FINAL REPORT

Texas High School Coastal Monitoring Program: 2007–2009

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Ball, Palacios, Port Aransas, Port Isabel, Van Vleck High Schools, and Cunningham and Tidehaven Middle Schools

Tiffany L. Caudle

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INTRODUCTION

The Texas Coastal Monitoring Program engages people who live along the Texas coast in the study of their natural environment. High school students, teachers, and scientists work together to gain a better understanding of dune and beach dynamics there. Scientists from The University of Texas at Austin (UT) provide the tools and training needed for scientific investigation. Students and teachers learn how to measure the topography, map the vegetation line and shoreline, and observe weather and wave conditions. By participating in an actual research project, the students obtain an enhanced science education. Public awareness of coastal processes and the Texas Coastal Management Program is heightened through this program. The students' efforts also provide coastal communities with valuable data on their changing shoreline.

This report describes the program and our experiences during the 2007–2008 and 2008–2009 academic years. During this time, Ball High School on Galveston Island completed its eleventh year in the program, and Port Aransas and Port Isabel High Schools completed their ninth and tenth years, respectively (Fig. 1). All three high schools are continuing the program during the 2009–2010 academic year. Through collaboration with the Lower Colorado River Authority, the program expanded to three schools in the Bay City, Texas, region. Tidehaven Middle School and Van Vleck High School completed their fifth year in the program, and Palacios High School completed its third year. Cunningham Middle School in the Corpus Christi Independent School District participated in its first field trip in late spring of the 2008–2009 academic year. All of the schools anticipate continuing with the program during the 2009–2010 academic year. Discussions of data collected by the students and recommendations for future high school projects are also included in this report. A manual with detailed field procedures, field forms, classroom exercises, and teaching materials was prepared during the first year of the project at Ball High School in 1997–1998. The manual was updated with the addition of the Bay City region schools in 2005. The program is also enhanced by a continuously updated website (http://coastal.beg.utexas.edu/thscmp/).

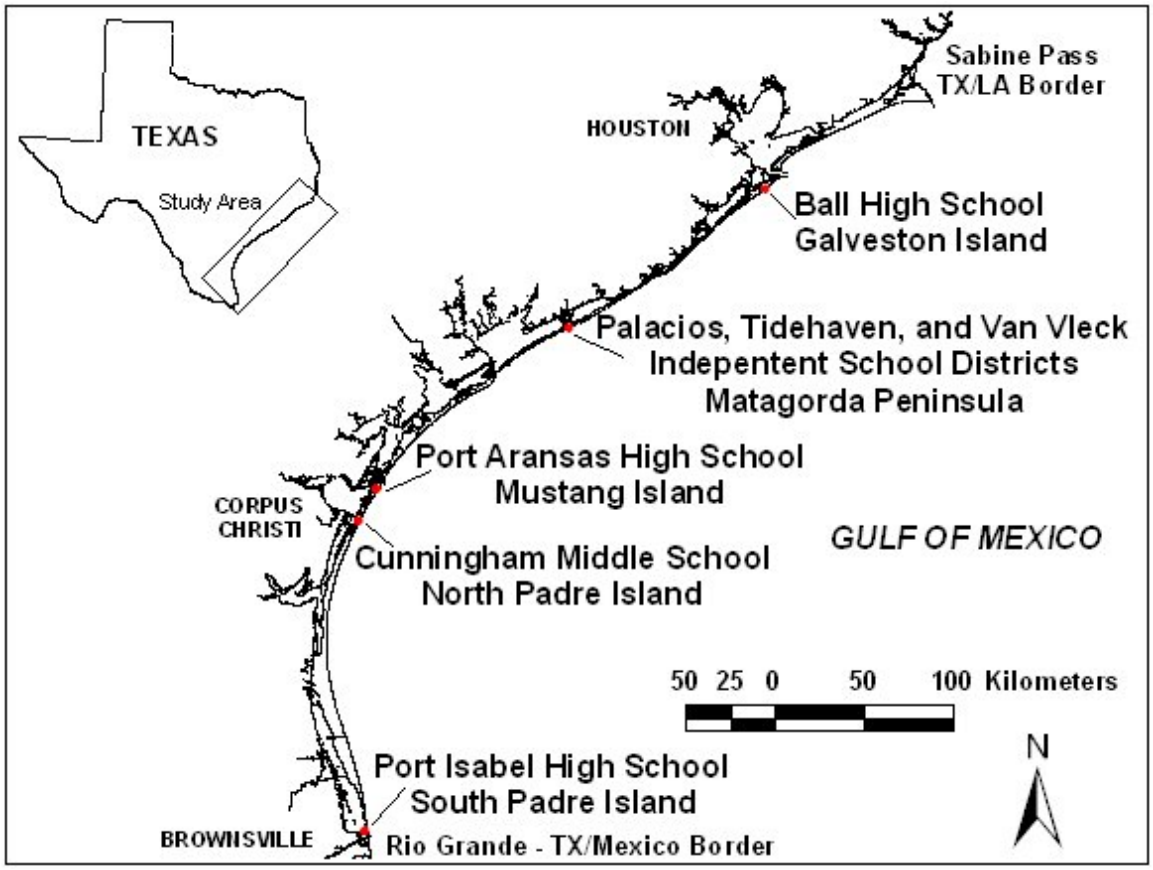


Figure 1. Participating schools.

PROGRAM DESCRIPTION

Goals

The coastal monitoring program has three major goals:

(1) Provide high school 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. UT scientists provide background information and guide inquiries about the data, but students are encouraged to form their own hypotheses and test them. 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. We expect that participating students will discuss the program with their parents, classmates, and neighbors, further expanding the reach of the

program. We also expect the program to attract media attention, as it has in the past. The program was featured in the winter 2006 issue of *On the Coast*, a coastal-issues newsletter from the Texas General Land Office. 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. A website (http://coastal.beg.utexas.edu/thscmp/) containing the latest information is central to the community outreach part of the project. Coastal residents may wish to view the effects of a storm that strikes the upper coast. They are able to do so by accessing the Texas High School Coastal Monitoring Program website to view maps, graphs, and photographs collected by Ball High School. Curiosity may drive this inquiry at first, but eventually awareness and appreciation of coastal processes and how future storms could affect a community will increase.

(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 of Economic Geology (Bureau) at UT has conducted a 30-year research program to monitor shorelines and investigate coastal processes. An important part of this program is the repeated mapping of the shoreline and measurement of beach profiles. Over time, these data are used to determine the rate of shoreline change. A problem we face is the limited temporal resolution in our shoreline data. The beach is a dynamic environment where significant changes in shape and sand volume can occur over periods of days or even hours. Tides, storms, and seasonal wind patterns cause large, periodic or quasi-periodic 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 Texas High School Coastal Monitoring Program 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 in the high school 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 measuring beach morphology and making observations on beach, weather, and wave conditions. These procedures were developed during the program's pilot year (1997–1998) and are presented in detail in a manual and on the website, which also includes field forms. Following is a general discussion of the field measurements.

(1) 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 (Figure 2). The students begin the profile at a presurveyed 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.

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

(2) Shoreline and vegetation line mapping. Using a differential Global Positioning System (GPS) receiver, students walk along the vegetation line and shoreline mapping these features for display on Geographic Information System software. The GPS mapping provides measurements of the rate of change.

(3) Sediment sampling. Students occasionally take sediment samples along the beach profile at the foredune crest, berm top, and beach face. They then sieve the samples, weigh the grain-size fractions, and inspect the grains using a microscope. These samples show the dependence of sand characteristics on the various processes acting on the beach.

(4) Beach processes (Figure 3). Students measure wind speed and direction, estimate the width of the surf zone, and observe the breaker type. They note wave direction, height, and period and estimate longshore current speed and direction using a float, stop watch, and tape measure. They also take readings of shoreline and foredune orientation. From these measurements, students can infer relationships between physical processes and beach changes in time and space. Students also learn to obtain weather and oceanographic data from resources on the Internet.

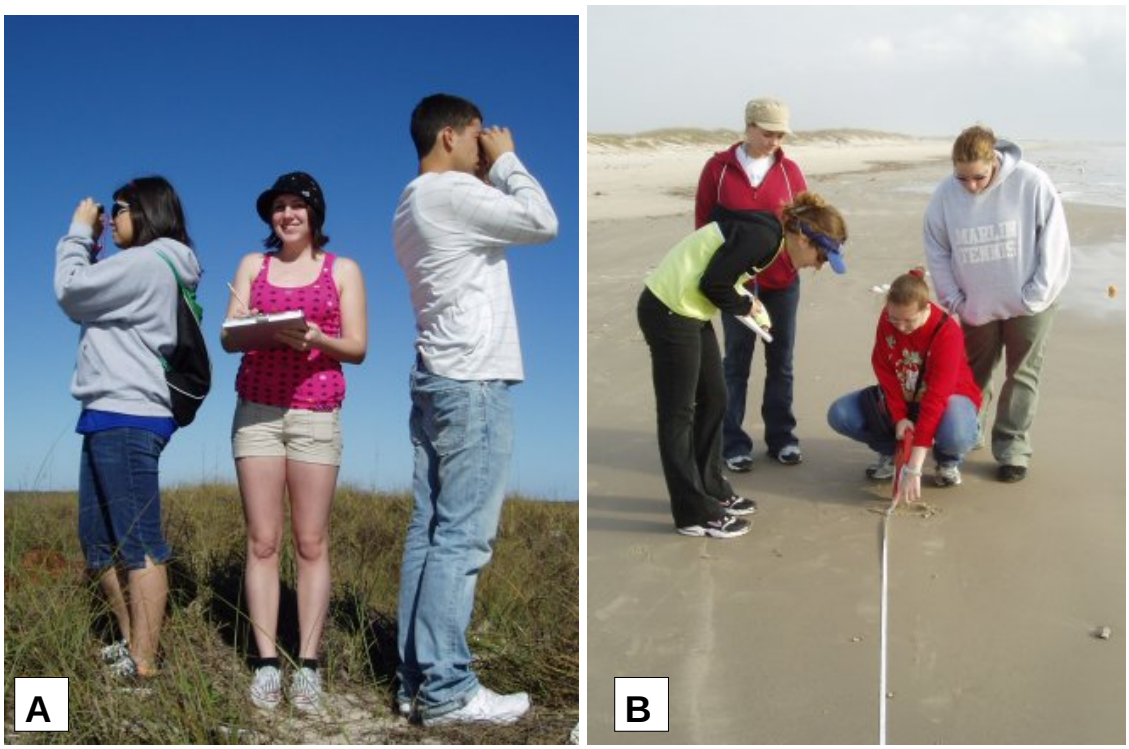


Figure 3. Students (A) using a sighting compass to measure dune orientation and (B) measuring how far along the shoreline the float (an orange) drifted to determine longshore current.

Training

UT scientists provide teachers with all the training, information, field forms, and equipment needed to conduct field and lab measurements. During the school year, UT scientists accompany students on at least one field trip and make at least two classroom visits, which may be included with the field trips. The classroom visits provide students with more insight into conducting scientific research. The scientists discuss with the students general and theoretical issues regarding scientific research, as well as specific techniques and issues related to coastal research. The visits also provide scientists with an opportunity to ensure quality of the data.

Data Management, Data Analysis, and Dissemination of Information

The web is central to the dissemination of data collected for this program. A website (http://coastal.beg.utexas.edu/thscmp/), which resides on a UT server, was implemented toward the end of the 1998–1999 academic year. The website provides all the information needed to begin a beach monitoring program, as well as curriculum materials for high school teachers. Each school in the program has an area on the website for posting its data and observations, including photos taken by an electronic camera. UT scientists manage the data in an electronic database and make them available to the public. UT scientists also evaluate the

data in light of coastal management problems. Students and the public can now interactively plot beach profiles and retrieve data through the website.

STUDENT, TEACHER, AND SCIENTIST INTERACTIONS DURING THE 2007–2008 and 2008–2009 ACADEMIC YEARS

UT scientist Ms. Tiffany Caudle worked with teachers Mr. Ron Wooten of Ball High School, Mr. William Slingerland of Port Aransas High School, and Dr. Michelle Zacher of Port Isabel High School. Mr. Wooten chose his Advanced Placement Environmental Science classes to participate in the program. Mr. Slingerland chose his Aquatic Sciences class to participate in the program. Port Isabel High School biology teacher, Dr. Zacher, employed her Advanced Placement Biology class.

The Bureau is working together with the Lower Colorado River Authority (LCRA) at Matagorda Bay Nature Park. This collaboration has allowed the Bureau to expand the program to three schools in the Bay City, Texas, region. Expansion of the Texas High School Coastal Monitoring Program has not only increased the number of schools, but now includes younger students, who are making the same field measurements as the high school students, but who are visiting only one profile site per field trip. Ms. Caudle worked with teachers Mr. Warren Morris of Palacios High School, Mr. Robert Hutto from Tidehaven Middle School, and Ms. Meredith Keelan of Van Vleck High School during the first field trip of the academic year. Representatives from LCRA worked with the teachers during the other field trips.

After a workshop that was held at Texas A&M University Corpus Christi, the Innovation Academy for Engineering, Environmental and Marine Science at Cunningham Middle School (Corpus Christi Independent School District) expressed interest in joining the Program. Ms. Caudle worked with Ms. Jamie Copeland of Cunningham Middle School. Approximately 80 students in 6th through 12th grades actively participated during each academic year.

UT scientists visited each school at least once, letting the visits coincide with field trips. During and after field trips and during lectures, UT scientists discussed careers in science and university life with students. These visits by UT scientists served not only to enhance scientific instruction, but they also gave students insight into science as a career.

During the field trips, students were divided into two or three teams, according to the size of the class. One team measured the profile while the other team collected data on weather and waves and conducted a GPS survey of the shoreline and vegetation line. Team members had specific tasks, and students took turns performing them. After each team completed its tasks at the first location, the teams switched roles so that everyone had an opportunity to conduct all measurements.

Dividing students into two four- to seven-member teams works well. One team conducts the beach profile and the other measures the processes and the shoreline. Extra tasks can be assigned to the team that finishes first. It is important to assign each student a job to keep him or her focused and interested. Time for a little fun should also be 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 method of breaking students into teams and collecting data works well for Advanced Placement students at Ball, Port Aransas, and Port Isabel High Schools. Adding middle school students to the program has changed our approach to working with students, but only slightly. For example, the Bay City region schools, which collect data on Matagorda Peninsula, collect data from only one monitoring site. Because of the distance from the schools to the beach (~45 minutes to 1 hour each way), time will not allow data collection from multiple sites. At Tidehaven Middle School, the Spanish Science Club usually conducts its field trips on Saturday mornings because the group from Tidehaven is a club and it is harder for the members to receive permission to leave school during regular hours. Instead of breaking into groups to collect the data, we attempt to keep the students active by constantly rotating them through the different positions. The last student to conduct a measurement teaches the next student.

The day of the field trip, students meet in the teacher's classroom to organize equipment and gather additional materials that they may need for the day (coolers with ice and water, lunches, etc.). Throughout the day, data and samples are collected from one to three locations, with sufficient time allotted for lunch and breaks. On some trips there is time for additional scientific inquiry. Port Isabel students visit the Laguna Madre Nature Trail on South Padre Island or use a seine net in Laguna Madre. Ball High School students observe the wetlands at Galveston Island State Park, as well as use different types of nets (seine, cast nets, etc.) to observe shrimp, crabs, and small fish that live in the waters at the edge of the wetlands. Port Aransas High School students visit the University of Texas Fisheries and Mariculture Laboratory or the Marine Science Institute. All trips allow ample time for careful data collection, while ensuring that the students are back at school about 1 hour before the end of the day. During this hour, equipment is stored and data are filed or transferred to the computer. Following are details on the activities at each school.

Ball High School

Mr. Ron Wooten's AP Environmental Science classes at Ball High School participated in field trips on September 20, 2007; February 8, 2008; and April 23, 2008. They conducted surveys at the same two locations as previous Ball High classes—one at the Galveston Island State Park, BEG02, and one on Follets

Island southwest of San Luis Pass, BEG08 (Fig. 4). The Bureau has been measuring these profiles since the 1980's. Ms. Caudle accompanied the class and provided further training and background information to the students.

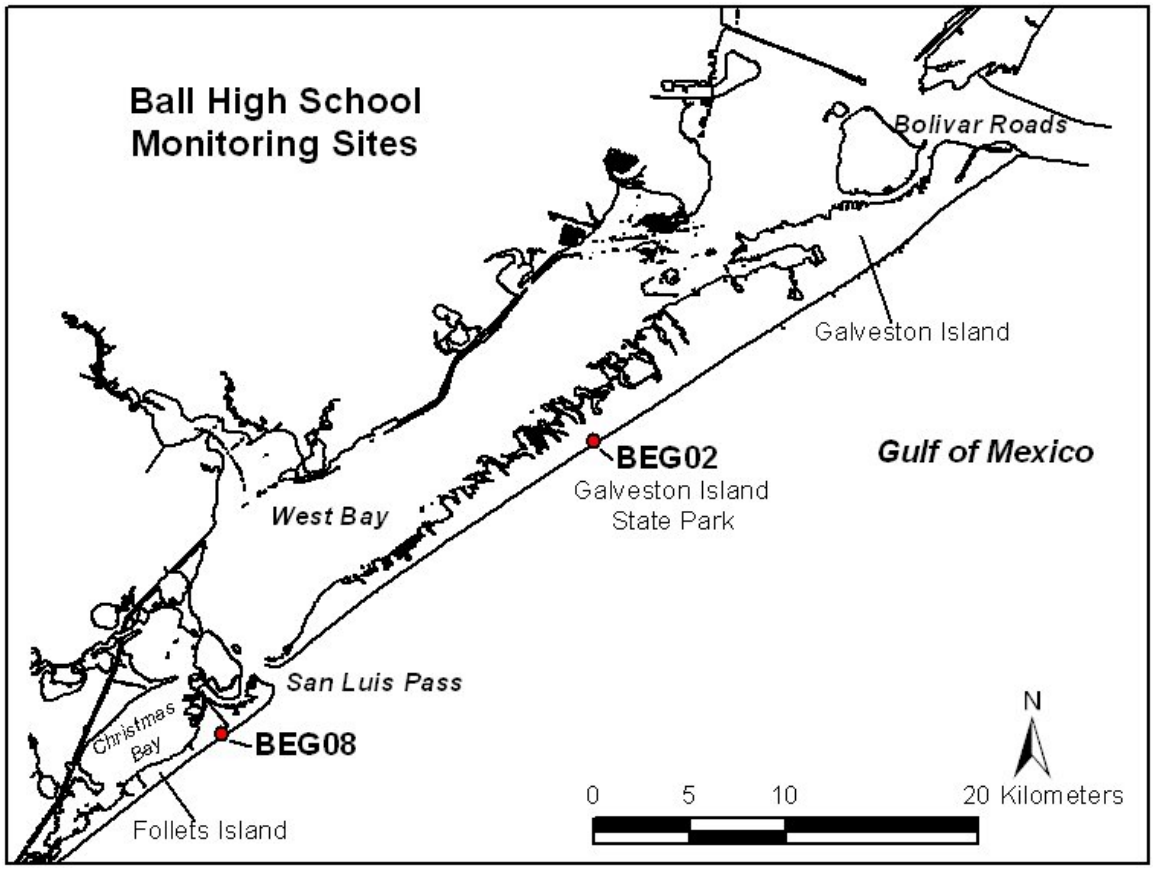


Figure 4. Location map of Ball High School monitoring sites.

Ms. Caudle was attempting to contact the teacher at Ball High School to establish a first field-trip date for the 2008–2009 academic year when Hurricane Ike struck the Texas coast at Galveston Island. Because of the catastrophic impact Galveston Island received from the hurricane, Ball High School was closed for several weeks. In early October 2008, after inspection of the Island by the Bureau and Texas A&M University Corpus Christi (TAMUCC) scientist, it was determined that the monitoring site at Galveston Island State Park would be unsafe for students to visit until the park reopened. Also, until recently the monitoring site on Follets Island was inaccessible by bus because of road damage. Students from Ball High School therefore did not participate in the program during the 2008–2009 academic year, and data were collected at these sites by the Bureau and TAMUCC scientists. Ball High School will be rejoining the program for the 2009–2010 academic year but with a new teacher.

Port Aransas High School

Port Aransas students participated in field trips on September 21, 2007; January 17, 2008; May 14, 2008; September 24, 2008; January 21, 2009; and April 15, 2009. Mr. Slingerland's classes collected data at three profile locations on Mustang Island: MUI01 near Horace Caldwell Pier, MUI02 in Mustang Island State Park, and MUI03 (Fig. 5). Port Aransas High School has been measuring these profiles since 1999. Ms. Caudle accompanied the class and provided further training and background information to the students.

