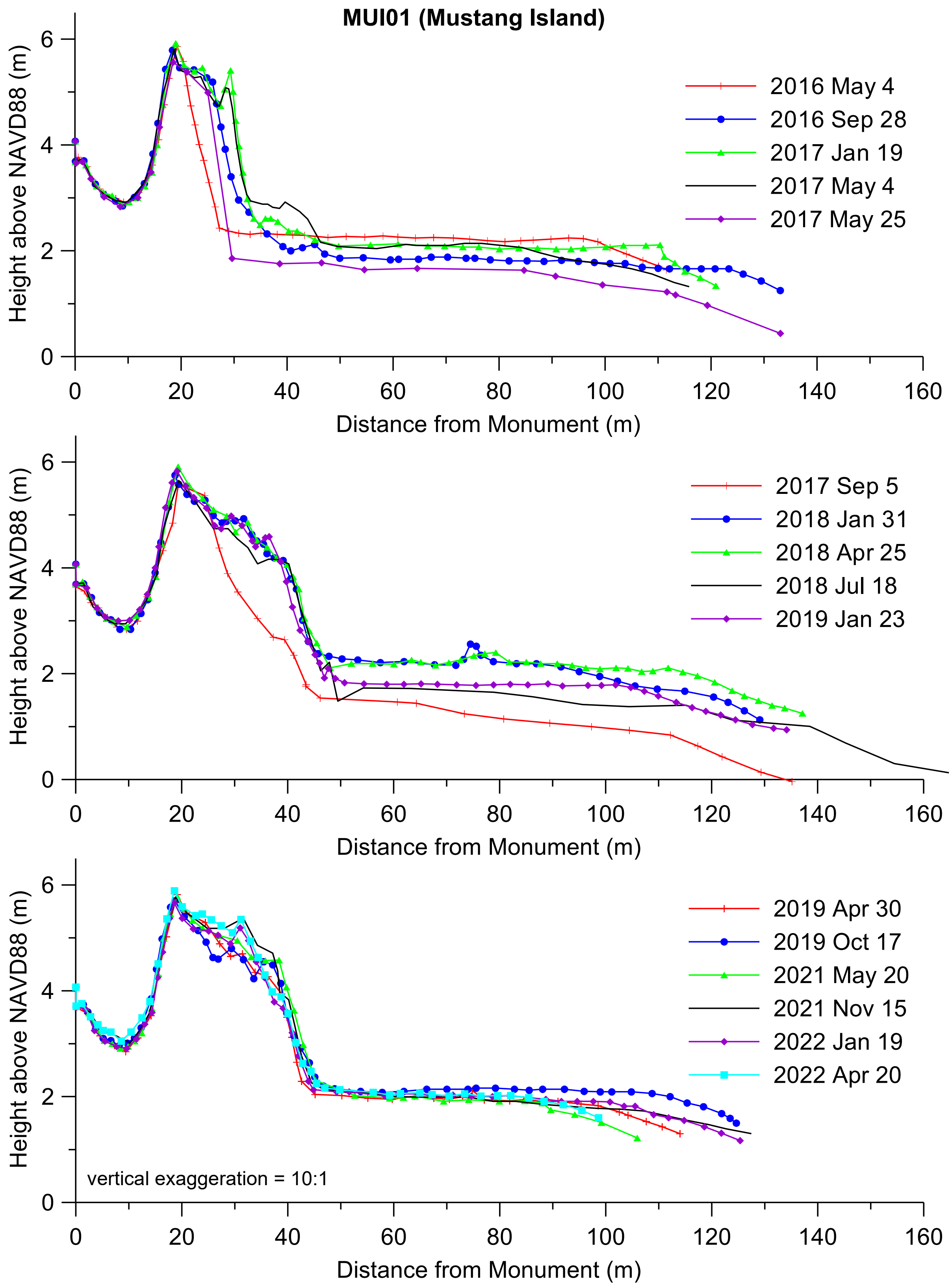


MUI01

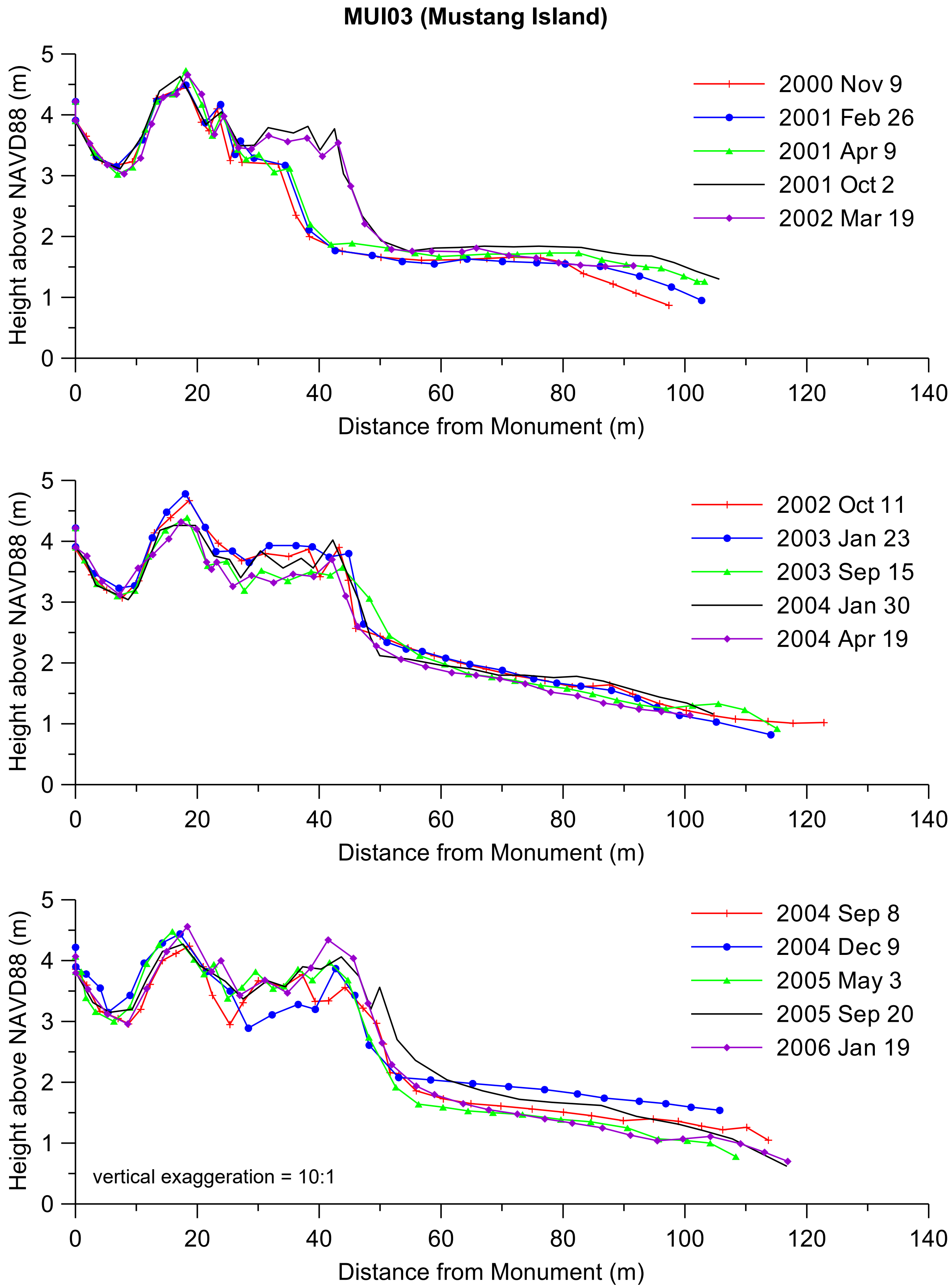

MUI01 (Mustang Island)
Height above NAVD88 (m)
Distance from Monument (m)
0
2
4
6
0
20
40
60
80
100
120
140
160
1999 Oct 23
1999 Nov 4
2000 Nov 9
2001 Feb 26
2001 Apr 9
2001 Oct 2
2002 Mar 19
2002 Oct 11
2003 Jan 23
2003 Sep 15
2004 Jan 30
2004 Apr 19
2004 Sep 8
2004 Dec 9
2005 May 3
vertical exaggeration = 10:1


MUI01 (Mustang Island)
Height above NAVD88 (m)
Distance from Monument (m)
2005 Sep 20
2006 Jan 19
2006 Mar 21
2006 Sep 14
2007 Jan 12
2007 May 1
2007 Sep 21
2008 Jan 17
2008 May 14
2008 Sep 24
2009 Jan 21
2009 Apr 15
2009 Sep 17
2010 Jan 21
2010 May 11
vertical exaggeration = 10:1


MUI01 (Mustang Island)
Height above NAVD88 (m)
Distance from Monument (m)
2011 May 11
2011 Sep 15
2012 Jan 25
2012 May 8
2012 Oct 25
2013 Jan 31
2013 May 2
2013 Oct 3
2014 Jan 30
2014 Apr 24
2014 Oct 7
2015 Jan 29
2015 Apr 30
2015 Sep 30
2016 Jan 27
vertical exaggeration = 10:1

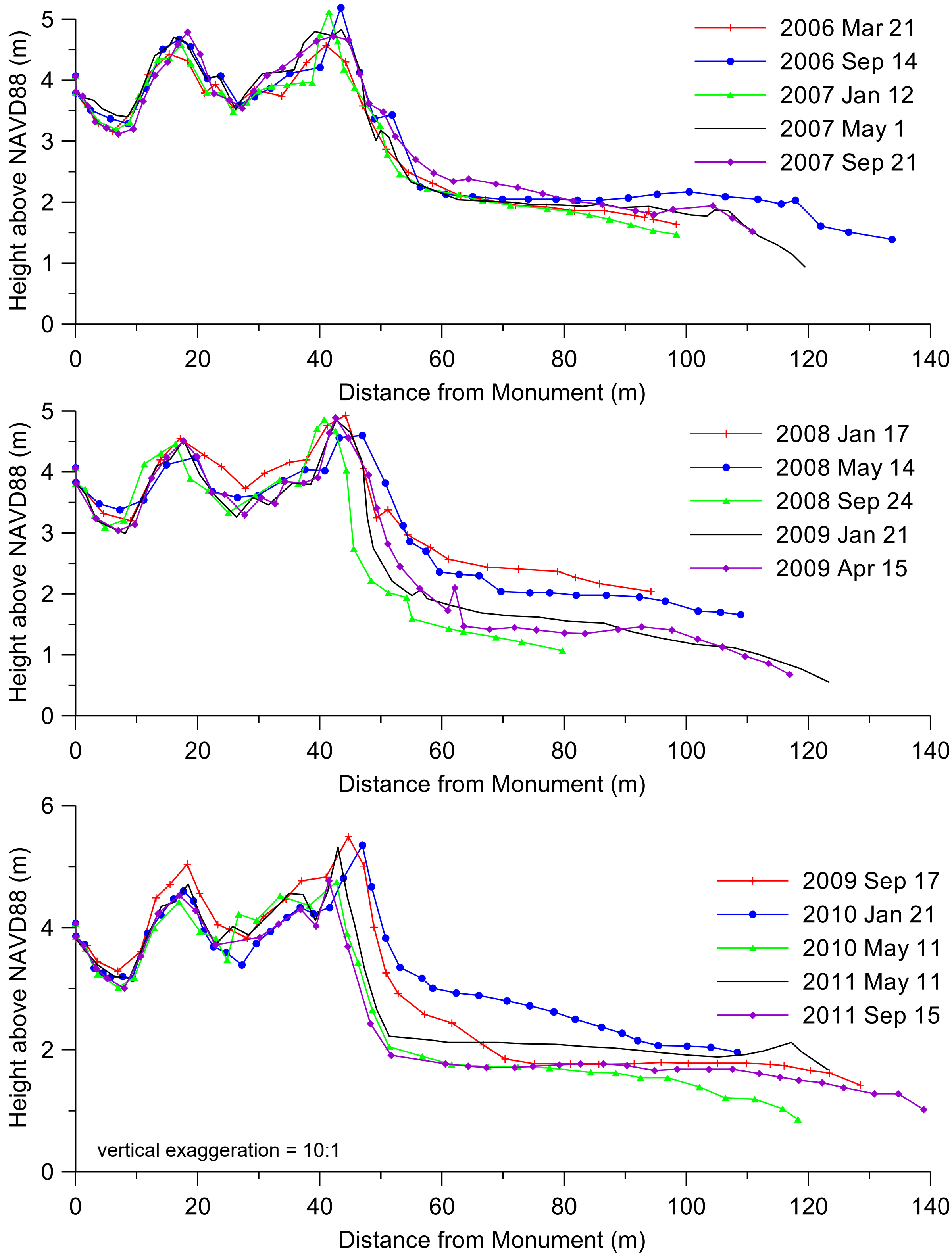

MUI01 (Mustang Island)
Height above NAVD88 (m)
Distance from Monument (m)
2016 May 4
2016 Sep 28
2017 Jan 19
2017 May 4
2017 May 25
2017 Sep 5
2018 Jan 31
2018 Apr 25
2018 Jul 18
2019 Jan 23
2019 Apr 30
2019 Oct 17
2021 May 20
2021 Nov 15
2022 Jan 19
2022 Apr 20
vertical exaggeration = 10:1

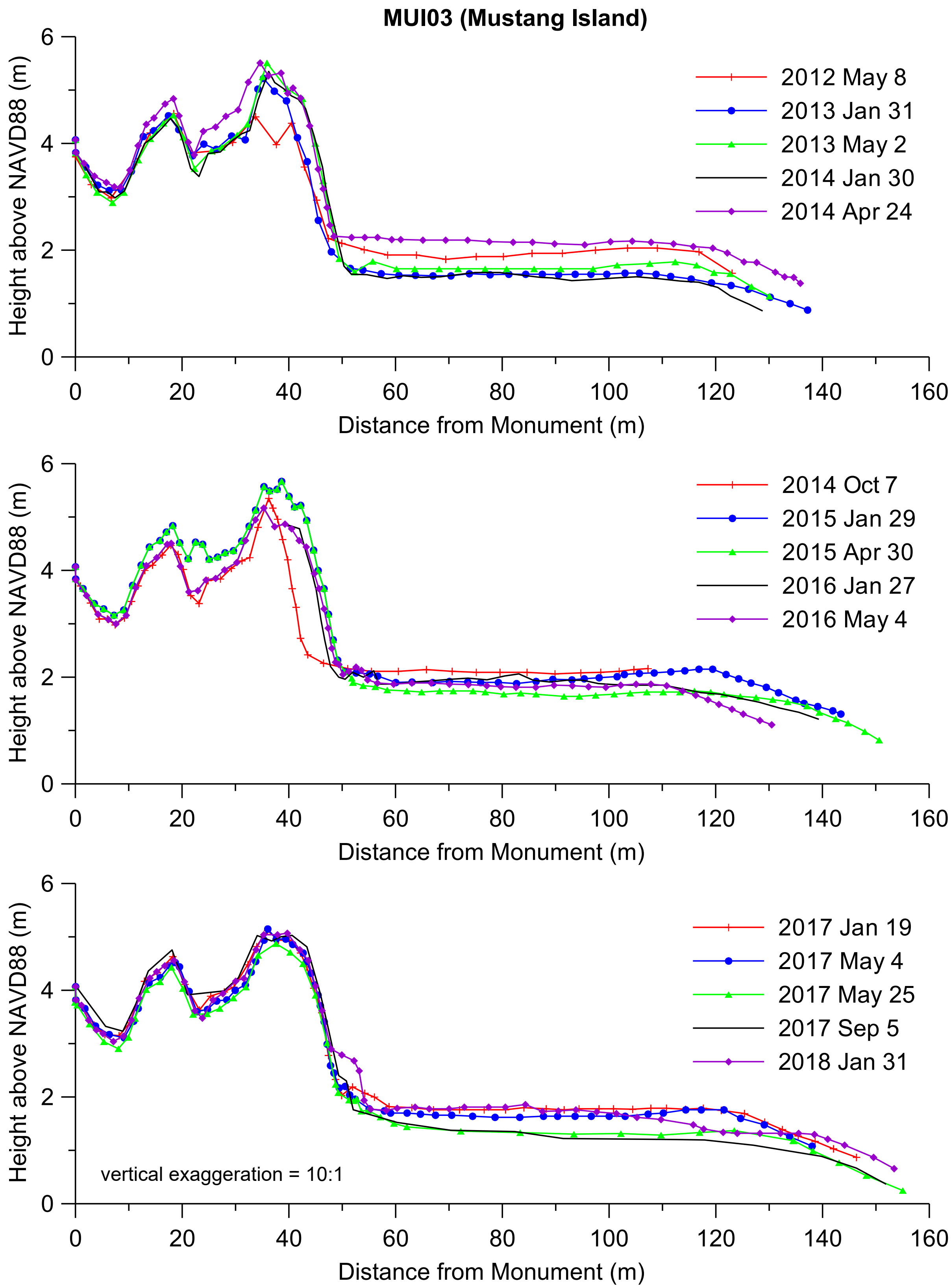
MUI03



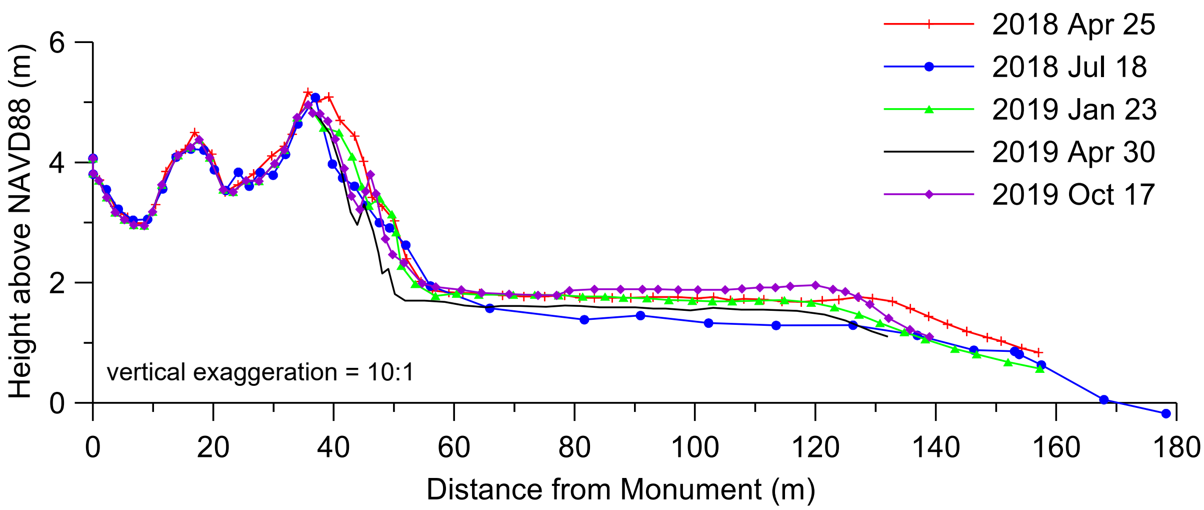
MUI03 (Mustang Island)
Height above NAVD88 (m)
Distance from Monument (m)
2000 Nov 9
2001 Feb 26
2001 Apr 9
2001 Oct 2
2002 Mar 19
2002 Oct 11
2003 Jan 23
2003 Sep 15
2004 Jan 30
2004 Apr 19
2004 Sep 8
2004 Dec 9
2005 May 3
2005 Sep 20
2006 Jan 19
vertical exaggeration = 10:1

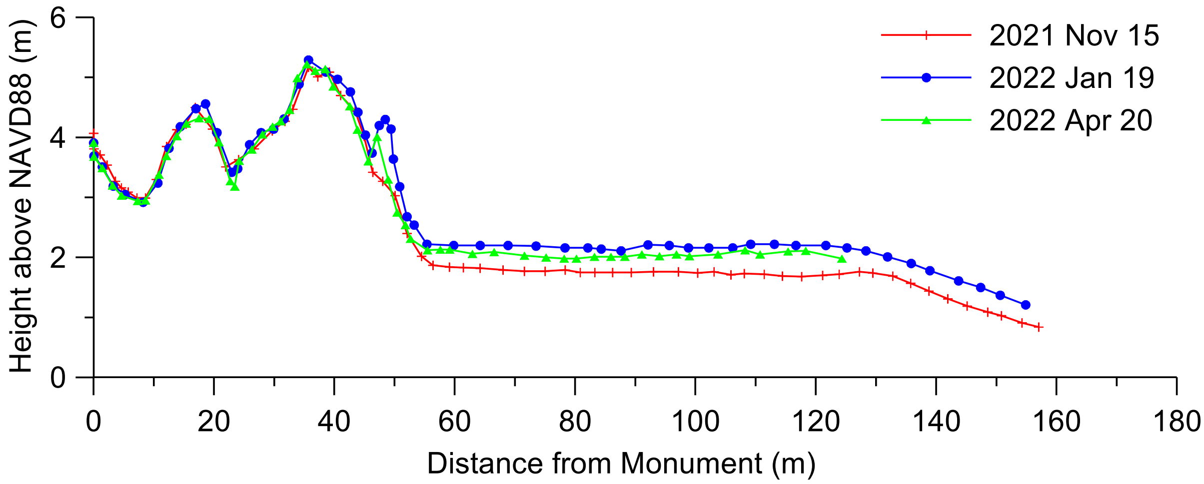
MUI03 (Mustang Island)



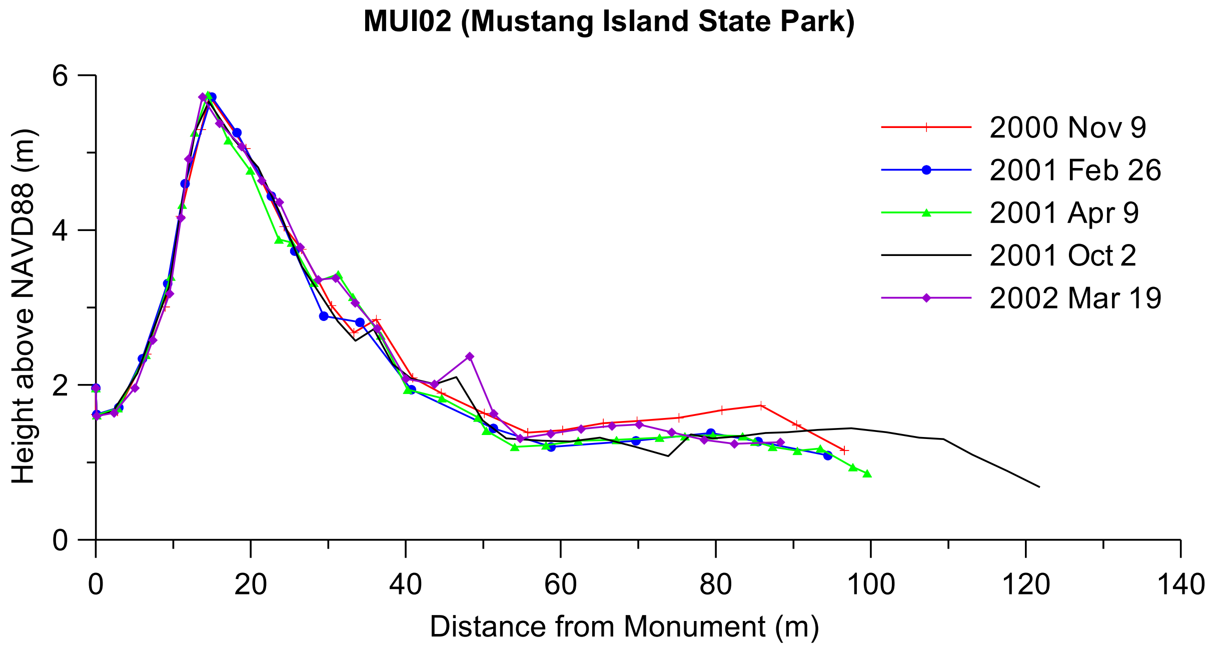

MUI03 (Mustang Island)
2012 May 8
2013 Jan 31
2013 May 2
2014 Jan 30
2014 Apr 24
2014 Oct 7
2015 Jan 29
2015 Apr 30
2016 Jan 27
2016 May 4
2017 Jan 19
2017 May 4
2017 May 25
2017 Sep 5
2018 Jan 31
vertical exaggeration = 10:1
Height above NAVD88 (m)
Distance from Monument (m)
0
2
4
6
0
20
40
60
80
100
120
140
160

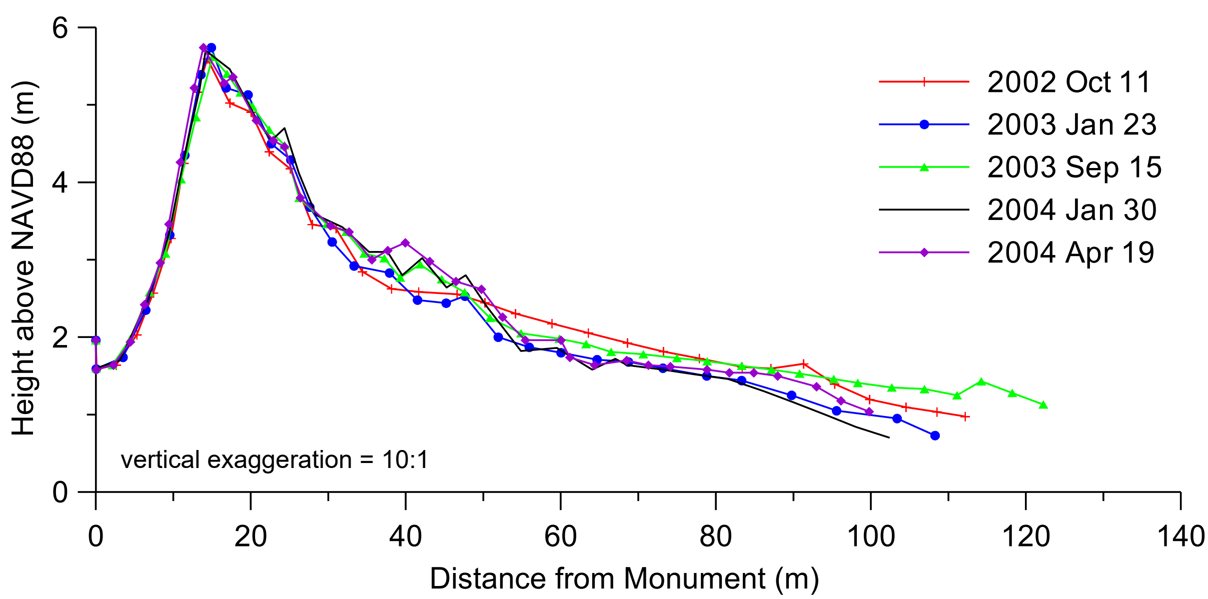
MUI03 (Mustang Island)



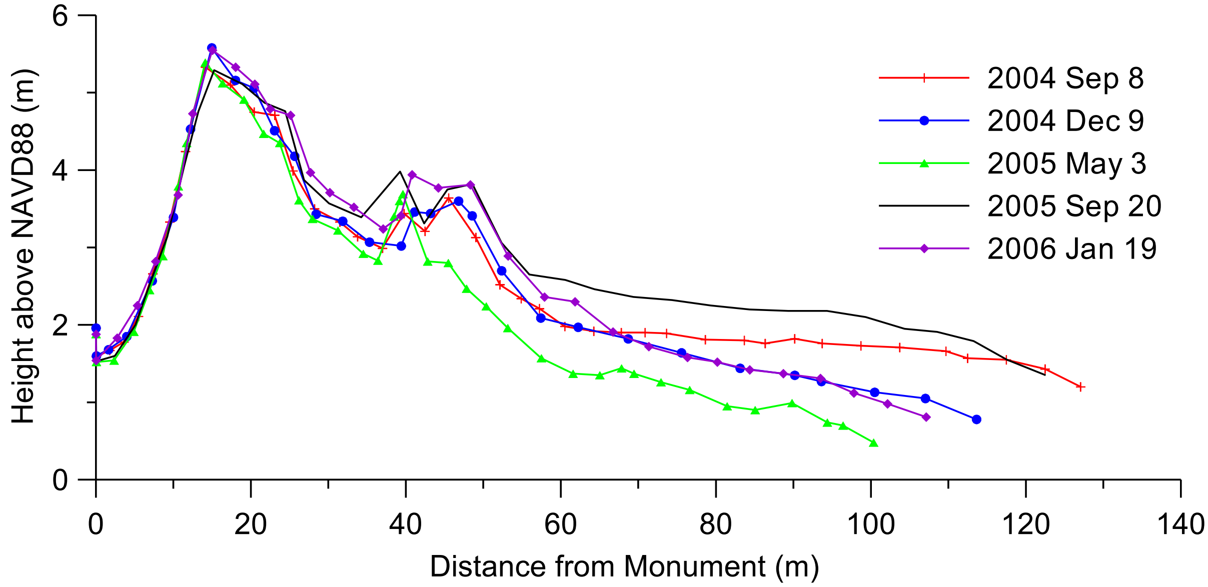


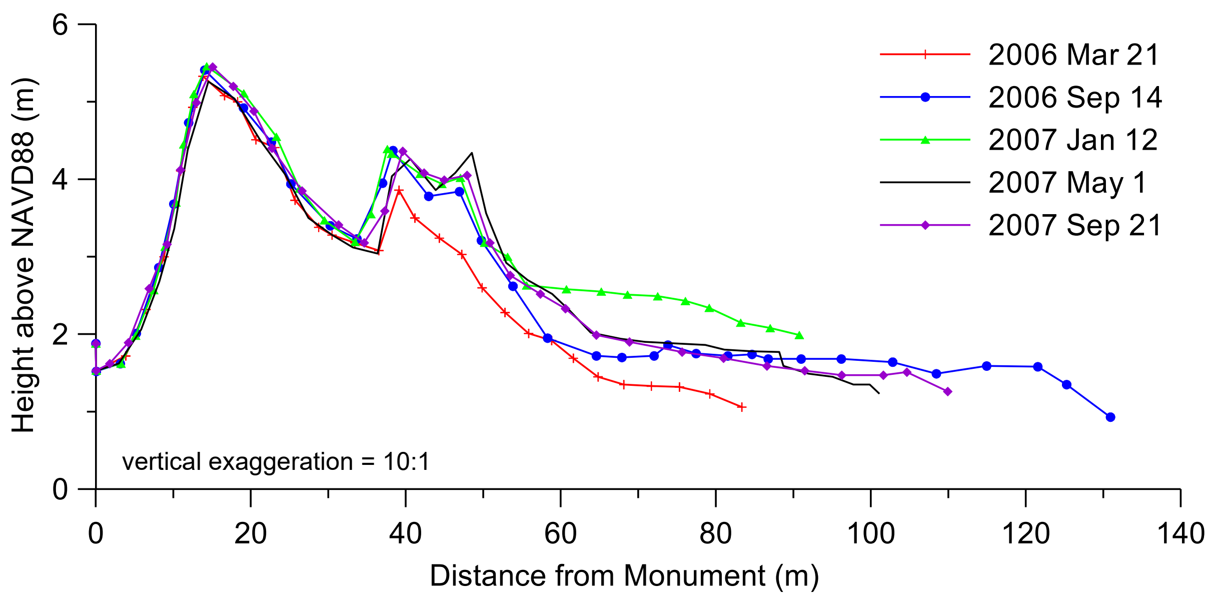
MUI02


MUI02 (Mustang Island State Park)
2000 Nov 9
2001 Feb 26
2001 Apr 9
2001 Oct 2
2002 Mar 19
Height above NAVD88 (m)
Distance from Monument (m)
0
2
4
6
0
20
40
60
80
100
120
140

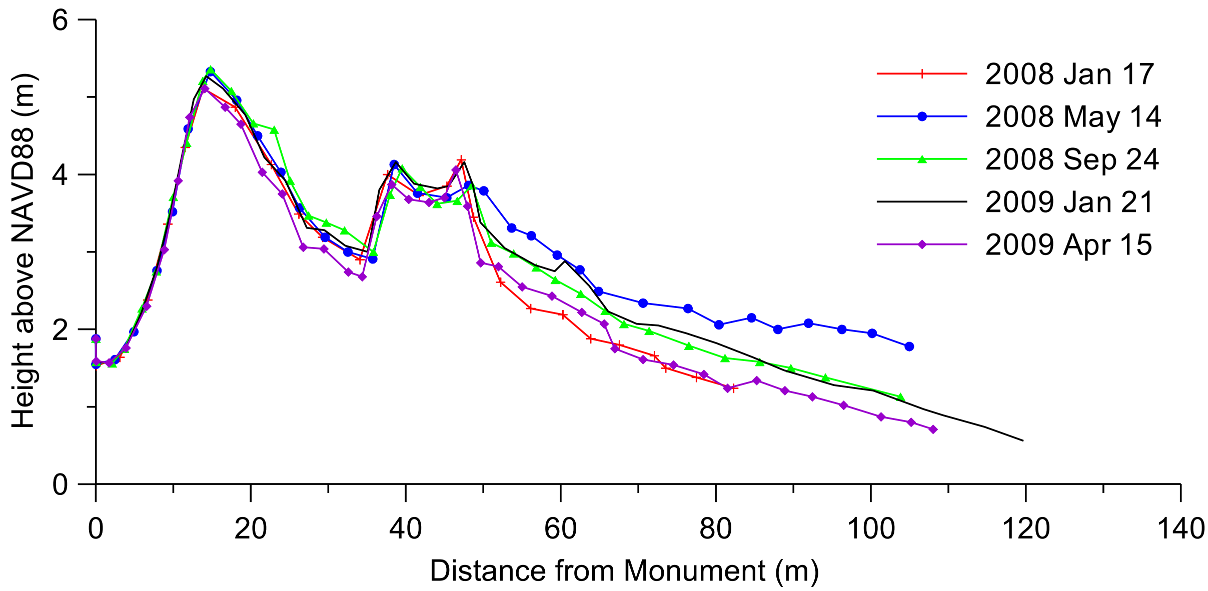

2002 Oct 11
2003 Jan 23
2003 Sep 15
2004 Jan 30
2004 Apr 19
vertical exaggeration = 10:1
Height above NAVD88 (m)
Distance from Monument (m)
0
2
4
6
0
20
40
60
80
100
120
140