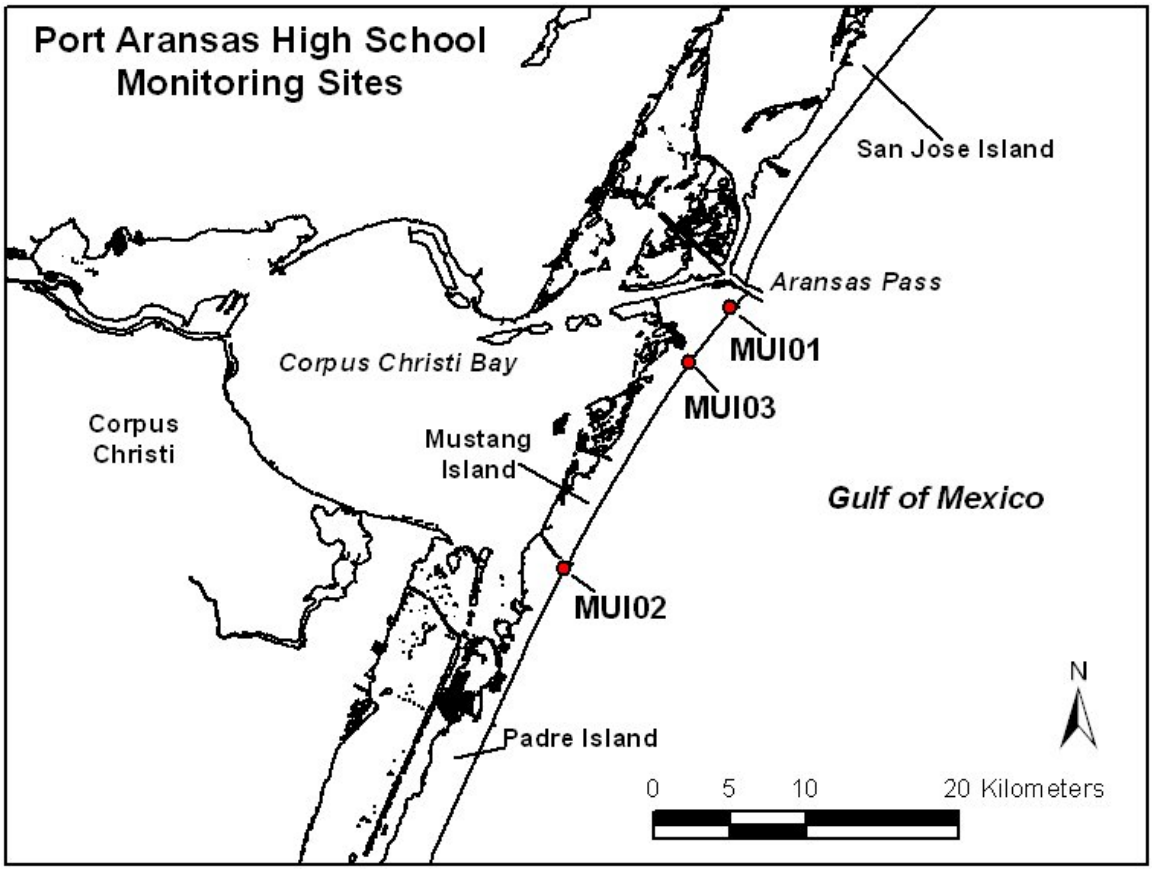


Figure 5. Location map of Port Aransas High School monitoring sites.

Port Isabel High School

Port Isabel students participated in field trips on September 24, 2007; January 10, 2008; April 18, 2008; October 3, 2008; January 15, 2009; and May 15, 2009. Dr. Zacher's Advanced Biology class collected data at three profile locations on South Padre Island: SPI01 in Isla Blanca Park, SPI02 at Beach Access #13, and the newest site, SPI08, at the Tiki Condominiums (E. Whitesands Street) (Fig. 6). Port Isabel High School has been measuring SPI01 and SPI02 since 1999. Ms. Caudle was able to accompany the class on every field trip to provide further training and background information to the students.

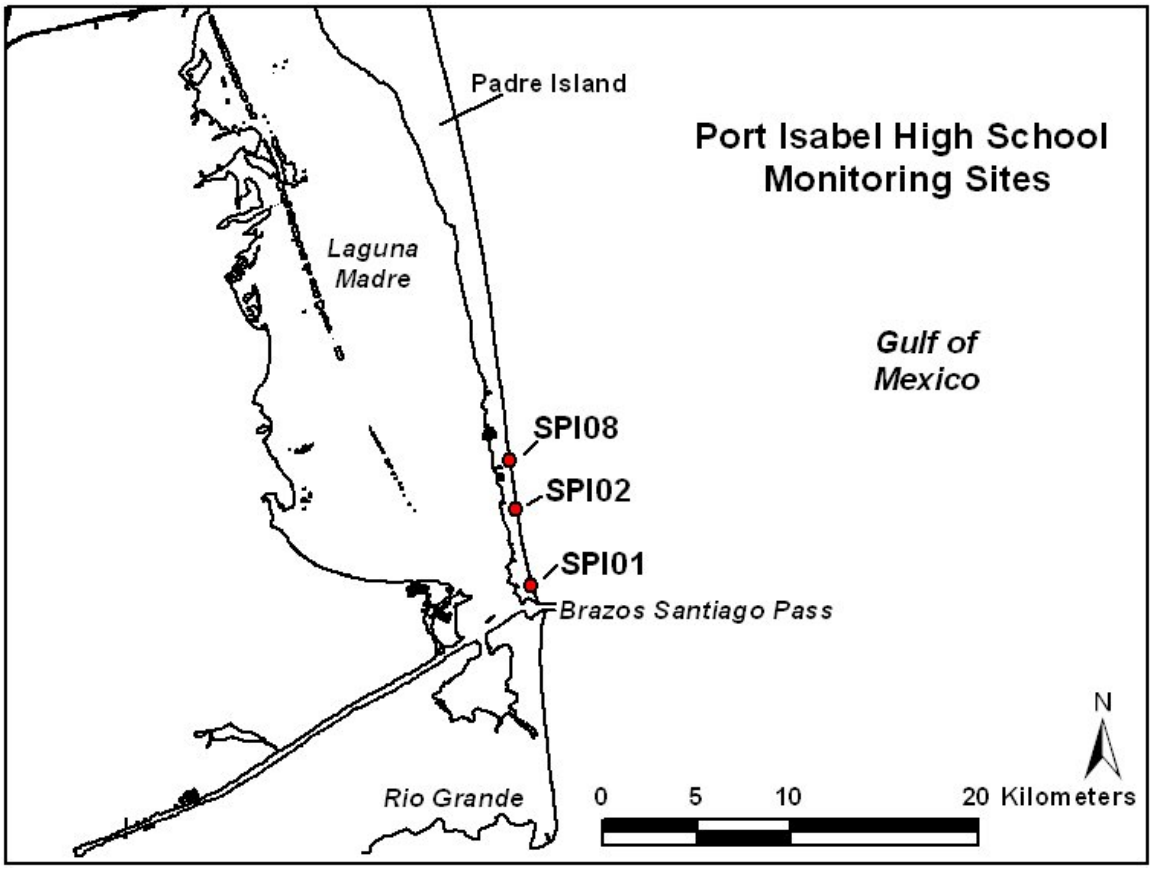


Figure 6. Location map of Port Isabel High School monitoring sites.

Bay City Area Schools

Van Vleck High School biology students participated in field trips on September 28, 2007; February 1, 2008; May 9, 2008; September 26, 2008; December 12, 2008; and May 22, 2009. Ms. Keelen's class collected data at MAT01 (Fig. 7). Physics students from Palacios High School participated in field trips on September 27, 2007; January 31, 2008; May 8, 2008; October 16, 2008; January 22, 2009; and May 14, 2009. Palacios students collected data at MAT02 (Fig. 7). The Spanish Science Club at Tidehaven Middle School participated in field trips on September 22, 2007; February 2, 2008; May 14, 2008; September 27, 2008; February 7, 2009; and May 30, 2009. The students from Tidehaven collected data at MAT03 (Fig. 7).

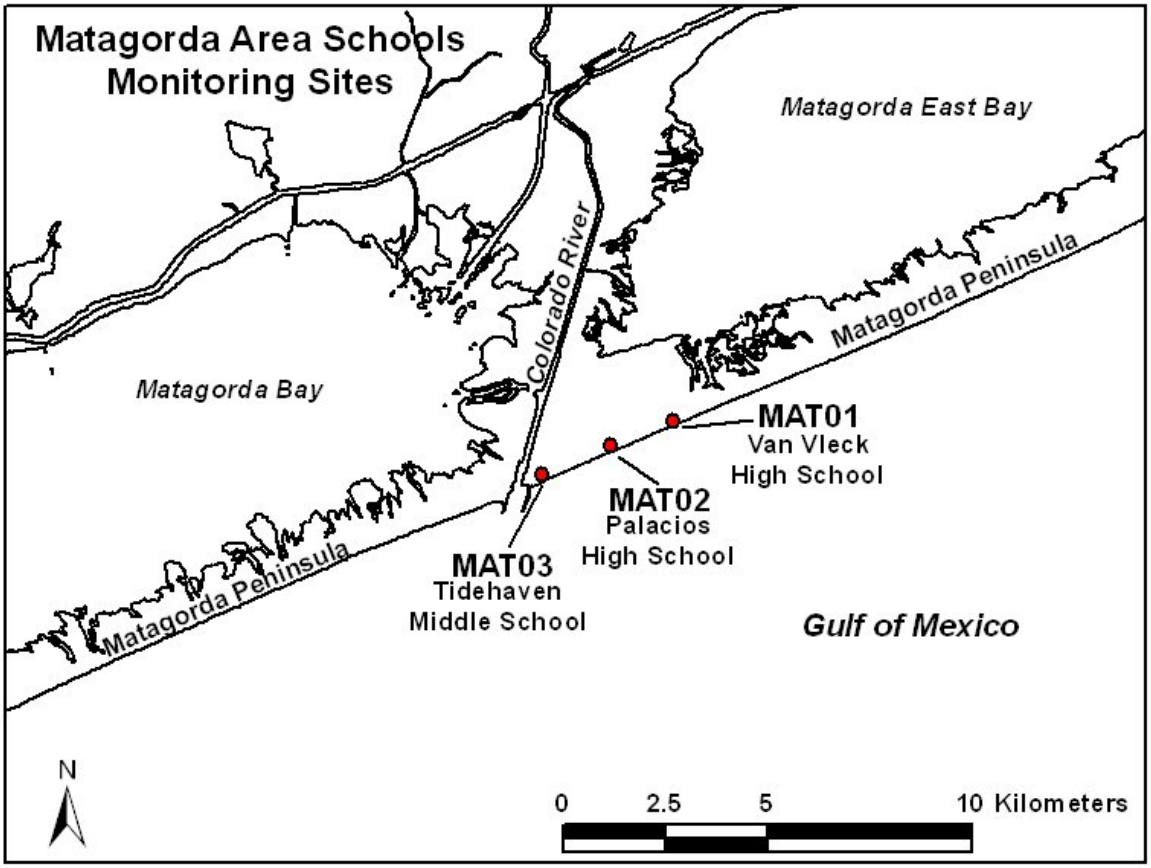


Figure 7. Location map of Matagorda Peninsula monitoring sites.

Cunningham Middle School

The 7th graders in the Innovation Academy at Cunningham Middle School asked to join the program after participating in a workshop at TAMUCC in November 2008. A field trip was held on April 14, 2009, to introduce 7th grade ambassadors to the program. The teachers at Cunningham Middle School expressed a desire to include all 7th grade students (~75 students) in the field trips. For the first outing in April, only the ambassadors participated in order to learn measurement techniques, however. They, in turn, would be able to assist their classmates on the next field trip. A second field trip was being planned for mid- to late-May of 2009 but was cancelled owing to the H1N1 flu (swine flu) outbreak in South Texas. Teachers and Bureau staff decided to wait until the 2009–2010 academic year to continue field trips. The Bureau will need to collaborate with graduate students and staff at TAMUCC to conduct field trips with Cunningham Middle School, owing to the number of students that will participate in the program.

EFFECTS ON SCIENCE CURRICULUM

The Texas High School Coastal Monitoring Program addresses several requirements of Texas Essential Knowledge and Skills (TEKS) for science, and

the program was relevant in these 2007–2009 Texas high school courses: (1) Environmental Systems, (2) Aquatic Sciences, and (3) Geology, Meteorology, and Oceanography. The Texas High School Coastal Monitoring Program also addresses several National Science Education Standards: (1) unifying concepts and processes in science, (2) science as inquiry, (3) physical science, (4) Earth and space science, (5) science and technology, and (6) science in personal and social perspectives.

TEKS and Standards related to applying scientific methods in field and laboratory investigations in these courses are well covered in the coastal monitoring program. Specific requirements, such as (1) collecting data and making measurements with precision, (2) analyzing data using mathematical methods, (3) evaluating data and identifying trends, and (4) planning and implementing investigative procedures, are an excellent fit with the program. TEKS and Standards, which require students to use critical thinking and scientific problem solving to make informed decisions, are also well served. Teachers and scientists can use the program to illustrate to students the role science could, should, or does play in developing public policy. A case study of a local erosion problem could be used to illustrate.

EFFECTS ON SCIENTIFIC RESEARCH, COASTAL MANAGEMENT, AND PUBLIC AWARENESS

During the 2007–2008 academic year, Ball High School students measured profile locations in Galveston Island State Park (BEG02, Fig. 4) and on Follets Island to the southwest of Galveston Island. Ball High School students had measured these same locations in previous years, and the Bureau had conducted quarterly surveys at these locations from 1983 through 1985 after Hurricane Alicia. Since 1985, however, the beaches had been surveyed on an irregular schedule, about once a year, and only when specific projects were funded to do so or when Bureau personnel were in the area conducting other work. The high school beach-monitoring program helps ensure that time series at these key locations are continued. The Galveston Island State Park profile has increased in importance because it served as a control site for comparing profiles measured in front of geotextile tube projects along Pirates Beach to the northeast. Results of a study utilizing data collected by Ball High School students were published in *Shore & Beach*, the journal of the American Shore & Beach Preservation Association. The data have increased scientific understanding of recovery of beaches and dunes following storms (Hurricane Alicia, Tropical Storm Frances, Hurricane Claudette, Hurricane Rita) that have impacted the area.

Port Aransas and Port Isabel High Schools continued the beach-profile time series at their established locations. Palacios and Van Vleck High Schools and Tidehaven Middle School continued collecting data at their established locations. The profile and processes data that the students collected have been

incorporated into the beach-profile database at the Bureau, and scientists are using these data to investigate beach erosion patterns. These data can be viewed at the Texas High School Coastal Monitoring Program website at http://coastal.beg.utexas.edu/thscmp/.

Although it will take time to incorporate data into products that support coastal management, it is clear that the data will be useful in explaining beach cycles and defining short-term versus long-term trends. Defining these trends is important for making decisions regarding coastal development and beach nourishment. The program has also increased public awareness through the students. Given the number of inquiries from people wishing to enter their school or group in THSCMP, we think that the program is reaching the public. Television reports, presentations at conferences, and newspaper articles have helped. The Website will continue to be instrumental in extending the reach of the program and increasing public awareness of coastal processes.

SCIENTIFIC RESULTS OF 1997–2009 STUDIES

The first goal of the Texas High School Coastal Monitoring Program is to provide high school students with an inquiry-based learning experience, which is achieved by involving students in a real-world research project. The student-collected beach data can and have been used by researchers at the Bureau to help respond to several beach-related issues. The data are also available to coastal managers and the public online at http://coastal.beg.utexas.edu/thscmp/.

Profile data are entered into the public-domain software package, *Beach Morphology and Analysis Package* (BMAP). BMAP Version 2, developed by the U.S. Army Corp of Engineers, is commonly used by coastal engineers and scientists for beach-profile analysis. Beach-volume calculations were made using BMAP, and shoreline and vegetation-line positions were determined from notes made by students and scientists while in the field collecting data. The shoreline is designated by the wet/dry line or a berm crest. Volume, shoreline, and vegetation-line plots for sites collected by Ball, Port Aransas, and Port Isabel High Schools are found in Appendix B, profile plots are in Appendix C, and profile plots from Matagorda Peninsula are also in Appendix C.

Students from Ball High School have been collecting data for the coastal monitoring program since 1997. During this timeframe, Tropical Storm Frances (September 1998) played a major role in reshaping the beaches in Galveston County. Data collected by Ball High School students on Galveston Island have been used by scientists at the Bureau to track beach and dune recovery stages following Tropical Storm Frances. The storm caused significant damage to beaches along the southeast coast of Texas that was comparable to damage caused by category-3 Hurricane Alicia in 1983 (Hepner and Gibeaut, 2004). Several other severe storms have impacted the study area. Allison (June 2001),

Fay (September 2002), Hurricane Claudette (July 2003), and Hurricane Rita (September 2005) have each caused varying amounts of damage to beaches and dunes along the Texas coast (Fig. 8).

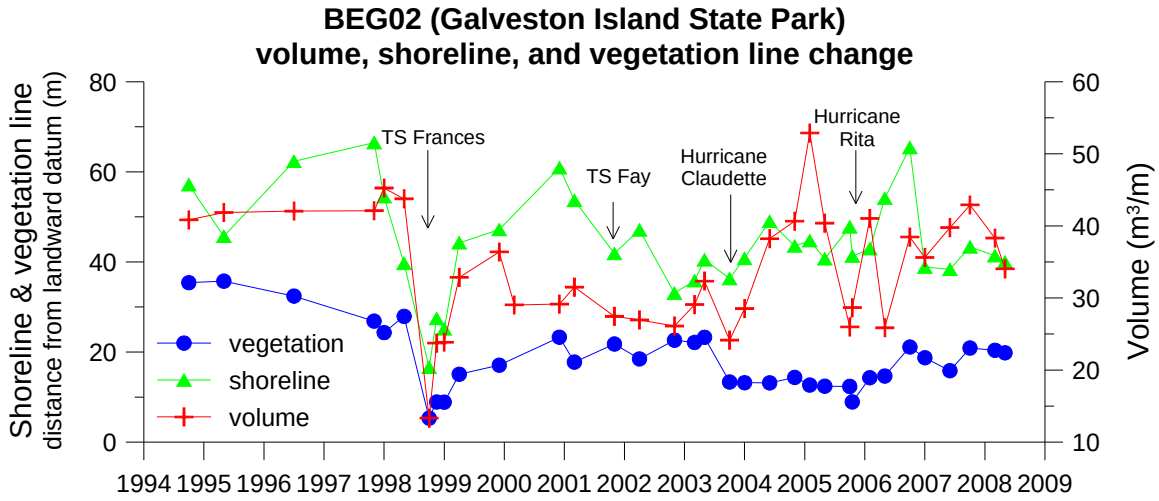


Figure 8. Profile volume, shoreline, and vegetation-line changes at Galveston Island State Park.

Ball High School students provided important pre-storm beach topography data from their two key locations during the 2005–2006 academic year. Hurricane Rita made landfall at Sabine Pass on the Texas/Louisiana border at 7:30 UTC on September 24, 2005. Rita was a category 3 hurricane with maximum sustained winds of about 105 knots. Overall, Rita did not cause the kind of episodic beach or dune erosion on Galveston or Follets Islands that Frances had in 1998. Figure 9 is a plot of pre- and post-storm beach profiles measured at Galveston Island State Park. The pre-storm profile was measured by Ball High School science students, and the post-storm profile was measured by scientists from the Bureau. Rita flattened the profile and caused a small amount of overwash deposition, but the position of the vegetation line and shoreline was not greatly affected (Fig. 8) (Gibeaut, 2005).

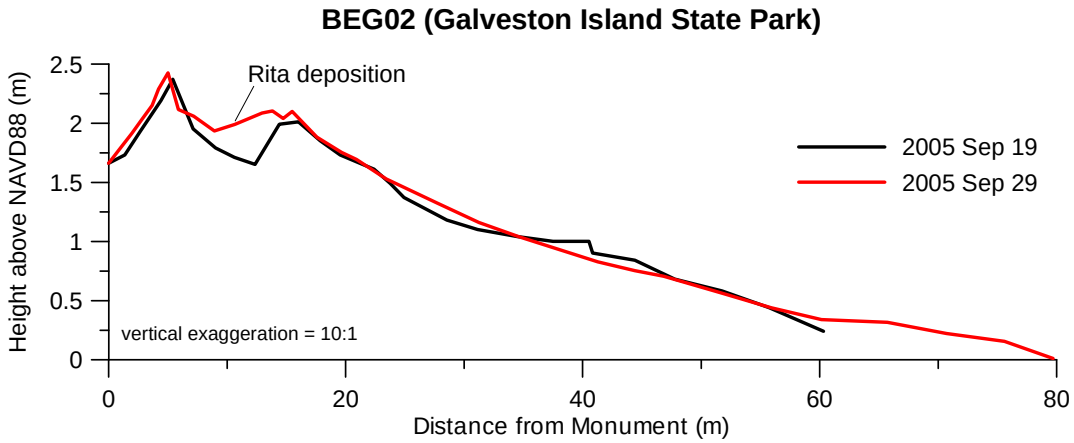


Figure 9. Plot of pre- and post-storm beach profiles measured at Galveston Island State Park.

The 2008–2009 academic year was devastated by the landfall of Hurricane Ike on Galveston Island September 13, 2008. Field trips with Palacios, Port Aransas, Tidehaven, and Van Vleck schools were postponed because of school closings in preparation for the hurricane. Impacts from this hurricane were seen along the entire Texas coast, despite Ike's being a Category 2 storm at the time of landfall, owing to the shear size of the storm. Dune erosion was also documented at Matagorda Peninsula and Mustang Island (see Appendix C).