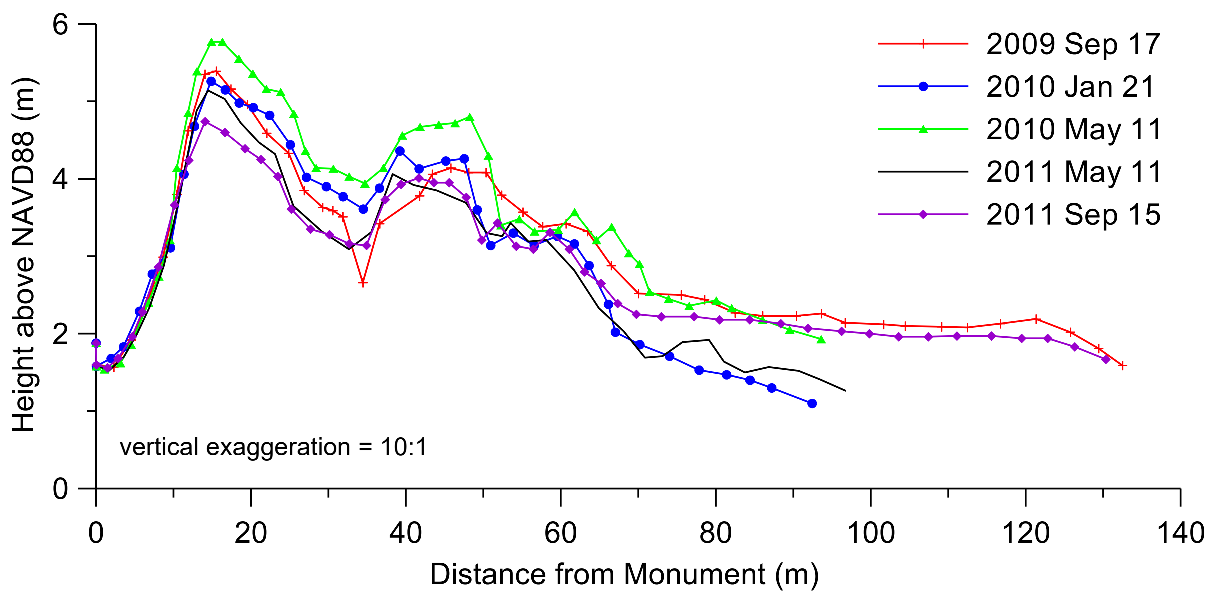
MUI02 (Mustang Island State Park)



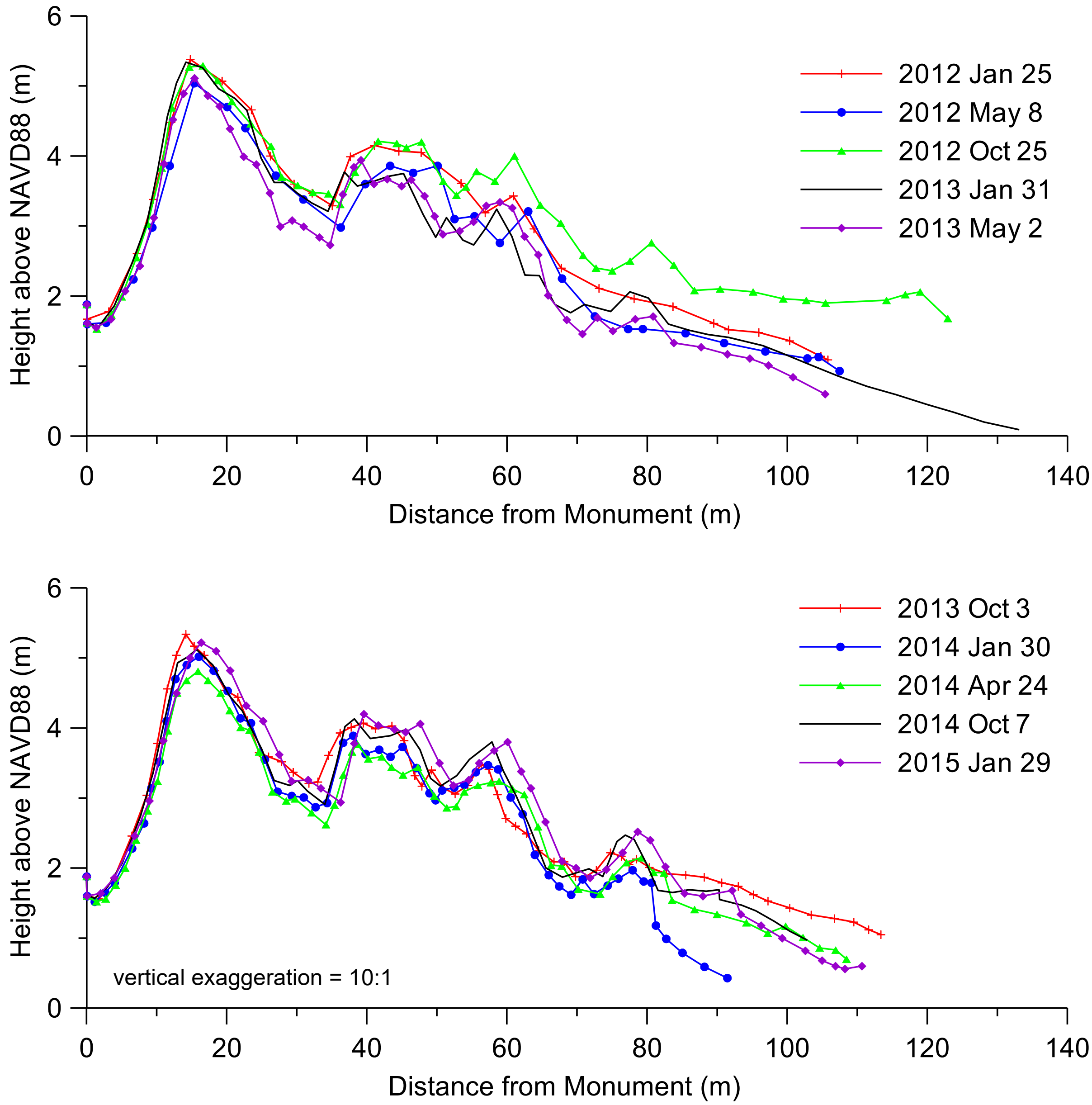


MUI02 (Mustang Island State Park)

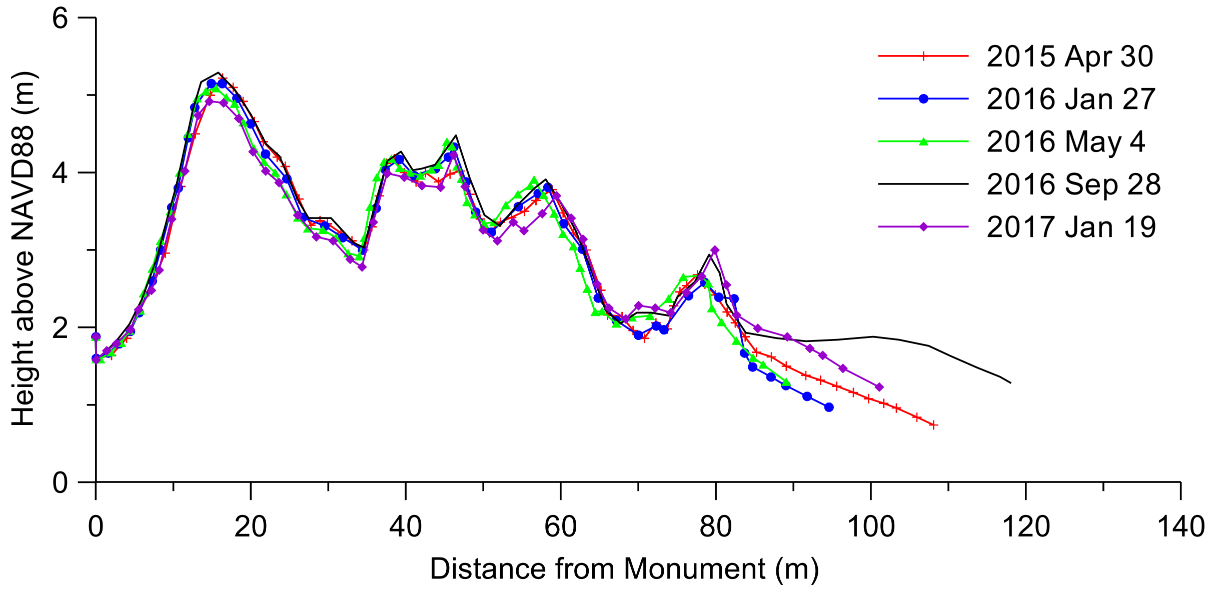


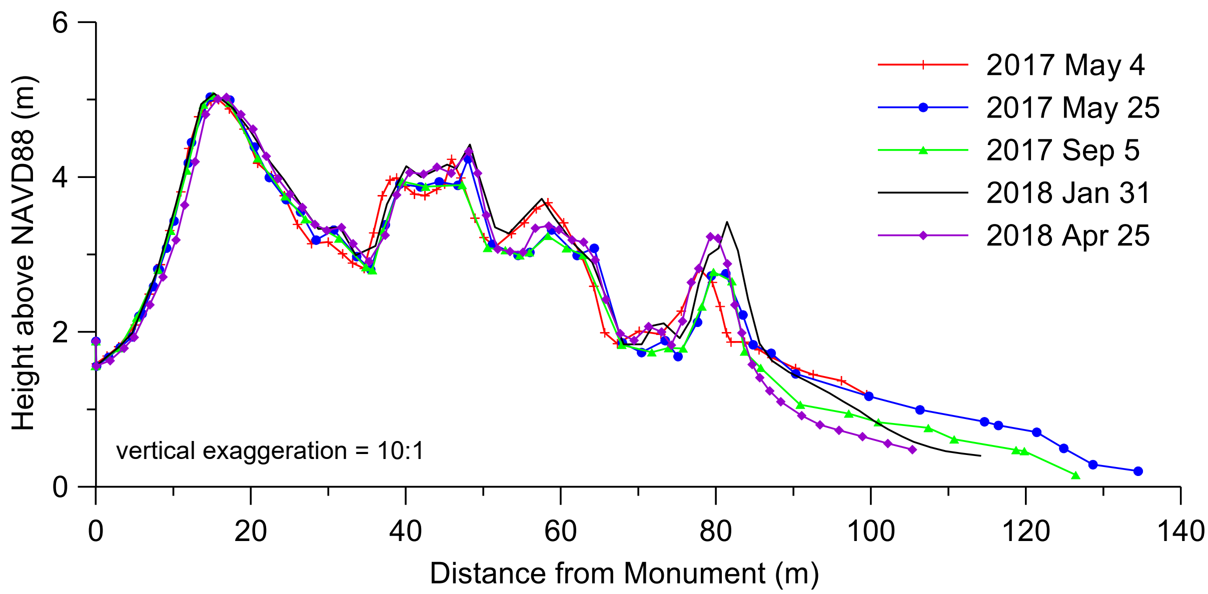


MUI02 (Mustang Island State Park)

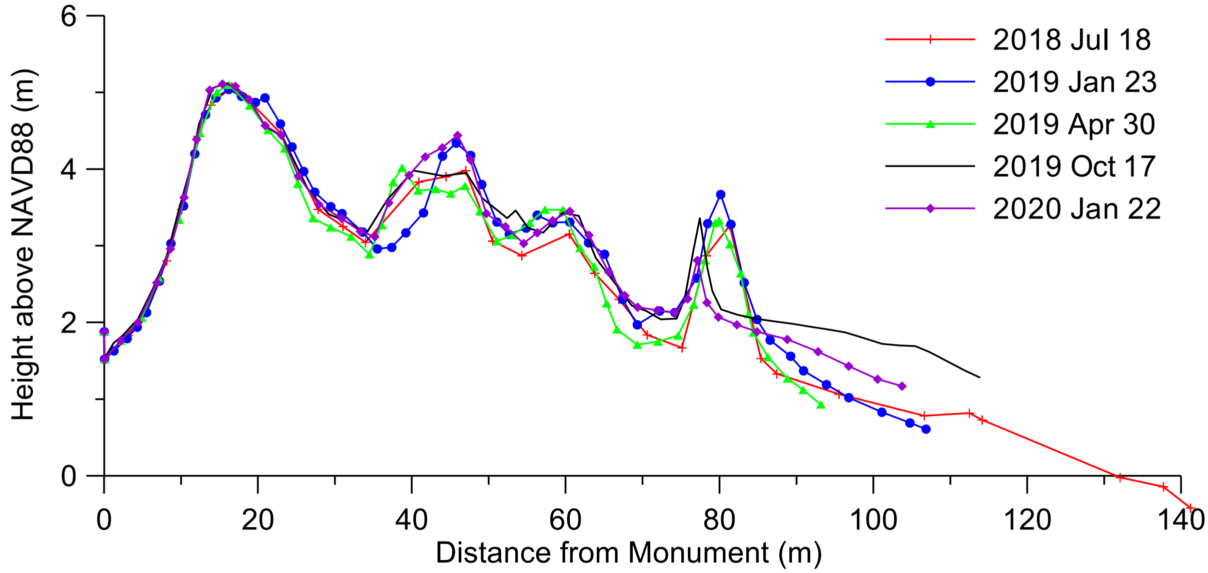


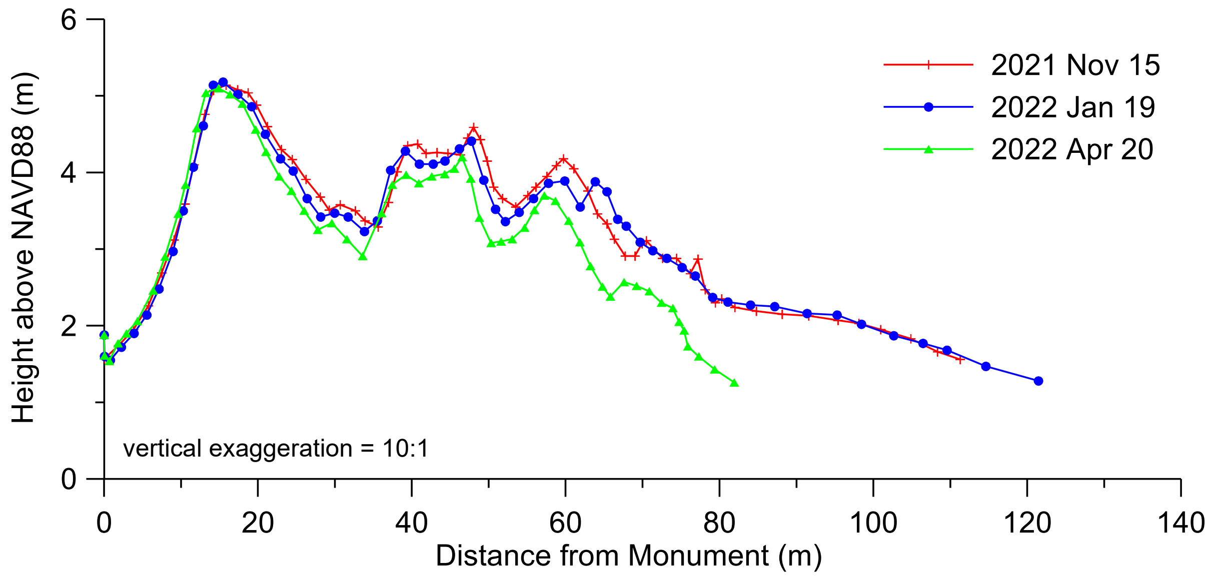
MUI02 (Mustang Island State Park)



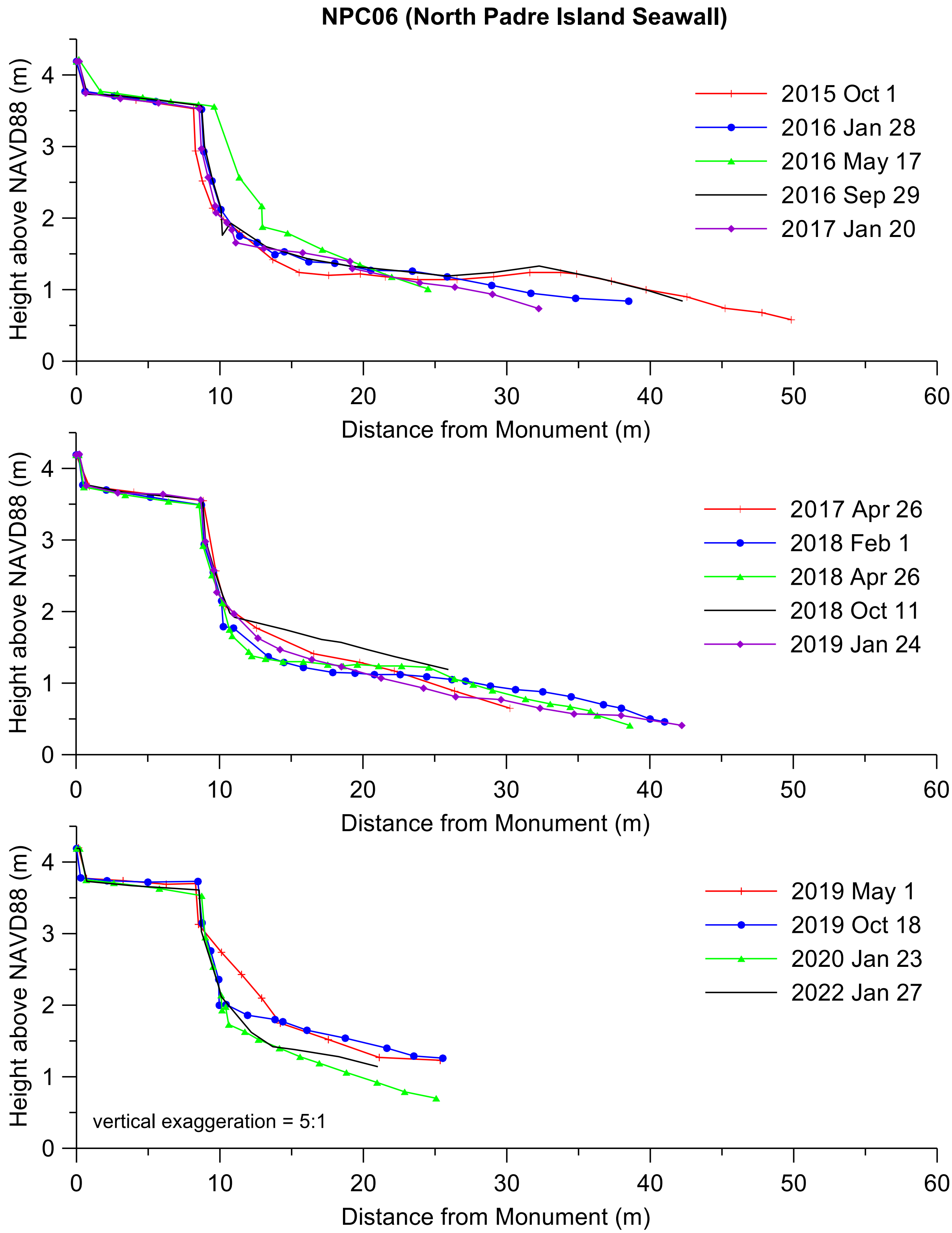


MUI02 (Mustang Island State Park)

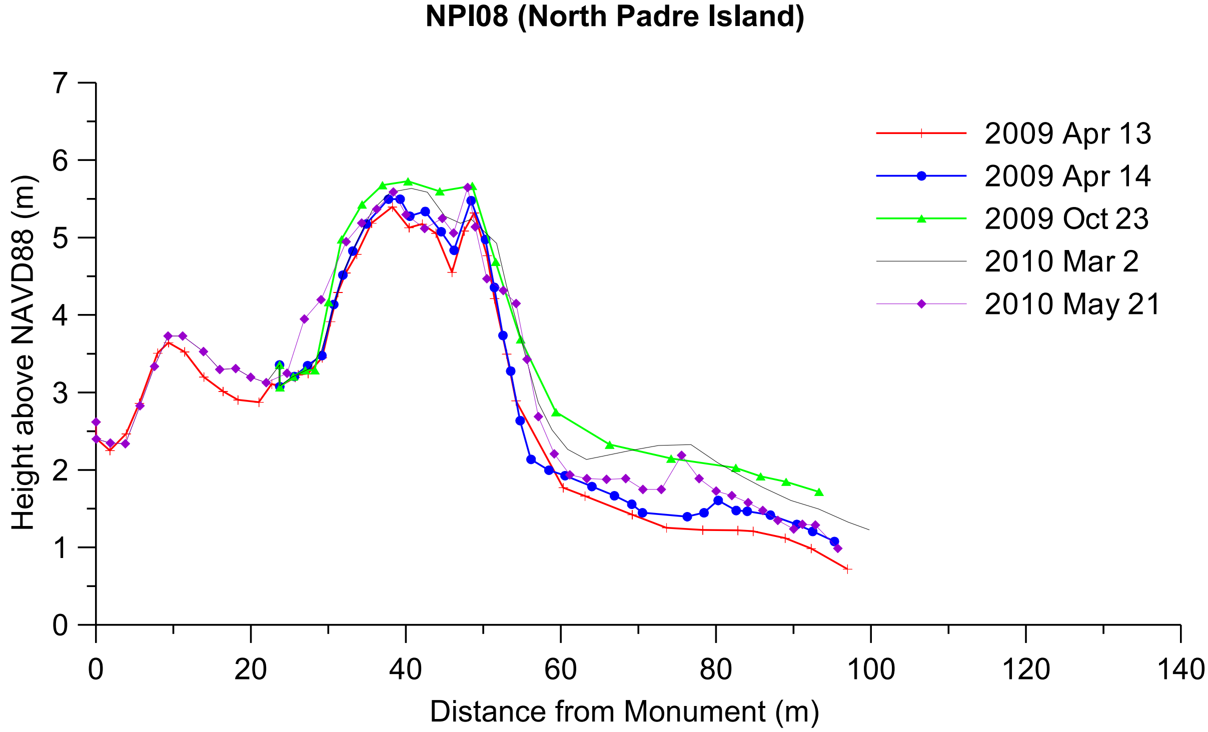


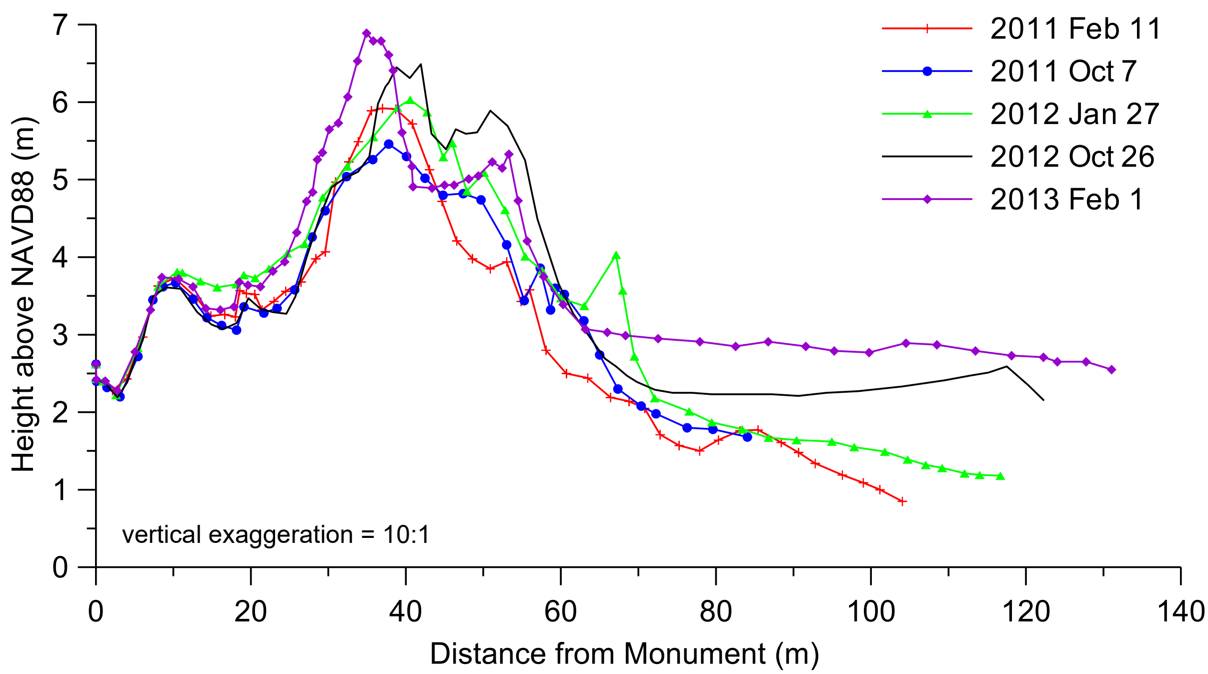


NPC06

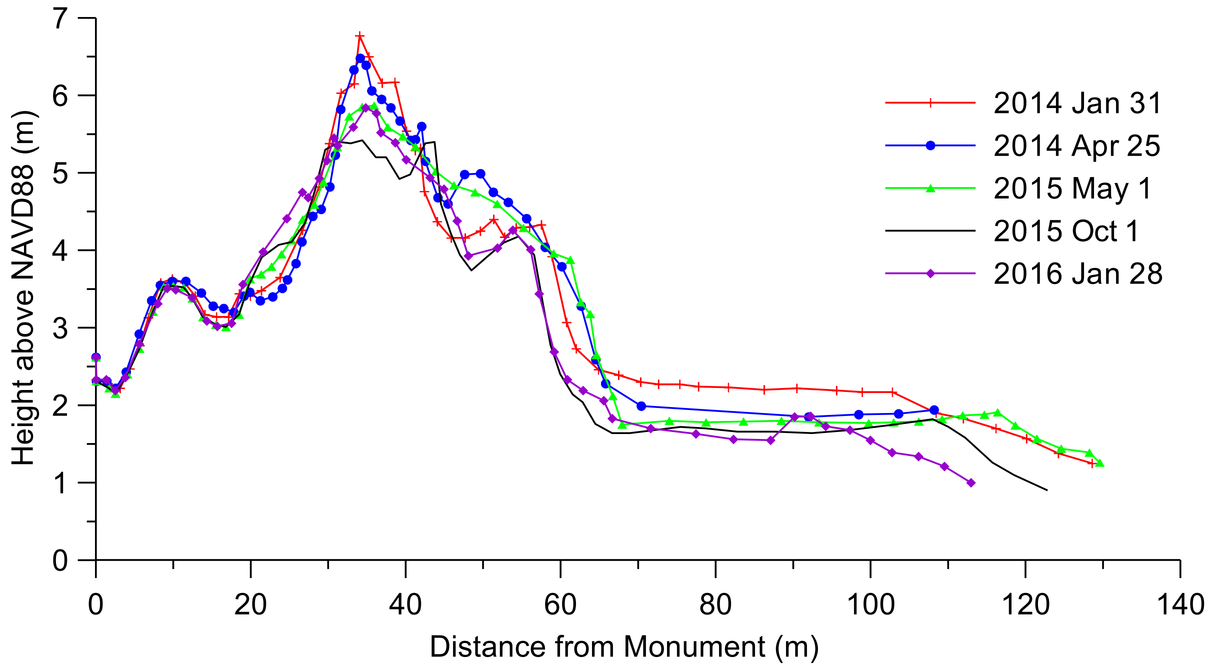

NPC06 (North Padre Island Seawall)
Height above NAVD88 (m)
Distance from Monument (m)
2015 Oct 1
2016 Jan 28
2016 May 17
2016 Sep 29
2017 Jan 20
2017 Apr 26
2018 Feb 1
2018 Apr 26
2018 Oct 11
2019 Jan 24
2019 May 1
2019 Oct 18
2020 Jan 23
2022 Jan 27
vertical exaggeration = 5:1

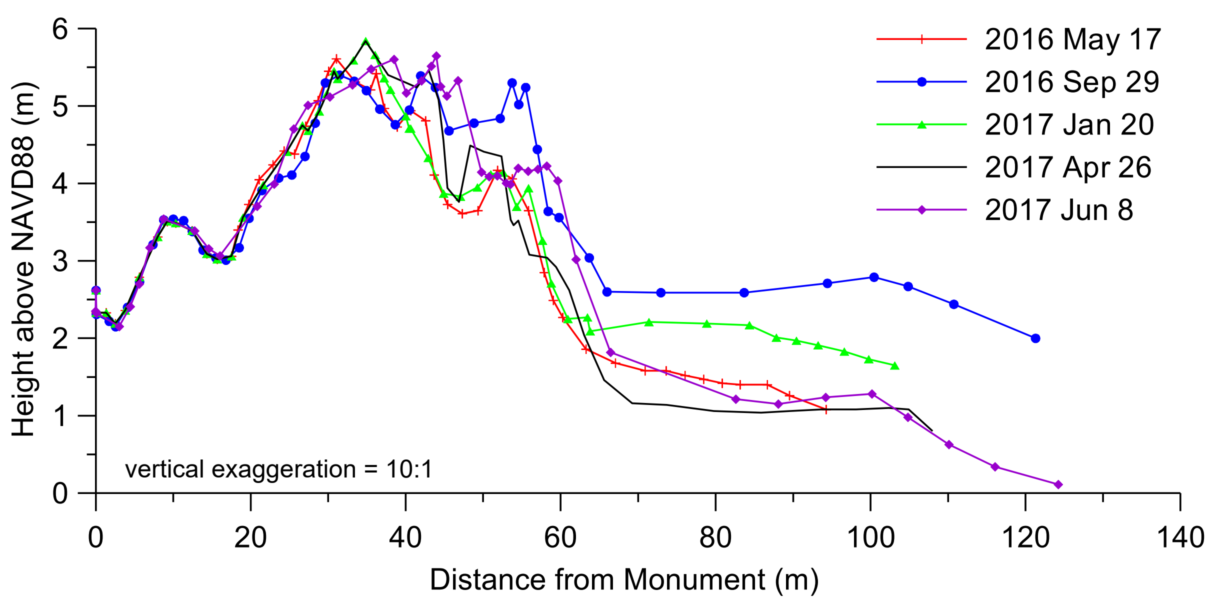
NPI08


NPI08 (North Padre Island)
Height above NAVD88 (m)
Distance from Monument (m)
2009 Apr 13
2009 Apr 14
2009 Oct 23
2010 Mar 2
2010 May 21

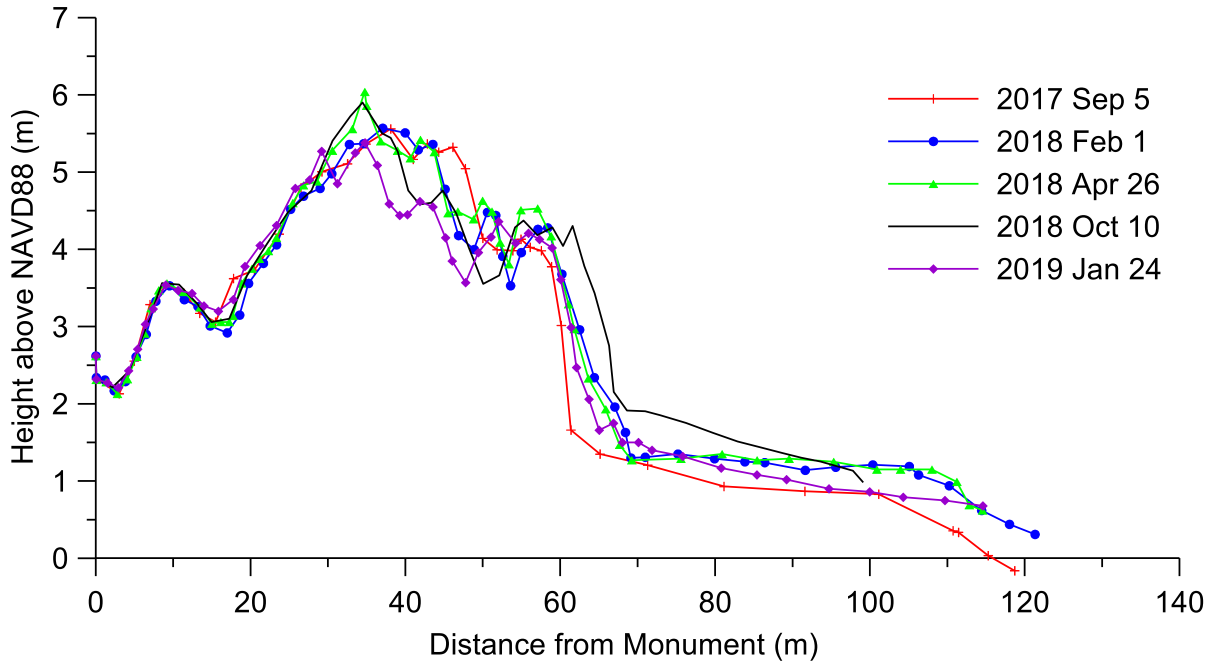

Height above NAVD88 (m)
Distance from Monument (m)
2011 Feb 11
2011 Oct 7
2012 Jan 27
2012 Oct 26
2013 Feb 1
vertical exaggeration = 10:1

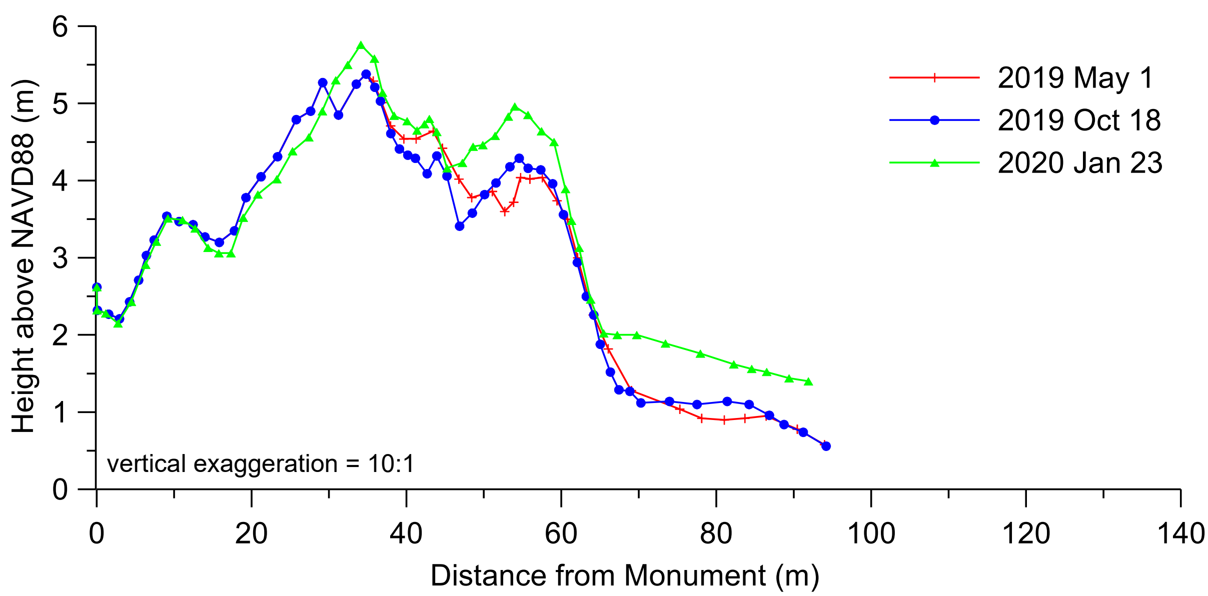
NPI08 (North Padre Island)



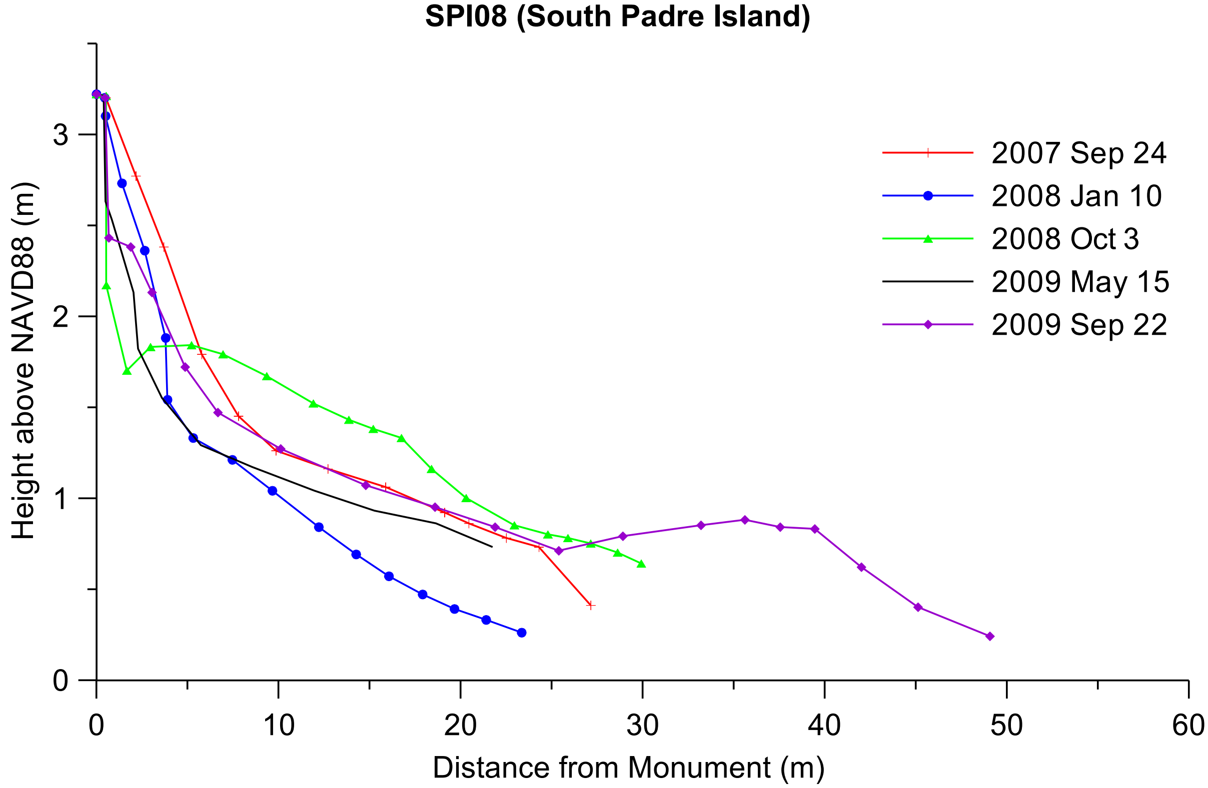


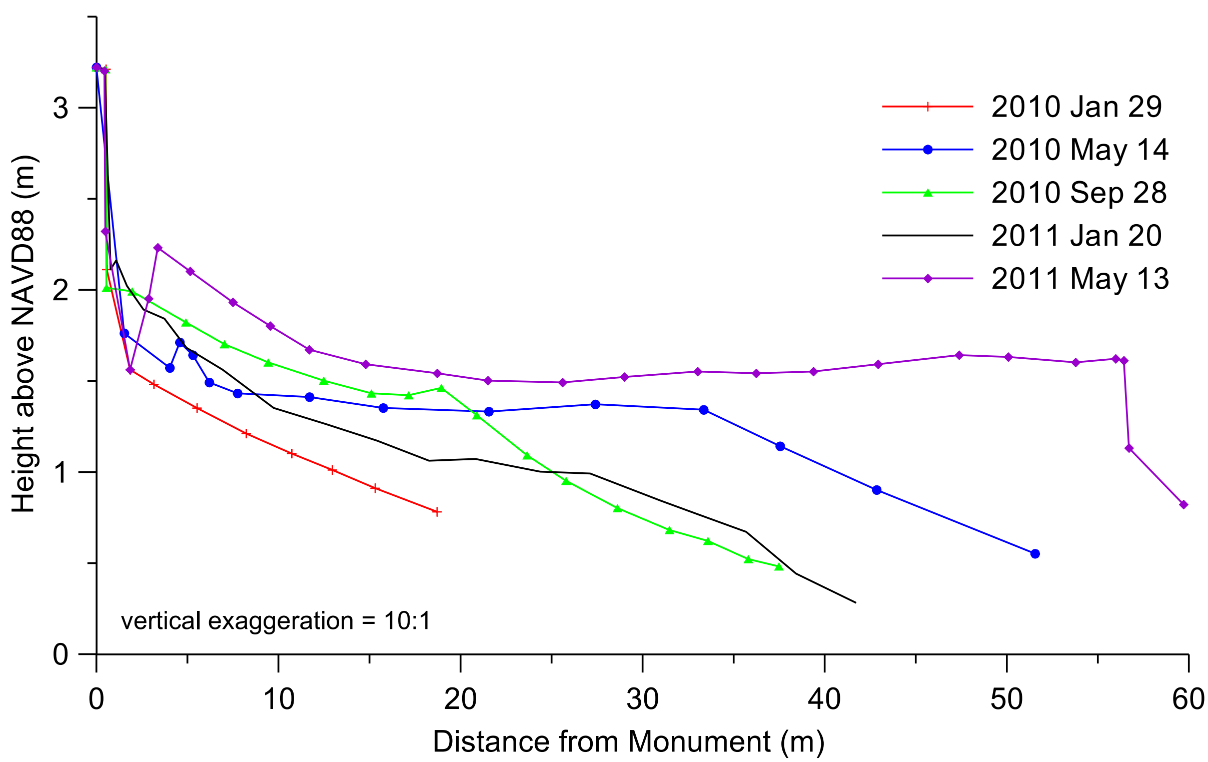
NPI08 (North Padre Island)

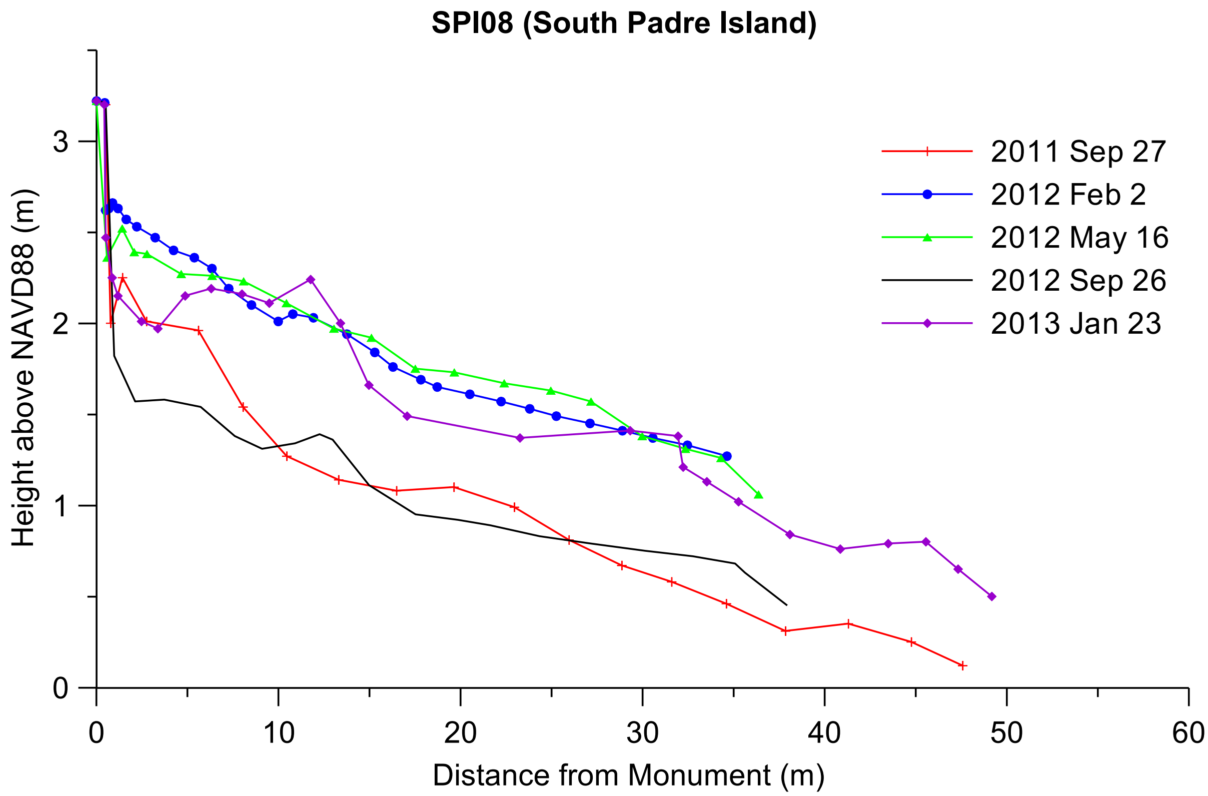


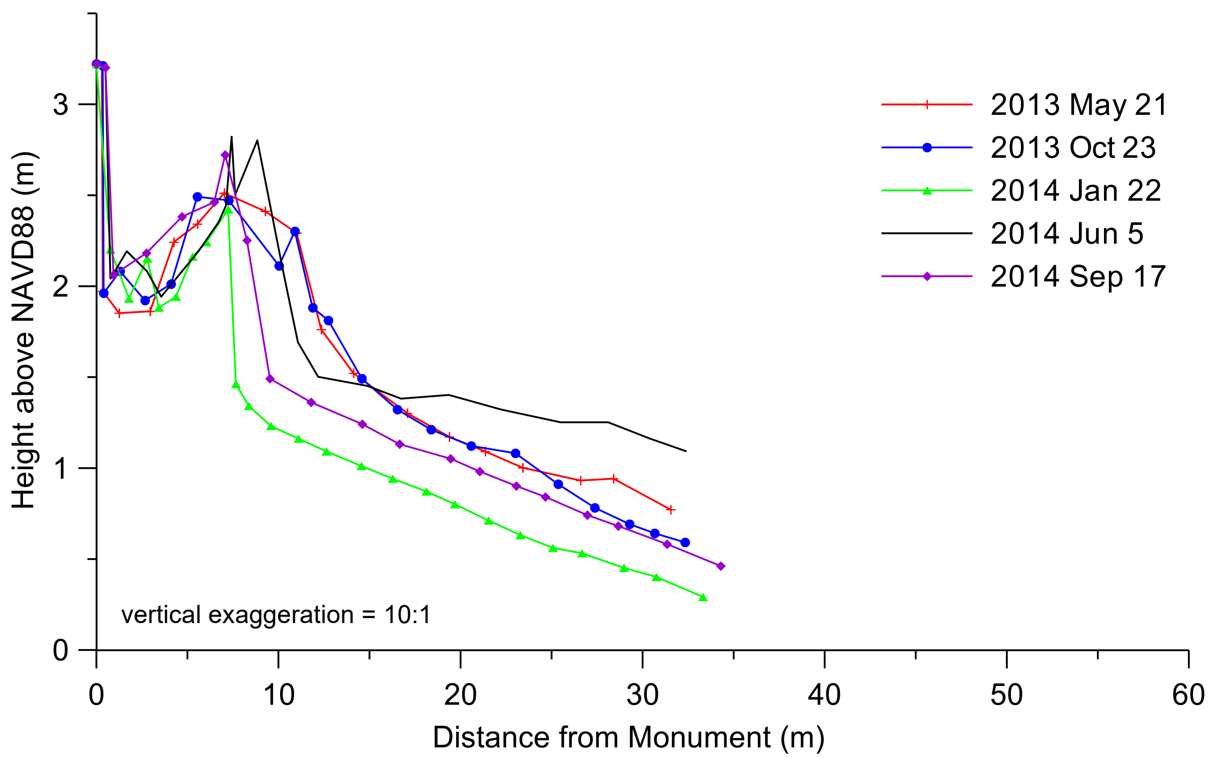


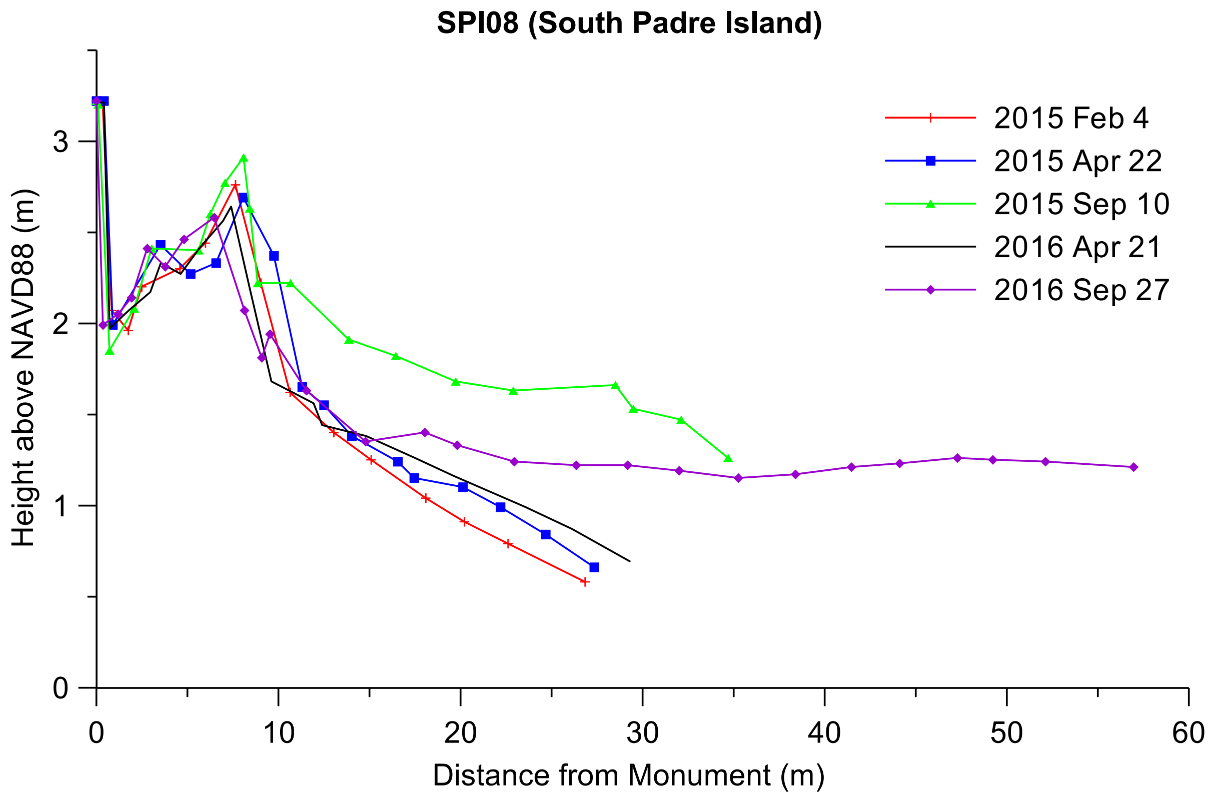
SPI08

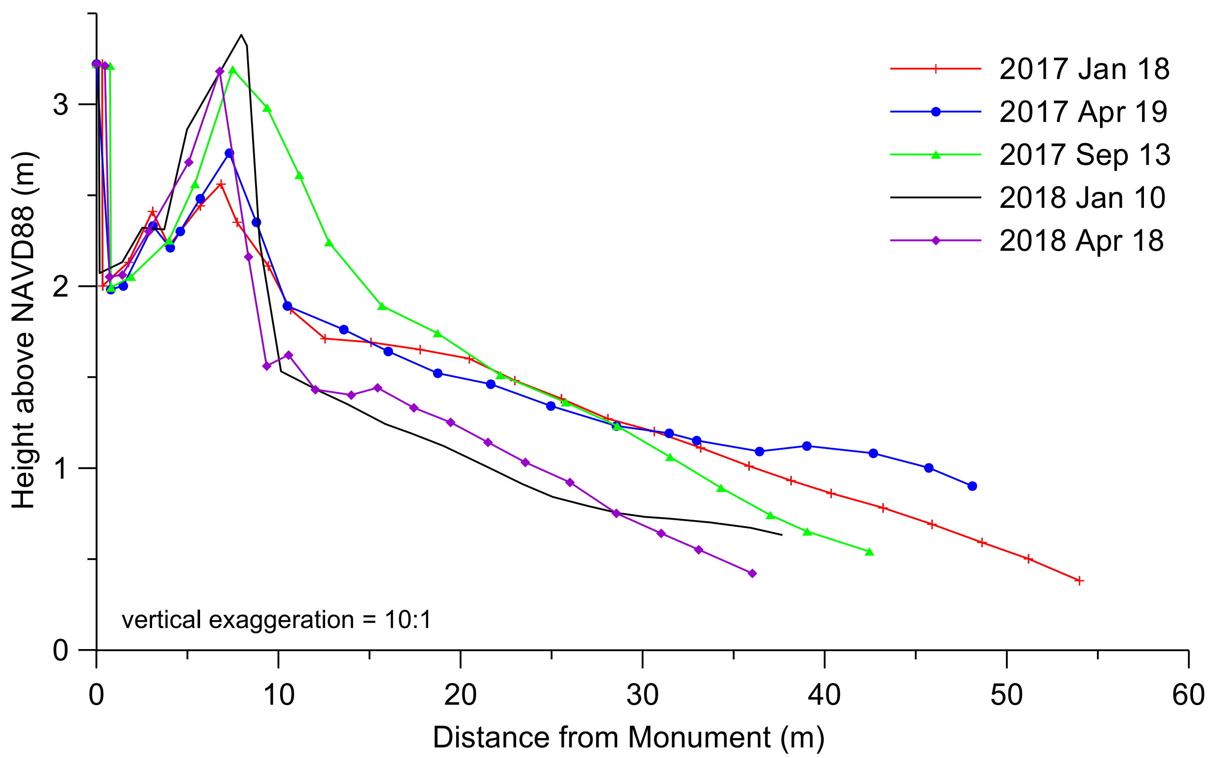

SPI08 (South Padre Island)
Height above NAVD88 (m)
Distance from Monument (m)
2007 Sep 24
2008 Jan 10
2008 Oct 3
2009 May 15
2009 Sep 22
0
1
2
3
0
10
20
30
40
50
60

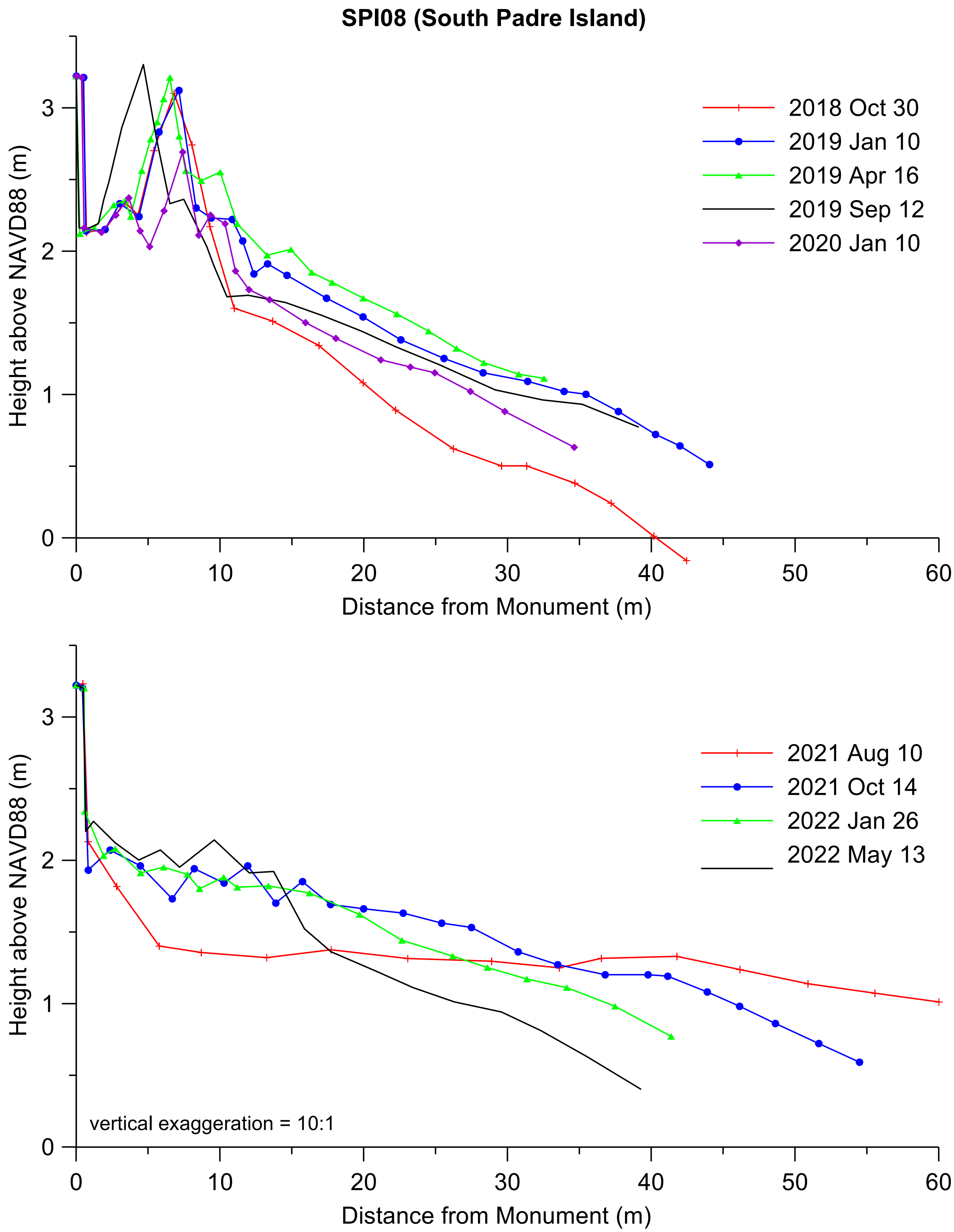

Height above NAVD88 (m)
Distance from Monument (m)
2010 Jan 29
2010 May 14
2010 Sep 28
2011 Jan 20
2011 May 13
vertical exaggeration = 10:1
0
1
2
3
0
10
20
30
40
50
60


SPI08 (South Padre Island)
Height above NAVD88 (m)
Distance from Monument (m)
2011 Sep 27
2012 Feb 2
2012 May 16
2012 Sep 26
2013 Jan 23


Height above NAVD88 (m)
Distance from Monument (m)
2013 May 21
2013 Oct 23
2014 Jan 22
2014 Jun 5
2014 Sep 17
vertical exaggeration = 10:1

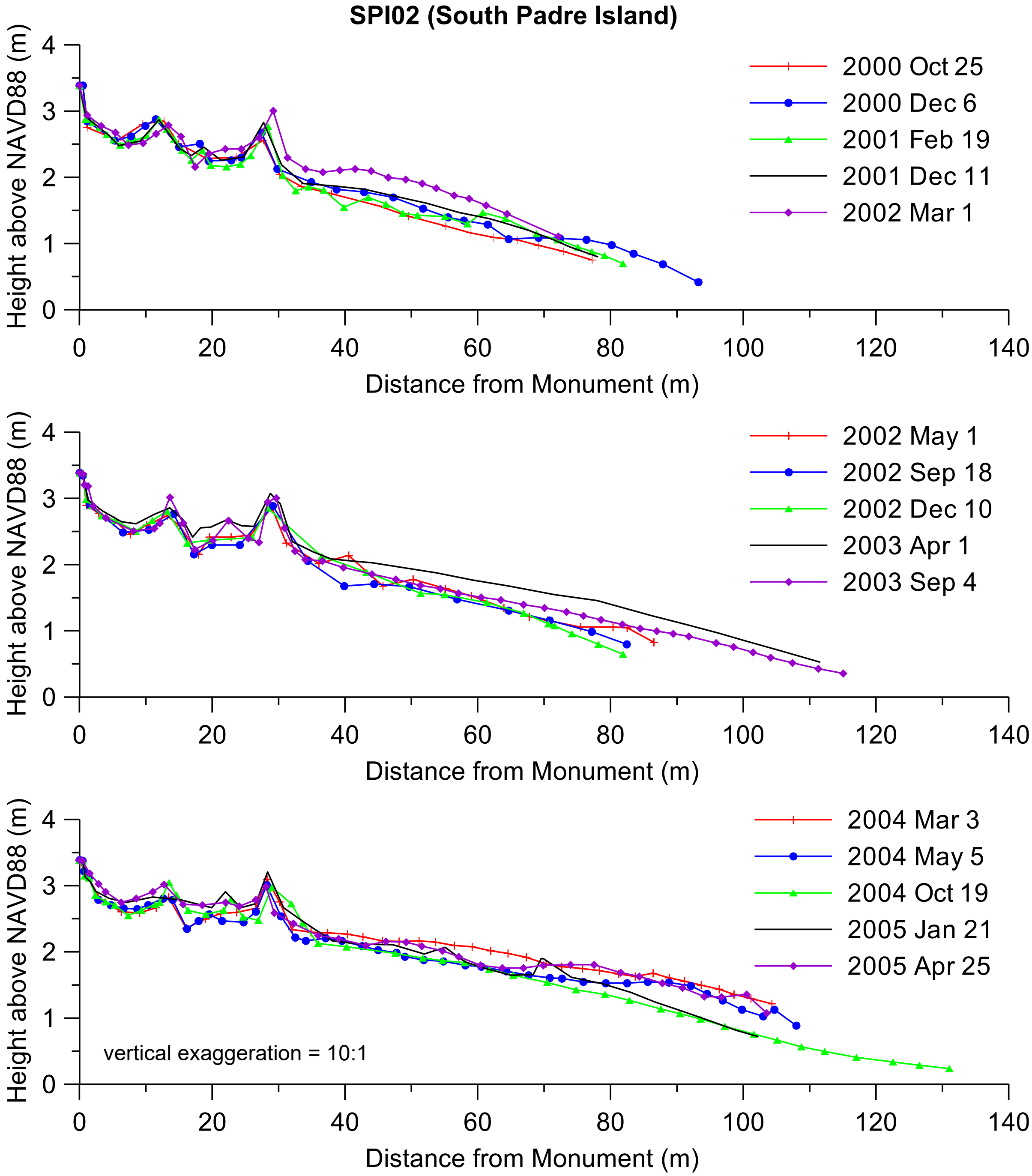

SPI08 (South Padre Island)
Height above NAVD88 (m)
Distance from Monument (m)
0
1
2
3
0
10
20
30
40
50
60
2015 Feb 4
2015 Apr 22
2015 Sep 10
2016 Apr 21
2016 Sep 27


Height above NAVD88 (m)
Distance from Monument (m)
0
1
2
3
0
10
20
30
40
50
60
2017 Jan 18
2017 Apr 19
2017 Sep 13
2018 Jan 10
2018 Apr 18
vertical exaggeration = 10:1

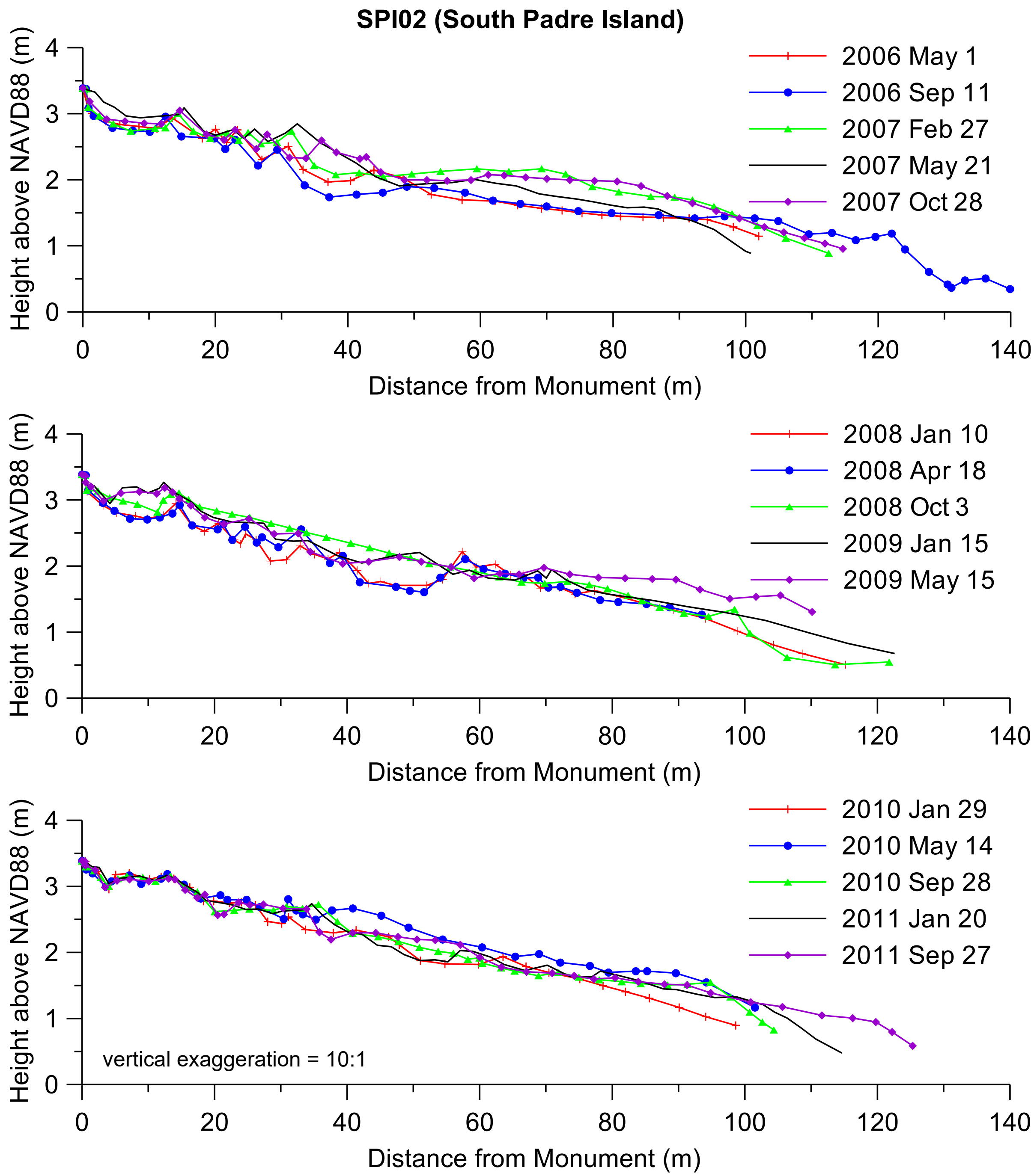


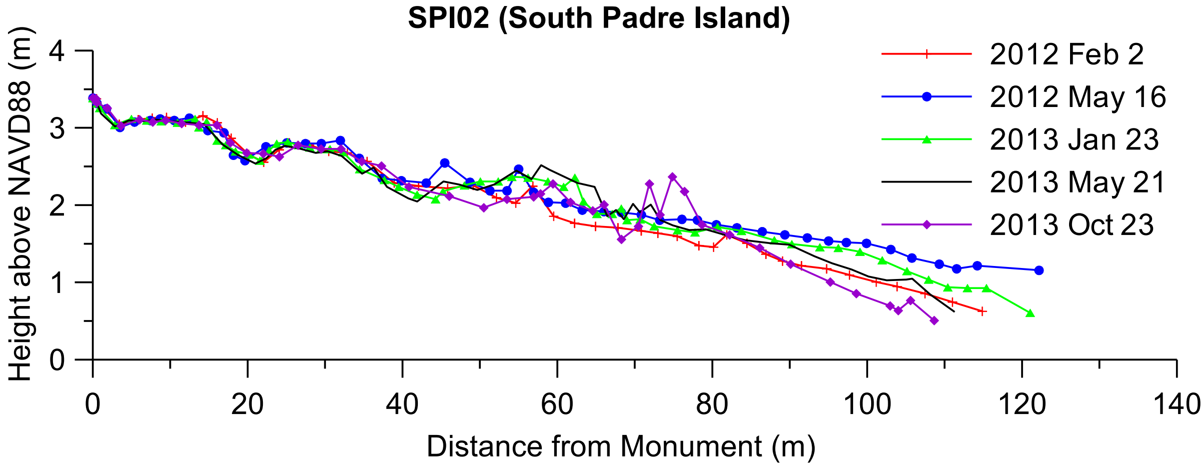
SPI08 (South Padre Island)
Height above NAVD88 (m)
Distance from Monument (m)
2018 Oct 30
2019 Jan 10
2019 Apr 16
2019 Sep 12
2020 Jan 10
Height above NAVD88 (m)
Distance from Monument (m)
2021 Aug 10
2021 Oct 14
2022 Jan 26
2022 May 13
vertical exaggeration = 10:1