Galveston Island experienced significant beach and dune erosion, as well as extensive damage to property and infrastructure, because of Hurricane Ike. Ball High School students were unable to participate in the program during the 2008–2009 academic year owing to safety concerns about accessing their monitoring sites. Galveston Island State Park (profile site BEG02) was determined to be unsafe for students until debris could be removed and facilities were reopened to the public (summer 2009). Profile BEG08 on Follets Island was inaccessible to buses because the Blue Water Highway (FM 3005) was severely damaged during the storm surge. The highway is now reopened, but it is unlikely that Ball High students will resume monitoring this location. The original datum point for BEG08 was unrecoverable following Hurricane Ike. A new datum point was reset on the landward side of the Blue Water Highway, which would require students to cross the highway on foot while conducting the profile. Although it is unfortunate that students will be unable to continue collecting data at this site, other profile locations on Galveston Island that would be acceptable replacement monitoring sites have been monitored by Bureau staff for a long period of time.

Bureau and TAMUCC scientists visited Galveston Island in early October to conduct ground surveys—beach profiles, photography, and observations of beach and dune conditions—of the area impacted by Hurricane Ike. Profile location BEG02 in Galveston Island State Park was visited during this reconnaissance trip, and it was found that the datum marker at BEG02 had been destroyed by the storm. Global Positioning System techniques were used to navigate to the location of the datum marker, which is now on the open beach. The datum marker had been the corner of a concrete picnic pavilion located landward of the foredunes. BEG02 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. A topographic profile was conducted at this time. Students will be able to visit this site starting in September 2009 to continue collecting data at this important monitoring site.

Ball High School students from the 2007–2008 academic year provided extremely valuable pre-storm profile data on February 8, 2008, and April 23, 2008. These data have been used to determine how much the beach and dune changed after Hurricane Ike. Figure 10 is a profile plot at BEG02 comparing Ball High pre-storm profiles (February and 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. The dune system at

Galveston Island State Park was completely destroyed, and the shoreline (wet–dry line) moved 53 m landward between April 23, 2008, and October 7, 2008. The vegetation line moved 56 m landward. The old datum point was 1.14 m above the current surface of the beach.

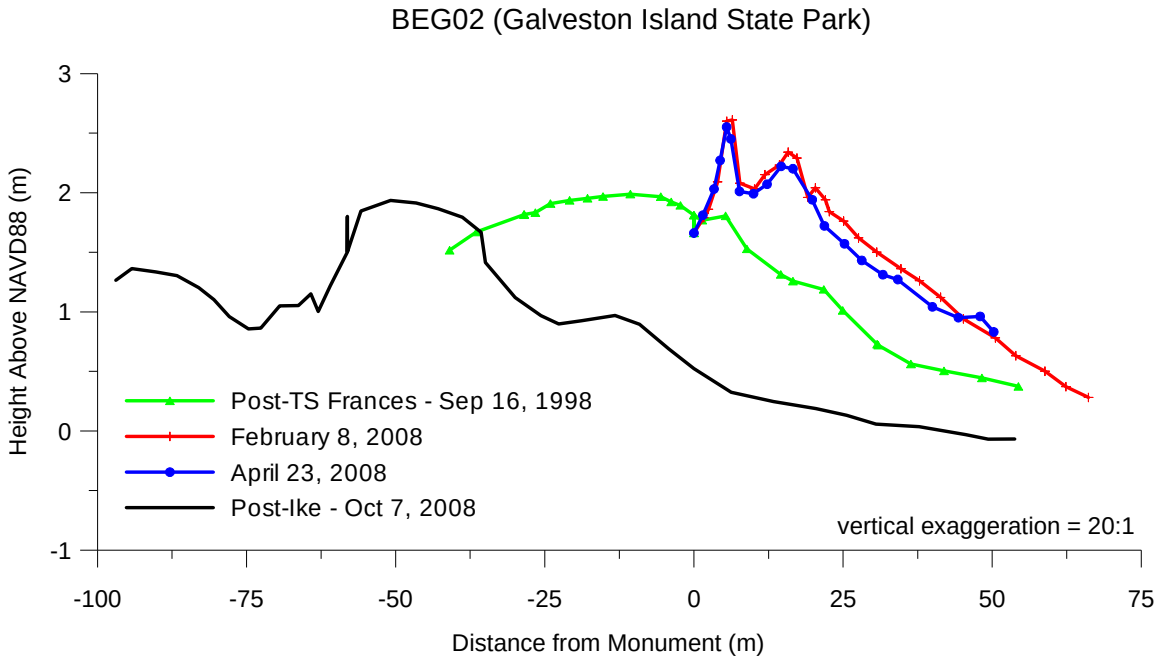


Figure 10. Beach profile plot from Galveston Island State Park showing the post-Hurricane Ike profile compared with two pre-storm profiles from early 2008 and the post-Tropical Storm Frances profile from September 1998.

Port Aransas and Port Isabel High Schools have been collecting beach-profile data and coastal-process observations since 1999. Although neither location has experienced the type of dramatic shoreline change that Galveston and Follets Islands have, the information gained from the students' work has been beneficial to Bureau researchers' understanding of the dynamics of the Texas coast. Brazos Santiago Pass, the southern border of South Padre Island, is dredged biannually. The pass serves as the southern Gulf of Mexico access to the Gulf Intracoastal Waterway and the Port of Brownsville. Dredged material is placed on beaches of South Padre Island, and the two sites monitored by Port Isabel High School students are within the nourishment areas. The SPI02 monitoring site has also been used by students and scientists to monitor the growth of dunes. When SPI02 was established in August 2000, there were no dunes between the seawall and the waterline at this location. Since that time, sand fences were installed, and vegetation has been planted. Profile data have been quantifying the effects of these actions (Fig. 11). The storm surge due to Hurricane Ike deposited sand in the dune area at SPI02 and covered the vegetation, essentially flattening the profile. Port Isabel students will be monitoring new dunes that form at this location. Hurricane Dolly made landfall on South Padre Island near Port Mansfield on July 23, 2008. Impacts to beaches

and dunes in the Port Isabel students' study area were not measured because of the arrival of Hurricane Ike before their first field trip.

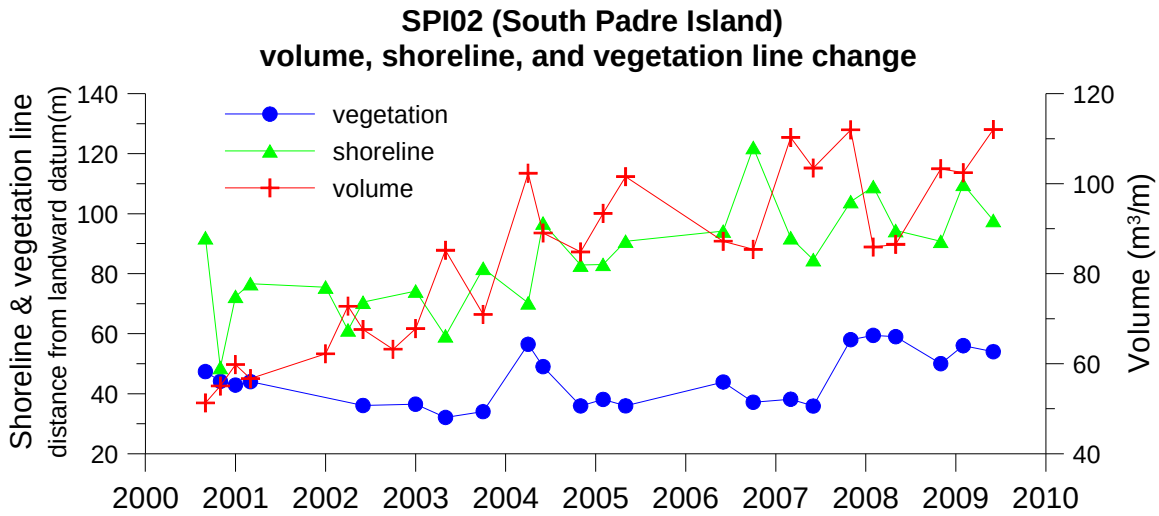


Figure 11. Changes at SPI02 on South Padre Island due to installation of sand fence and beach nourishment.

Palacios, Van Vleck, and Tidehaven students have continued their beach measurements at Matagorda Bay Nature Park. The park has two special circumstances that make this monitoring especially informative and important. Monitoring sites have been established on the up-drift side of the jetty at the mouth of the Colorado River and at sites that allow us to compare a beach/dune system where vehicular traffic on the beach will be strictly prohibited (MAT03), along with an adjacent area where vehicular traffic will continue to be permitted (MAT01 and MAT02). Impacts of coastal structures (jetties) are critical to coastal management, and impacts of vehicles on Texas' beaches are not well documented. Vehicular traffic was permitted on the pedestrian beach at the Nature Park until 2007. There is now a call to reopen this section of beach to vehicular traffic because of a perceived lack of use by pedestrian-only beachgoers. Data collected between 2005 and 2007 will serve as baseline data for the study on vehicular impact on beaches if the beach remains closed to vehicles. Because it is still too early in the study to compare the beaches, in the interest of scientific study, we hope that the beach remains a pedestrian beach. Future measurements will show not only change through time at each location, but also spatial variation along the Texas coast. Through time, data collected from Matagorda Peninsula will help scientists better understand the relationship between coastal processes, beach morphology, and shoreline change at these locations.

WEBSITE UPGRADES

The program's website (http://coastal.beg.utexas.edu/thscmp/index.html) was redesigned and evolved during the 2006–2007 academic year. The color scheme was changed to make it more appealing, and several exercises were

developed as part of a National Science Foundation grant that utilize data collected by participants in the program, which were added to the new site. Field guides for Mustang and Galveston Islands were added in 2007. The photo gallery has been updated as well to include all photos since the program began.

An exciting upgrade to the website during the 2008–2009 academic year is an interactive virtual barrier island. The Bureau, along with the TAMUCC, has developed a 3-D virtual model of the Gulf of Mexico and Texas coastal environments for use in the classroom and for the general public to explore how relative sea-level change, caused by climate change and other things, may impact the coastal zone. The virtual barrier island can be downloaded from the website to run on users' computers. A lesson plan titled *Sea-Level Changes and the Texas Coastal Environment* has also been created for use in the classroom. This lesson encourages students to consider the impacts of increased greenhouse gases in the atmosphere and how they may affect climate change, sea level, and, eventually, coastal environments. A PowerPoint presentation offers teachers the opportunity to introduce the lesson in their classrooms, and a 10-minute video explains how to navigate and manipulate the data within the model.

CONCLUSIONS

The Texas High School Coastal Monitoring Program provides high school students with a real-world learning experience outside the everyday classroom. The coastal monitoring program not only provides hands-on education, but it also complies with many TEKS requirements. The 2007–2008 and 2008–2009 academic years were productive, with Ball, Palacios, Port Aransas, Port Isabel, and Van Vleck High Schools and Tidehaven Middle School collecting data on several field trips and Cunningham Middle School joining the program. Another exciting addition to the program has been completion of the virtual barrier island.

In the 12 years since the inception of the Texas High School Coastal Monitoring Program, work by students at Ball, Port Aransas, Port Isabel, Palacios, and Van Vleck High Schools and Tidehaven Middle School has been beneficial to Bureau researchers and coastal managers in several Bureau research projects. Availability of data through the program's website allows access to coastal managers and the public. Scientists, students, and the public will continue to gain a better understanding of coastal processes and shoreline change along the Texas coast through this successful student research program.

RECOMMENDATIONS

We consider the eleventh through twelfth years of the Texas High School Coastal Monitoring Program a success and offer the following recommendations for continuance and expansion of the program.

1. Emphasize to students that they are working on a real research project and are collecting scientifically valid data that will eventually appear in a scientific publication. This is a major point that makes this program different from most other field trips or laboratory exercises. Asking students to conduct experiments that have real consequences seems to make a difference to them, and it probably improves the quality of the data.

2. Clearly tell students about the specific scientific problems being addressed, but also emphasize that what they are gaining in experience is not just how to measure beaches but how to conduct scientific field research in general. Students are also learning a different way of viewing their surroundings.

3. Survey a reasonable number of beaches, which, in most cases, means two or three. The program goals of scientific research and science education could be at odds with one another. From a purely scientific point of view, it would be desirable to acquire as many data as possible. That approach, however, would not allow time for discussions on the beach that are not directly related to the measurements. Taking up too much time taking measurements would also hinder development of observation skills and keep students from enjoying their work.

4. The number of official field trips depends on the class, but a maximum of four trips is reasonable. Some trips may have to be cancelled because of bad weather or other unusual circumstances, and cancelled trips can be difficult to reschedule. Therefore, some freedom must be allowed in the program regarding number of trips and sites measured. Even if just one good data set is collected during the year, it will be useful scientifically. Some students might be encouraged to make additional trips on weekends or after school. Interested students should be encouraged to use the program in a science fair project.

5. A website adds an important dimension to the project, especially when multiple schools are participating. A website at which students can exchange observations with those of other schools in Texas increases the educational value of the program by allowing students to observe differences in processes along the coast. A website also illustrates to students how the Internet can be used to conduct research. Furthermore, the Internet is crucial in increasing public awareness of coastal processes, so providing immediate feedback to students through the Internet is important. Students want to see their data

and photographs on the web, and feedback increases their interest in the project.

6. Encourage teachers to incorporate the data into the curricula for their other classes. One of the goals of the program is to increase public awareness and understanding of coastal processes and hazards. Disseminating data gathered by their peers may increase the interest of students not directly involved in the coastal monitoring program. Data collected and knowledge gained from analysis of the data are applicable to all Environmental Science, Geology, Aquatic Sciences, and Oceanography curricula.

REFERENCES CITED

Gibeaut, J. C., 2005. Field Surveys following Hurricane Rita: Preliminary Observations. The University of Texas at Austin, Bureau of Economic Geology. Open-File Report for Texas General Land Office. 22 pages.

Hepner, T. L., and Gibeaut, J. C., 2004. Tracking post-storm beach recovery using data collected by Texas high school students. *Shore and Beach*. Volume 72, Number 4. Pages 5 to 9.

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 Geiod99 Ellipsoid Model.

Profile	Latitude (deg min)	Longitude (deg min)	Easting (m)	Northing (m)	HAE (m)	NAVD88 (m)	Azimuth (M)
BEG02	29 11.64	94 57.09	310255.20	3231059.16	-24.75	1.66	139
BEG02R	29 11.67	94 57.11	310228.82	3231110.58	-24.61	1.80	139
BEG08	29 3.22	95 8.90	290838.52	3215830.51	-25.21	2.09	145

*BEG02 reset in October 2008 owing to Hurricane Ike.

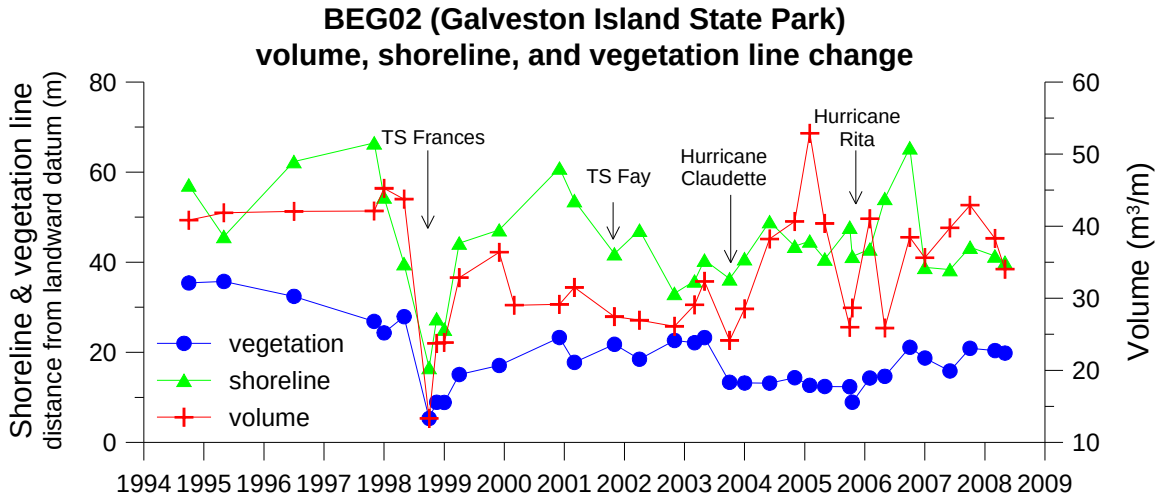
Profile	Latitude (deg min)	Longitude (deg min)	Easting (m)	Northing (m)	HAE (m)	NAVD88 (m)	Azimuth (M)
MAT01	28 36.67	95 56.55	212269.73	3168453.74	-22.77	3.69	148
MAT02	28 36.31	95 57.47	210751.39	3167825.80	-23.25	3.22	148
MAT03	28 35.91	95 58.48	309090.26	3167112.23	-21.81	4.68	148

Profile	Latitude (deg min)	Longitude (deg min)	Easting (m)	Northing (m)	HAE (m)	NAVD88 (m)	Azimuth (M)
MUI01	27 49.53	97 03.40	691396.24	3079393.46	-22.29	3.79	123
MUI02	27 40.42	97 10.19	680502.58	3062388.03	-24.14	1.69	120
MUI03	27 47.66	97 05.08	688697.42	3075882.34	-22.08	3.95	125

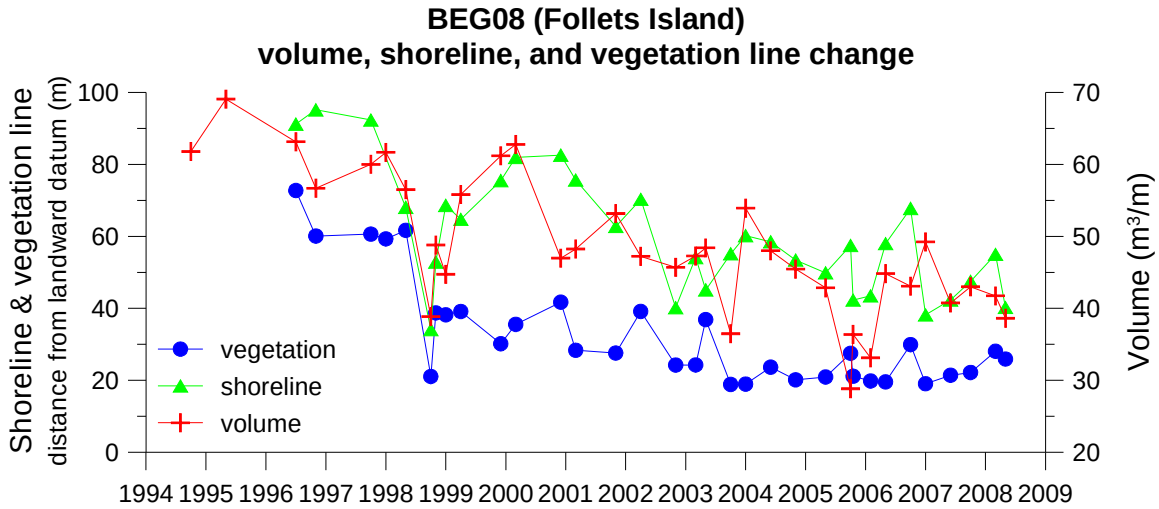
Profile	Latitude (deg min)	Longitude (deg min)	Easting (m)	Northing (m)	HAE (m)	NAVD88 (m)	Azimuth (M)
SPI01	26 4.57	97 9.46	684274.71	2885422.83	-18.48	2.75	70
SPI02	26 6.79	97 9.93	683438.99	2889509.24	-18.11	3.19	78
SPI08	26 8.17	97 10.10	683116.29	2892056.38	-18.32	3.01	75

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

BEG02 volumes are calculated from datum to 0.75 m below datum. Profiles that did not extend to –0.75 m were extrapolated.

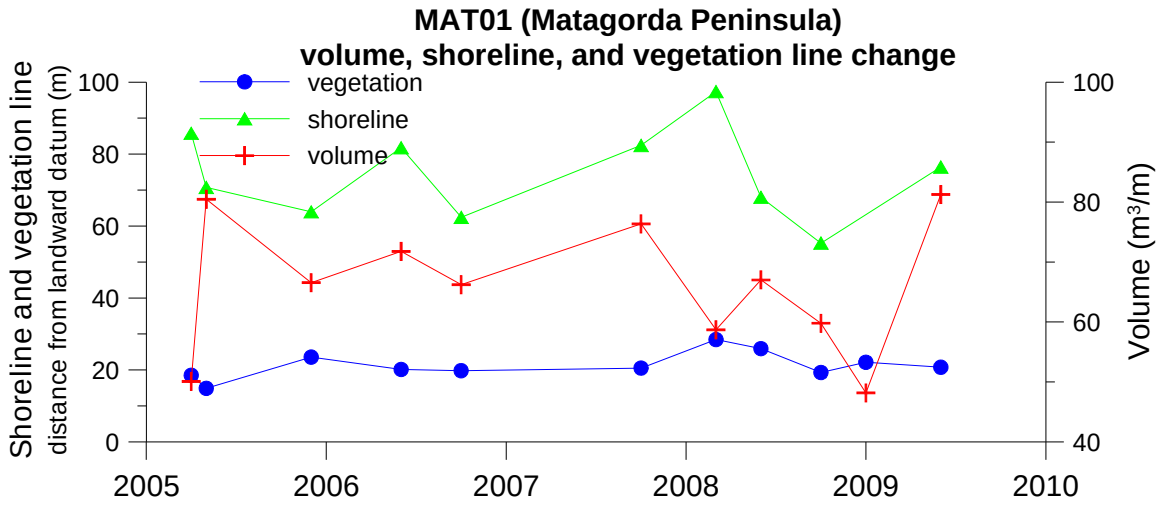


BEG08 volumes are calculated from datum to 1 m below datum. Profiles that did not extend to –1 m were extrapolated.