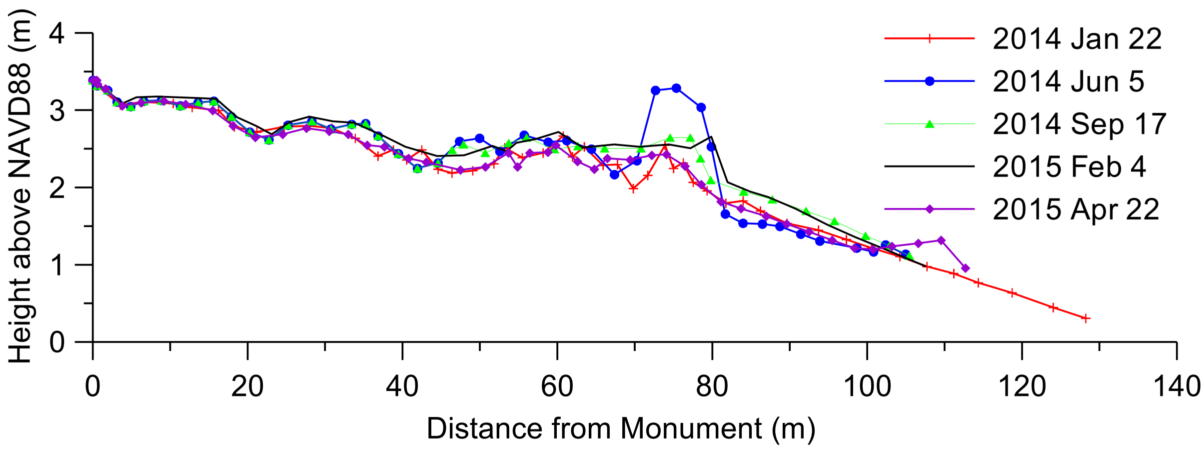
SPI02

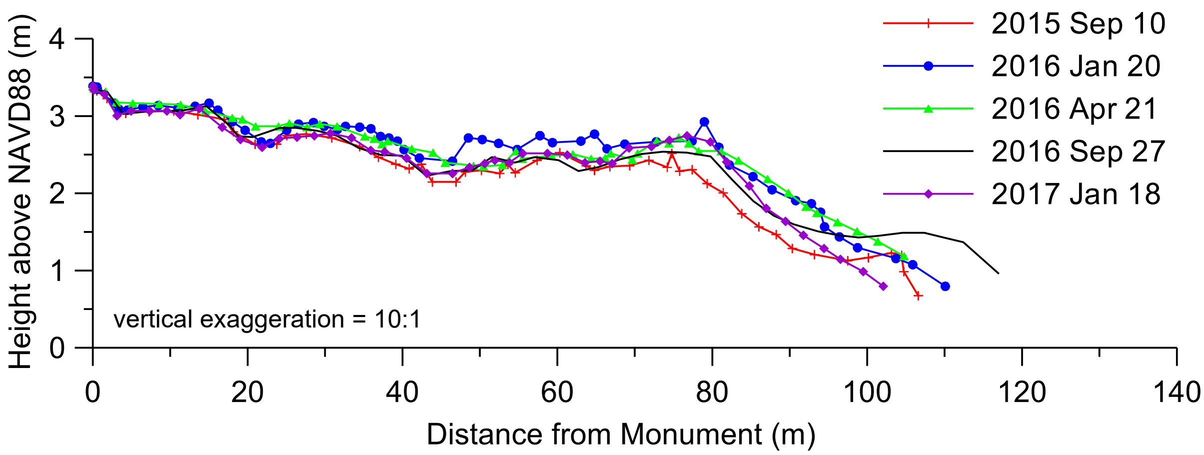


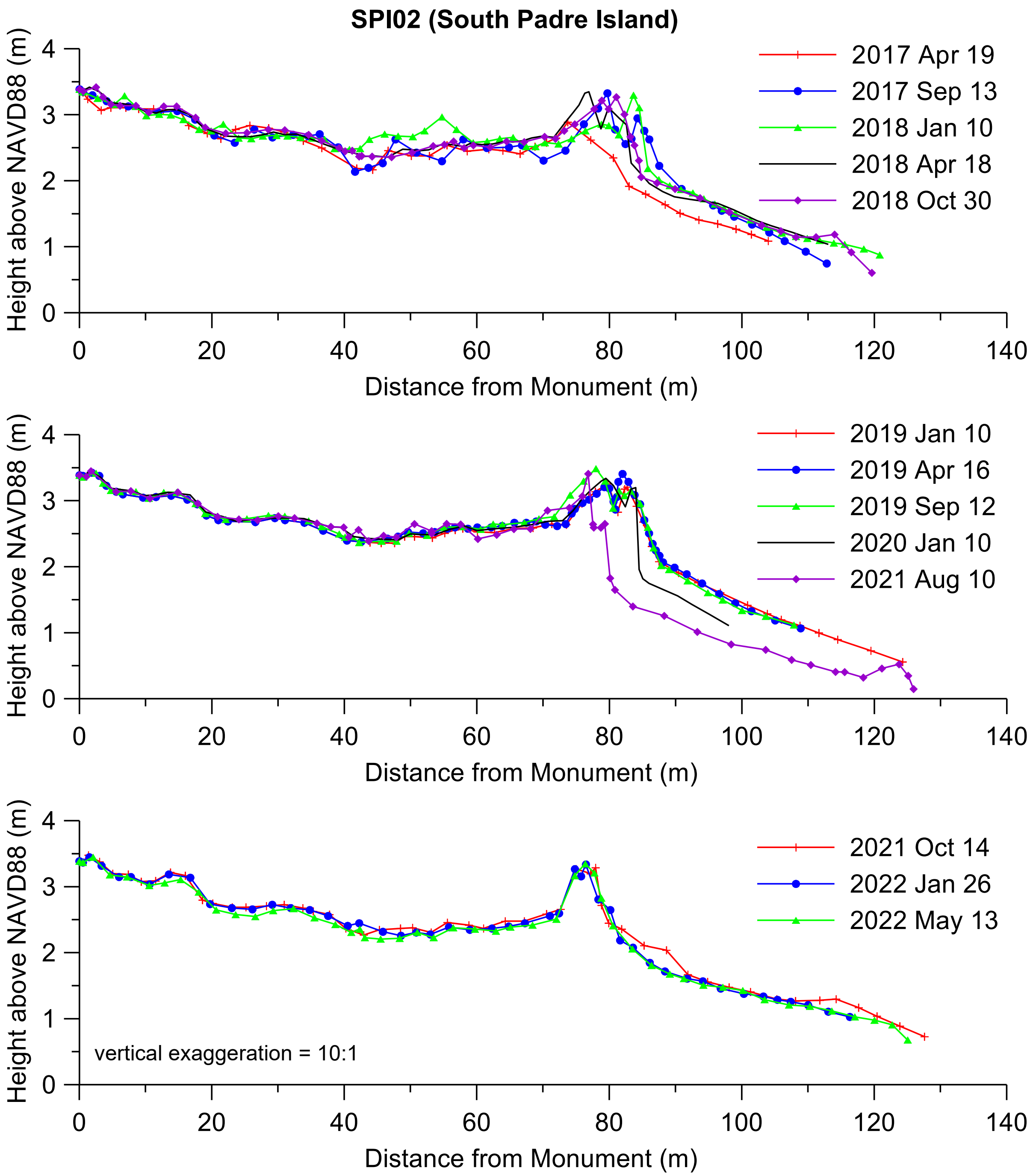
SPI02 (South Padre Island)
Height above NAVD88 (m)
Distance from Monument (m)
2000 Oct 25
2000 Dec 6
2001 Feb 19
2001 Dec 11
2002 Mar 1
2002 May 1
2002 Sep 18
2002 Dec 10
2003 Apr 1
2003 Sep 4
2004 Mar 3
2004 May 5
2004 Oct 19
2005 Jan 21
2005 Apr 25
vertical exaggeration = 10:1


SPI02 (South Padre Island)
Height above NAVD88 (m)
Distance from Monument (m)
2006 May 1
2006 Sep 11
2007 Feb 27
2007 May 21
2007 Oct 28
2008 Jan 10
2008 Apr 18
2008 Oct 3
2009 Jan 15
2009 May 15
2010 Jan 29
2010 May 14
2010 Sep 28
2011 Jan 20
2011 Sep 27
vertical exaggeration = 10:1

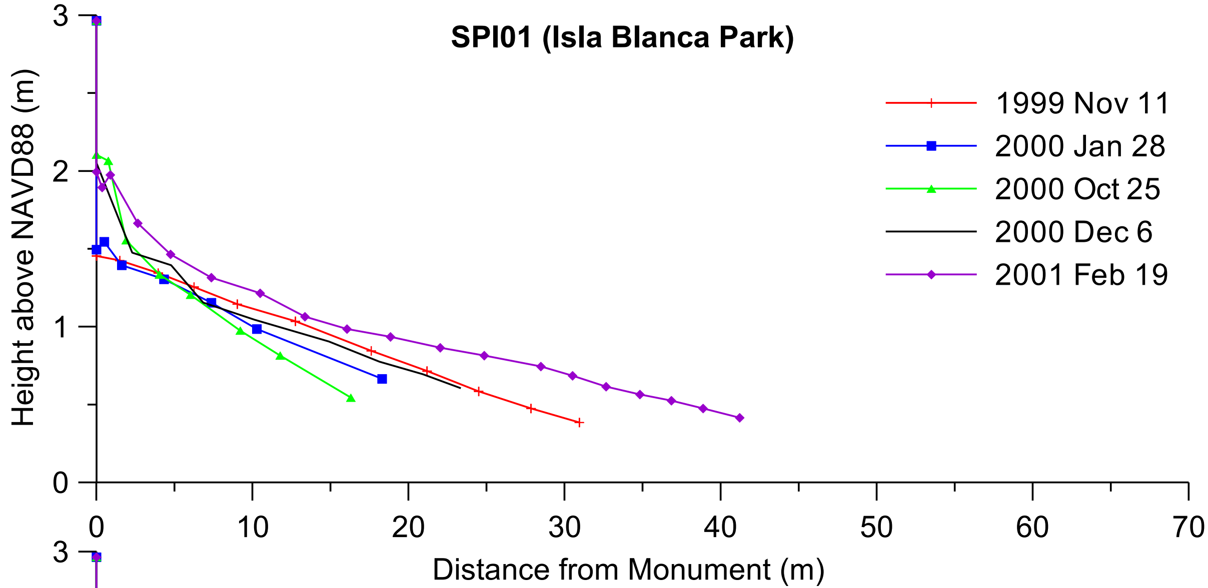

SPI02 (South Padre Island)
Height above NAVD88 (m)
Distance from Monument (m)
2012 Feb 2
2012 May 16
2013 Jan 23
2013 May 21
2013 Oct 23


Height above NAVD88 (m)
Distance from Monument (m)
2014 Jan 22
2014 Jun 5
2014 Sep 17
2015 Feb 4
2015 Apr 22

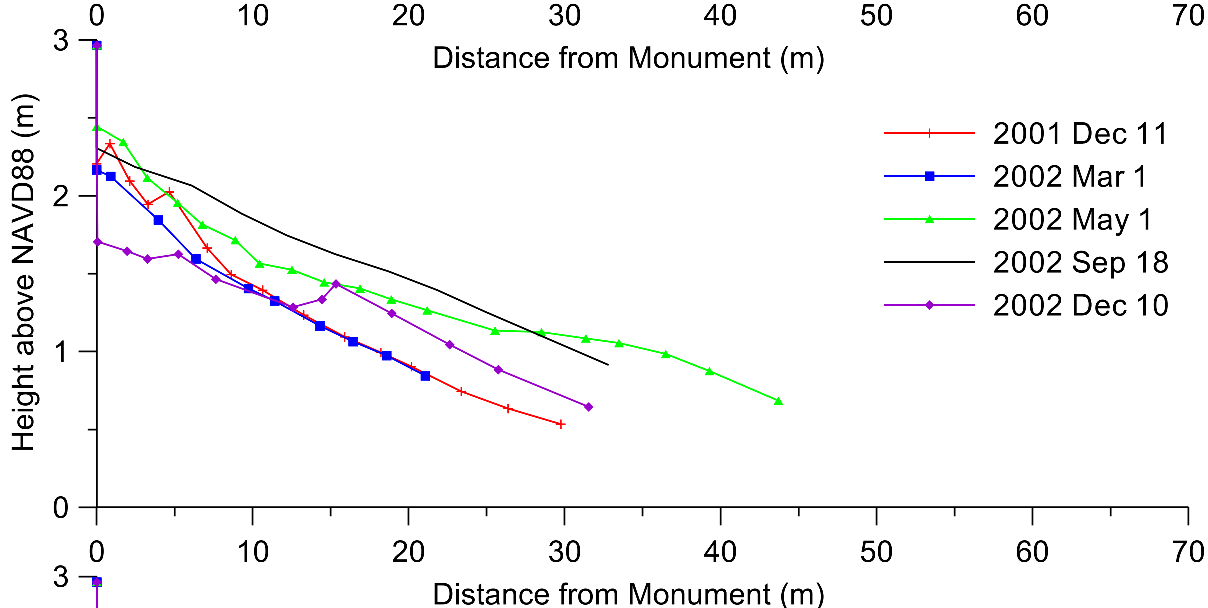

Height above NAVD88 (m)
Distance from Monument (m)
2015 Sep 10
2016 Jan 20
2016 Apr 21
2016 Sep 27
2017 Jan 18
vertical exaggeration = 10:1


SPI02 (South Padre Island)
Height above NAVD88 (m)
Distance from Monument (m)
2017 Apr 19
2017 Sep 13
2018 Jan 10
2018 Apr 18
2018 Oct 30
2019 Jan 10
2019 Apr 16
2019 Sep 12
2020 Jan 10
2021 Aug 10
2021 Oct 14
2022 Jan 26
2022 May 13
vertical exaggeration = 10:1

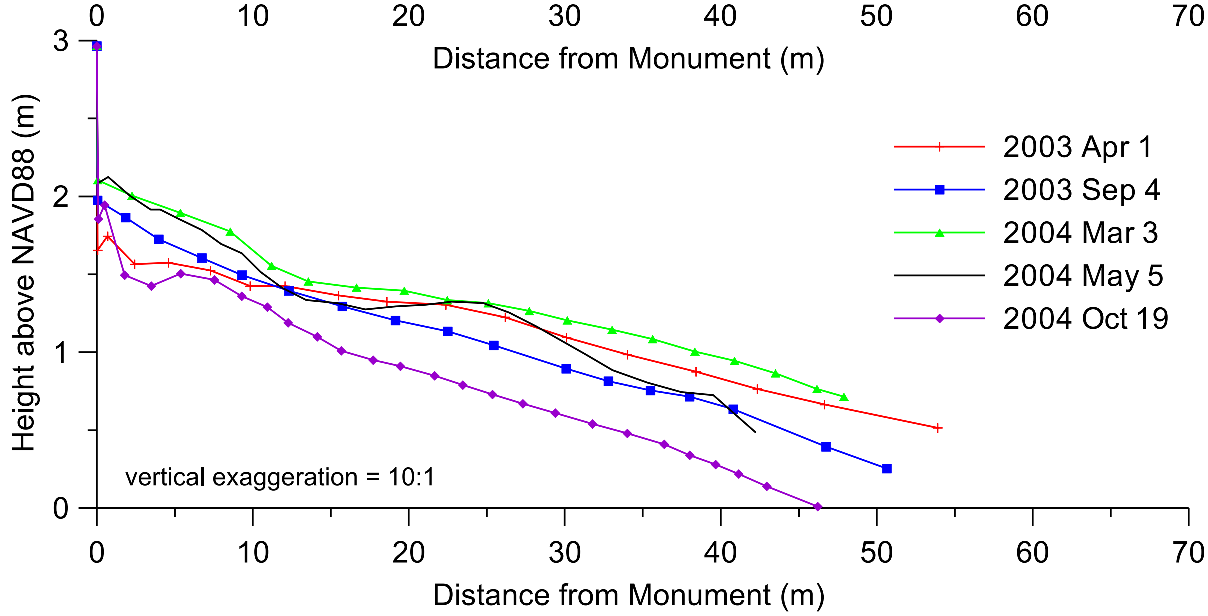
SPI01



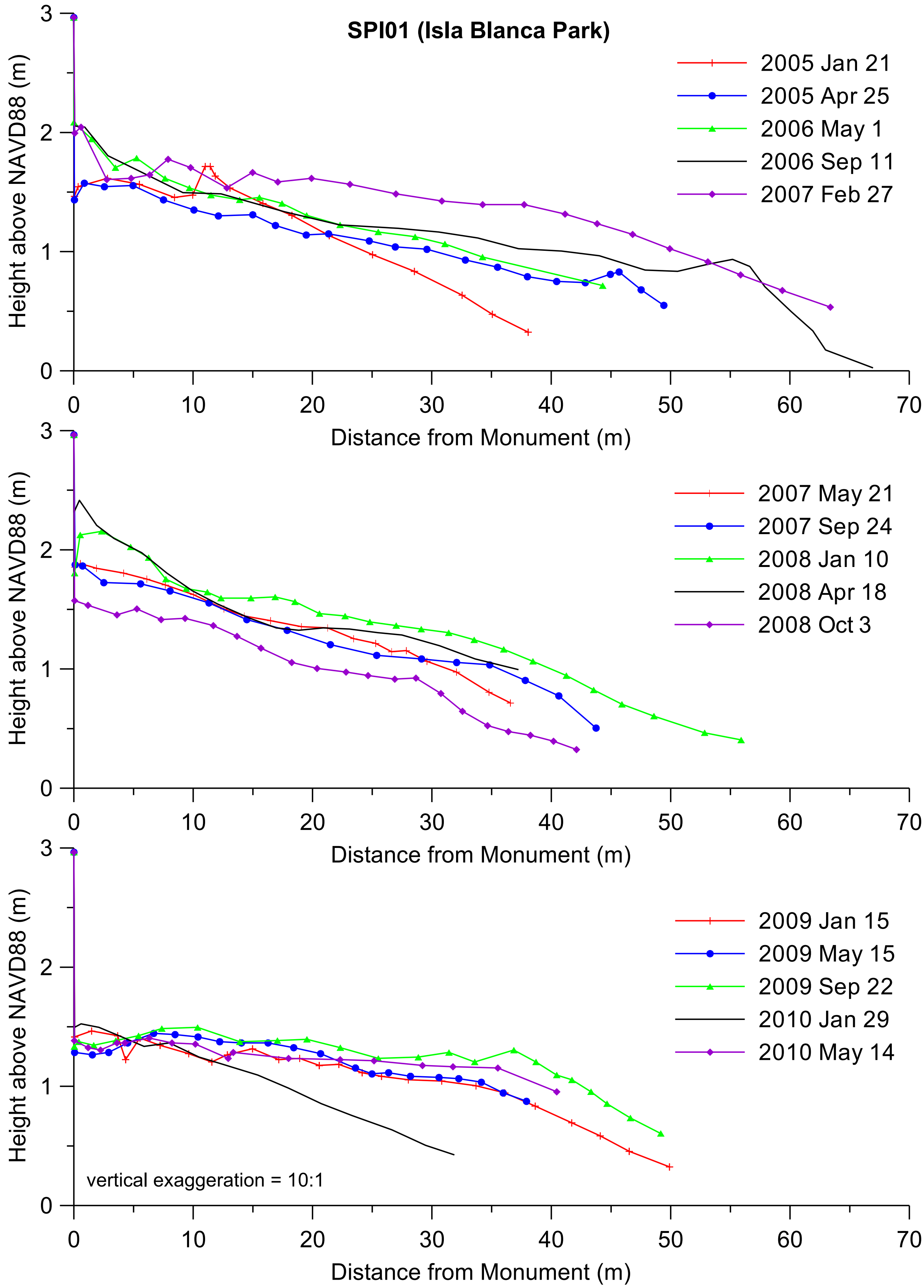
SPI01 (Isla Blanca Park)
1999 Nov 11
2000 Jan 28
2000 Oct 25
2000 Dec 6
2001 Feb 19
Height above NAVD88 (m)
Distance from Monument (m)
0
1
2
3
0
10
20
30
40
50
60
70

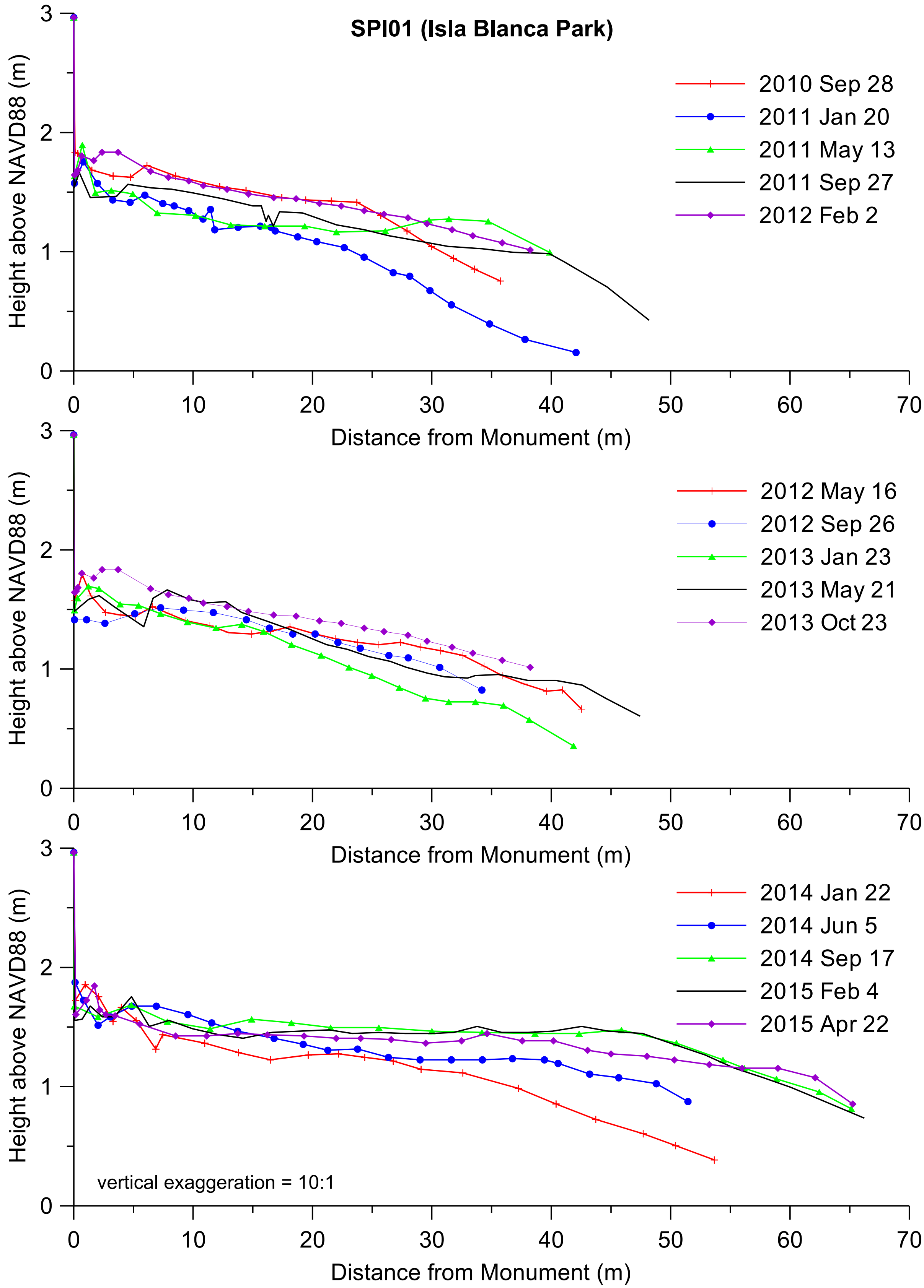


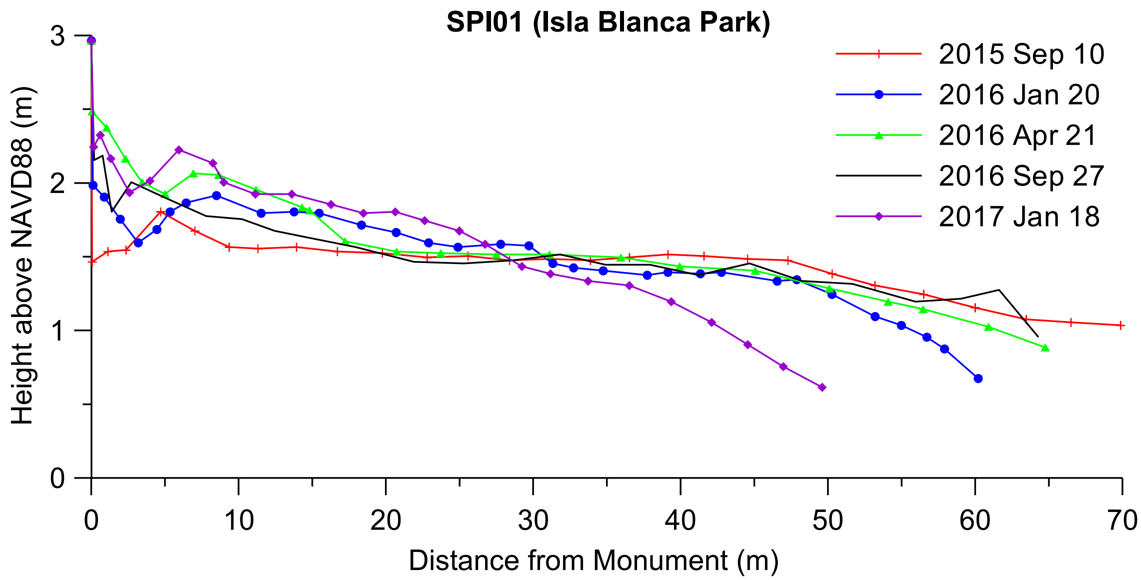
2001 Dec 11
2002 Mar 1
2002 May 1
2002 Sep 18
2002 Dec 10
Height above NAVD88 (m)
Distance from Monument (m)
0
1
2
3
0
10
20
30
40
50
60
70

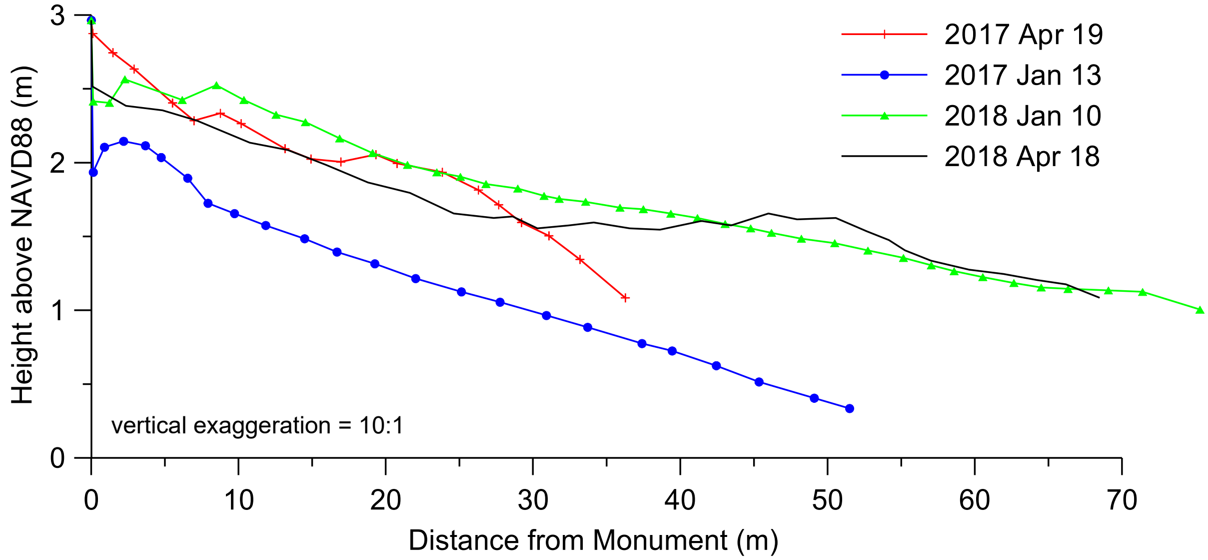


2003 Apr 1
2003 Sep 4
2004 Mar 3
2004 May 5
2004 Oct 19
vertical exaggeration = 10:1
Height above NAVD88 (m)
Distance from Monument (m)
0
1
2
3
0
10
20
30
40
50
60
70

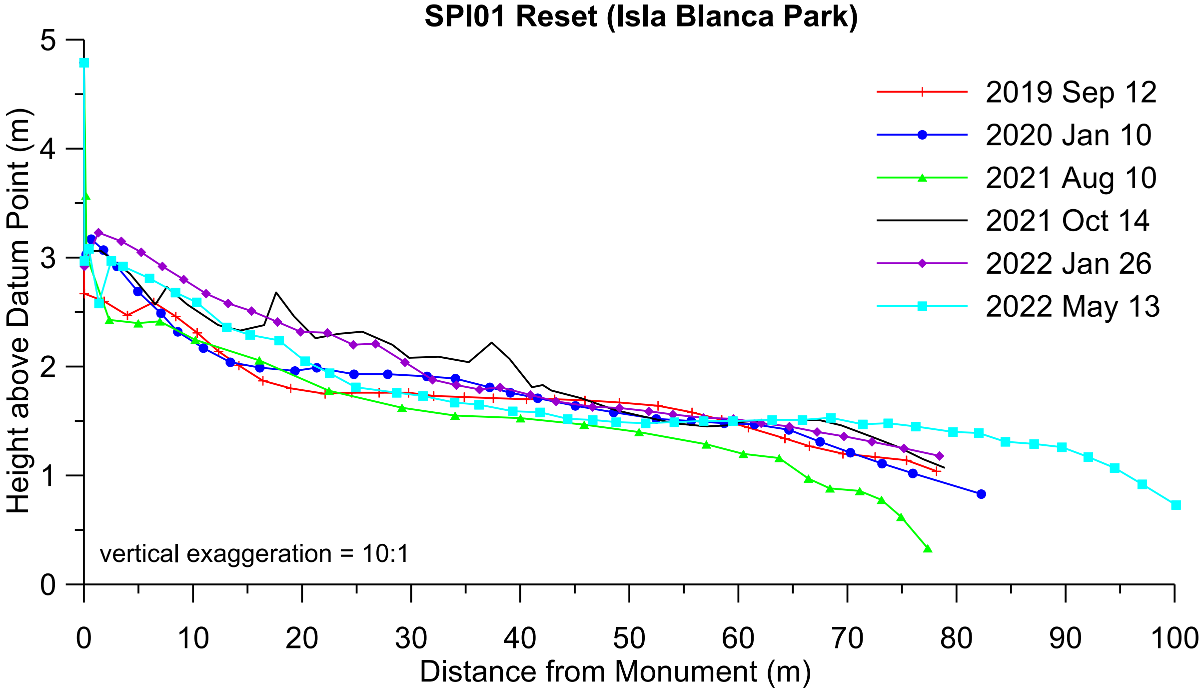

SPI01 (Isla Blanca Park)
2005 Jan 21
2005 Apr 25
2006 May 1
2006 Sep 11
2007 Feb 27
Height above NAVD88 (m)
Distance from Monument (m)
2007 May 21
2007 Sep 24
2008 Jan 10
2008 Apr 18
2008 Oct 3
Height above NAVD88 (m)
Distance from Monument (m)
2009 Jan 15
2009 May 15
2009 Sep 22
2010 Jan 29
2010 May 14
vertical exaggeration = 10:1
Height above NAVD88 (m)
Distance from Monument (m)


SPI01 (Isla Blanca Park)
Height above NAVD88 (m)
Distance from Monument (m)
2010 Sep 28
2011 Jan 20
2011 May 13
2011 Sep 27
2012 Feb 2
2012 May 16
2012 Sep 26
2013 Jan 23
2013 May 21
2013 Oct 23
2014 Jan 22
2014 Jun 5
2014 Sep 17
2015 Feb 4
2015 Apr 22
vertical exaggeration = 10:1


SPI01 (Isla Blanca Park)
2015 Sep 10
2016 Jan 20
2016 Apr 21
2016 Sep 27
2017 Jan 18
Height above NAVD88 (m)
Distance from Monument (m)
0
1
2
3
0
10
20
30
40
50
60
70

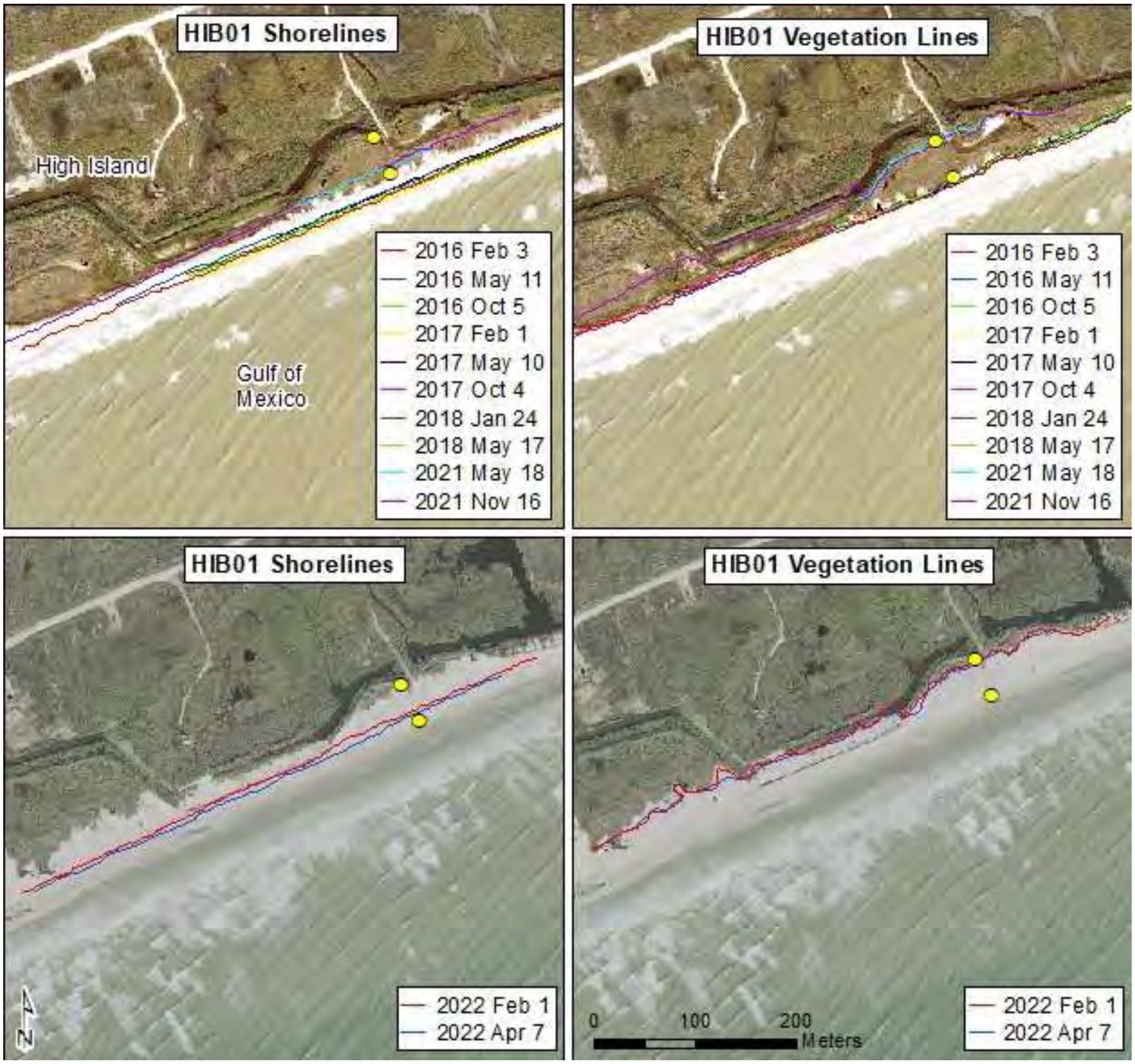

2017 Apr 19
2017 Jan 13
2018 Jan 10
2018 Apr 18
Height above NAVD88 (m)
Distance from Monument (m)
vertical exaggeration = 10:1
0
1
2
3
0
10
20
30
40
50
60
70

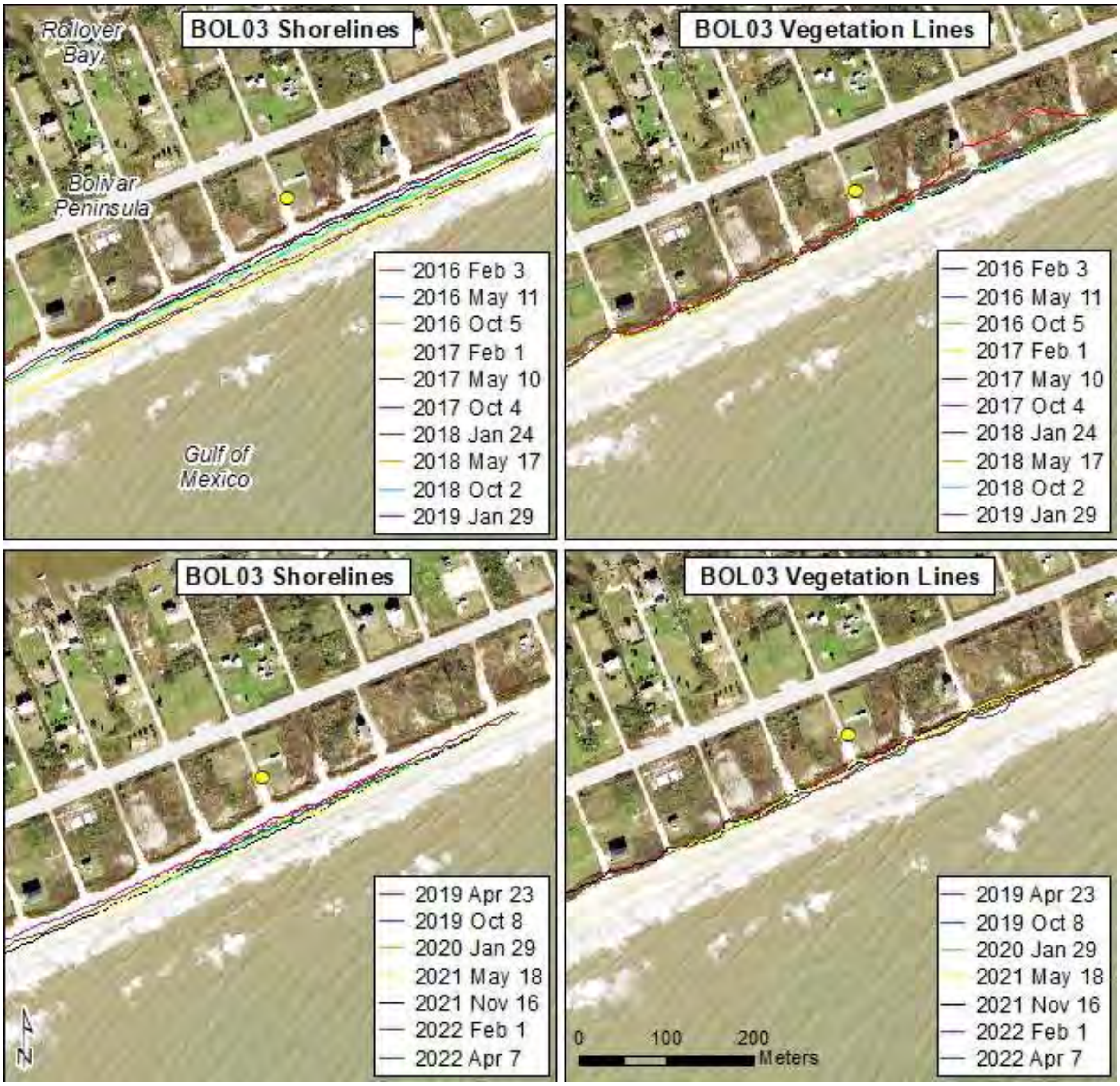
SPI01R

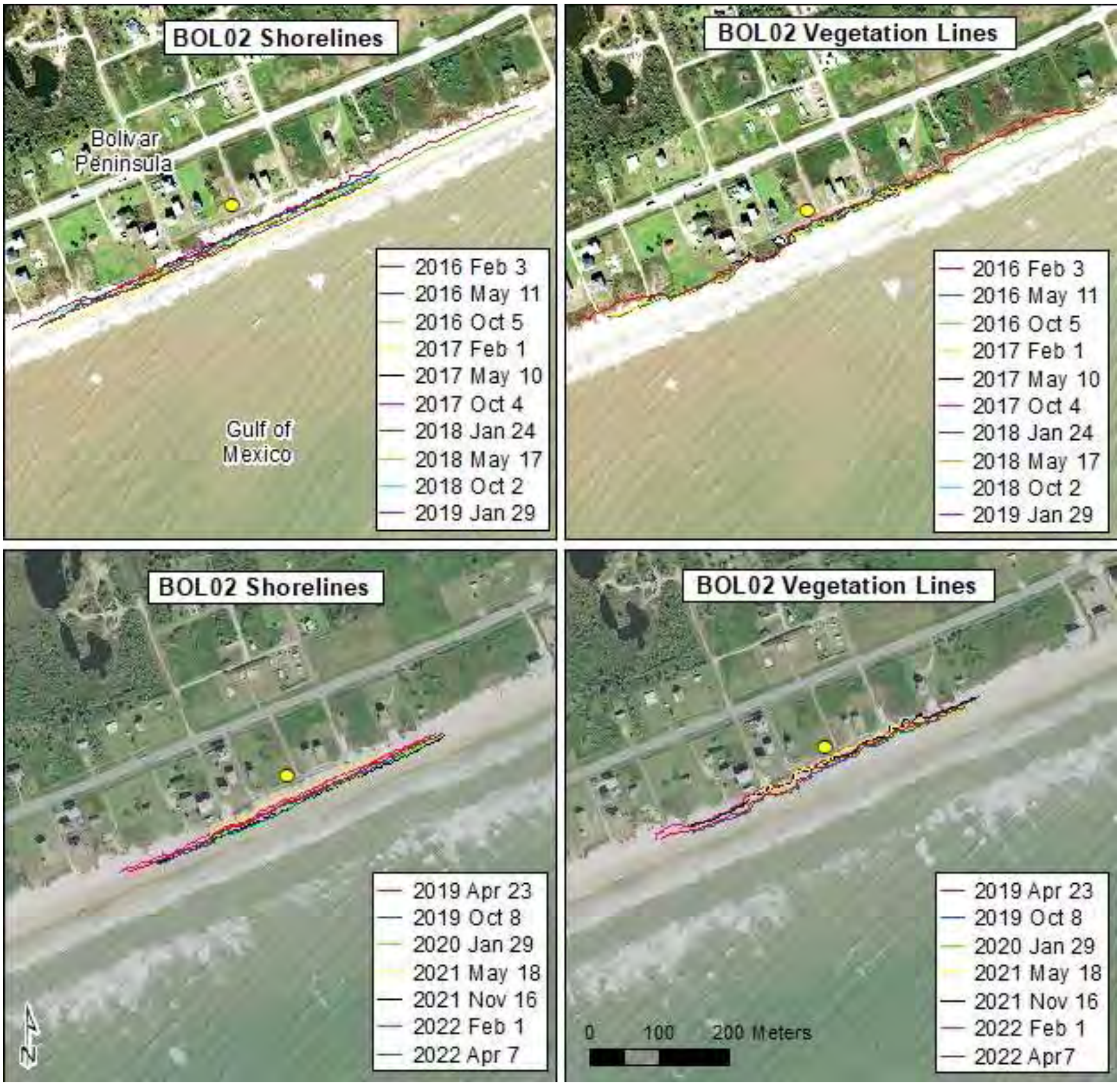


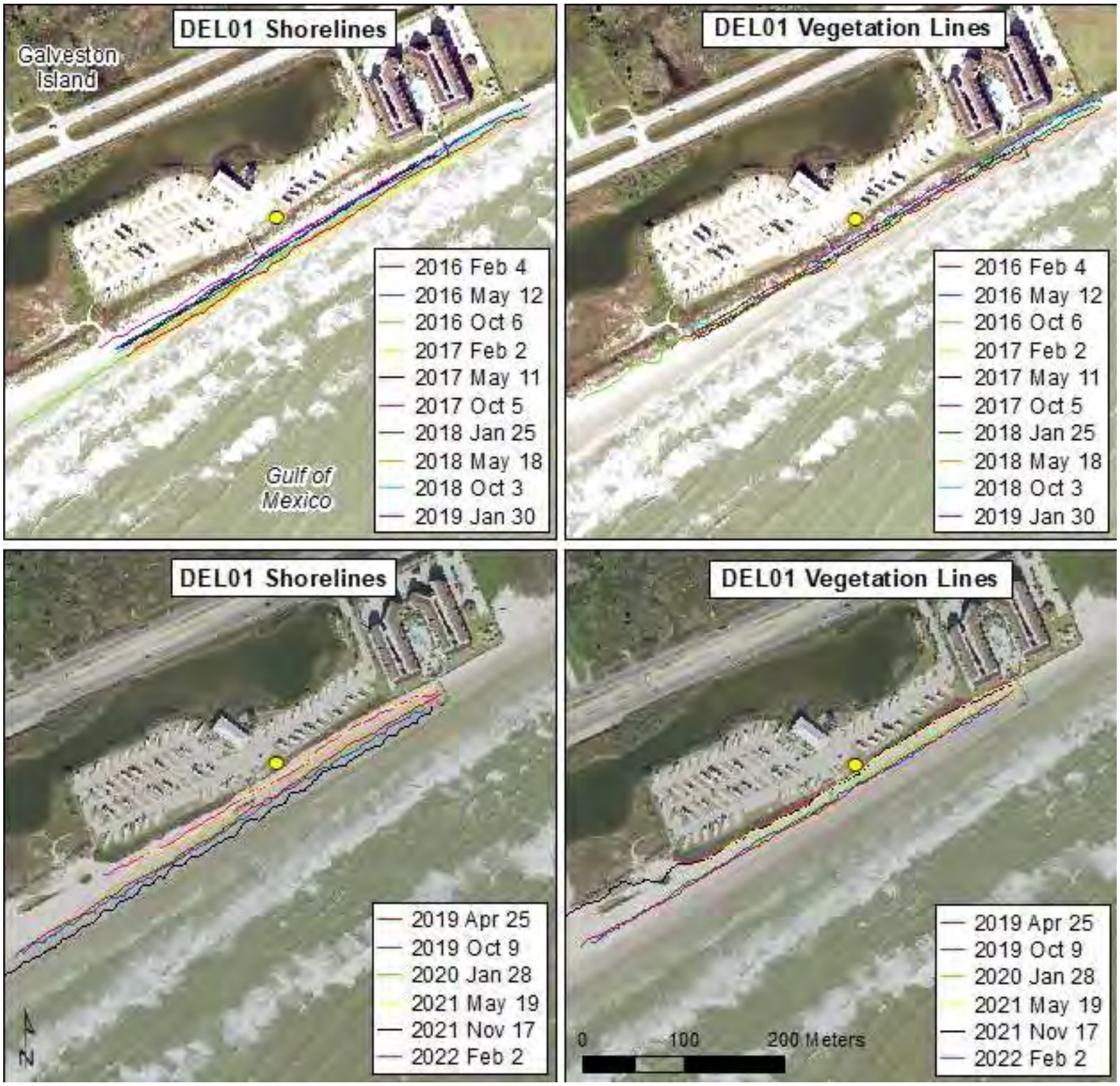
SPI01 Reset (Isla Blanca Park)
Height above Datum Point (m)
Distance from Monument (m)
2019 Sep 12
2020 Jan 10
2021 Aug 10
2021 Oct 14
2022 Jan 26
2022 May 13
vertical exaggeration = 10:1

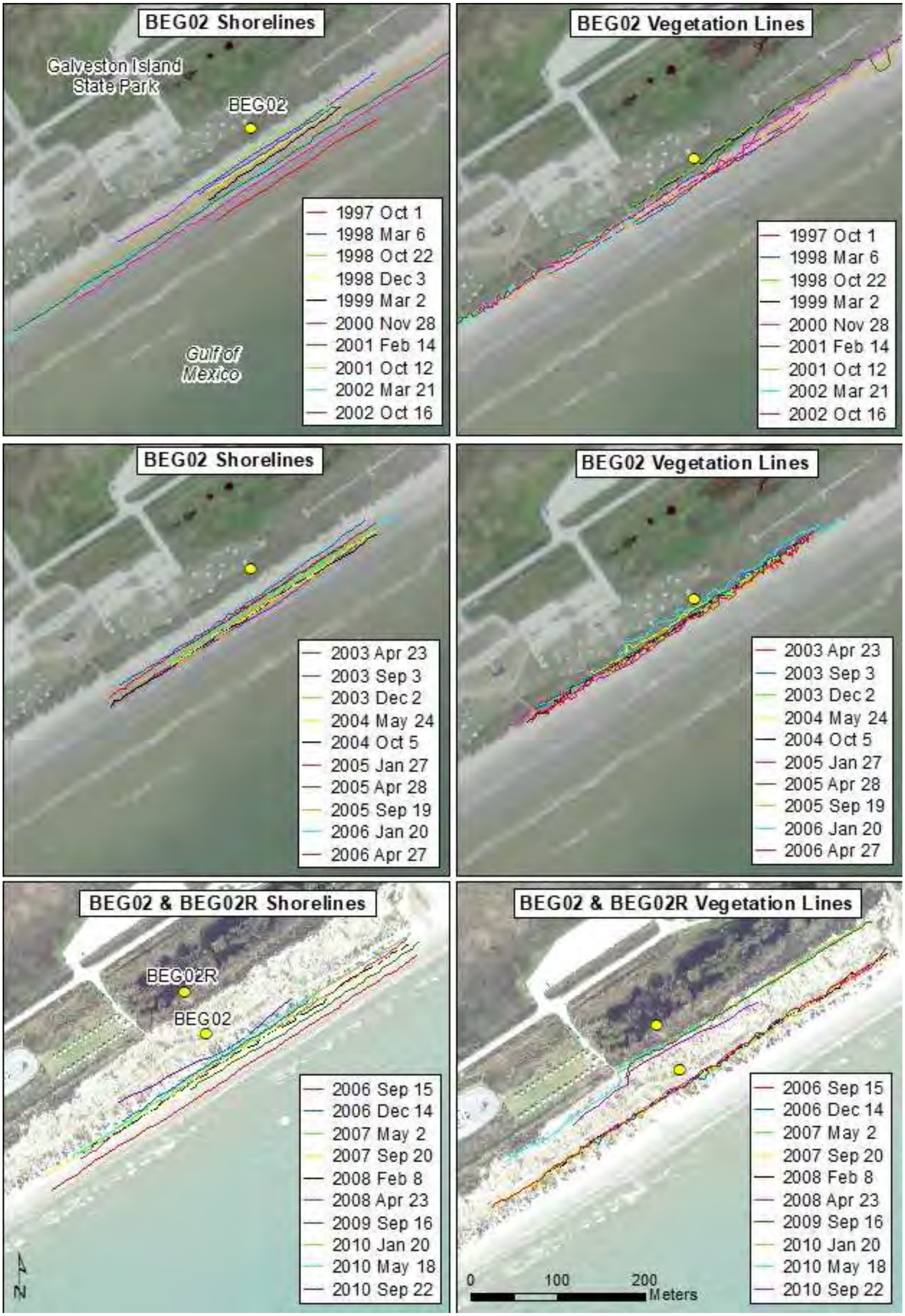
APPENDIX D: MAPS OF GPS SHORELINE AND VEGETATION LINE POSITIONS

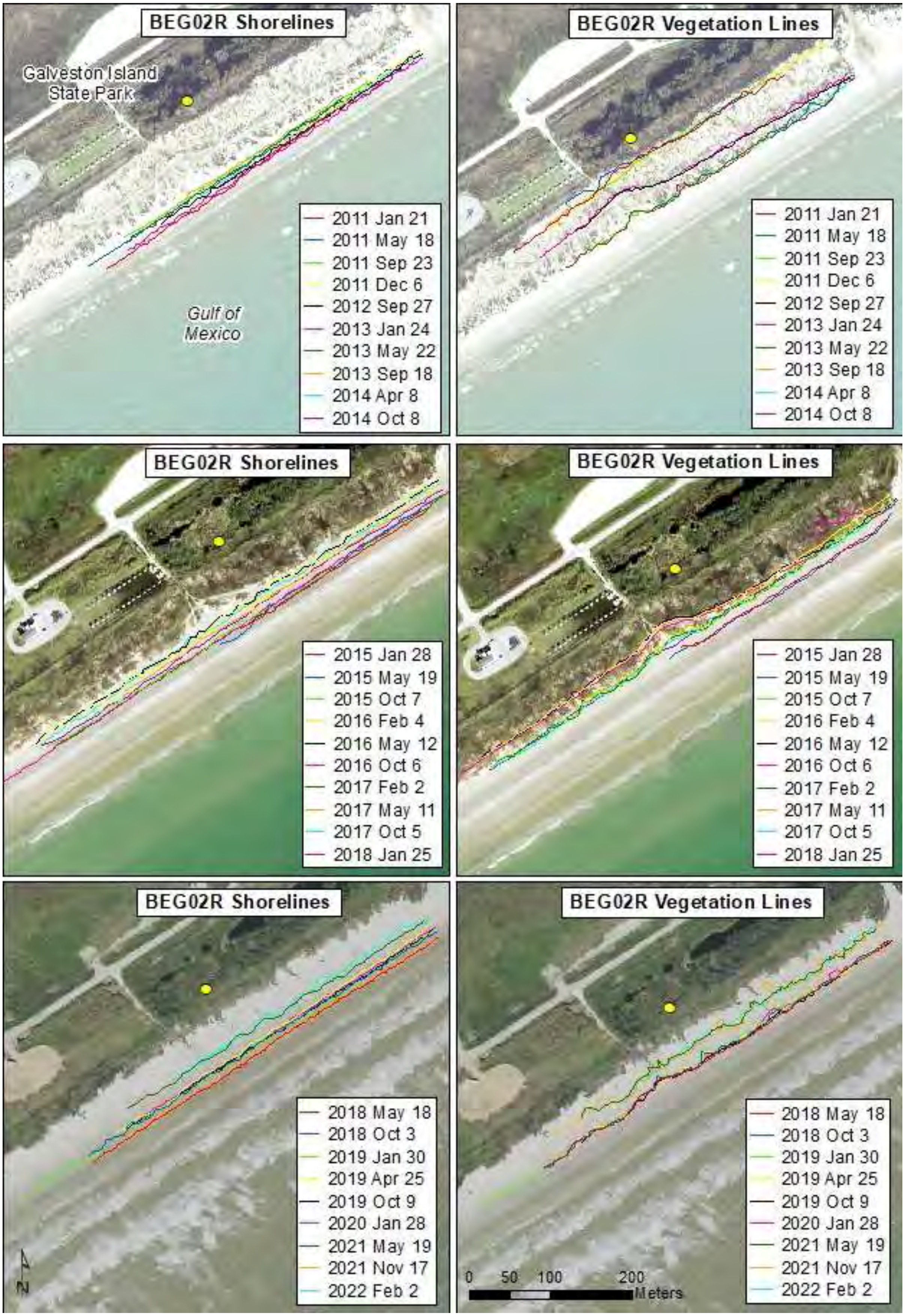


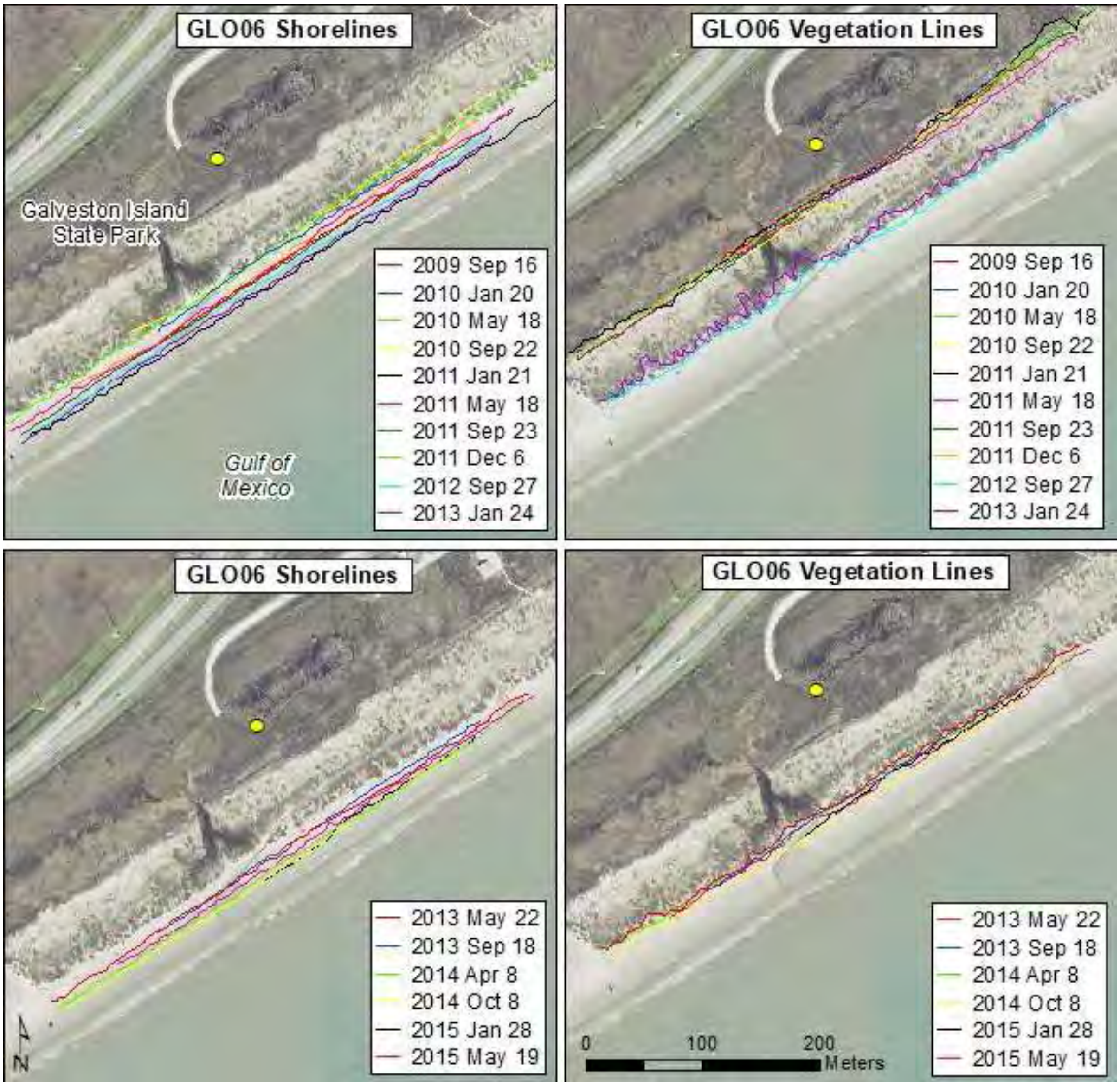

BOL03 Shorelines
Rollover Bay
Bolivar Peninsula
Gulf of Mexico
2016 Feb 3
2016 May 11
2016 Oct 5
2017 Feb 1
2017 May 10
2017 Oct 4
2018 Jan 24
2018 May 17
2018 Oct 2
2019 Jan 29
BOL03 Vegetation Lines
2016 Feb 3
2016 May 11
2016 Oct 5
2017 Feb 1
2017 May 10
2017 Oct 4
2018 Jan 24
2018 May 17
2018 Oct 2
2019 Jan 29
BOL03 Shorelines
2019 Apr 23
2019 Oct 8
2020 Jan 29
2021 May 18
2021 Nov 16
2022 Feb 1
2022 Apr 7
N
BOL03 Vegetation Lines
2019 Apr 23
2019 Oct 8
2020 Jan 29
2021 May 18
2021 Nov 16
2022 Feb 1
2022 Apr 7
0 100 200 Meters

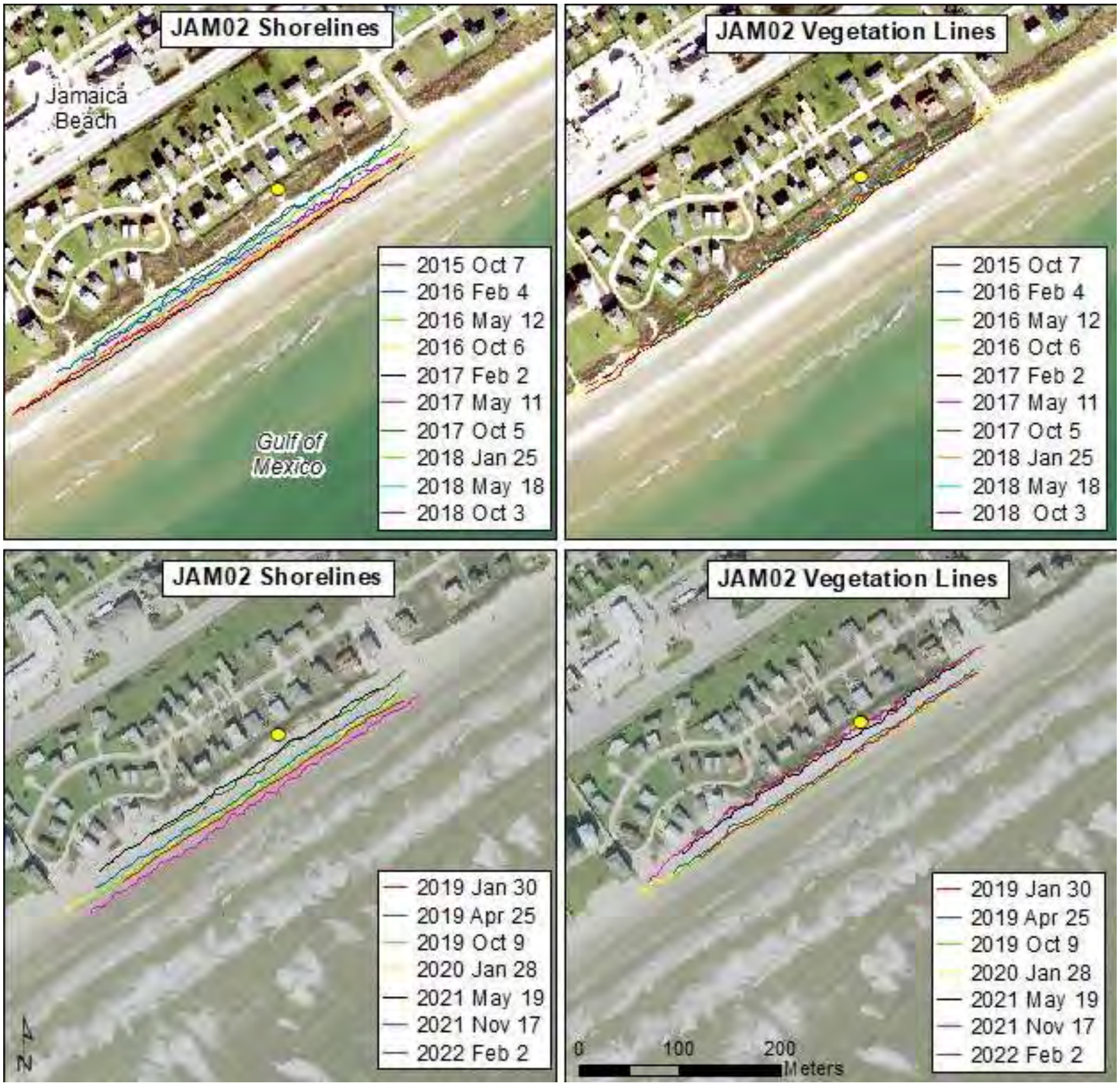

BOL02 Shorelines
Bolivar Peninsula
Gulf of Mexico
2016 Feb 3
2016 May 11
2016 Oct 5
2017 Feb 1
2017 May 10
2017 Oct 4
2018 Jan 24
2018 May 17
2018 Oct 2
2019 Jan 29
BOL02 Vegetation Lines
2016 Feb 3
2016 May 11
2016 Oct 5
2017 Feb 1
2017 May 10
2017 Oct 4
2018 Jan 24
2018 May 17
2018 Oct 2
2019 Jan 29
BOL02 Shorelines
2019 Apr 23
2019 Oct 8
2020 Jan 29
2021 May 18
2021 Nov 16
2022 Feb 1
2022 Apr 7
N
BOL02 Vegetation Lines
0 100 200 Meters
2019 Apr 23
2019 Oct 8
2020 Jan 29
2021 May 18
2021 Nov 16
2022 Feb 1
2022 Apr7