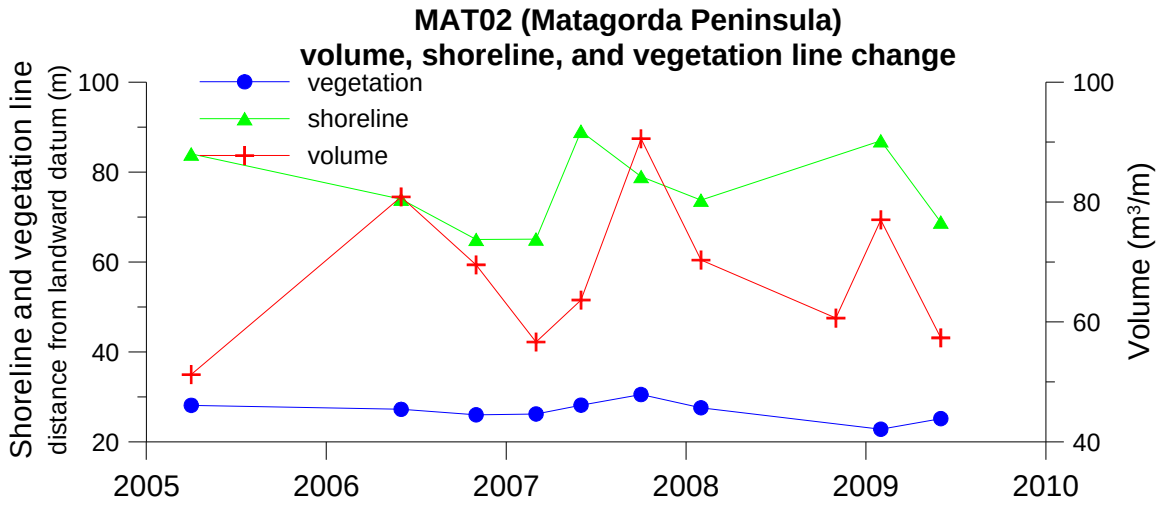


BEG02 and BEG08 have data from 1994 through the spring of 2008. Ball High School did not participate in the program because of Hurricane Ike's impact on Galveston Island. Their data collection will resume with the 2009–2010 semester.

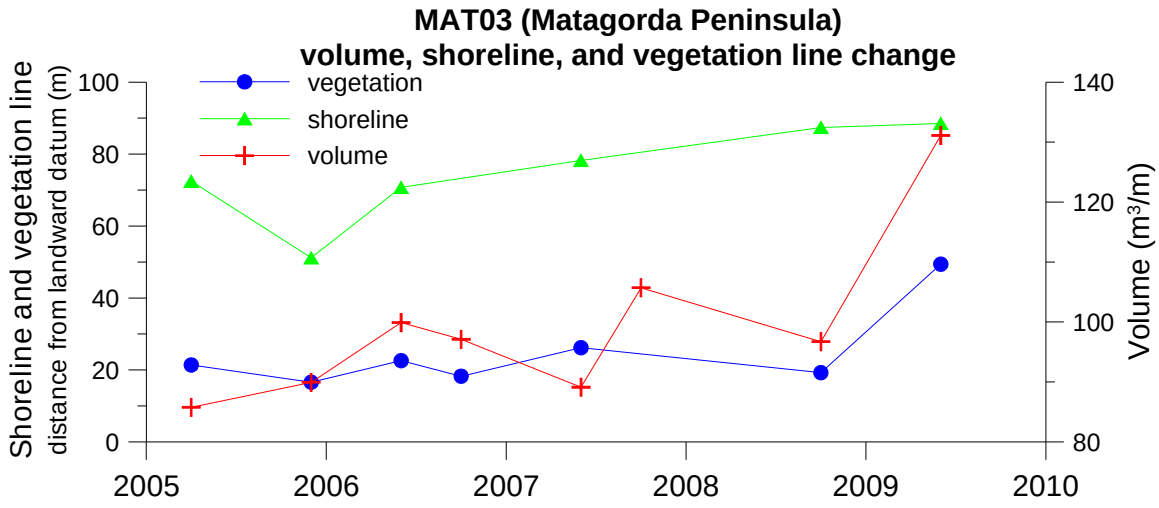
MAT01 volumes were calculated from datum to 2.5 m below datum. Profiles that did not extend to –2.5 m were extrapolated.



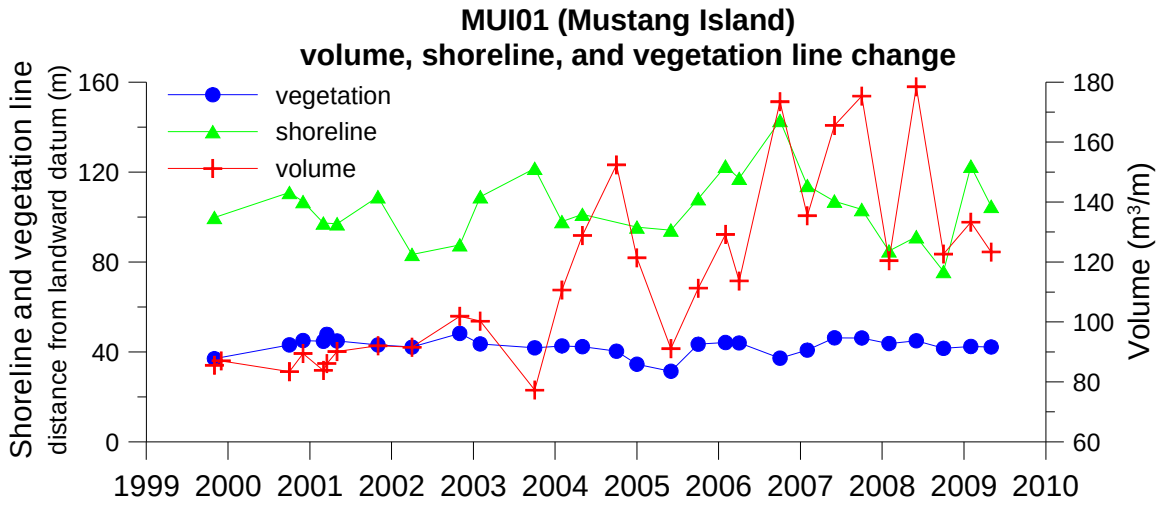
MAT02 volumes were calculated from datum to 2 m below datum. Profiles that did not extend to –2 m were extrapolated.



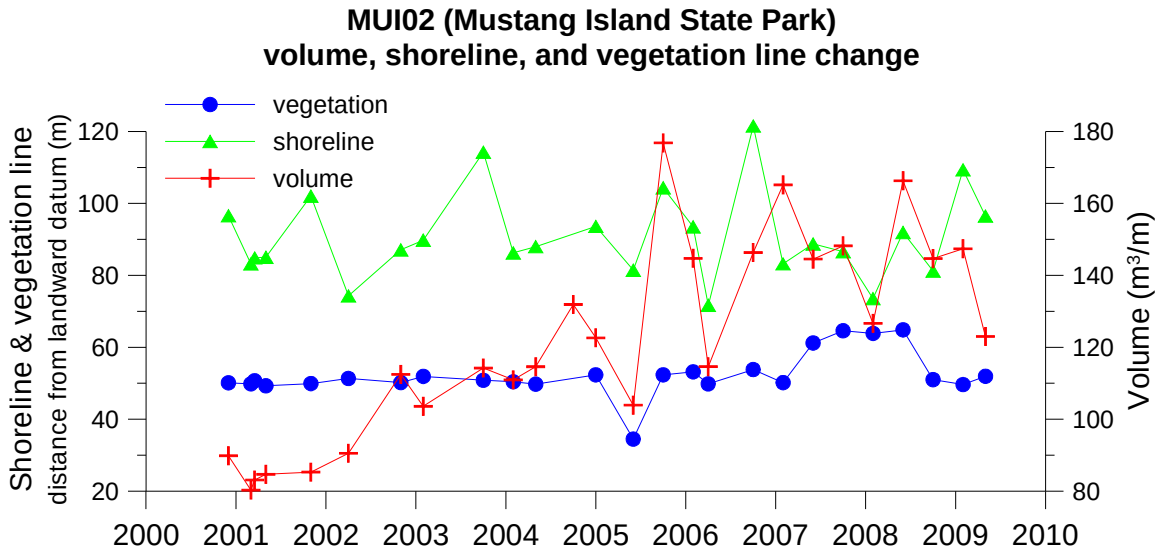
MAT03 volumes are calculated from datum to 4 m below datum. Profiles that did not extend to –4 m were extrapolated.



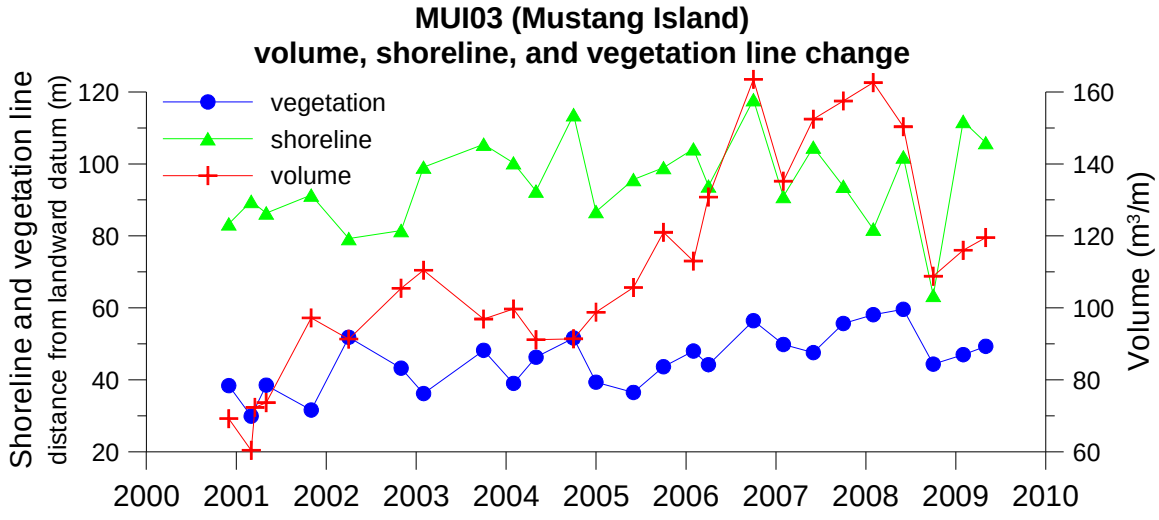
MUI01 volumes are calculated from datum to 2.5 m below datum. Profiles that did not extend to –2.5 m were extrapolated.



MUI02 volumes were calculated from datum to 0.5 m below datum. Profiles that did not extend to –0. 5 m were extrapolated.



MUI03 volumes were calculated from datum to 2.5 m below datum. Profiles that did not extend to –2.5 m were extrapolated.



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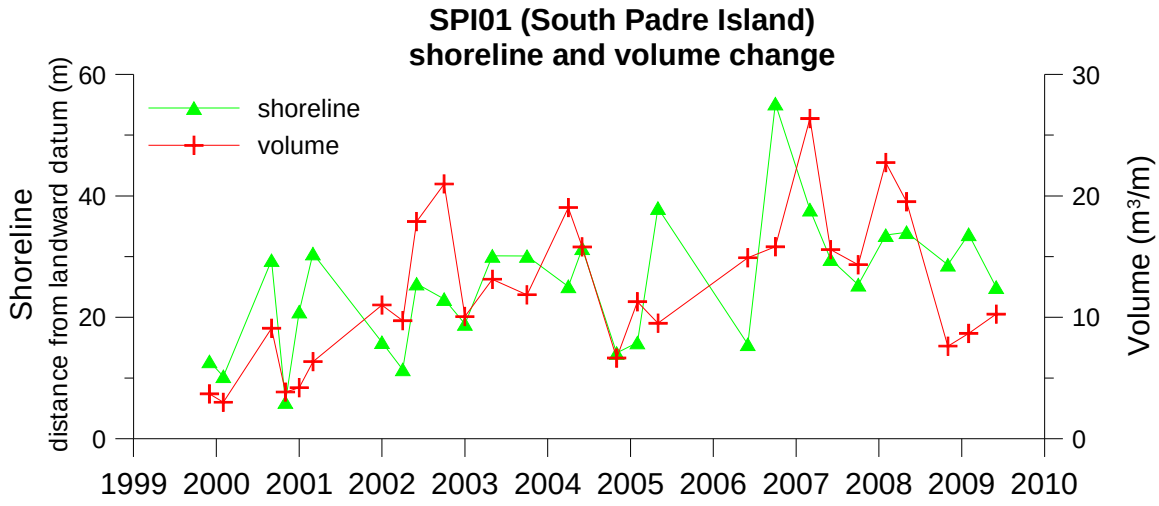

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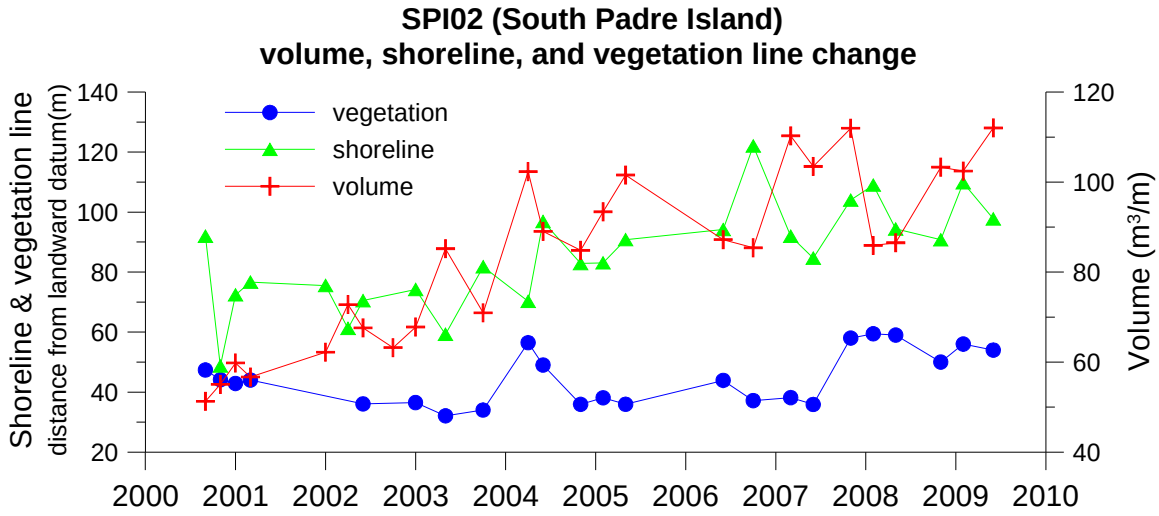
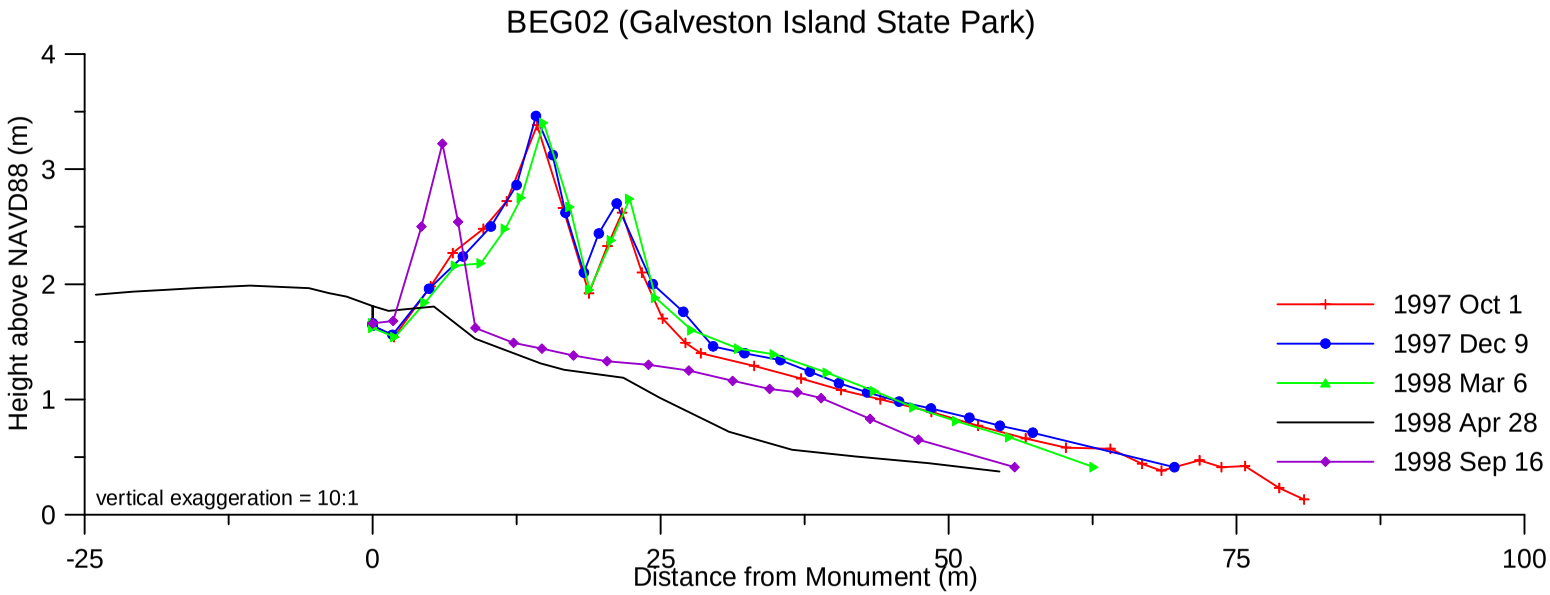