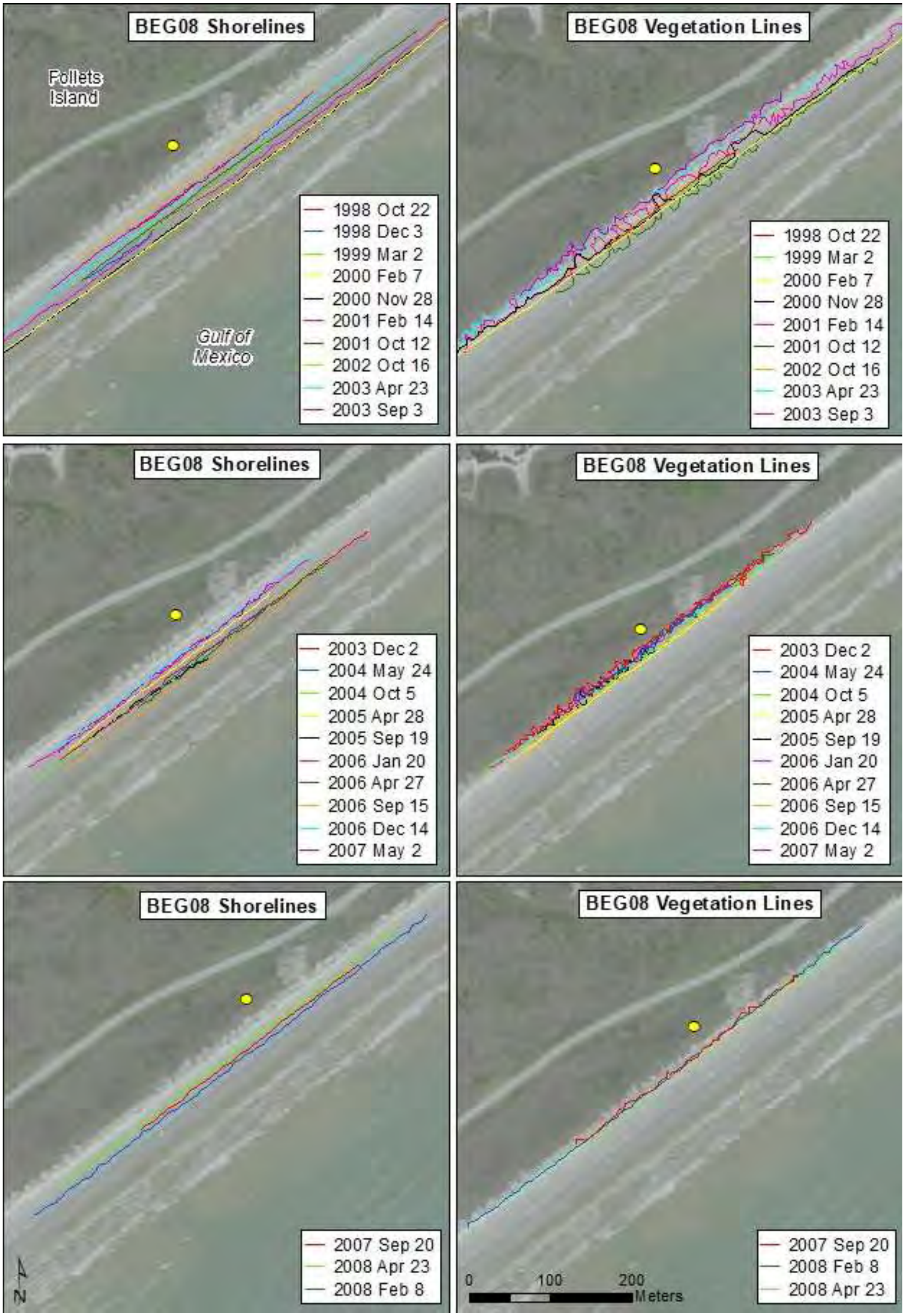

DEL01 Shorelines
Galveston Island
Gulf of Mexico
2016 Feb 4
2016 May 12
2016 Oct 6
2017 Feb 2
2017 May 11
2017 Oct 5
2018 Jan 25
2018 May 18
2018 Oct 3
2019 Jan 30
DEL01 Vegetation Lines
2016 Feb 4
2016 May 12
2016 Oct 6
2017 Feb 2
2017 May 11
2017 Oct 5
2018 Jan 25
2018 May 18
2018 Oct 3
2019 Jan 30
DEL01 Shorelines
2019 Apr 25
2019 Oct 9
2020 Jan 28
2021 May 19
2021 Nov 17
2022 Feb 2
N
DEL01 Vegetation Lines
0 100 200 Meters
2019 Apr 25
2019 Oct 9
2020 Jan 28
2021 May 19
2021 Nov 17
2022 Feb 2

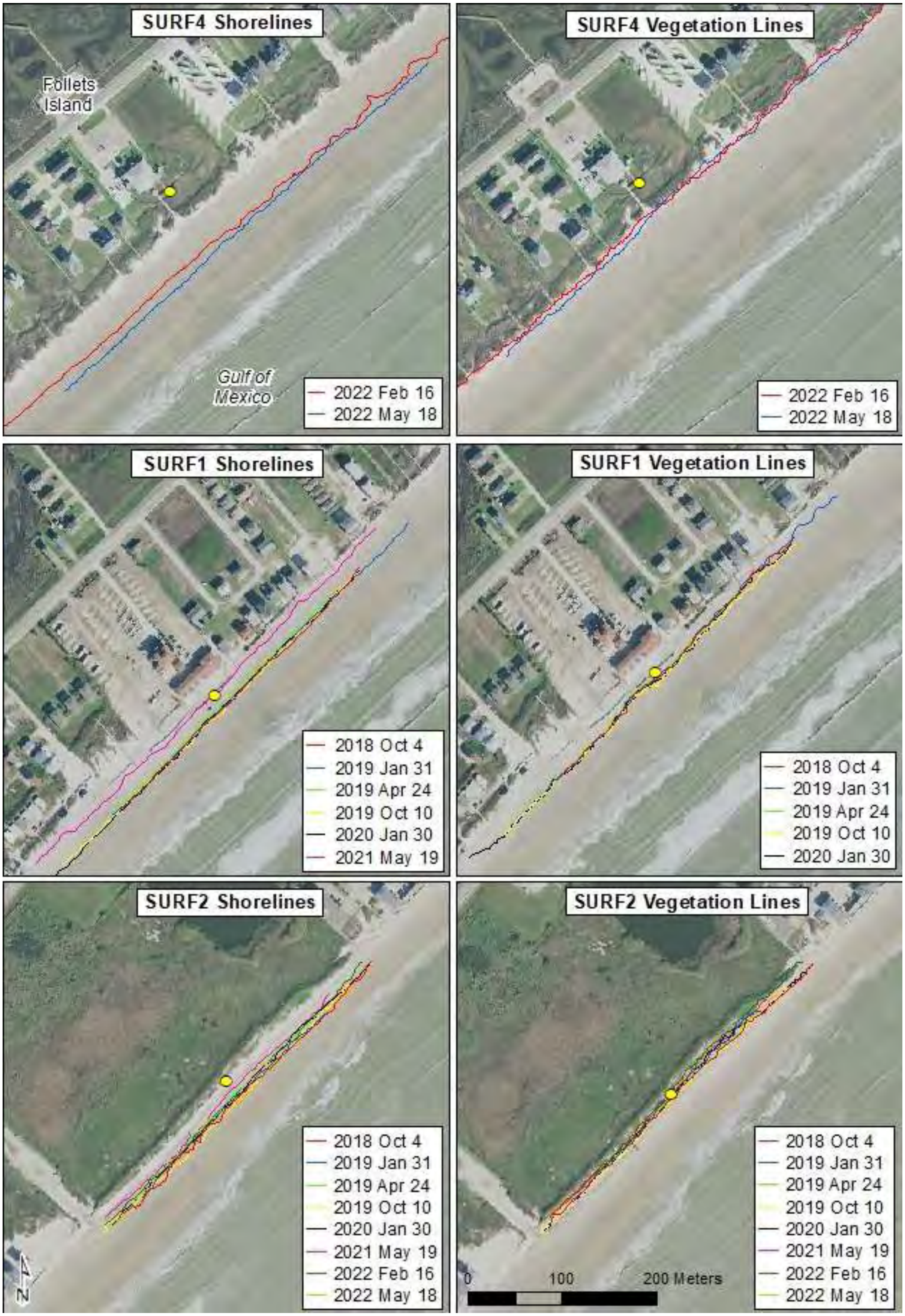

BEG02 Shorelines
Galveston Island State Park
BEG02
Gulf of Mexico
1997 Oct 1
1998 Mar 6
1998 Oct 22
1998 Dec 3
1999 Mar 2
2000 Nov 28
2001 Feb 14
2001 Oct 12
2002 Mar 21
2002 Oct 16
BEG02 Vegetation Lines
1997 Oct 1
1998 Mar 6
1998 Oct 22
1999 Mar 2
2000 Nov 28
2001 Feb 14
2001 Oct 12
2002 Mar 21
2002 Oct 16
BEG02 Shorelines
2003 Apr 23
2003 Sep 3
2003 Dec 2
2004 May 24
2004 Oct 5
2005 Jan 27
2005 Apr 28
2005 Sep 19
2006 Jan 20
2006 Apr 27
BEG02 Vegetation Lines
2003 Apr 23
2003 Sep 3
2003 Dec 2
2004 May 24
2004 Oct 5
2005 Jan 27
2005 Apr 28
2005 Sep 19
2006 Jan 20
2006 Apr 27
BEG02 & BEG02R Shorelines
BEG02R
BEG02
2006 Sep 15
2006 Dec 14
2007 May 2
2007 Sep 20
2008 Feb 8
2008 Apr 23
2009 Sep 16
2010 Jan 20
2010 May 18
2010 Sep 22
N
BEG02 & BEG02R Vegetation Lines
2006 Sep 15
2006 Dec 14
2007 May 2
2007 Sep 20
2008 Feb 8
2008 Apr 23
2009 Sep 16
2010 Jan 20
2010 May 18
2010 Sep 22
0
100
200
Meters

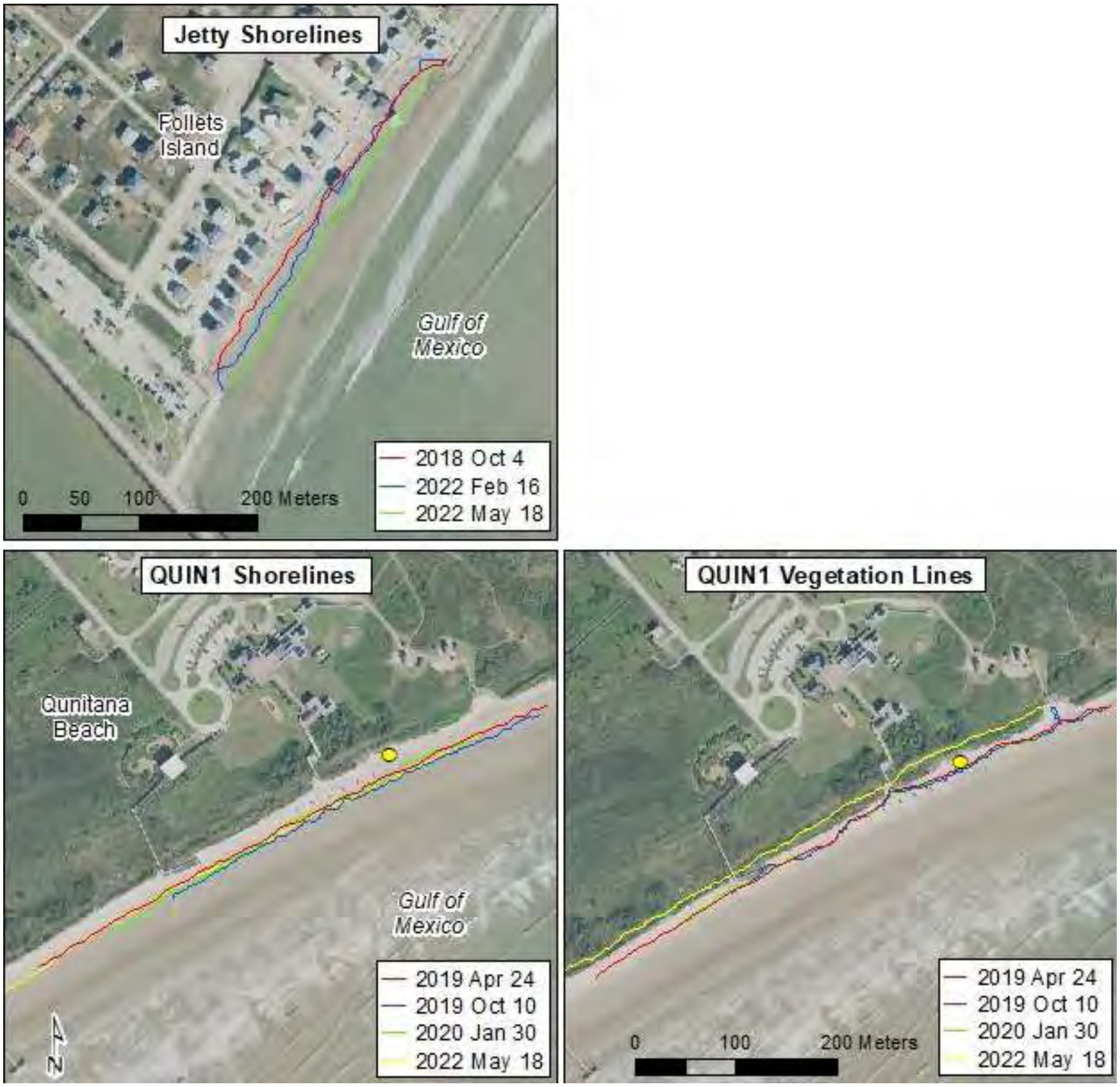

BEG02R Shorelines
Galveston Island State Park
Gulf of Mexico
2011 Jan 21
2011 May 18
2011 Sep 23
2011 Dec 6
2012 Sep 27
2013 Jan 24
2013 May 22
2013 Sep 18
2014 Apr 8
2014 Oct 8
BEG02R Vegetation Lines
2011 Jan 21
2011 May 18
2011 Sep 23
2011 Dec 6
2012 Sep 27
2013 Jan 24
2013 May 22
2013 Sep 18
2014 Apr 8
2014 Oct 8
BEG02R Shorelines
2015 Jan 28
2015 May 19
2015 Oct 7
2016 Feb 4
2016 May 12
2016 Oct 6
2017 Feb 2
2017 May 11
2017 Oct 5
2018 Jan 25
BEG02R Vegetation Lines
2015 Jan 28
2015 May 19
2015 Oct 7
2016 Feb 4
2016 May 12
2016 Oct 6
2017 Feb 2
2017 May 11
2017 Oct 5
2018 Jan 25
BEG02R Shorelines
2018 May 18
2018 Oct 3
2019 Jan 30
2019 Apr 25
2019 Oct 9
2020 Jan 28
2021 May 19
2021 Nov 17
2022 Feb 2
N
BEG02R Vegetation Lines
0 50 100 200
Meters
2018 May 18
2018 Oct 3
2019 Jan 30
2019 Apr 25
2019 Oct 9
2020 Jan 28
2021 May 19
2021 Nov 17
2022 Feb 2


GLO06 Shorelines
Galveston Island State Park
Gulf of Mexico
2009 Sep 16
2010 Jan 20
2010 May 18
2010 Sep 22
2011 Jan 21
2011 May 18
2011 Sep 23
2011 Dec 6
2012 Sep 27
2013 Jan 24
GLO06 Vegetation Lines
2009 Sep 16
2010 Jan 20
2010 May 18
2010 Sep 22
2011 Jan 21
2011 May 18
2011 Sep 23
2011 Dec 6
2012 Sep 27
2013 Jan 24
GLO06 Shorelines
2013 May 22
2013 Sep 18
2014 Apr 8
2014 Oct 8
2015 Jan 28
2015 May 19
N
GLO06 Vegetation Lines
0
100
200
Meters
2013 May 22
2013 Sep 18
2014 Apr 8
2014 Oct 8
2015 Jan 28
2015 May 19

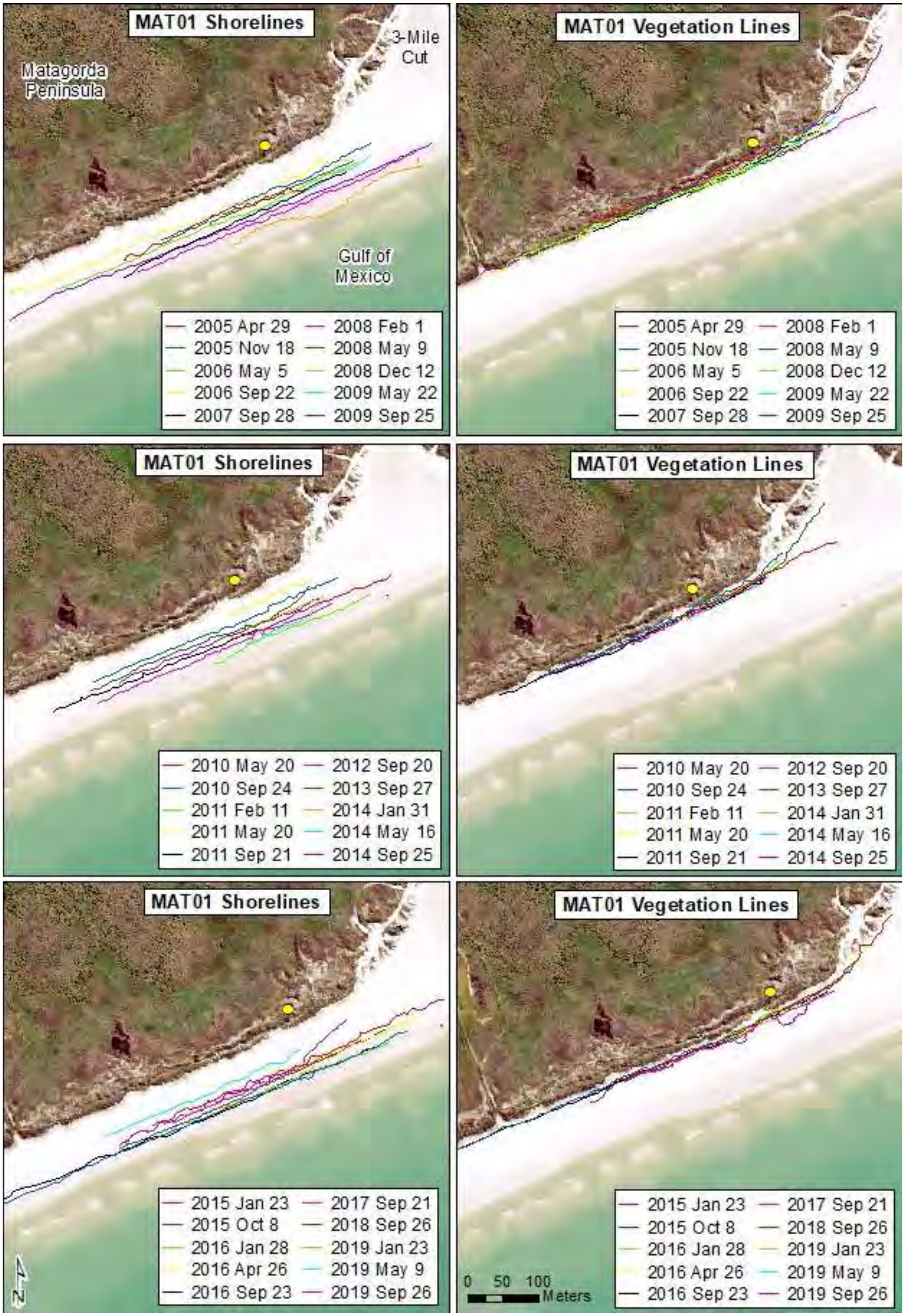

JAM02 Shorelines
Jamaica Beach
Gulf of Mexico
2015 Oct 7
2016 Feb 4
2016 May 12
2016 Oct 6
2017 Feb 2
2017 May 11
2017 Oct 5
2018 Jan 25
2018 May 18
2018 Oct 3
JAM02 Vegetation Lines
2015 Oct 7
2016 Feb 4
2016 May 12
2016 Oct 6
2017 Feb 2
2017 May 11
2017 Oct 5
2018 Jan 25
2018 May 18
2018 Oct 3
JAM02 Shorelines
2019 Jan 30
2019 Apr 25
2019 Oct 9
2020 Jan 28
2021 May 19
2021 Nov 17
2022 Feb 2
N
JAM02 Vegetation Lines
0
100
200
Meters
2019 Jan 30
2019 Apr 25
2019 Oct 9
2020 Jan 28
2021 May 19
2021 Nov 17
2022 Feb 2

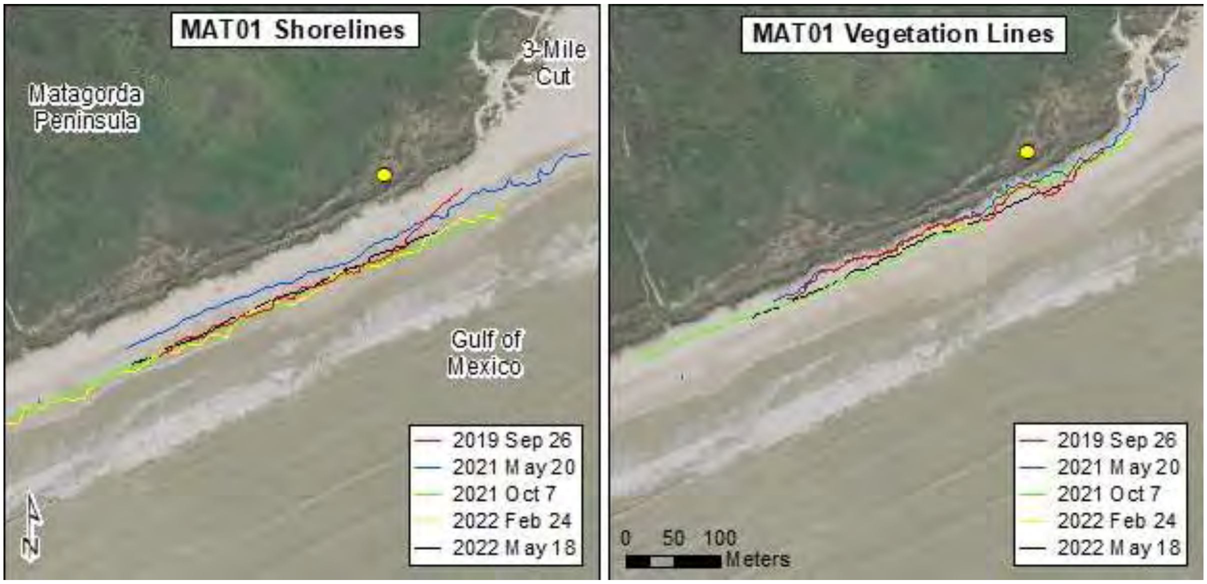

BEG08 Shorelines
Follets Island
Gulf of Mexico
1998 Oct 22
1998 Dec 3
1999 Mar 2
2000 Feb 7
2000 Nov 28
2001 Feb 14
2001 Oct 12
2002 Oct 16
2003 Apr 23
2003 Sep 3
BEG08 Vegetation Lines
1998 Oct 22
1999 Mar 2
2000 Feb 7
2000 Nov 28
2001 Feb 14
2001 Oct 12
2002 Oct 16
2003 Apr 23
2003 Sep 3
BEG08 Shorelines
2003 Dec 2
2004 May 24
2004 Oct 5
2005 Apr 28
2005 Sep 19
2006 Jan 20
2006 Apr 27
2006 Sep 15
2006 Dec 14
2007 May 2
BEG08 Vegetation Lines
2003 Dec 2
2004 May 24
2004 Oct 5
2005 Apr 28
2005 Sep 19
2006 Jan 20
2006 Apr 27
2006 Sep 15
2006 Dec 14
2007 May 2
BEG08 Shorelines
2007 Sep 20
2008 Apr 23
2008 Feb 8
N
BEG08 Vegetation Lines
2007 Sep 20
2008 Feb 8
2008 Apr 23
0
100
200
Meters

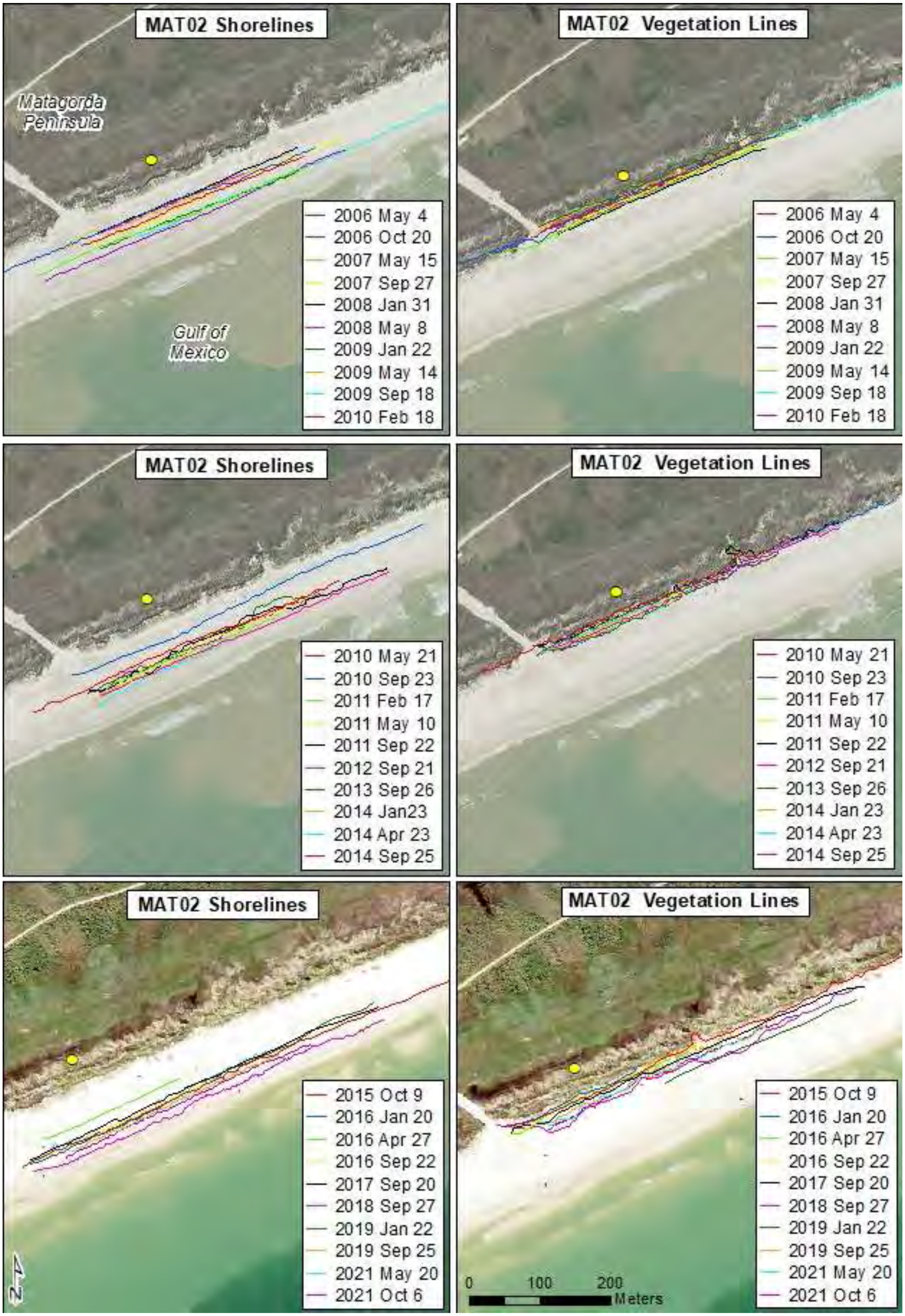

SURF4 Shorelines
Follets Island
Gulf of Mexico
2022 Feb 16
2022 May 18
SURF4 Vegetation Lines
2022 Feb 16
2022 May 18
SURF1 Shorelines
2018 Oct 4
2019 Jan 31
2019 Apr 24
2019 Oct 10
2020 Jan 30
2021 May 19
SURF1 Vegetation Lines
2018 Oct 4
2019 Jan 31
2019 Apr 24
2019 Oct 10
2020 Jan 30
SURF2 Shorelines
2018 Oct 4
2019 Jan 31
2019 Apr 24
2019 Oct 10
2020 Jan 30
2021 May 19
2022 Feb 16
2022 May 18
N
SURF2 Vegetation Lines
0
100
200 Meters
2018 Oct 4
2019 Jan 31
2019 Apr 24
2019 Oct 10
2020 Jan 30
2021 May 19
2022 Feb 16
2022 May 18

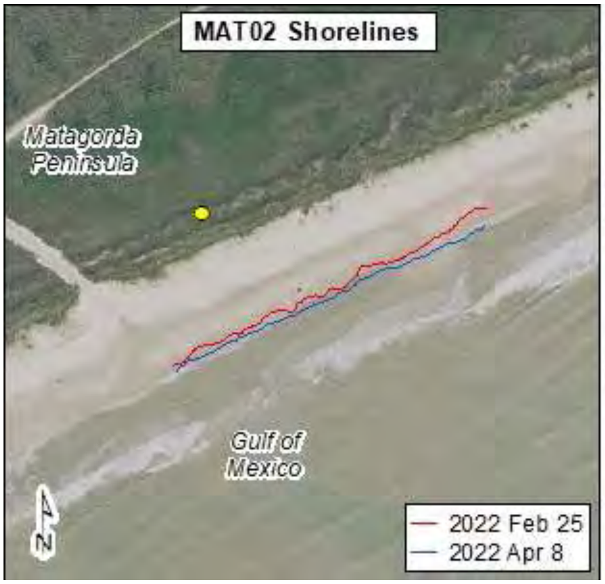


Jetty Shorelines
Follets Island
Gulf of Mexico
2018 Oct 4
2022 Feb 16
2022 May 18
0 50 100 200 Meters
QUIN1 Shorelines
Qunitana Beach
Gulf of Mexico
2019 Apr 24
2019 Oct 10
2020 Jan 30
2022 May 18
N
QUIN1 Vegetation Lines
2019 Apr 24
2019 Oct 10
2020 Jan 30
2022 May 18
0 100 200 Meters