APPENDIX C: GRAPHS OF BEACH PROFILES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1998 Mar 6
1998 Apr 28
1998 Sep 16
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2
3
4
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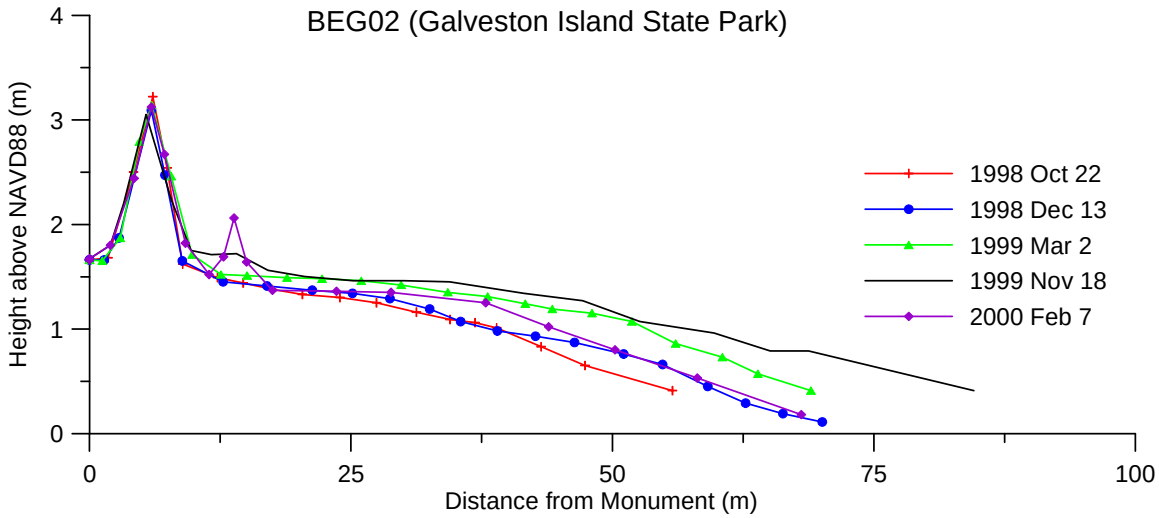
0
25
50
75
100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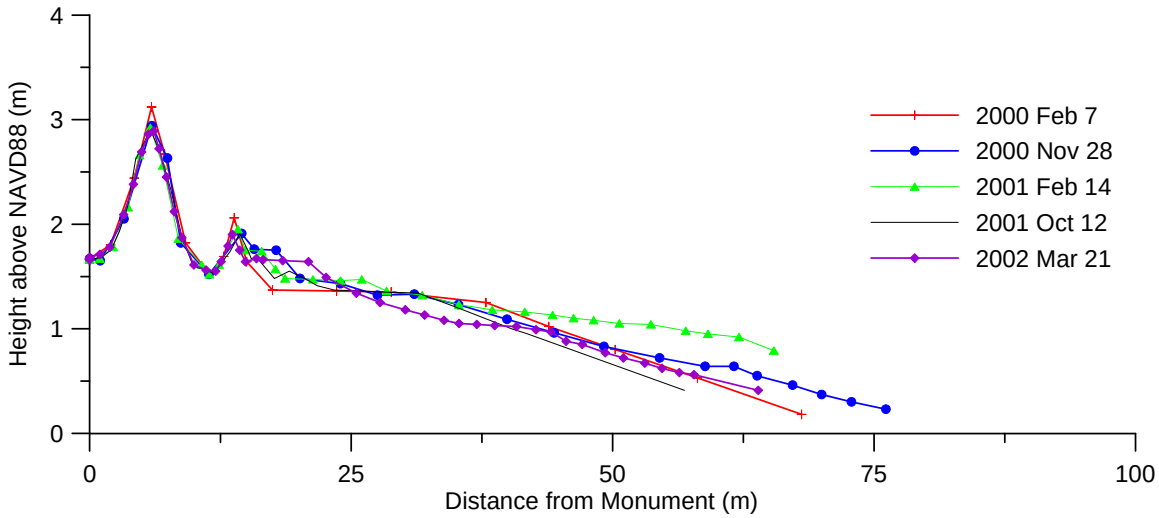
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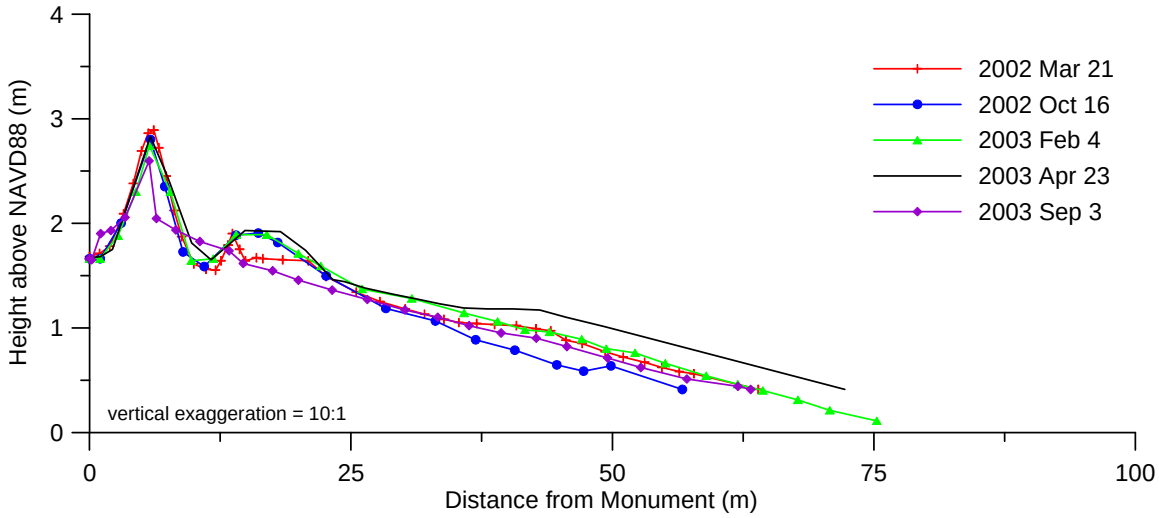
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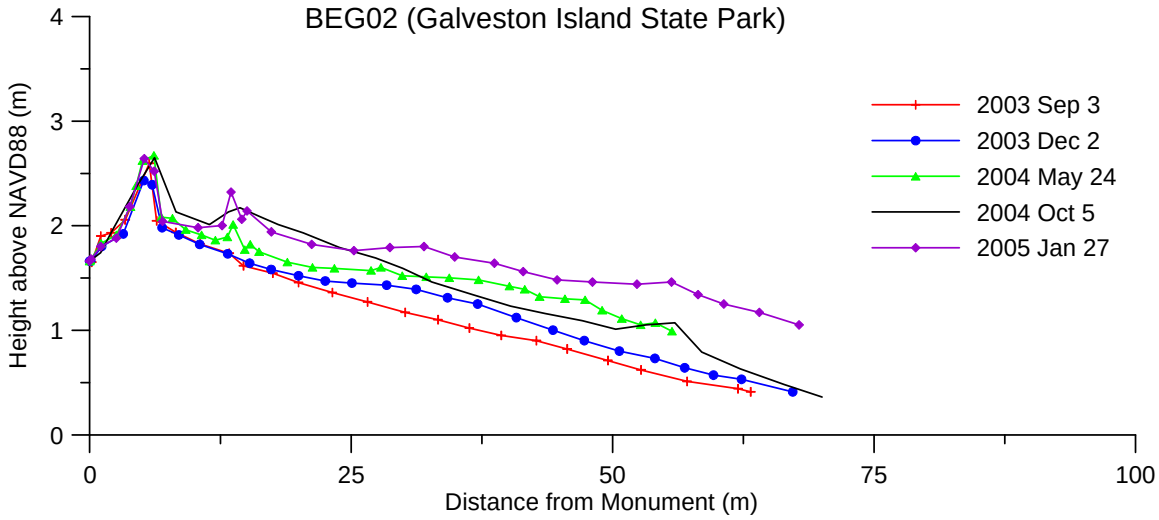
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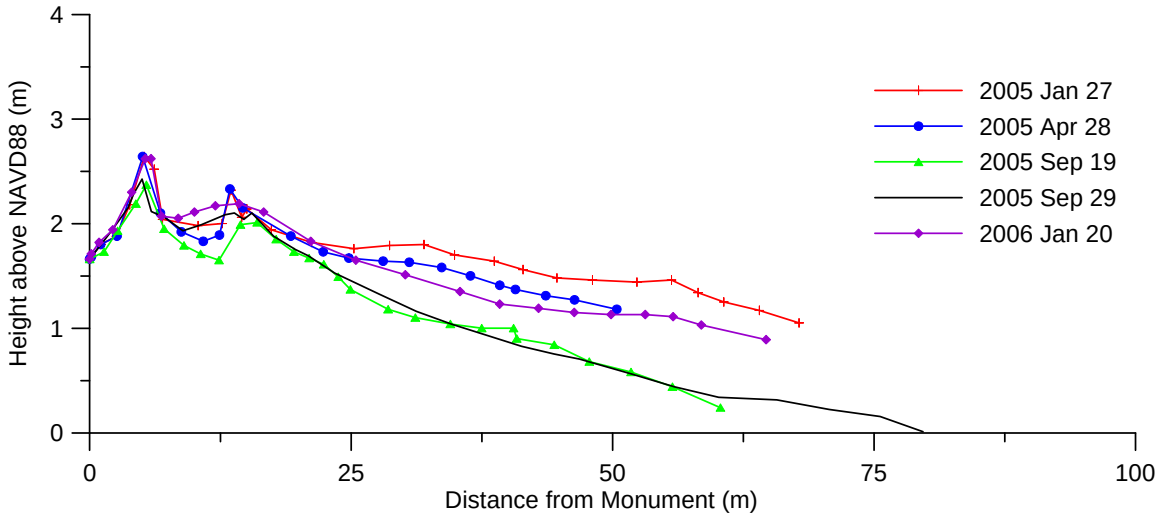
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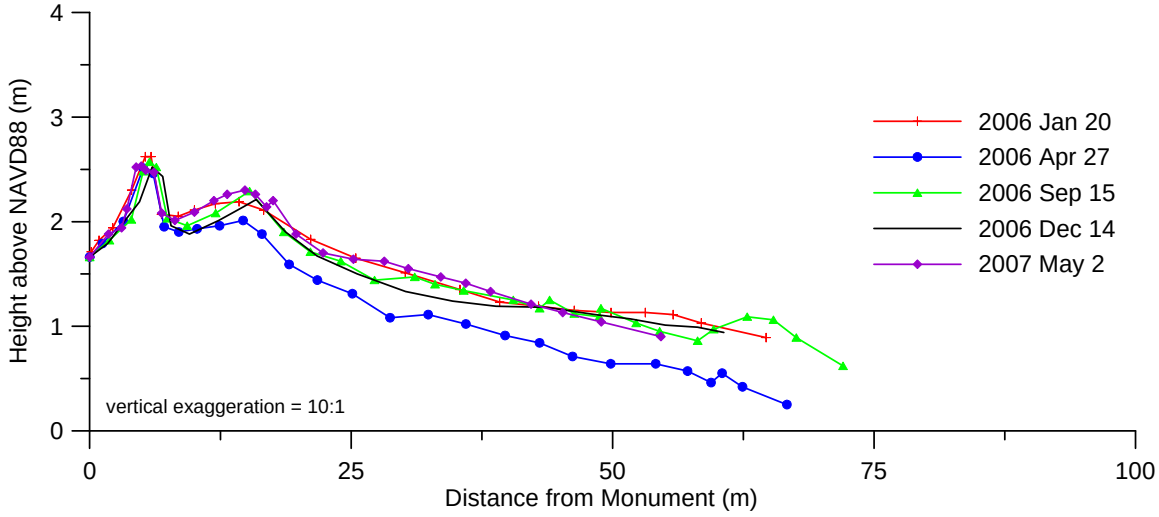
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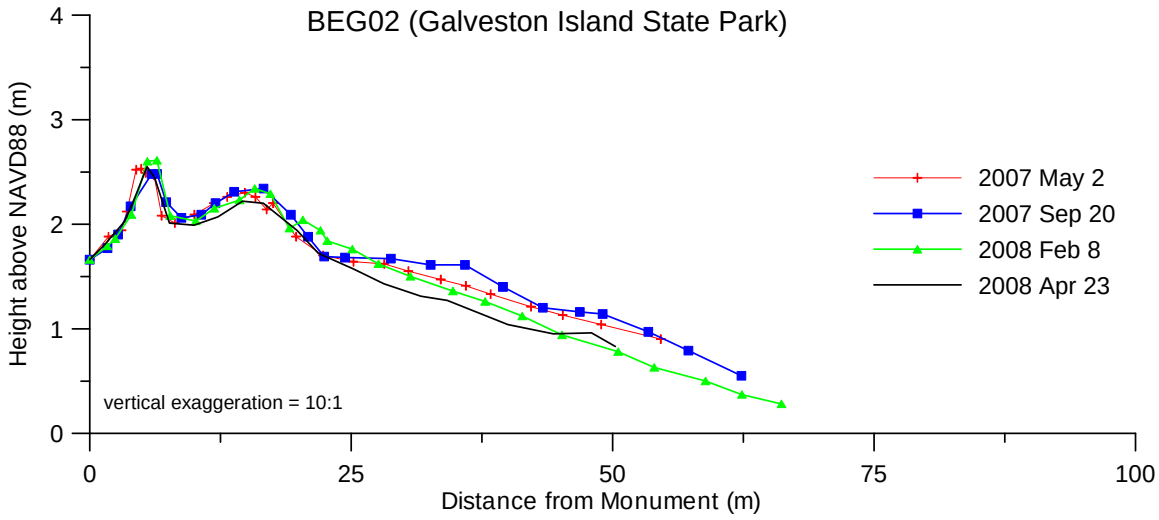
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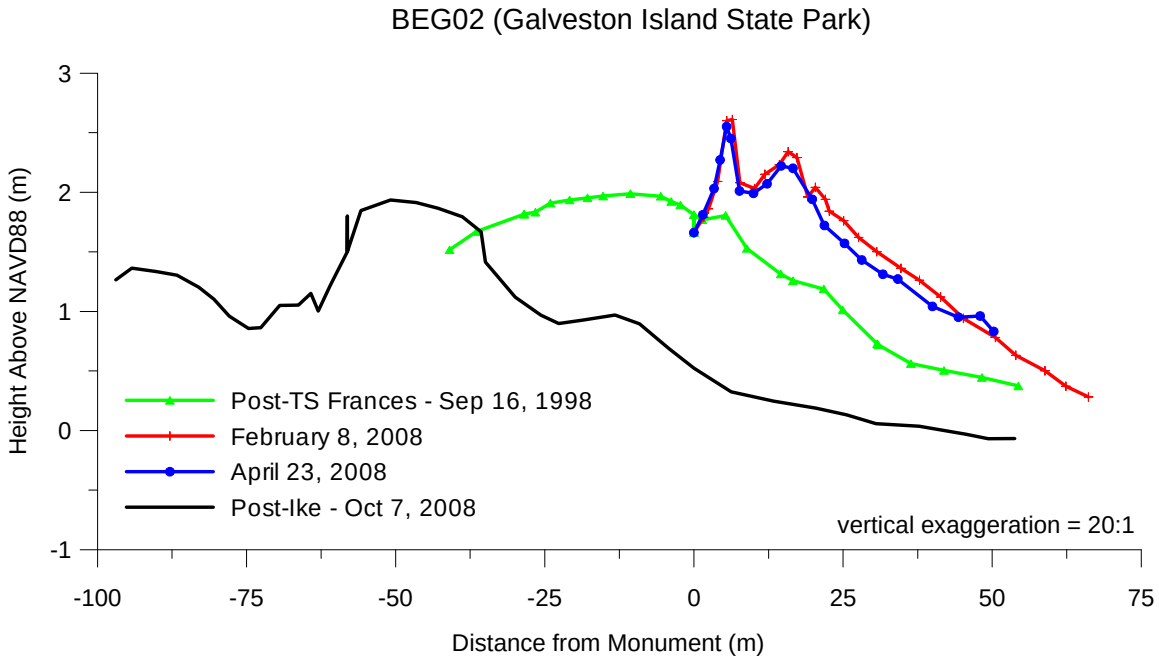
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April 23, 2008
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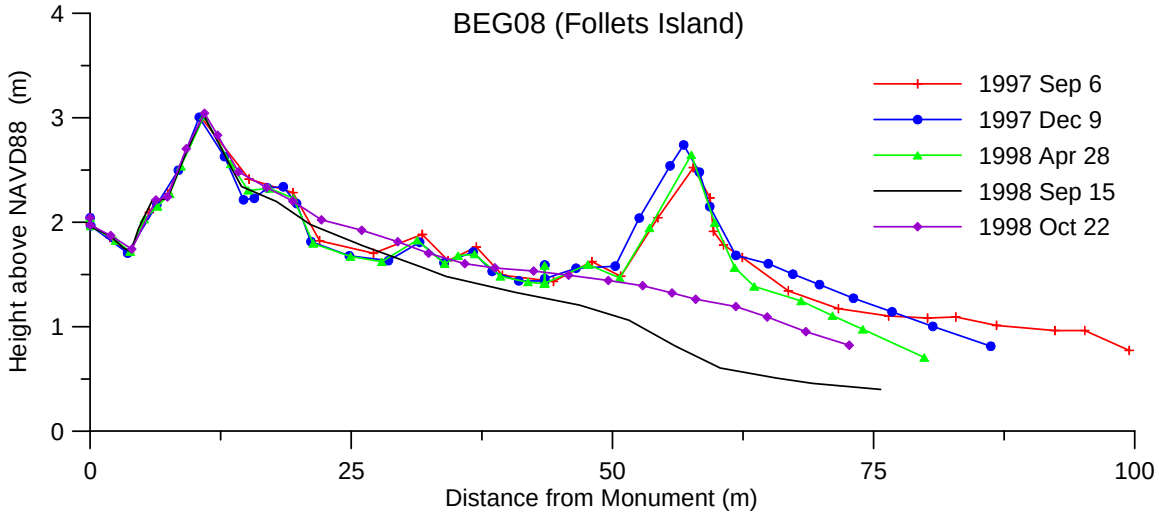
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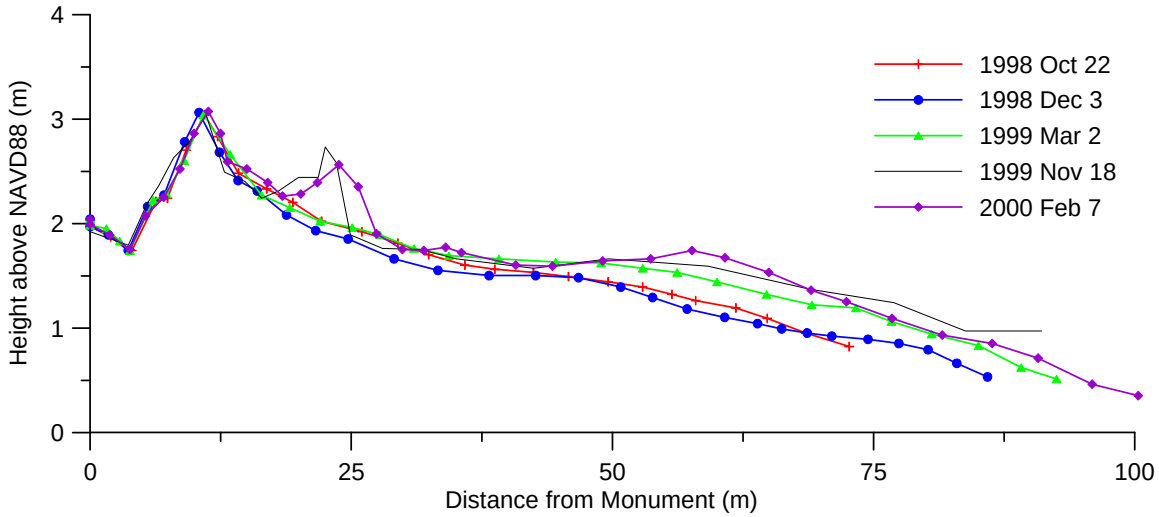
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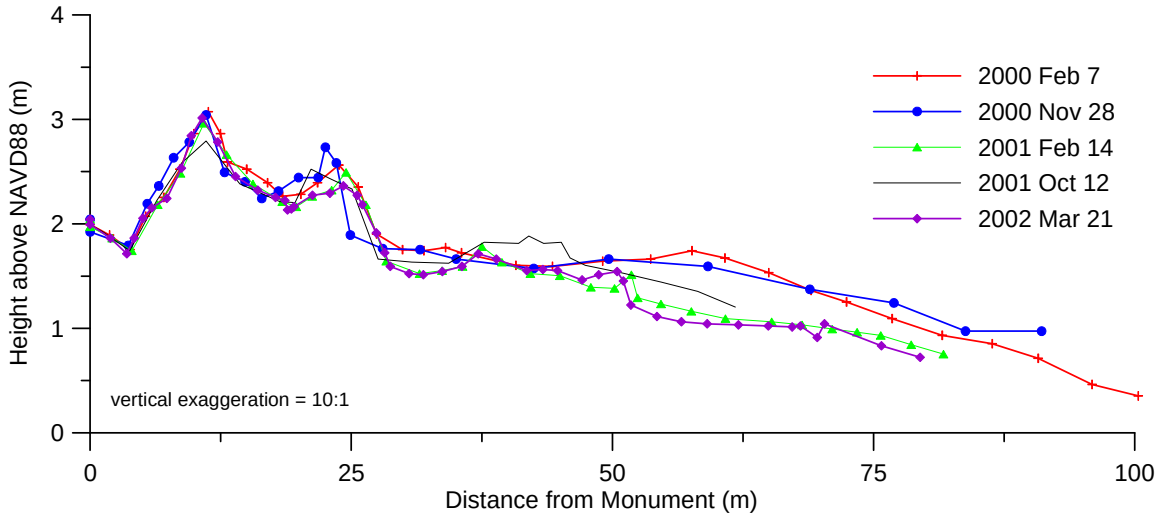
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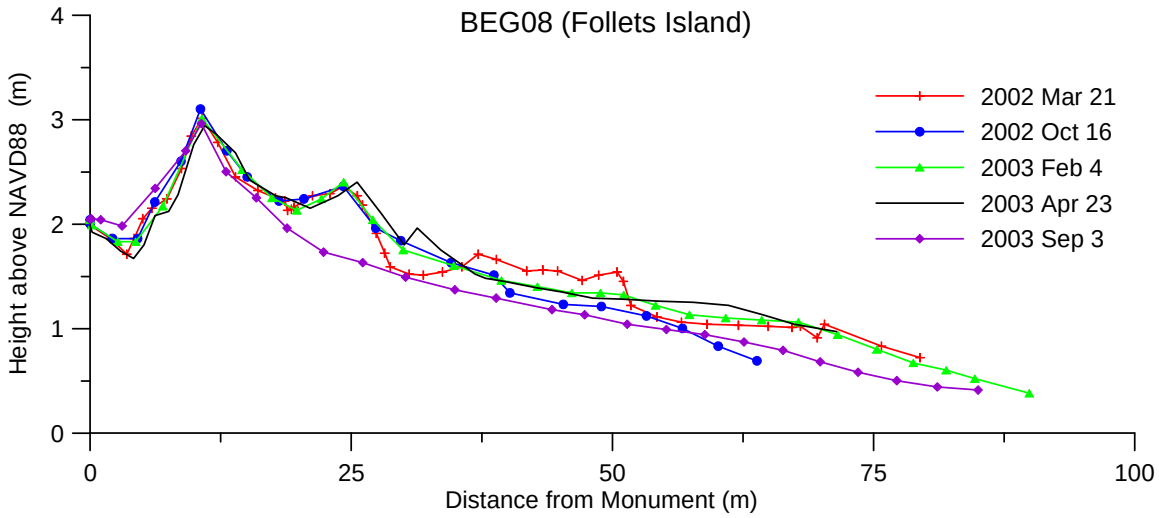
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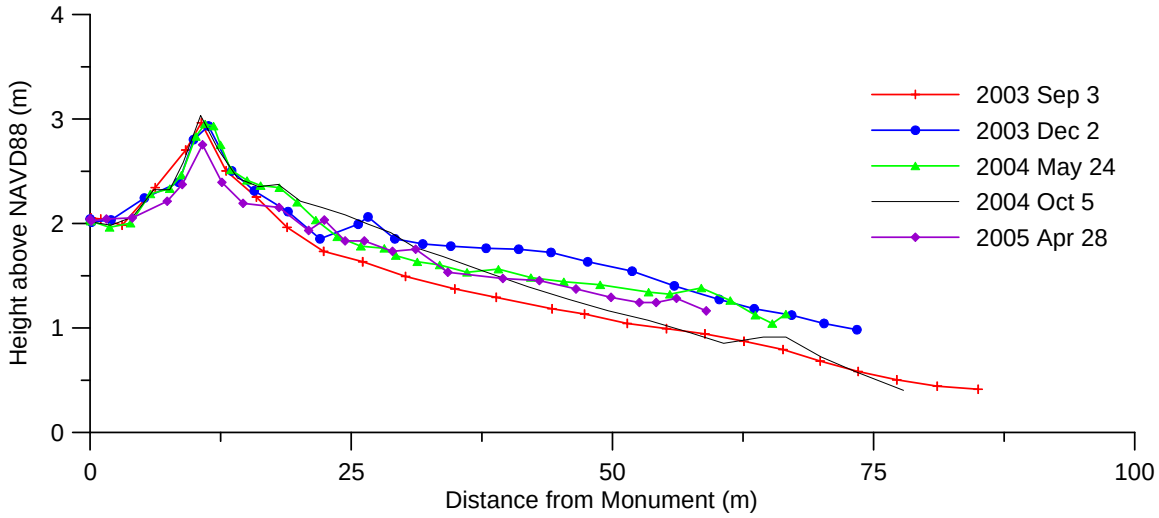
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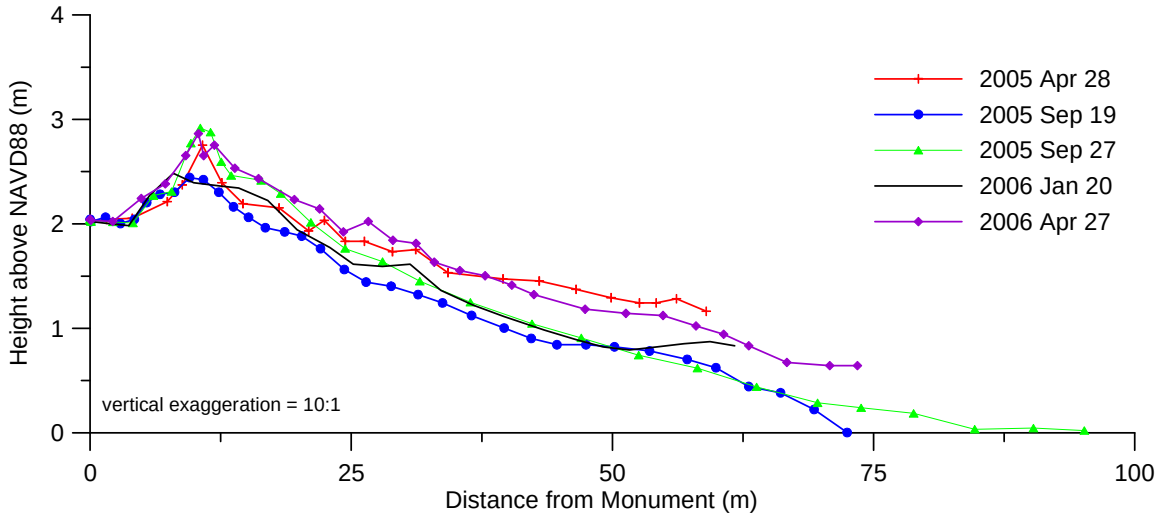
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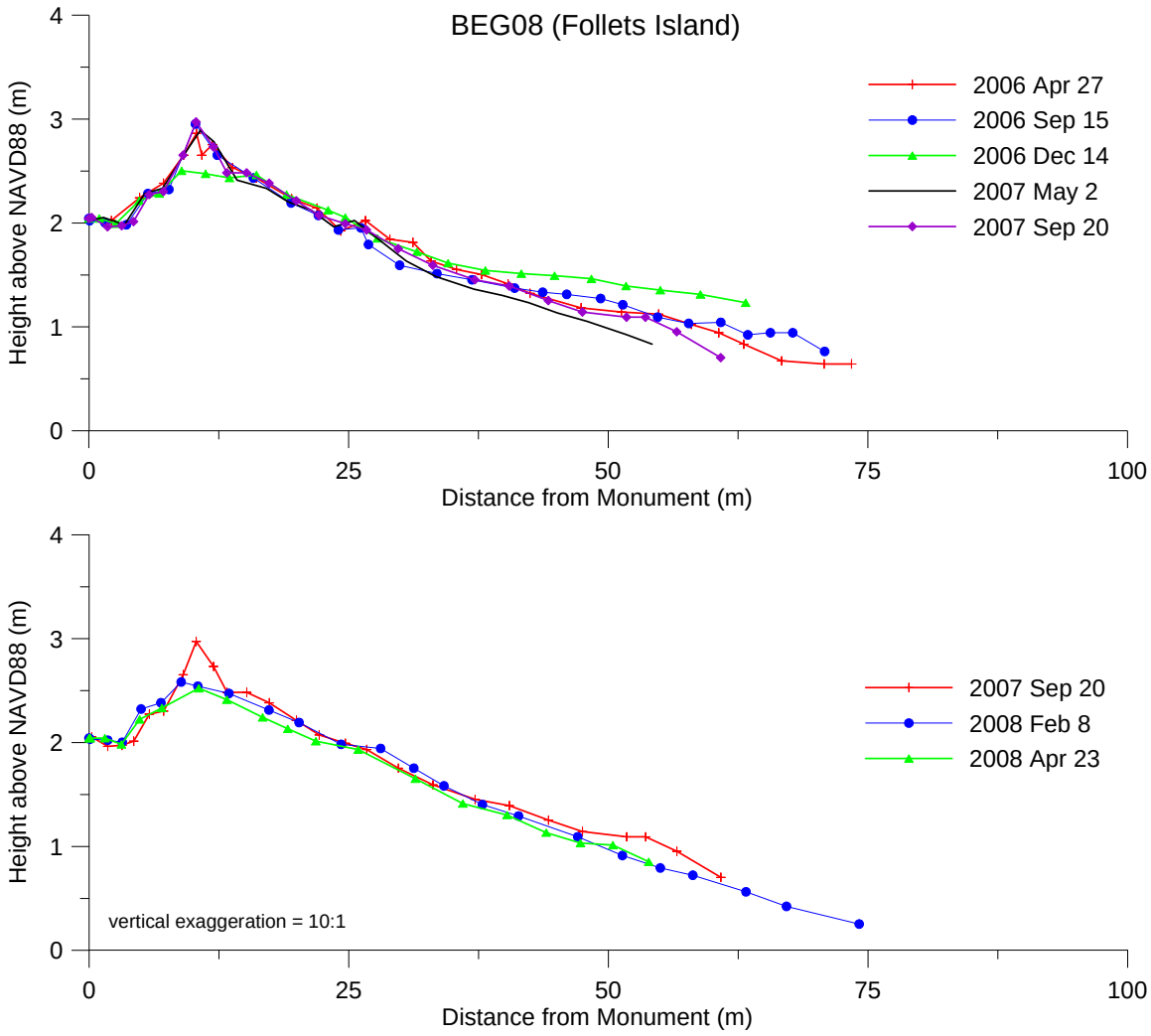
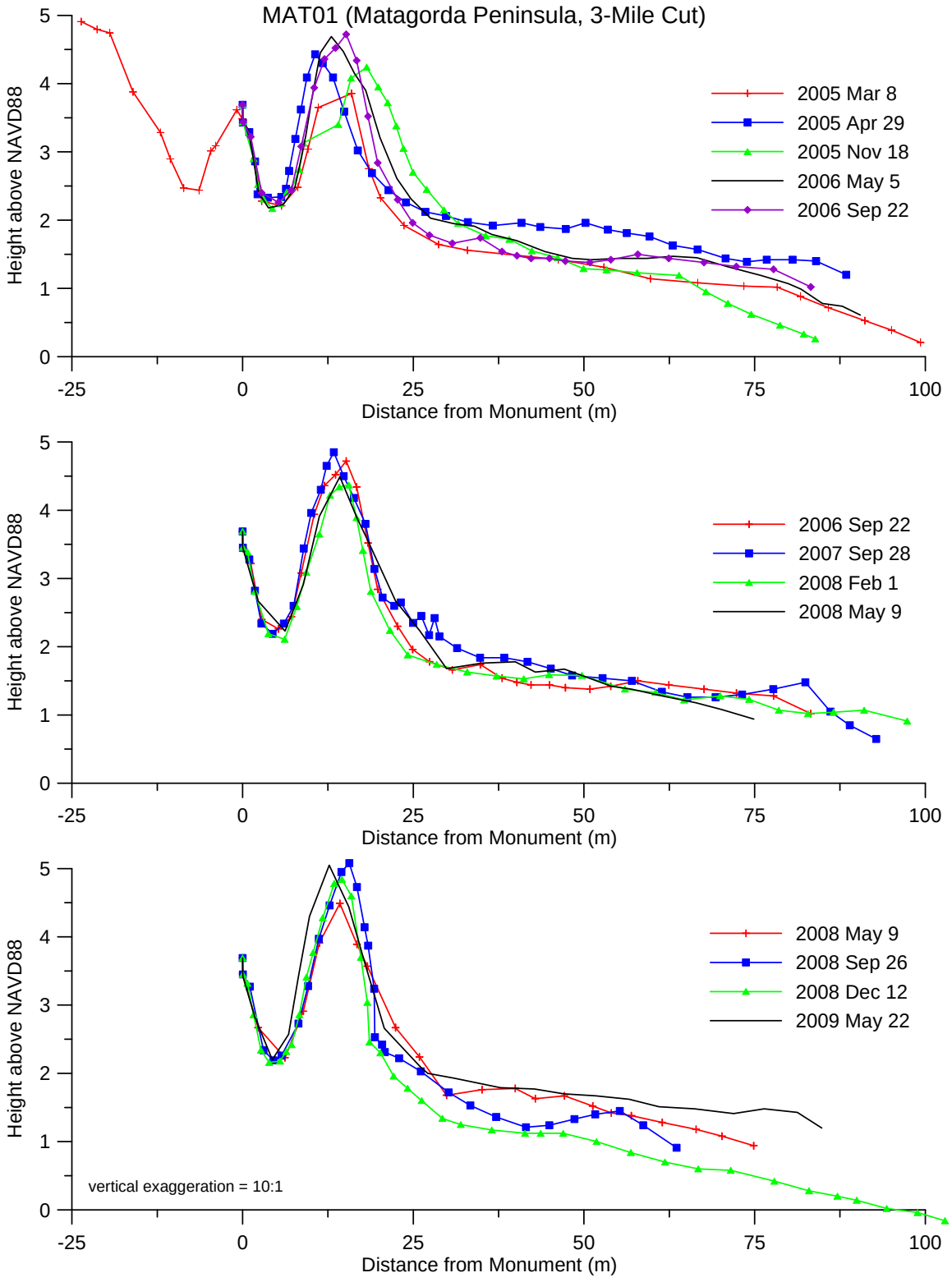
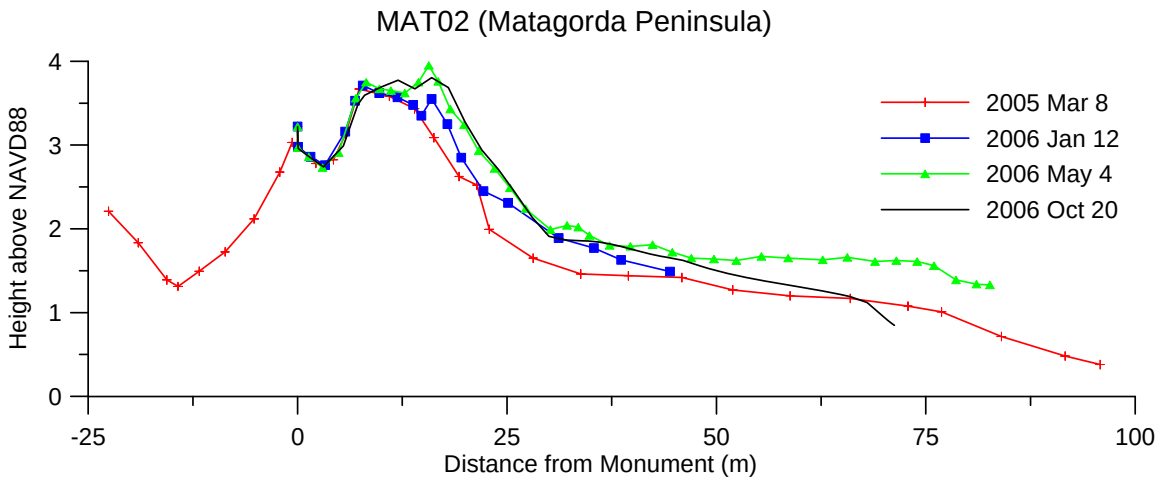
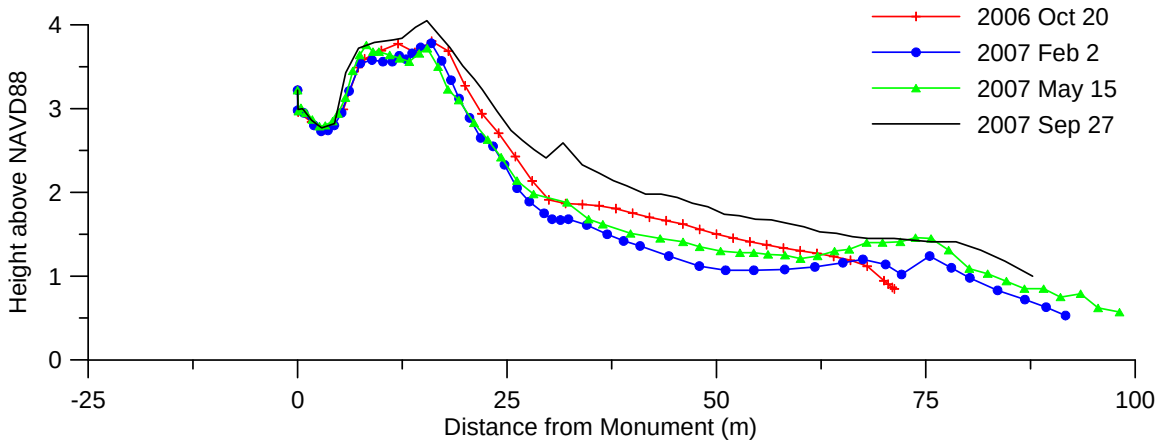
2006 Apr 27
vertical exaggeration = 10:1

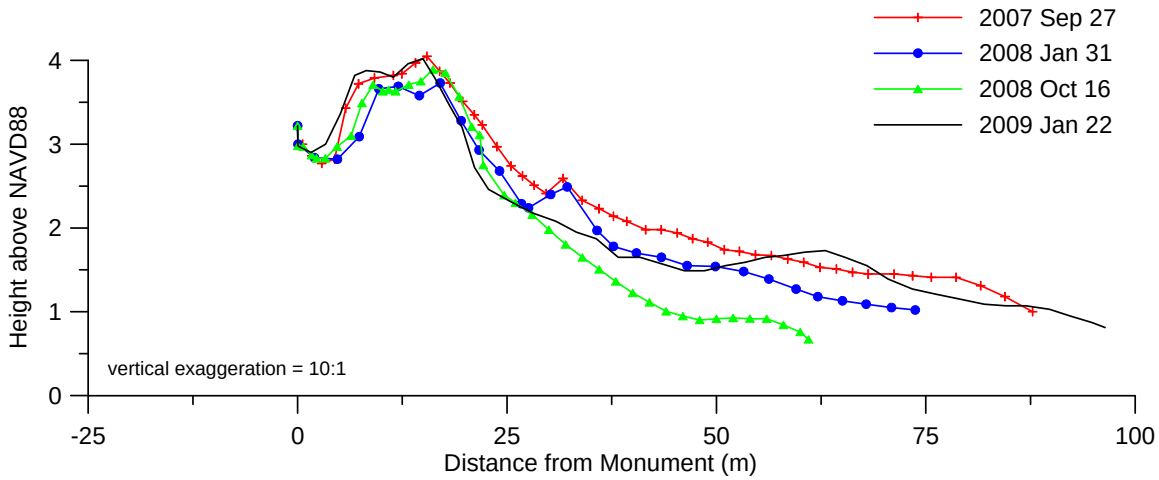

BEG08 (Follets Island)
Height above NAVD88 (m)
Distance from Monument (m)
2006 Apr 27
2006 Sep 15
2006 Dec 14
2007 May 2
2007 Sep 20
0
1
2
3
4
0
25
50
75
100

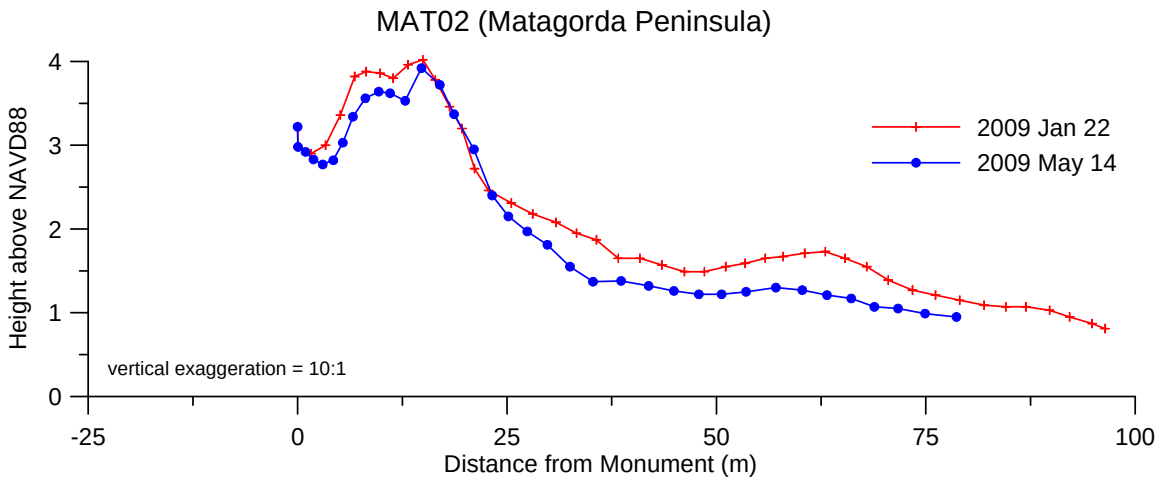
Height above NAVD88 (m)
Distance from Monument (m)
2007 Sep 20
2008 Feb 8
2008 Apr 23
vertical exaggeration = 10:1
0
1
2
3
4
0
25
50
75
100

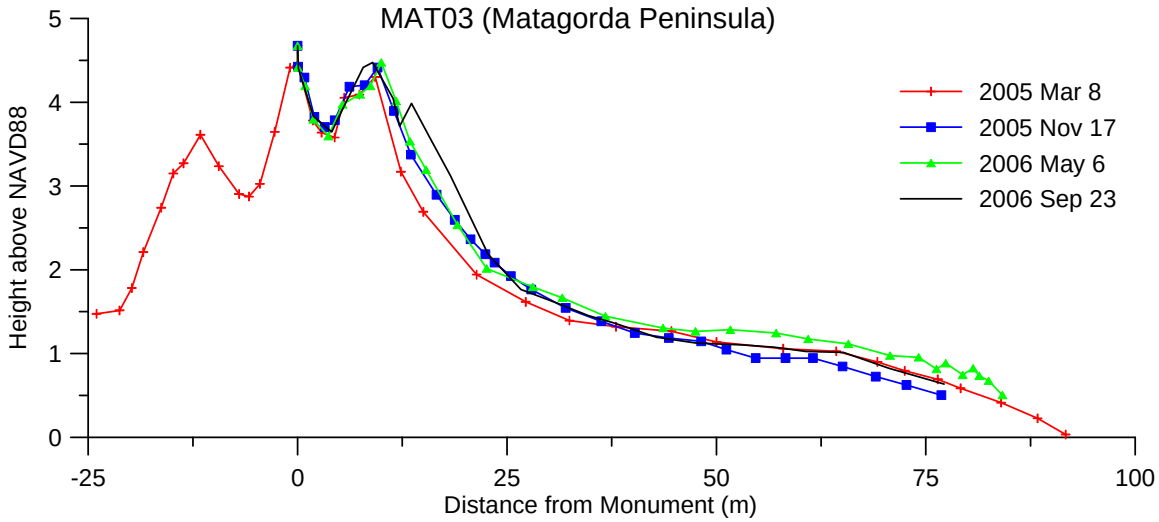

MAT01 (Matagorda Peninsula, 3-Mile Cut)
Height above NAVD88
Distance from Monument (m)
2005 Mar 8
2005 Apr 29
2005 Nov 18
2006 May 5
2006 Sep 22
2006 Sep 22
2007 Sep 28
2008 Feb 1
2008 May 9
2008 May 9
2008 Sep 26
2008 Dec 12
2009 May 22
vertical exaggeration = 10:1