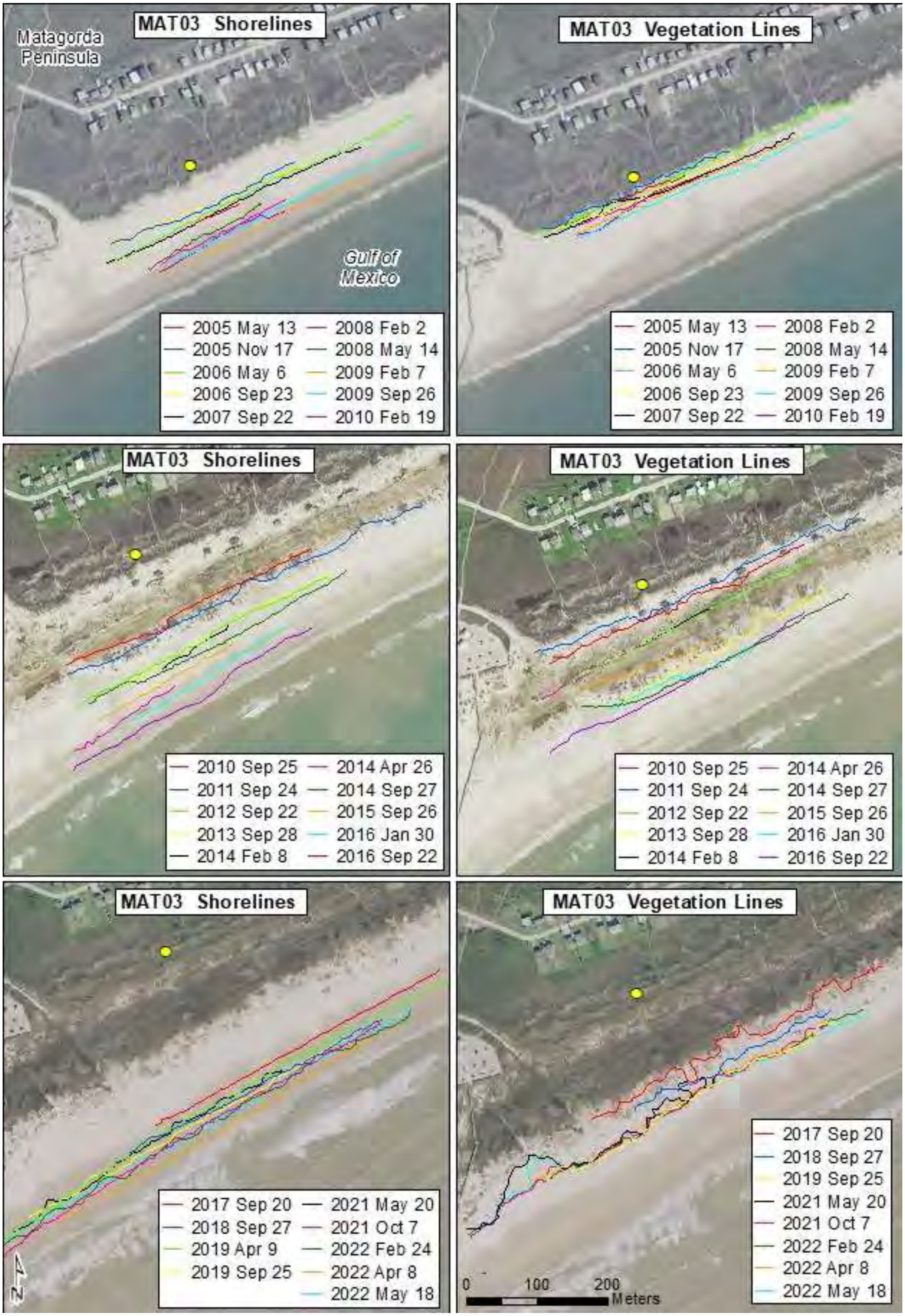

MAT01 Shorelines
3-Mile Cut
Matagorda Peninsula
Gulf of Mexico
2005 Apr 29
2005 Nov 18
2006 May 5
2006 Sep 22
2007 Sep 28
2008 Feb 1
2008 May 9
2008 Dec 12
2009 May 22
2009 Sep 25
MAT01 Vegetation Lines
2005 Apr 29
2005 Nov 18
2006 May 5
2006 Sep 22
2007 Sep 28
2008 Feb 1
2008 May 9
2008 Dec 12
2009 May 22
2009 Sep 25
MAT01 Shorelines
2010 May 20
2010 Sep 24
2011 Feb 11
2011 May 20
2011 Sep 21
2012 Sep 20
2013 Sep 27
2014 Jan 31
2014 May 16
2014 Sep 25
MAT01 Vegetation Lines
2010 May 20
2010 Sep 24
2011 Feb 11
2011 May 20
2011 Sep 21
2012 Sep 20
2013 Sep 27
2014 Jan 31
2014 May 16
2014 Sep 25
MAT01 Shorelines
2015 Jan 23
2015 Oct 8
2016 Jan 28
2016 Apr 26
2016 Sep 23
2017 Sep 21
2018 Sep 26
2019 Jan 23
2019 May 9
2019 Sep 26
N
MAT01 Vegetation Lines
2015 Jan 23
2015 Oct 8
2016 Jan 28
2016 Apr 26
2016 Sep 23
2017 Sep 21
2018 Sep 26
2019 Jan 23
2019 May 9
2019 Sep 26
0 50 100
Meters

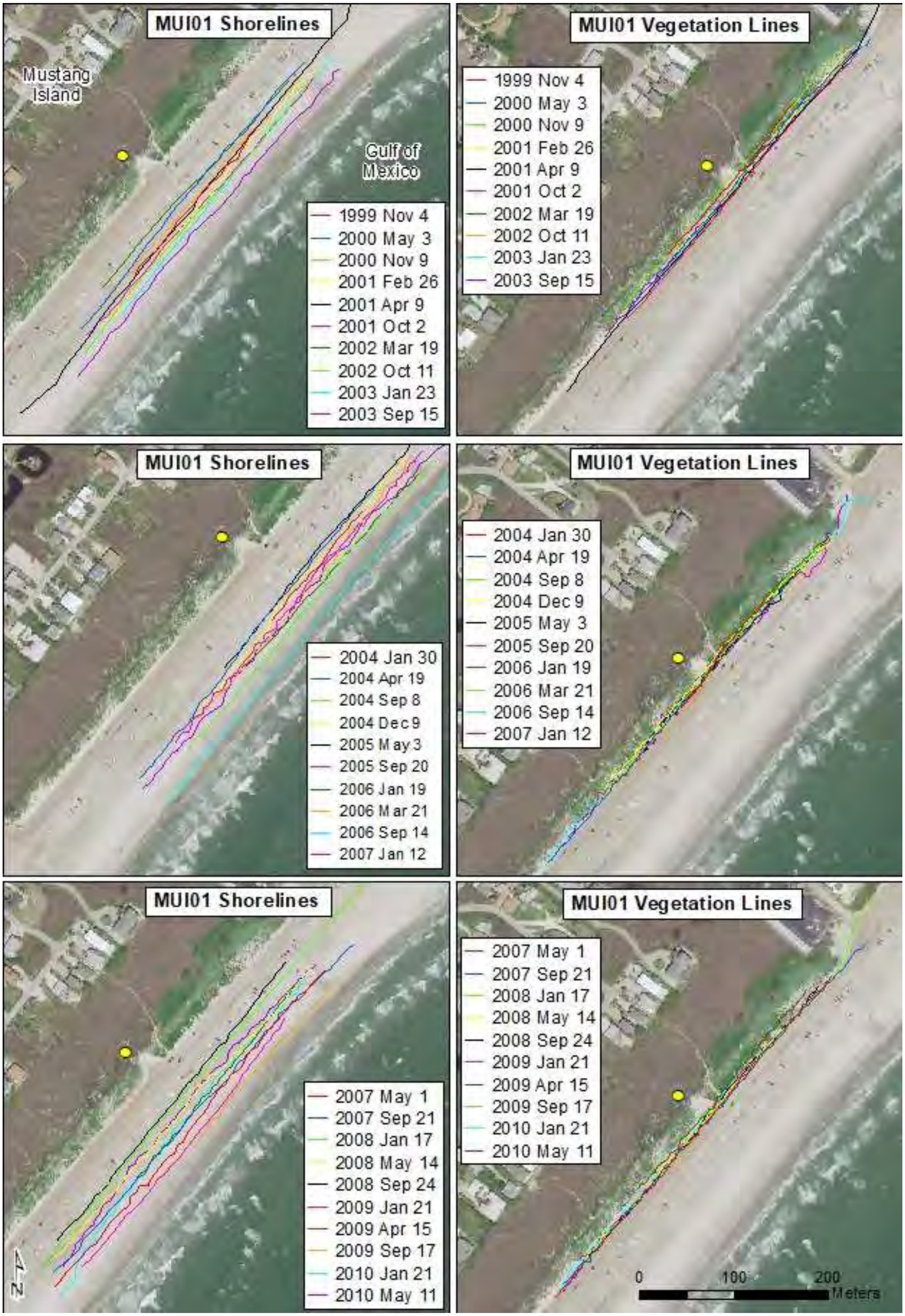

MAT01 Shorelines
Matagorda Peninsula
3-Mile Cut
Gulf of Mexico
2019 Sep 26
2021 May 20
2021 Oct 7
2022 Feb 24
2022 May 18
N
MAT01 Vegetation Lines
0 50 100
Meters
2019 Sep 26
2021 May 20
2021 Oct 7
2022 Feb 24
2022 May 18

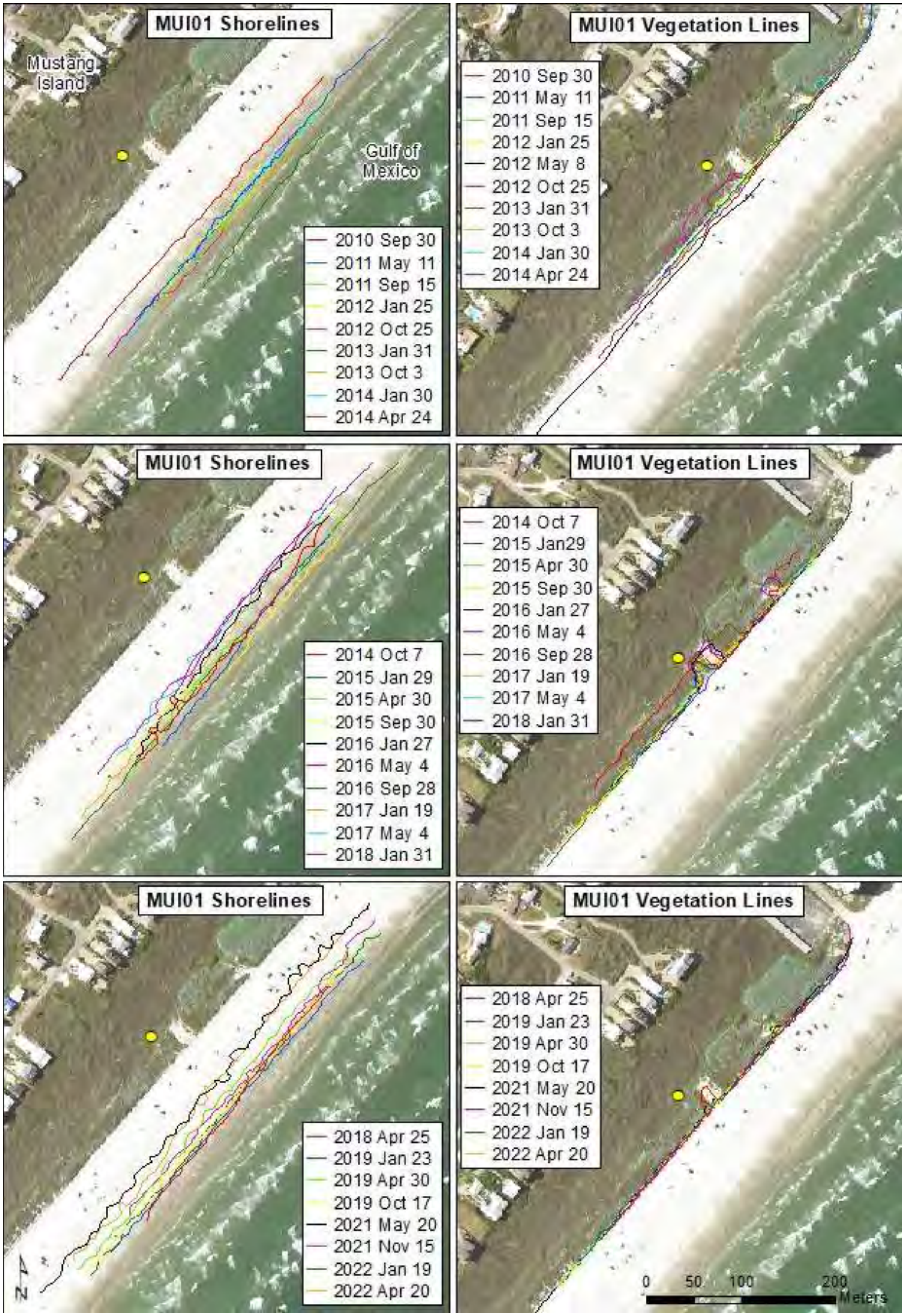

MAT02 Shorelines
Matagorda Peninsula
Gulf of Mexico
2006 May 4
2006 Oct 20
2007 May 15
2007 Sep 27
2008 Jan 31
2008 May 8
2009 Jan 22
2009 May 14
2009 Sep 18
2010 Feb 18
MAT02 Vegetation Lines
2006 May 4
2006 Oct 20
2007 May 15
2007 Sep 27
2008 Jan 31
2008 May 8
2009 Jan 22
2009 May 14
2009 Sep 18
2010 Feb 18
MAT02 Shorelines
2010 May 21
2010 Sep 23
2011 Feb 17
2011 May 10
2011 Sep 22
2012 Sep 21
2013 Sep 26
2014 Jan23
2014 Apr 23
2014 Sep 25
MAT02 Vegetation Lines
2010 May 21
2010 Sep 23
2011 Feb 17
2011 May 10
2011 Sep 22
2012 Sep 21
2013 Sep 26
2014 Jan 23
2014 Apr 23
2014 Sep 25
MAT02 Shorelines
2015 Oct 9
2016 Jan 20
2016 Apr 27
2016 Sep 22
2017 Sep 20
2018 Sep 27
2019 Jan 22
2019 Sep 25
2021 May 20
2021 Oct 6
N
MAT02 Vegetation Lines
2015 Oct 9
2016 Jan 20
2016 Apr 27
2016 Sep 22
2017 Sep 20
2018 Sep 27
2019 Jan 22
2019 Sep 25
2021 May 20
2021 Oct 6
0 100 200 Meters

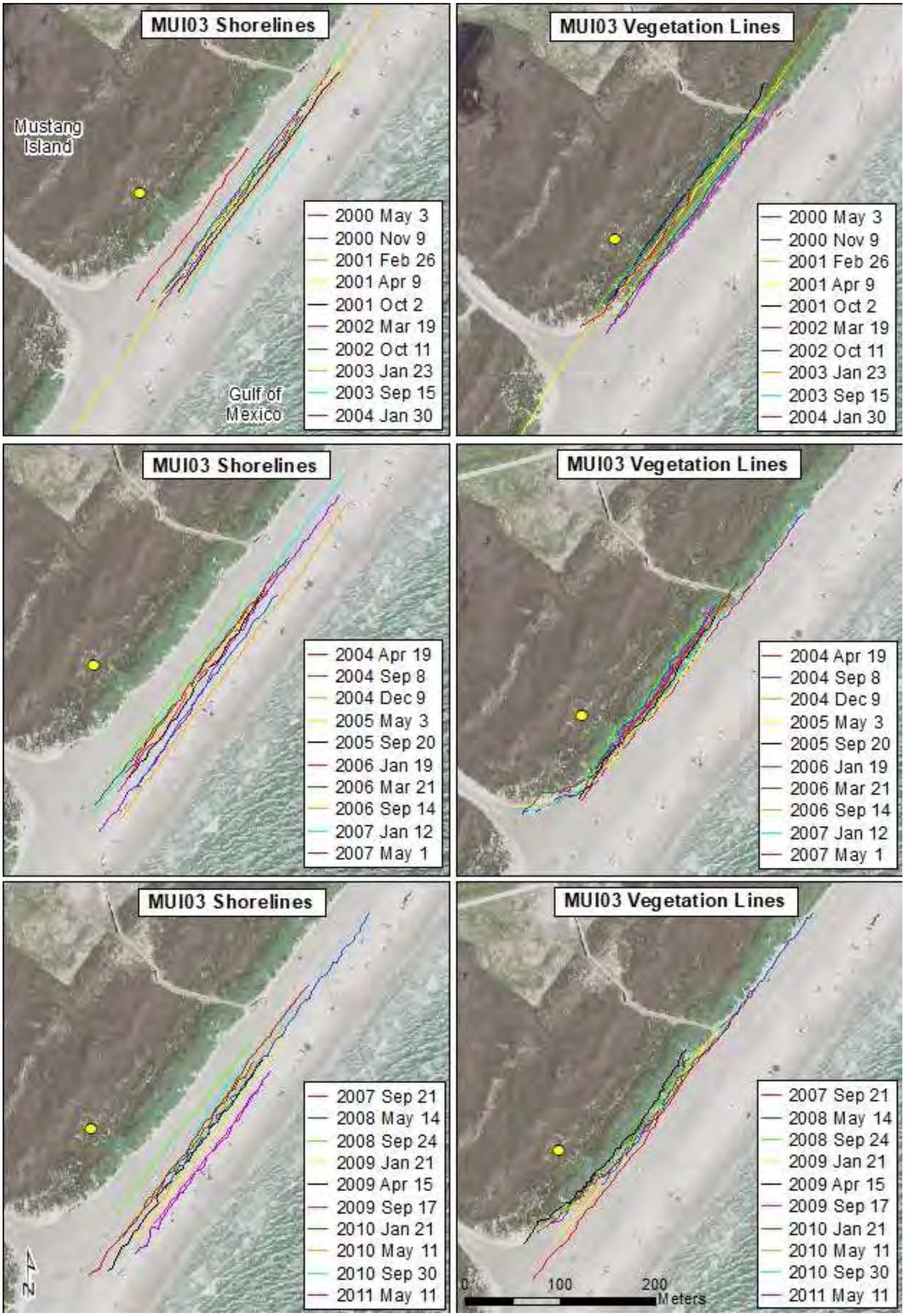

MAT02 Shorelines
Matagorda Peninsula
Gulf of Mexico
N
2022 Feb 25
2022 Apr 8


MAT02 Vegetation Lines
0
100
200
Meters
2022 Feb 25
2022 Apr 8

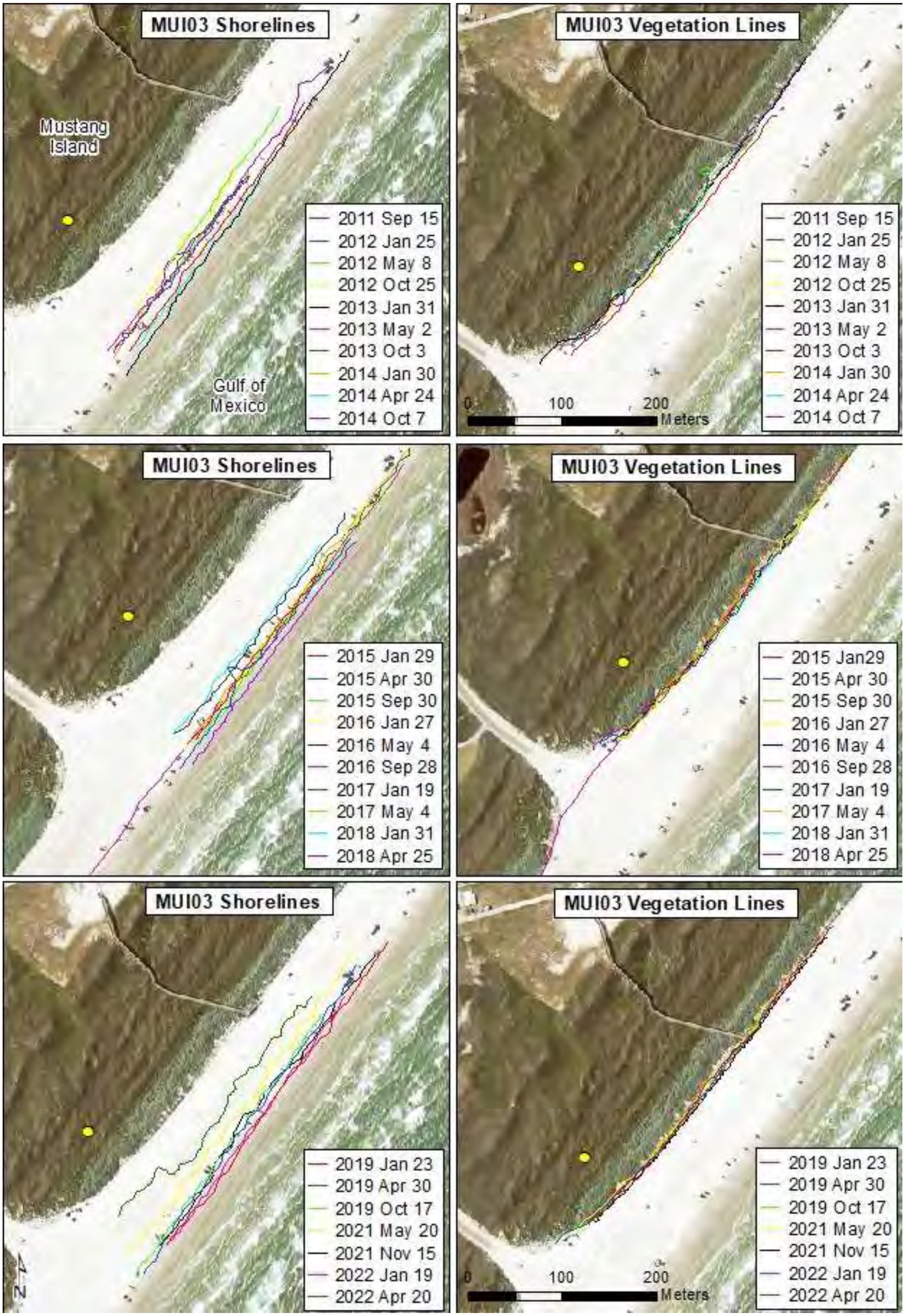

MAT03 Shorelines
Matagorda Peninsula
Gulf of Mexico
2005 May 13
2005 Nov 17
2006 May 6
2006 Sep 23
2007 Sep 22
2008 Feb 2
2008 May 14
2009 Feb 7
2009 Sep 26
2010 Feb 19
MAT03 Vegetation Lines
2005 May 13
2005 Nov 17
2006 May 6
2006 Sep 23
2007 Sep 22
2008 Feb 2
2008 May 14
2009 Feb 7
2009 Sep 26
2010 Feb 19
MAT03 Shorelines
2010 Sep 25
2011 Sep 24
2012 Sep 22
2013 Sep 28
2014 Feb 8
2014 Apr 26
2014 Sep 27
2015 Sep 26
2016 Jan 30
2016 Sep 22
MAT03 Vegetation Lines
2010 Sep 25
2011 Sep 24
2012 Sep 22
2013 Sep 28
2014 Feb 8
2014 Apr 26
2014 Sep 27
2015 Sep 26
2016 Jan 30
2016 Sep 22
MAT03 Shorelines
2017 Sep 20
2018 Sep 27
2019 Apr 9
2019 Sep 25
2021 May 20
2021 Oct 7
2022 Feb 24
2022 Apr 8
2022 May 18
N
MAT03 Vegetation Lines
2017 Sep 20
2018 Sep 27
2019 Sep 25
2021 May 20
2021 Oct 7
2022 Feb 24
2022 Apr 8
2022 May 18
0 100 200
Meters

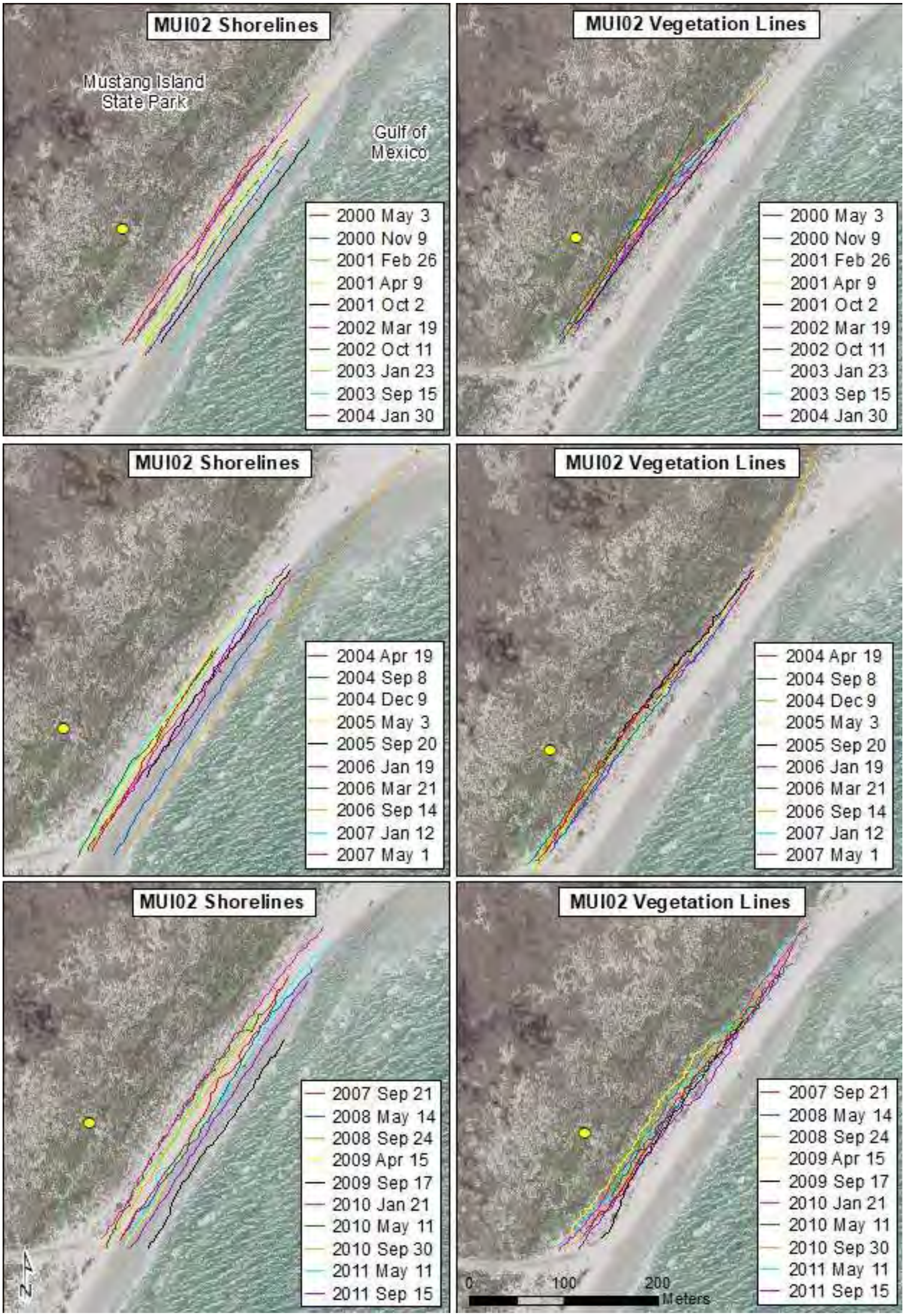

MUI01 Shorelines
Mustang Island
Gulf of Mexico
1999 Nov 4
2000 May 3
2000 Nov 9
2001 Feb 26
2001 Apr 9
2001 Oct 2
2002 Mar 19
2002 Oct 11
2003 Jan 23
2003 Sep 15
MUI01 Vegetation Lines
1999 Nov 4
2000 May 3
2000 Nov 9
2001 Feb 26
2001 Apr 9
2001 Oct 2
2002 Mar 19
2002 Oct 11
2003 Jan 23
2003 Sep 15
MUI01 Shorelines
2004 Jan 30
2004 Apr 19
2004 Sep 8
2004 Dec 9
2005 May 3
2005 Sep 20
2006 Jan 19
2006 Mar 21
2006 Sep 14
2007 Jan 12
MUI01 Vegetation Lines
2004 Jan 30
2004 Apr 19
2004 Sep 8
2004 Dec 9
2005 May 3
2005 Sep 20
2006 Jan 19
2006 Mar 21
2006 Sep 14
2007 Jan 12
MUI01 Shorelines
2007 May 1
2007 Sep 21
2008 Jan 17
2008 May 14
2008 Sep 24
2009 Jan 21
2009 Apr 15
2009 Sep 17
2010 Jan 21
2010 May 11
N
MUI01 Vegetation Lines
2007 May 1
2007 Sep 21
2008 Jan 17
2008 May 14
2008 Sep 24
2009 Jan 21
2009 Apr 15
2009 Sep 17
2010 Jan 21
2010 May 11
0
100
200
Meters

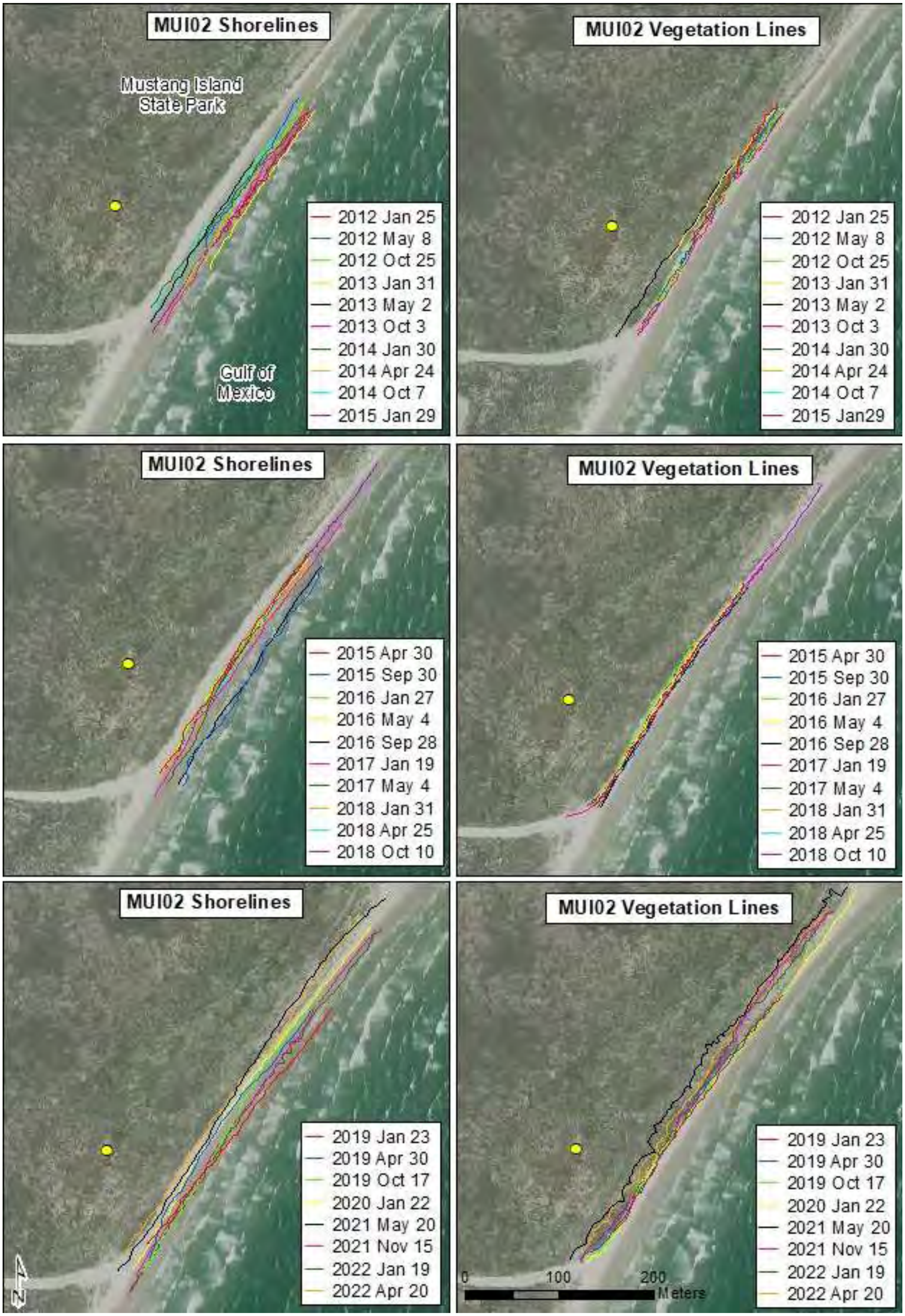

MUI01 Shorelines
Mustang Island
Gulf of Mexico
2010 Sep 30
2011 May 11
2011 Sep 15
2012 Jan 25
2012 Oct 25
2013 Jan 31
2013 Oct 3
2014 Jan 30
2014 Apr 24
MUI01 Vegetation Lines
2010 Sep 30
2011 May 11
2011 Sep 15
2012 Jan 25
2012 May 8
2012 Oct 25
2013 Jan 31
2013 Oct 3
2014 Jan 30
2014 Apr 24
MUI01 Shorelines
2014 Oct 7
2015 Jan 29
2015 Apr 30
2015 Sep 30
2016 Jan 27
2016 May 4
2016 Sep 28
2017 Jan 19
2017 May 4
2018 Jan 31
MUI01 Vegetation Lines
2014 Oct 7
2015 Jan29
2015 Apr 30
2015 Sep 30
2016 Jan 27
2016 May 4
2016 Sep 28
2017 Jan 19
2017 May 4
2018 Jan 31
MUI01 Shorelines
2018 Apr 25
2019 Jan 23
2019 Apr 30
2019 Oct 17
2021 May 20
2021 Nov 15
2022 Jan 19
2022 Apr 20
N
MUI01 Vegetation Lines
2018 Apr 25
2019 Jan 23
2019 Apr 30
2019 Oct 17
2021 May 20
2021 Nov 15
2022 Jan 19
2022 Apr 20
0 50 100 200
Meters