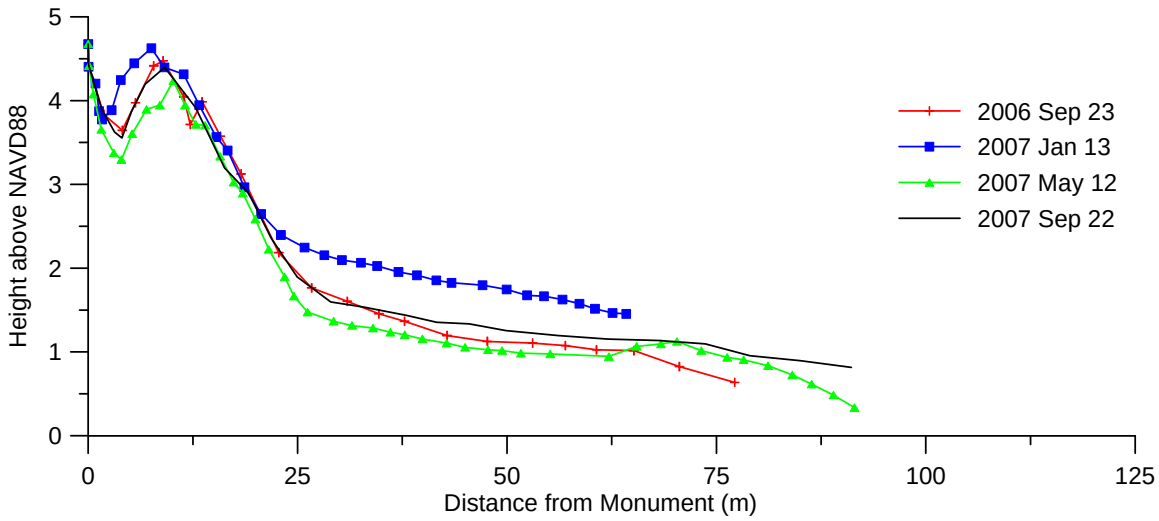

MAT02 (Matagorda Peninsula)
Height above NAVD88
Distance from Monument (m)
2005 Mar 8
2006 Jan 12
2006 May 4
2006 Oct 20

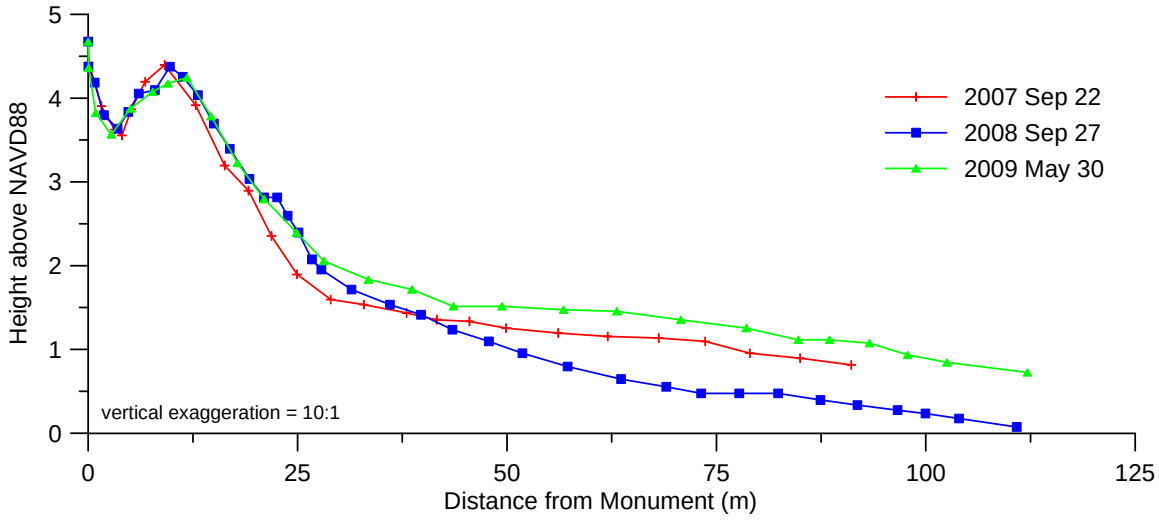

Height above NAVD88
Distance from Monument (m)
2006 Oct 20
2007 Feb 2
2007 May 15
2007 Sep 27

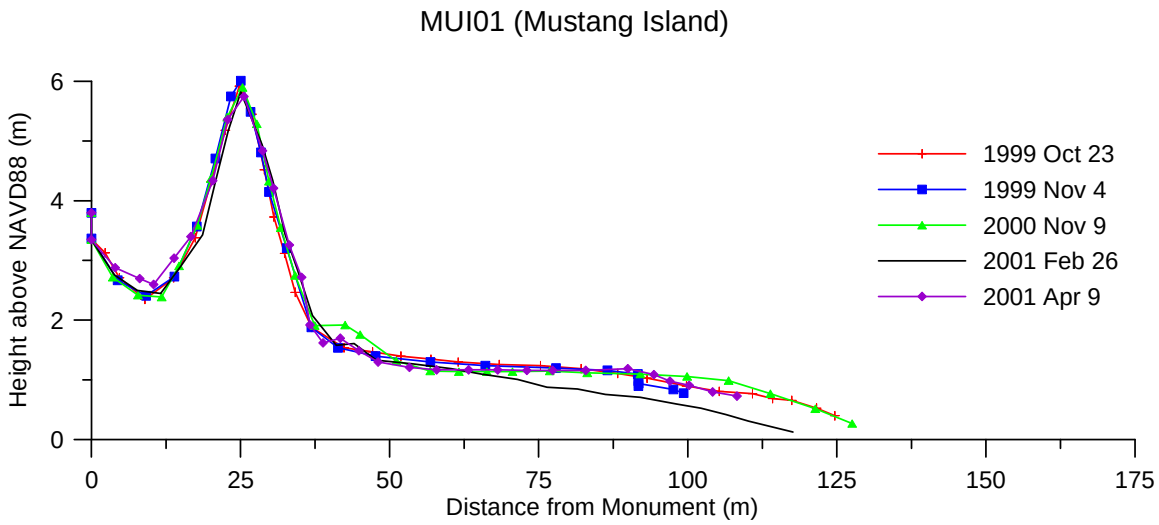

Height above NAVD88
Distance from Monument (m)
2007 Sep 27
2008 Jan 31
2008 Oct 16
2009 Jan 22
vertical exaggeration = 10:1

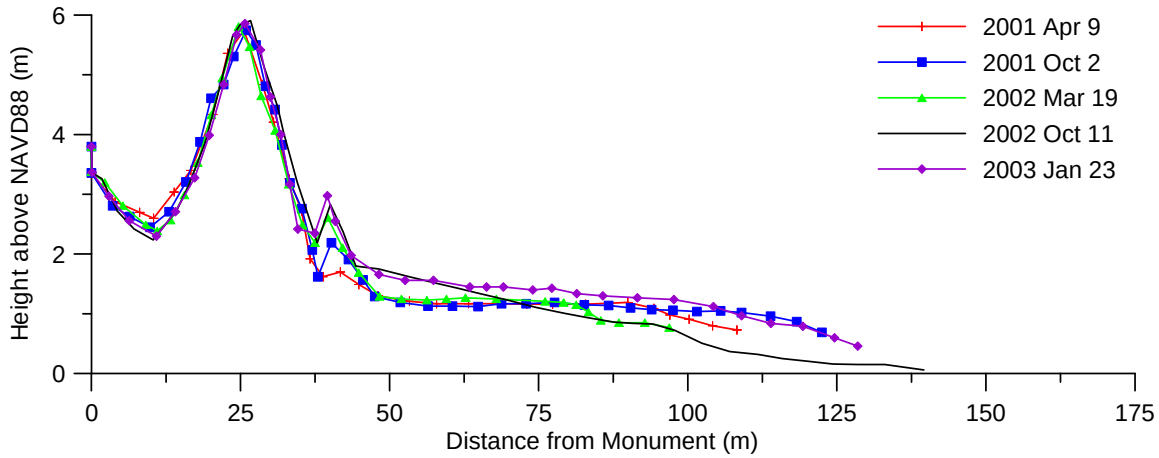

MAT02 (Matagorda Peninsula)
Height above NAVD88
Distance from Monument (m)
2009 Jan 22
2009 May 14
vertical exaggeration = 10:1
0
1
2
3
4
-25
0
25
50
75
100

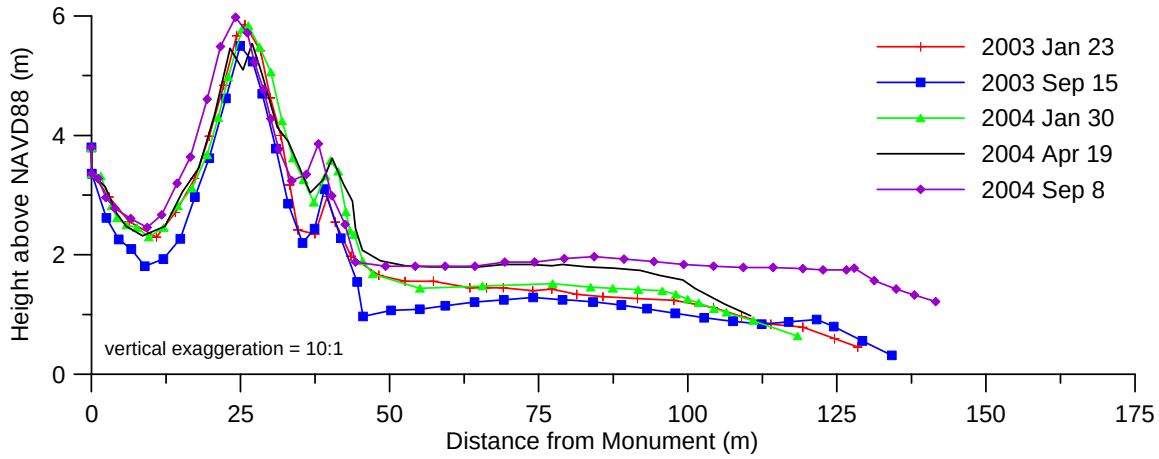

MAT03 (Matagorda Peninsula)
Height above NAVD88
Distance from Monument (m)
2005 Mar 8
2005 Nov 17
2006 May 6
2006 Sep 23

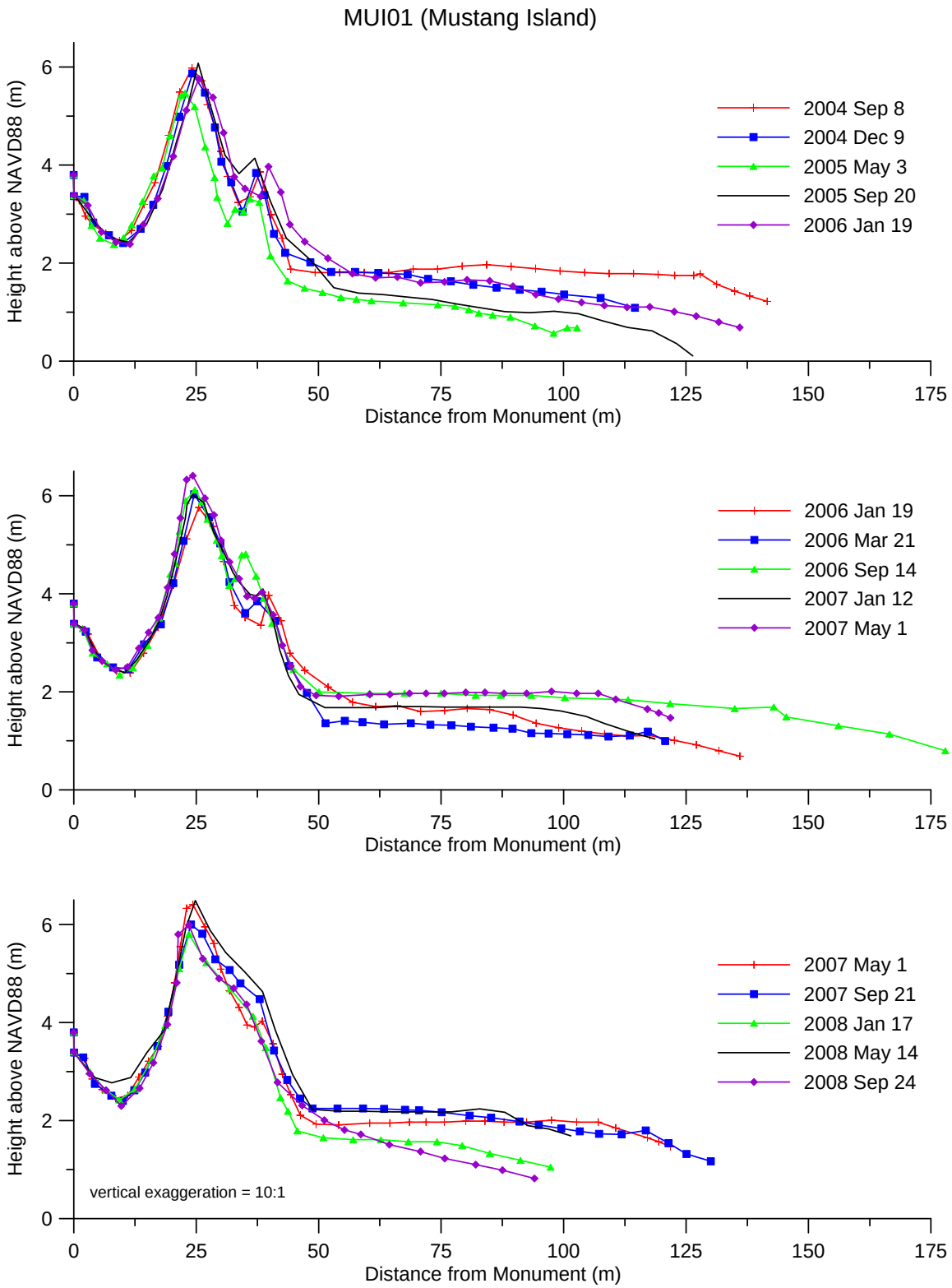

Height above NAVD88
Distance from Monument (m)
2006 Sep 23
2007 Jan 13
2007 May 12
2007 Sep 22

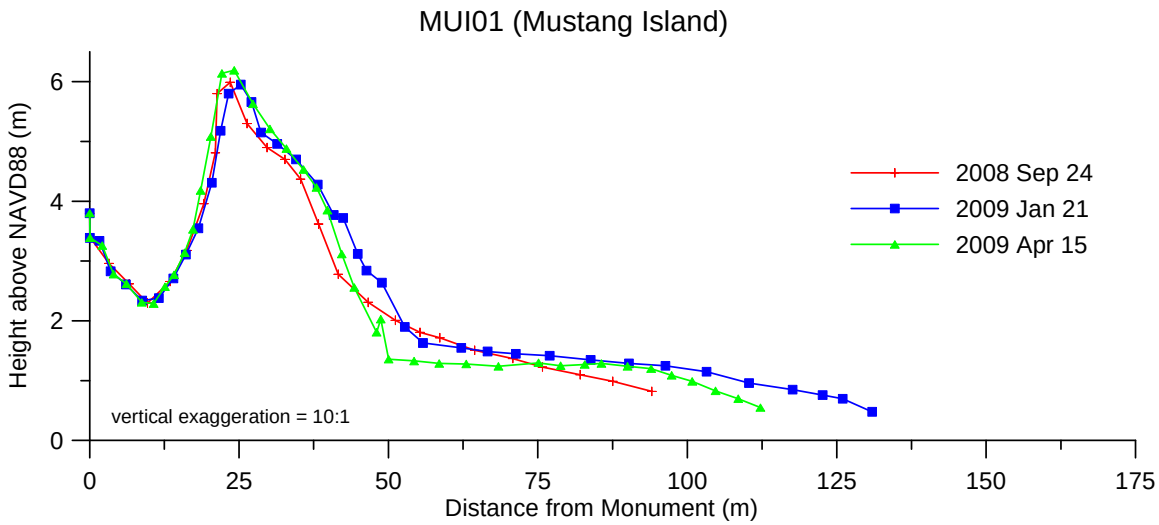

Height above NAVD88
Distance from Monument (m)
2007 Sep 22
2008 Sep 27
2009 May 30
vertical exaggeration = 10:1

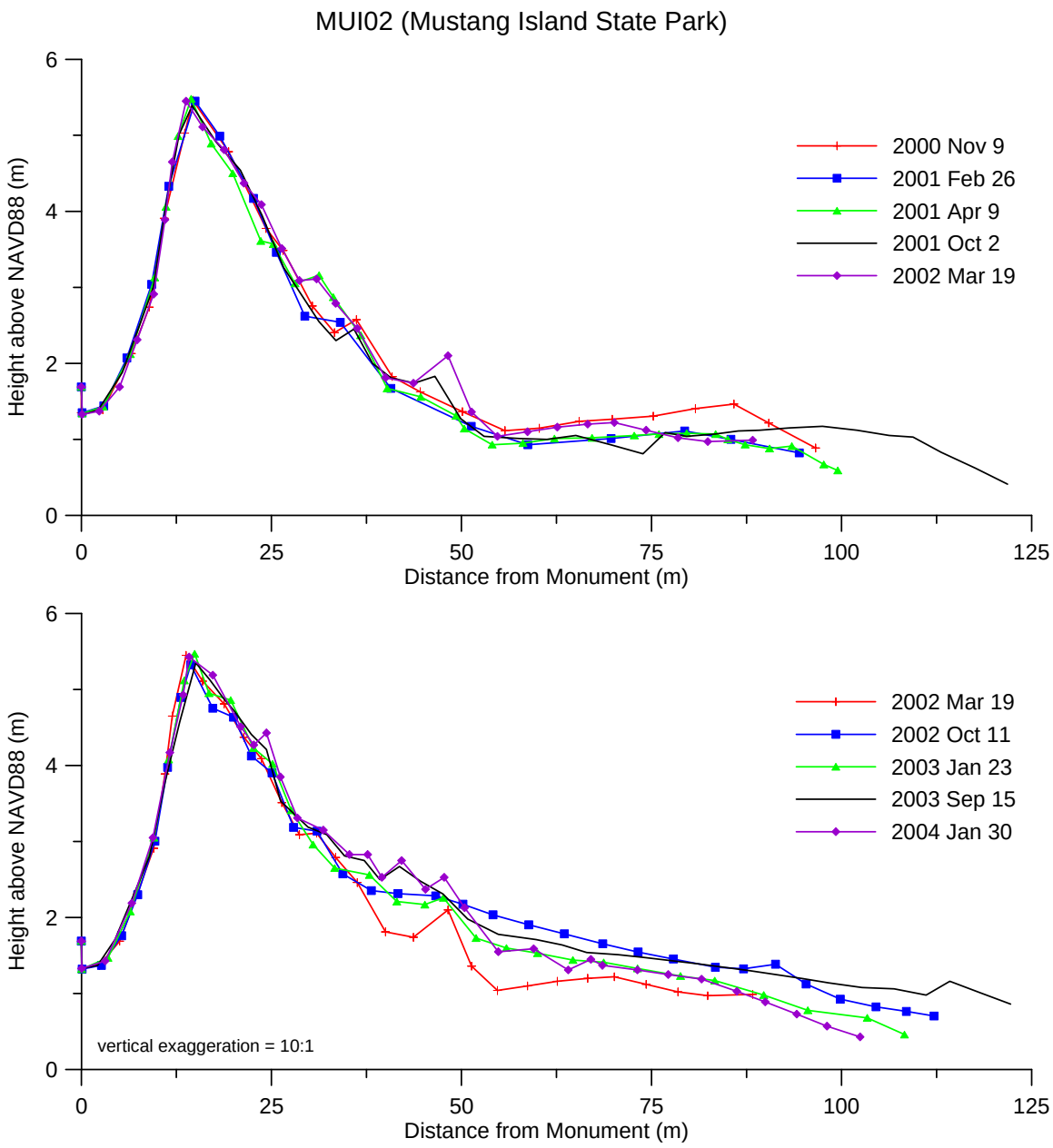

MUI01 (Mustang Island)
Height above NAVD88 (m)
Distance from Monument (m)
1999 Oct 23
1999 Nov 4
2000 Nov 9
2001 Feb 26
2001 Apr 9