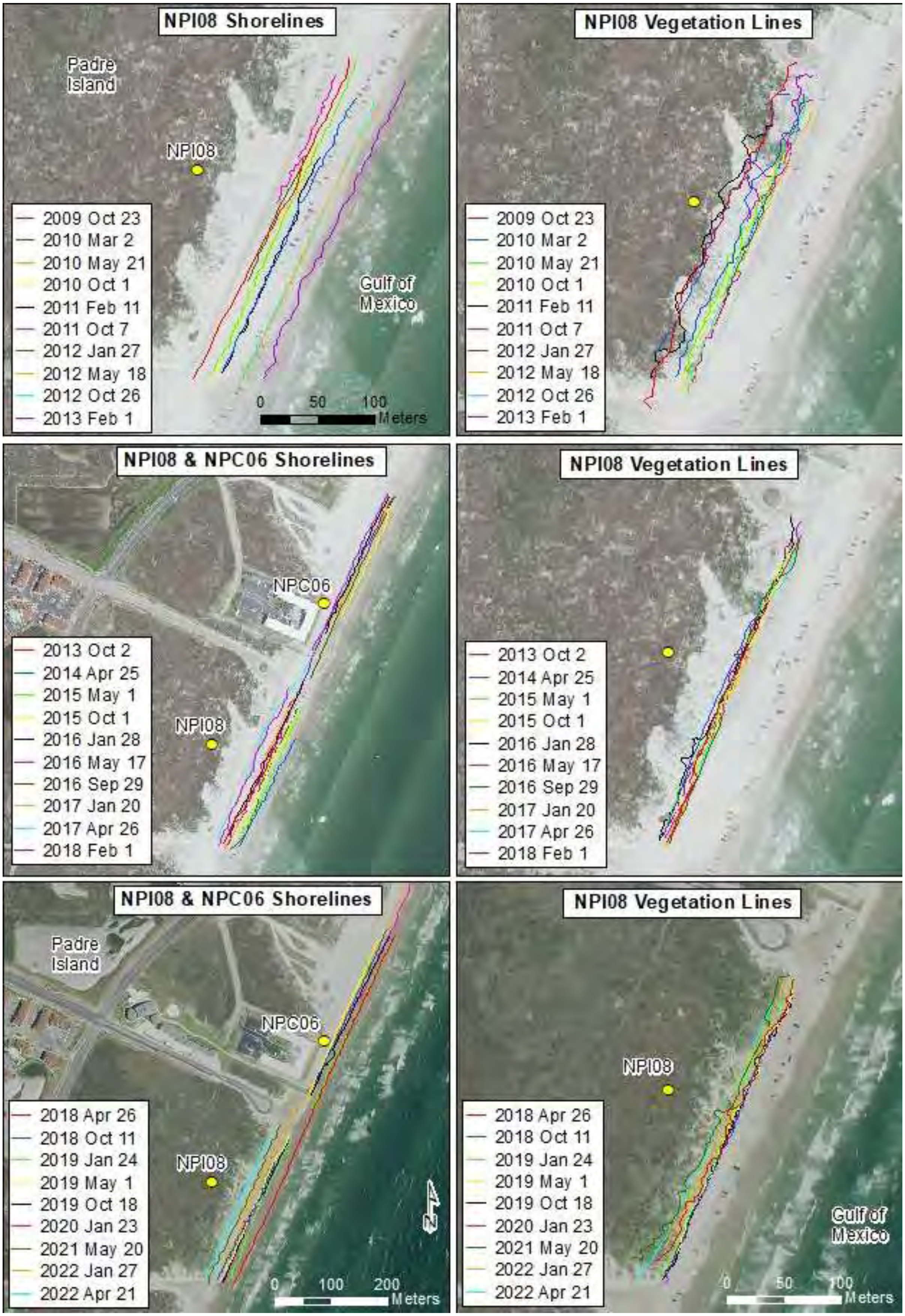


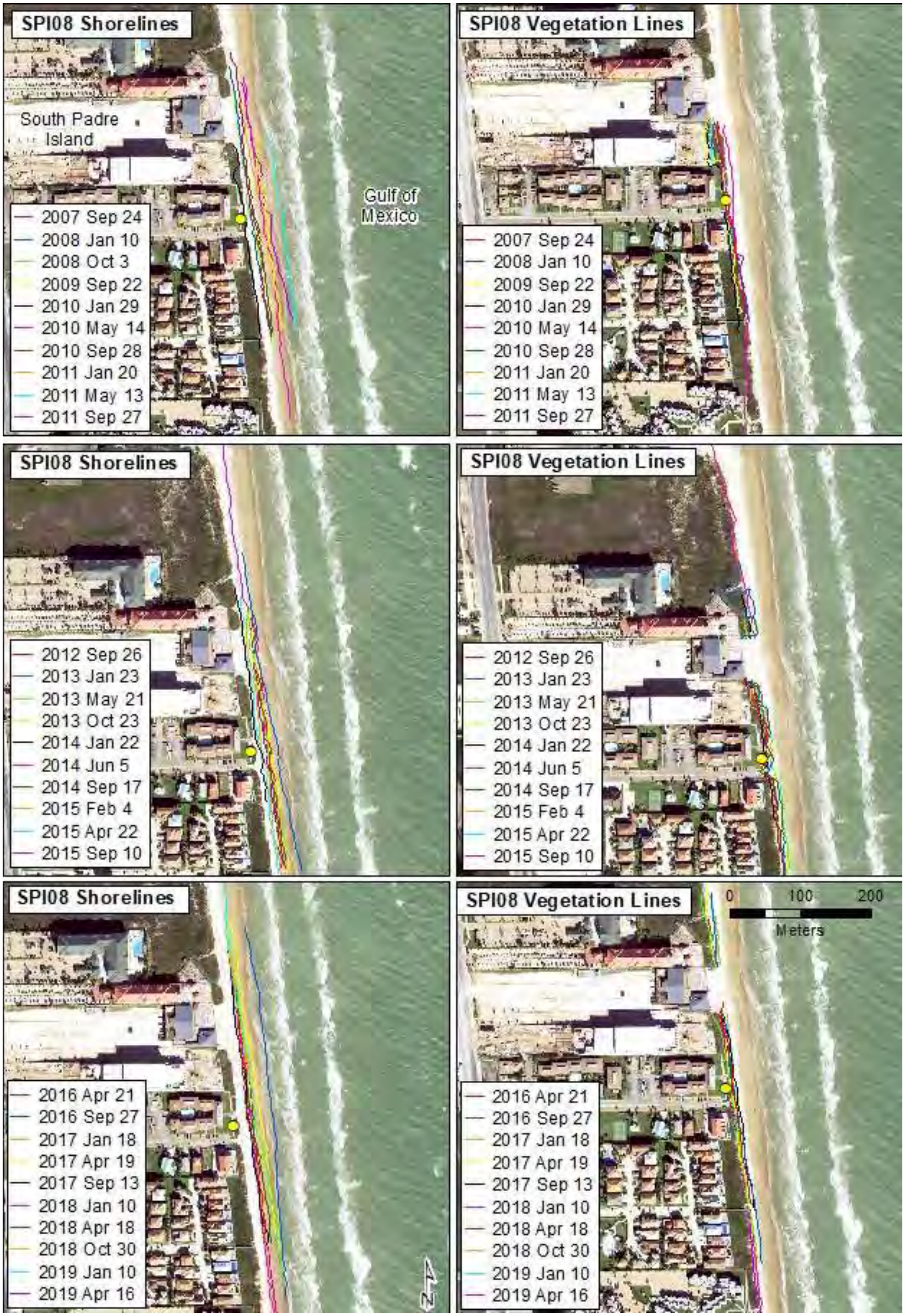
MUI03 Shorelines
Mustang Island
Gulf of Mexico
2000 May 3
2000 Nov 9
2001 Feb 26
2001 Apr 9
2001 Oct 2
2002 Mar 19
2002 Oct 11
2003 Jan 23
2003 Sep 15
2004 Jan 30
MUI03 Vegetation Lines
2000 May 3
2000 Nov 9
2001 Feb 26
2001 Apr 9
2001 Oct 2
2002 Mar 19
2002 Oct 11
2003 Jan 23
2003 Sep 15
2004 Jan 30
MUI03 Shorelines
2004 Apr 19
2004 Sep 8
2004 Dec 9
2005 May 3
2005 Sep 20
2006 Jan 19
2006 Mar 21
2006 Sep 14
2007 Jan 12
2007 May 1
MUI03 Vegetation Lines
2004 Apr 19
2004 Sep 8
2004 Dec 9
2005 May 3
2005 Sep 20
2006 Jan 19
2006 Mar 21
2006 Sep 14
2007 Jan 12
2007 May 1
MUI03 Shorelines
2007 Sep 21
2008 May 14
2008 Sep 24
2009 Jan 21
2009 Apr 15
2009 Sep 17
2010 Jan 21
2010 May 11
2010 Sep 30
2011 May 11
N
MUI03 Vegetation Lines
2007 Sep 21
2008 May 14
2008 Sep 24
2009 Jan 21
2009 Apr 15
2009 Sep 17
2010 Jan 21
2010 May 11
2010 Sep 30
2011 May 11
0
100
200
Meters


MUI03 Shorelines
Mustang Island
Gulf of Mexico
2011 Sep 15
2012 Jan 25
2012 May 8
2012 Oct 25
2013 Jan 31
2013 May 2
2013 Oct 3
2014 Jan 30
2014 Apr 24
2014 Oct 7
MUI03 Vegetation Lines
0 100 200 Meters
2011 Sep 15
2012 Jan 25
2012 May 8
2012 Oct 25
2013 Jan 31
2013 May 2
2013 Oct 3
2014 Jan 30
2014 Apr 24
2014 Oct 7
MUI03 Shorelines
2015 Jan 29
2015 Apr 30
2015 Sep 30
2016 Jan 27
2016 May 4
2016 Sep 28
2017 Jan 19
2017 May 4
2018 Jan 31
2018 Apr 25
MUI03 Vegetation Lines
2015 Jan29
2015 Apr 30
2015 Sep 30
2016 Jan 27
2016 May 4
2016 Sep 28
2017 Jan 19
2017 May 4
2018 Jan 31
2018 Apr 25
MUI03 Shorelines
N
2019 Jan 23
2019 Apr 30
2019 Oct 17
2021 May 20
2021 Nov 15
2022 Jan 19
2022 Apr 20
MUI03 Vegetation Lines
0 100 200 Meters
2019 Jan 23
2019 Apr 30
2019 Oct 17
2021 May 20
2021 Nov 15
2022 Jan 19
2022 Apr 20


MUI02 Shorelines
Mustang Island State Park
Gulf of Mexico
2000 May 3
2000 Nov 9
2001 Feb 26
2001 Apr 9
2001 Oct 2
2002 Mar 19
2002 Oct 11
2003 Jan 23
2003 Sep 15
2004 Jan 30
MUI02 Vegetation Lines
2000 May 3
2000 Nov 9
2001 Feb 26
2001 Apr 9
2001 Oct 2
2002 Mar 19
2002 Oct 11
2003 Jan 23
2003 Sep 15
2004 Jan 30
MUI02 Shorelines
2004 Apr 19
2004 Sep 8
2004 Dec 9
2005 May 3
2005 Sep 20
2006 Jan 19
2006 Mar 21
2006 Sep 14
2007 Jan 12
2007 May 1
MUI02 Vegetation Lines
2004 Apr 19
2004 Sep 8
2004 Dec 9
2005 May 3
2005 Sep 20
2006 Jan 19
2006 Mar 21
2006 Sep 14
2007 Jan 12
2007 May 1
MUI02 Shorelines
2007 Sep 21
2008 May 14
2008 Sep 24
2009 Apr 15
2009 Sep 17
2010 Jan 21
2010 May 11
2010 Sep 30
2011 May 11
2011 Sep 15
N
MUI02 Vegetation Lines
2007 Sep 21
2008 May 14
2008 Sep 24
2009 Apr 15
2009 Sep 17
2010 Jan 21
2010 May 11
2010 Sep 30
2011 May 11
2011 Sep 15
0
100
200
Meters

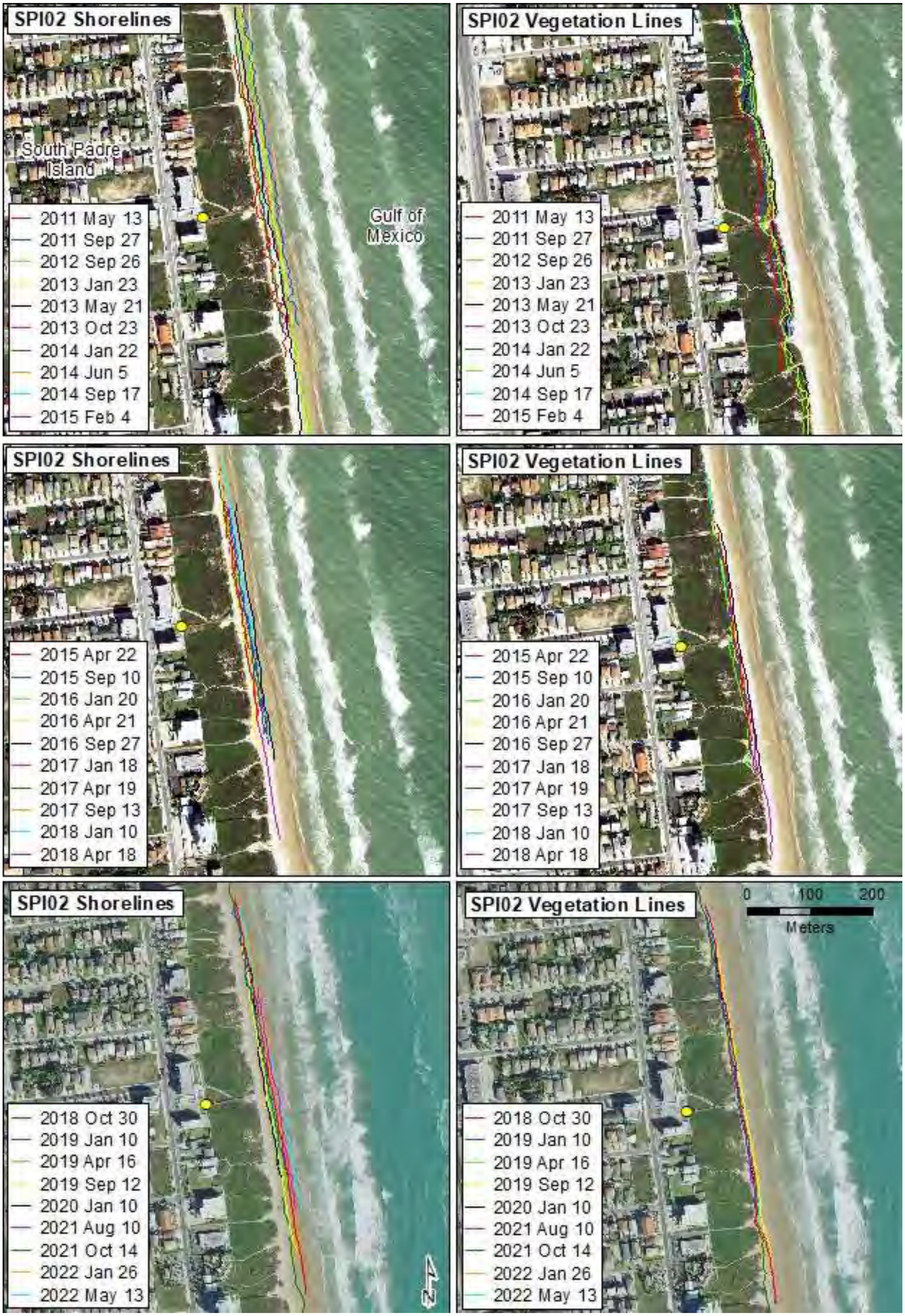

MUI02 Shorelines
Mustang Island State Park
Gulf of Mexico
2012 Jan 25
2012 May 8
2012 Oct 25
2013 Jan 31
2013 May 2
2013 Oct 3
2014 Jan 30
2014 Apr 24
2014 Oct 7
2015 Jan 29
MUI02 Vegetation Lines
2012 Jan 25
2012 May 8
2012 Oct 25
2013 Jan 31
2013 May 2
2013 Oct 3
2014 Jan 30
2014 Apr 24
2014 Oct 7
2015 Jan29
MUI02 Shorelines
2015 Apr 30
2015 Sep 30
2016 Jan 27
2016 May 4
2016 Sep 28
2017 Jan 19
2017 May 4
2018 Jan 31
2018 Apr 25
2018 Oct 10
MUI02 Vegetation Lines
2015 Apr 30
2015 Sep 30
2016 Jan 27
2016 May 4
2016 Sep 28
2017 Jan 19
2017 May 4
2018 Jan 31
2018 Apr 25
2018 Oct 10
MUI02 Shorelines
2019 Jan 23
2019 Apr 30
2019 Oct 17
2020 Jan 22
2021 May 20
2021 Nov 15
2022 Jan 19
2022 Apr 20
MUI02 Vegetation Lines
0 100 200
Meters
2019 Jan 23
2019 Apr 30
2019 Oct 17
2020 Jan 22
2021 May 20
2021 Nov 15
2022 Jan 19
2022 Apr 20

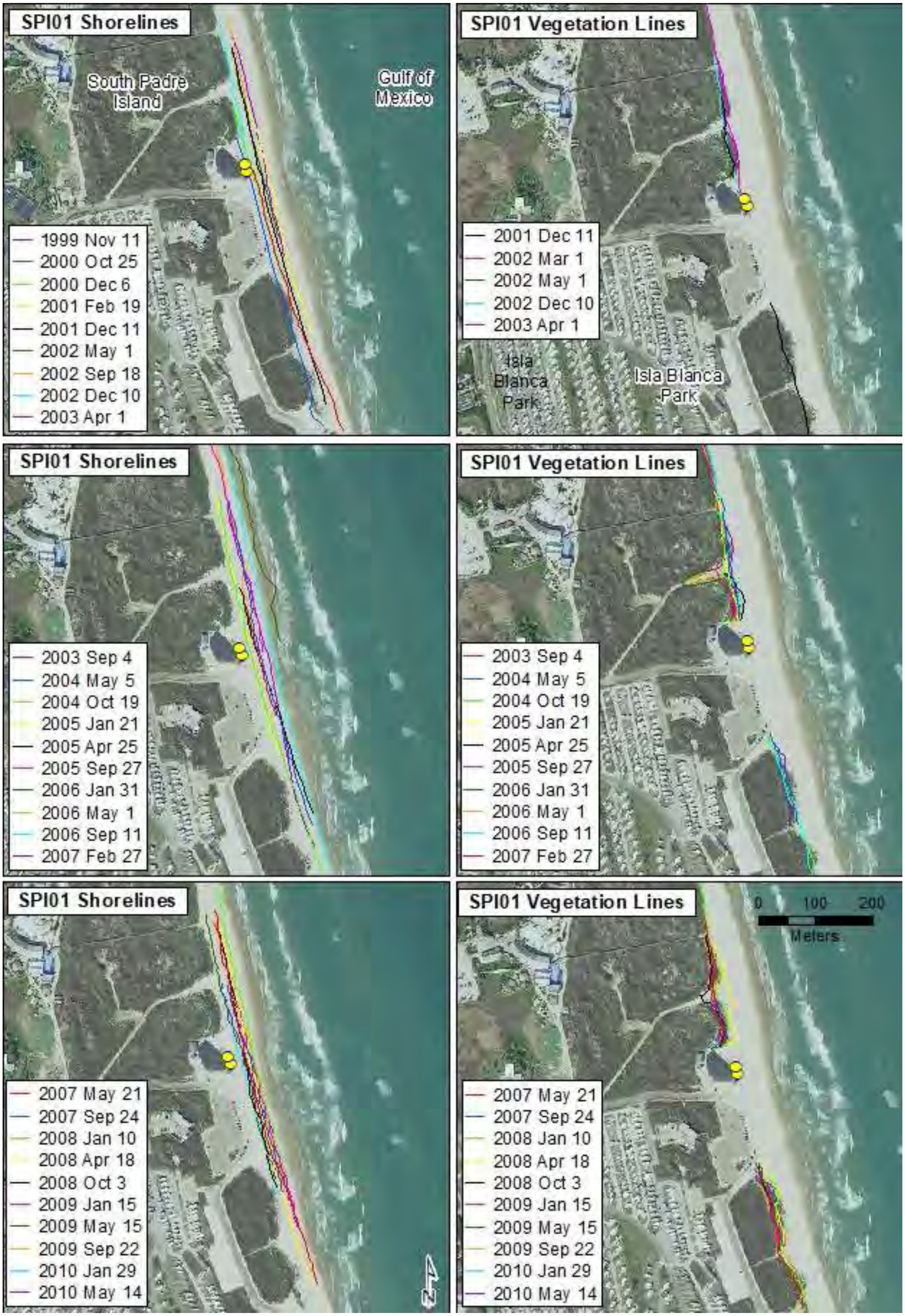

NPI08 Shorelines
Padre Island
NPI08
Gulf of Mexico
2009 Oct 23
2010 Mar 2
2010 May 21
2010 Oct 1
2011 Feb 11
2011 Oct 7
2012 Jan 27
2012 May 18
2012 Oct 26
2013 Feb 1
0 50 100 Meters
NPI08 Vegetation Lines
2009 Oct 23
2010 Mar 2
2010 May 21
2010 Oct 1
2011 Feb 11
2011 Oct 7
2012 Jan 27
2012 May 18
2012 Oct 26
2013 Feb 1
NPI08 & NPC06 Shorelines
NPC06
NPI08
2013 Oct 2
2014 Apr 25
2015 May 1
2015 Oct 1
2016 Jan 28
2016 May 17
2016 Sep 29
2017 Jan 20
2017 Apr 26
2018 Feb 1
NPI08 Vegetation Lines
2013 Oct 2
2014 Apr 25
2015 May 1
2015 Oct 1
2016 Jan 28
2016 May 17
2016 Sep 29
2017 Jan 20
2017 Apr 26
2018 Feb 1
NPI08 & NPC06 Shorelines
Padre Island
NPC06
NPI08
2018 Apr 26
2018 Oct 11
2019 Jan 24
2019 May 1
2019 Oct 18
2020 Jan 23
2021 May 20
2022 Jan 27
2022 Apr 21
0 100 200 Meters
NPI08 Vegetation Lines
NPI08
Gulf of Mexico
2018 Apr 26
2018 Oct 11
2019 Jan 24
2019 May 1
2019 Oct 18
2020 Jan 23
2021 May 20
2022 Jan 27
2022 Apr 21
0 50 100 Meters

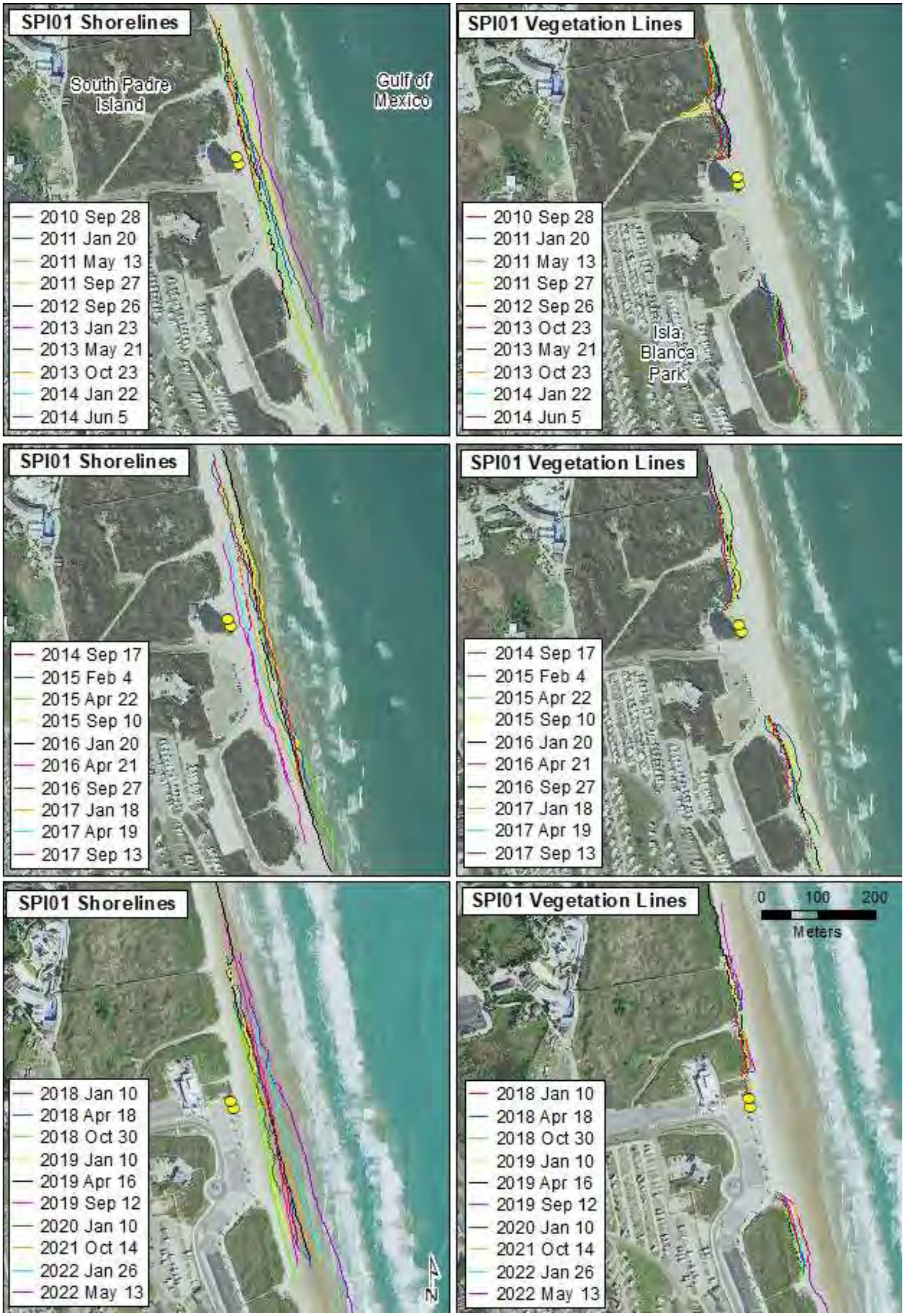

SPI08 Shorelines
South Padre Island
Gulf of Mexico
2007 Sep 24
2008 Jan 10
2008 Oct 3
2009 Sep 22
2010 Jan 29
2010 May 14
2010 Sep 28
2011 Jan 20
2011 May 13
2011 Sep 27
SPI08 Vegetation Lines
2007 Sep 24
2008 Jan 10
2009 Sep 22
2010 Jan 29
2010 May 14
2010 Sep 28
2011 Jan 20
2011 May 13
2011 Sep 27
SPI08 Shorelines
2012 Sep 26
2013 Jan 23
2013 May 21
2013 Oct 23
2014 Jan 22
2014 Jun 5
2014 Sep 17
2015 Feb 4
2015 Apr 22
2015 Sep 10
SPI08 Vegetation Lines
2012 Sep 26
2013 Jan 23
2013 May 21
2013 Oct 23
2014 Jan 22
2014 Jun 5
2014 Sep 17
2015 Feb 4
2015 Apr 22
2015 Sep 10
SPI08 Shorelines
2016 Apr 21
2016 Sep 27
2017 Jan 18
2017 Apr 19
2017 Sep 13
2018 Jan 10
2018 Apr 18
2018 Oct 30
2019 Jan 10
2019 Apr 16
SPI08 Vegetation Lines
0 100 200
Meters
2016 Apr 21
2016 Sep 27
2017 Jan 18
2017 Apr 19
2017 Sep 13
2018 Jan 10
2018 Apr 18
2018 Oct 30
2019 Jan 10
2019 Apr 16


SPI08 Shorelines
South Padre Island
Gulf of Mexico
2019 Sep 12
2020 Jan 10
2021 Aug 10
2021 Oct 14
2022 Jan 26
2022 May 13
SPI08 Vegetation Lines
0
100
200
Meters
2019 Sep 12
2020 Jan 10
2021 Aug 10
2021 Oct 14
2022 Jan 26
2022 May 13


SPI02 Shorelines
South Padre Island
Gulf of Mexico
2000 Oct 25
2000 Dec 6
2001 Feb 19
2001 Dec 11
2002 May 1
2002 Dec 10
2003 Apr 1
2003 Sep 4
2004 May 5
SPI02 Vegetation Lines
2000 Oct 25
2000 Dec 6
2001 Feb 19
2001 Dec 11
2002 Mar 1
2002 May 1
2002 Dec 10
2003 Apr 1
2003 Sep 4
2004 May 5
SPI02 Shorelines
2004 Oct 19
2005 Jan 21
2005 Apr 25
2005 Sep 27
2006 Jan 31
2006 May 1
2006 Sep 11
2007 Feb 27
2007 May 21
2007 Sep 24
SPI02 Vegetation Lines
2004 Oct 19
2005 Jan 21
2005 Apr 25
2005 Sep 27
2006 Jan 31
2006 May 1
2006 Sep 11
2007 Feb 27
2007 May 21
2007 Sep 24
SPI02 Shorelines
2008 Jan 10
2008 Apr 18
2008 Oct 3
2009 Jan 15
2009 May 15
2009 Sep 22
2010 Jan 29
2010 May 14
2010 Sep 28
2011 Jan 20
N
SPI02 Vegetation Lines
0 100 200
Meters
2008 Jan 10
2008 Apr 18
2008 Oct 3
2009 Jan 15
2009 May 15
2009 Sep 22
2010 Jan 29
2010 May 14
2010 Sep 28
2011 Jan 20


SPI02 Shorelines
South Padre Island
Gulf of Mexico
2011 May 13
2011 Sep 27
2012 Sep 26
2013 Jan 23
2013 May 21
2013 Oct 23
2014 Jan 22
2014 Jun 5
2014 Sep 17
2015 Feb 4
SPI02 Vegetation Lines
2011 May 13
2011 Sep 27
2012 Sep 26
2013 Jan 23
2013 May 21
2013 Oct 23
2014 Jan 22
2014 Jun 5
2014 Sep 17
2015 Feb 4
SPI02 Shorelines
2015 Apr 22
2015 Sep 10
2016 Jan 20
2016 Apr 21
2016 Sep 27
2017 Jan 18
2017 Apr 19
2017 Sep 13
2018 Jan 10
2018 Apr 18
SPI02 Vegetation Lines
2015 Apr 22
2015 Sep 10
2016 Jan 20
2016 Apr 21
2016 Sep 27
2017 Jan 18
2017 Apr 19
2017 Sep 13
2018 Jan 10
2018 Apr 18
SPI02 Shorelines
2018 Oct 30
2019 Jan 10
2019 Apr 16
2019 Sep 12
2020 Jan 10
2021 Aug 10
2021 Oct 14
2022 Jan 26
2022 May 13
N
SPI02 Vegetation Lines
0 100 200
Meters
2018 Oct 30
2019 Jan 10
2019 Apr 16
2019 Sep 12
2020 Jan 10
2021 Aug 10
2021 Oct 14
2022 Jan 26
2022 May 13


SPI01 Shorelines
South Padre Island
Gulf of Mexico
1999 Nov 11
2000 Oct 25
2000 Dec 6
2001 Feb 19
2001 Dec 11
2002 May 1
2002 Sep 18
2002 Dec 10
2003 Apr 1
SPI01 Vegetation Lines
2001 Dec 11
2002 Mar 1
2002 May 1
2002 Dec 10
2003 Apr 1
Isla Blanca Park
Isla Blanca Park
SPI01 Shorelines
2003 Sep 4
2004 May 5
2004 Oct 19
2005 Jan 21
2005 Apr 25
2005 Sep 27
2006 Jan 31
2006 May 1
2006 Sep 11
2007 Feb 27
SPI01 Vegetation Lines
2003 Sep 4
2004 May 5
2004 Oct 19
2005 Jan 21
2005 Apr 25
2005 Sep 27
2006 Jan 31
2006 May 1
2006 Sep 11
2007 Feb 27
SPI01 Shorelines
2007 May 21
2007 Sep 24
2008 Jan 10
2008 Apr 18
2008 Oct 3
2009 Jan 15
2009 May 15
2009 Sep 22
2010 Jan 29
2010 May 14
SPI01 Vegetation Lines
0 100 200
Meters
2007 May 21
2007 Sep 24
2008 Jan 10
2008 Apr 18
2008 Oct 3
2009 Jan 15
2009 May 15
2009 Sep 22
2010 Jan 29
2010 May 14


SPI01 Shorelines
South Padre Island
Gulf of Mexico
2010 Sep 28
2011 Jan 20
2011 May 13
2011 Sep 27
2012 Sep 26
2013 Jan 23
2013 May 21
2013 Oct 23
2014 Jan 22
2014 Jun 5
SPI01 Vegetation Lines
Isla Blanca Park
2010 Sep 28
2011 Jan 20
2011 May 13
2011 Sep 27
2012 Sep 26
2013 Oct 23
2013 May 21
2013 Oct 23
2014 Jan 22
2014 Jun 5
SPI01 Shorelines
2014 Sep 17
2015 Feb 4
2015 Apr 22
2015 Sep 10
2016 Jan 20
2016 Apr 21
2016 Sep 27
2017 Jan 18
2017 Apr 19
2017 Sep 13
SPI01 Vegetation Lines
2014 Sep 17
2015 Feb 4
2015 Apr 22
2015 Sep 10
2016 Jan 20
2016 Apr 21
2016 Sep 27
2017 Jan 18
2017 Apr 19
2017 Sep 13
SPI01 Shorelines
2018 Jan 10
2018 Apr 18
2018 Oct 30
2019 Jan 10
2019 Apr 16
2019 Sep 12
2020 Jan 10
2021 Oct 14
2022 Jan 26
2022 May 13
N
SPI01 Vegetation Lines
0
100
200
Meters
2018 Jan 10
2018 Apr 18
2018 Oct 30
2019 Jan 10
2019 Apr 16
2019 Sep 12
2020 Jan 10
2021 Oct 14
2022 Jan 26
2022 May 13