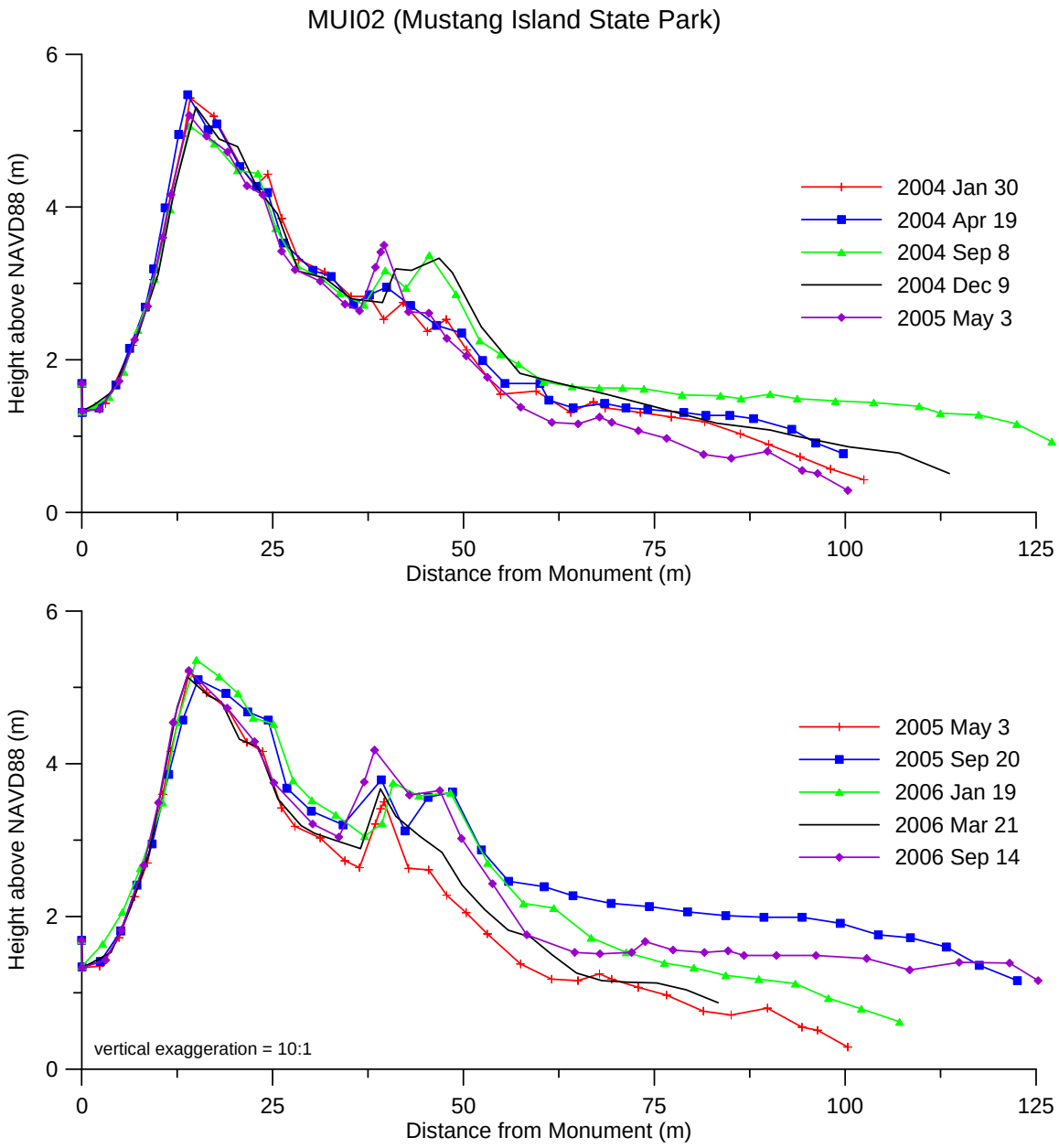

Height above NAVD88 (m)
Distance from Monument (m)
2001 Apr 9
2001 Oct 2
2002 Mar 19
2002 Oct 11
2003 Jan 23

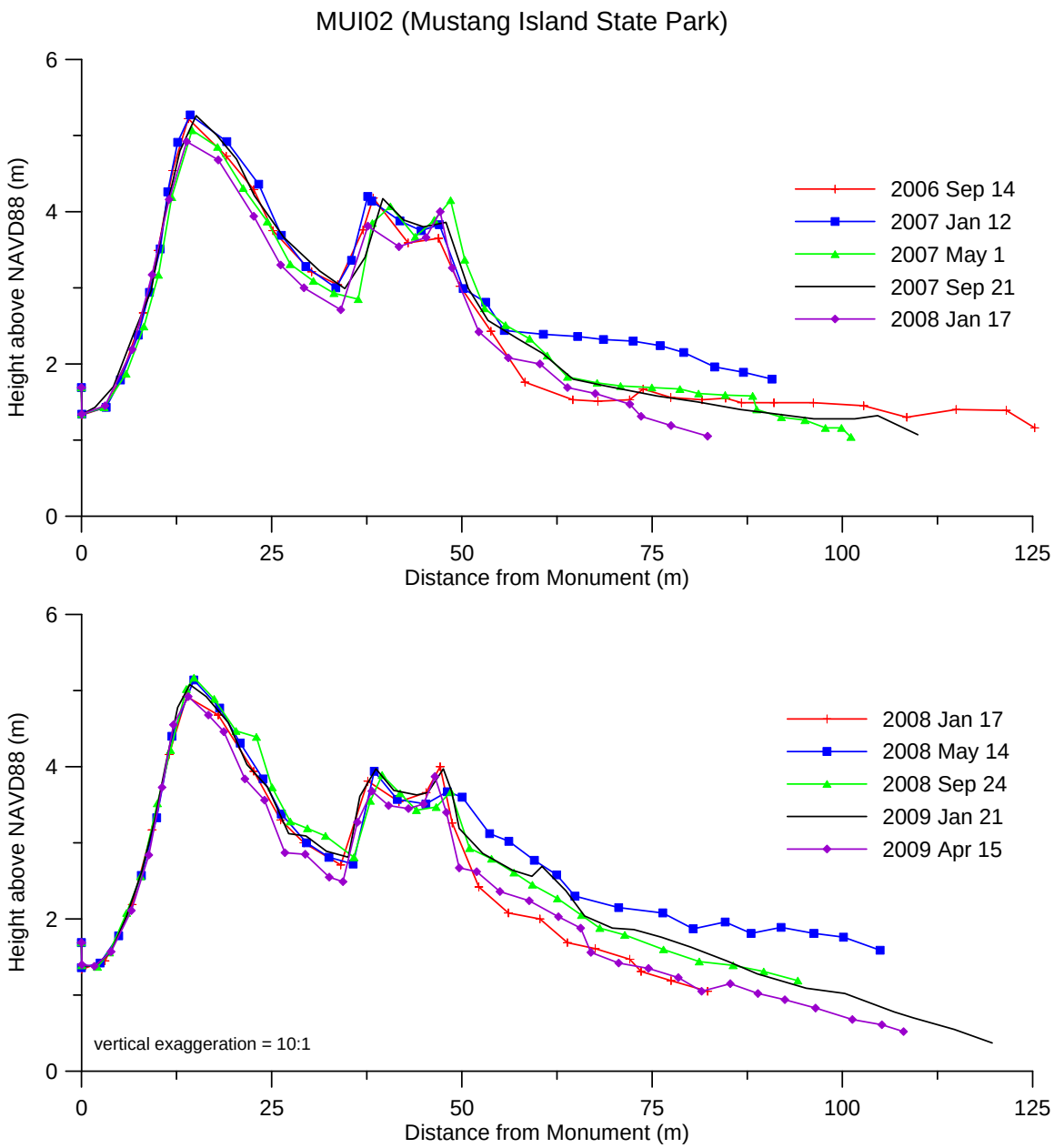

Height above NAVD88 (m)
Distance from Monument (m)
2003 Jan 23
2003 Sep 15
2004 Jan 30
2004 Apr 19
2004 Sep 8
vertical exaggeration = 10:1

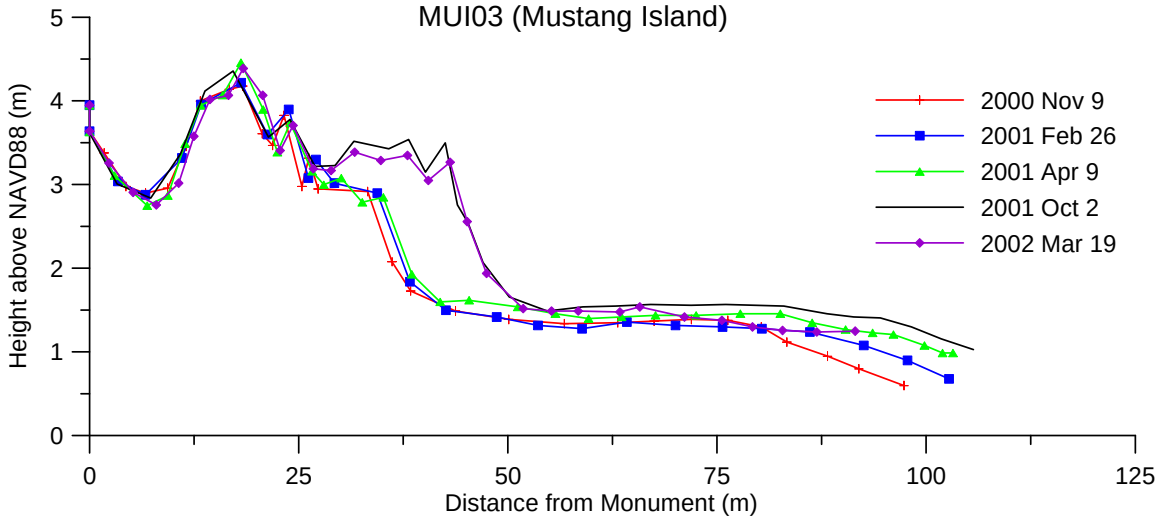

MUI01 (Mustang Island)
Height above NAVD88 (m)
Distance from Monument (m)
2004 Sep 8
2004 Dec 9
2005 May 3
2005 Sep 20
2006 Jan 19
2006 Jan 19
2006 Mar 21
2006 Sep 14
2007 Jan 12
2007 May 1
2007 May 1
2007 Sep 21
2008 Jan 17
2008 May 14
2008 Sep 24
vertical exaggeration = 10:1

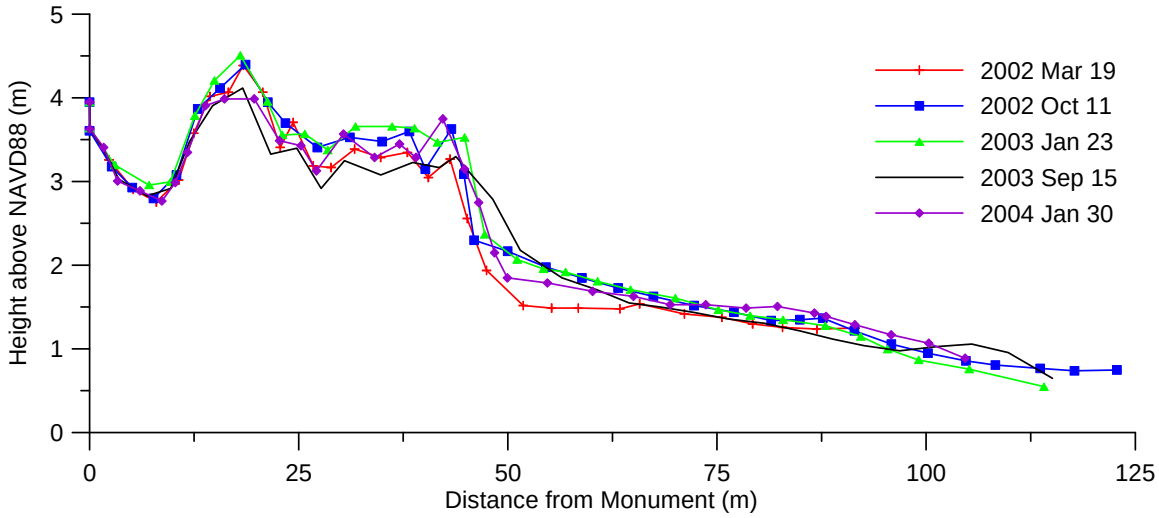

MUI01 (Mustang Island)
Height above NAVD88 (m)
Distance from Monument (m)
vertical exaggeration = 10:1
2008 Sep 24
2009 Jan 21
2009 Apr 15
0
2
4
6
0
25
50
75
100
125
150
175

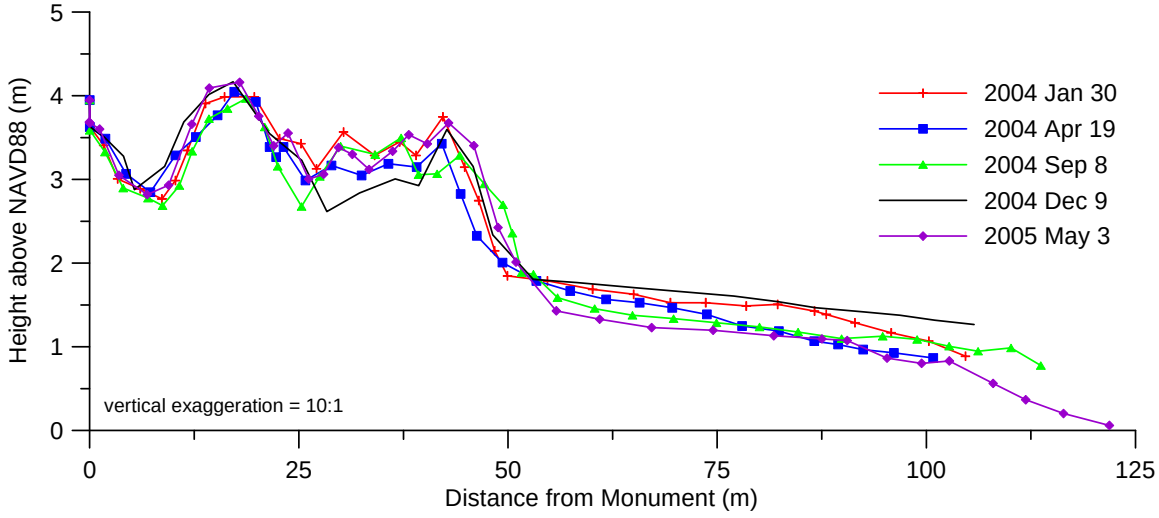

MUI02 (Mustang Island State Park)
Height above NAVD88 (m)
Distance from Monument (m)
2000 Nov 9
2001 Feb 26
2001 Apr 9
2001 Oct 2
2002 Mar 19
2002 Mar 19
2002 Oct 11
2003 Jan 23
2003 Sep 15
2004 Jan 30
vertical exaggeration = 10:1

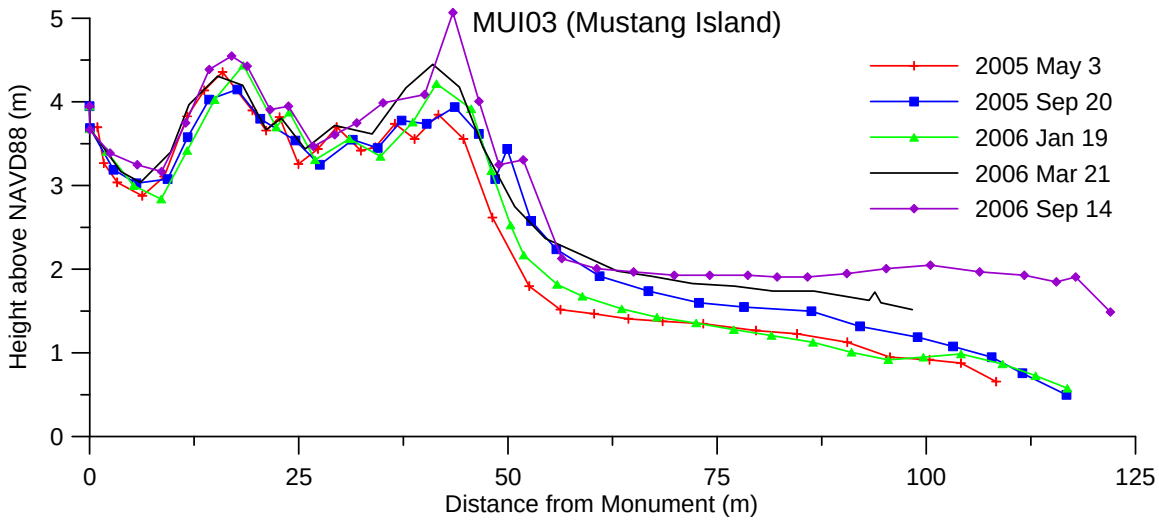

MUI02 (Mustang Island State Park)
Height above NAVD88 (m)
Distance from Monument (m)
2004 Jan 30
2004 Apr 19
2004 Sep 8
2004 Dec 9
2005 May 3
2005 May 3
2005 Sep 20
2006 Jan 19
2006 Mar 21
2006 Sep 14
vertical exaggeration = 10:1

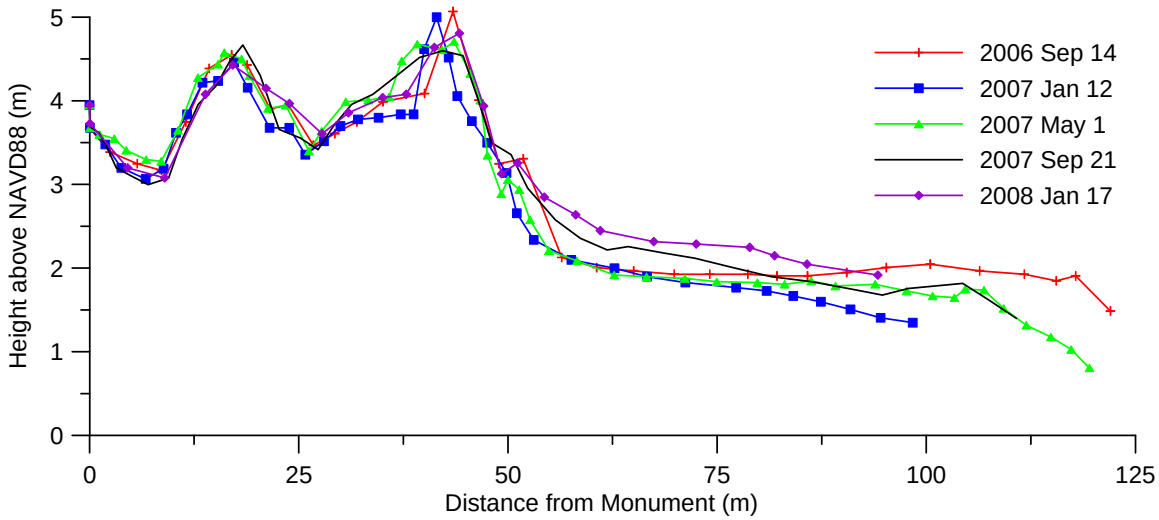

MUI02 (Mustang Island State Park)
Height above NAVD88 (m)
Distance from Monument (m)
2006 Sep 14
2007 Jan 12
2007 May 1
2007 Sep 21
2008 Jan 17
2008 Jan 17
2008 May 14
2008 Sep 24
2009 Jan 21
2009 Apr 15
vertical exaggeration = 10:1

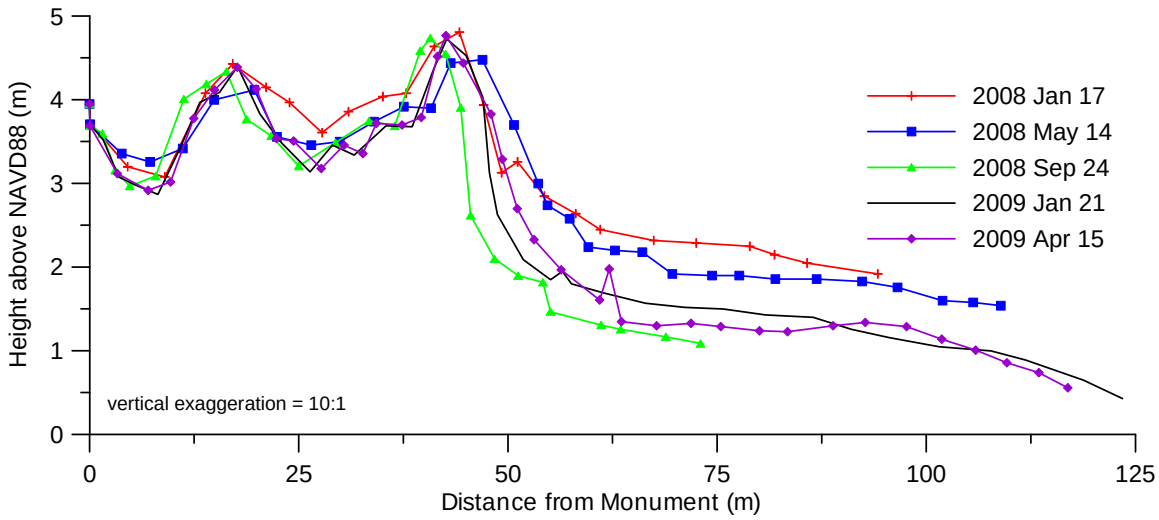

MUI03 (Mustang Island)
Height above NAVD88 (m)
Distance from Monument (m)
2000 Nov 9
2001 Feb 26
2001 Apr 9
2001 Oct 2
2002 Mar 19

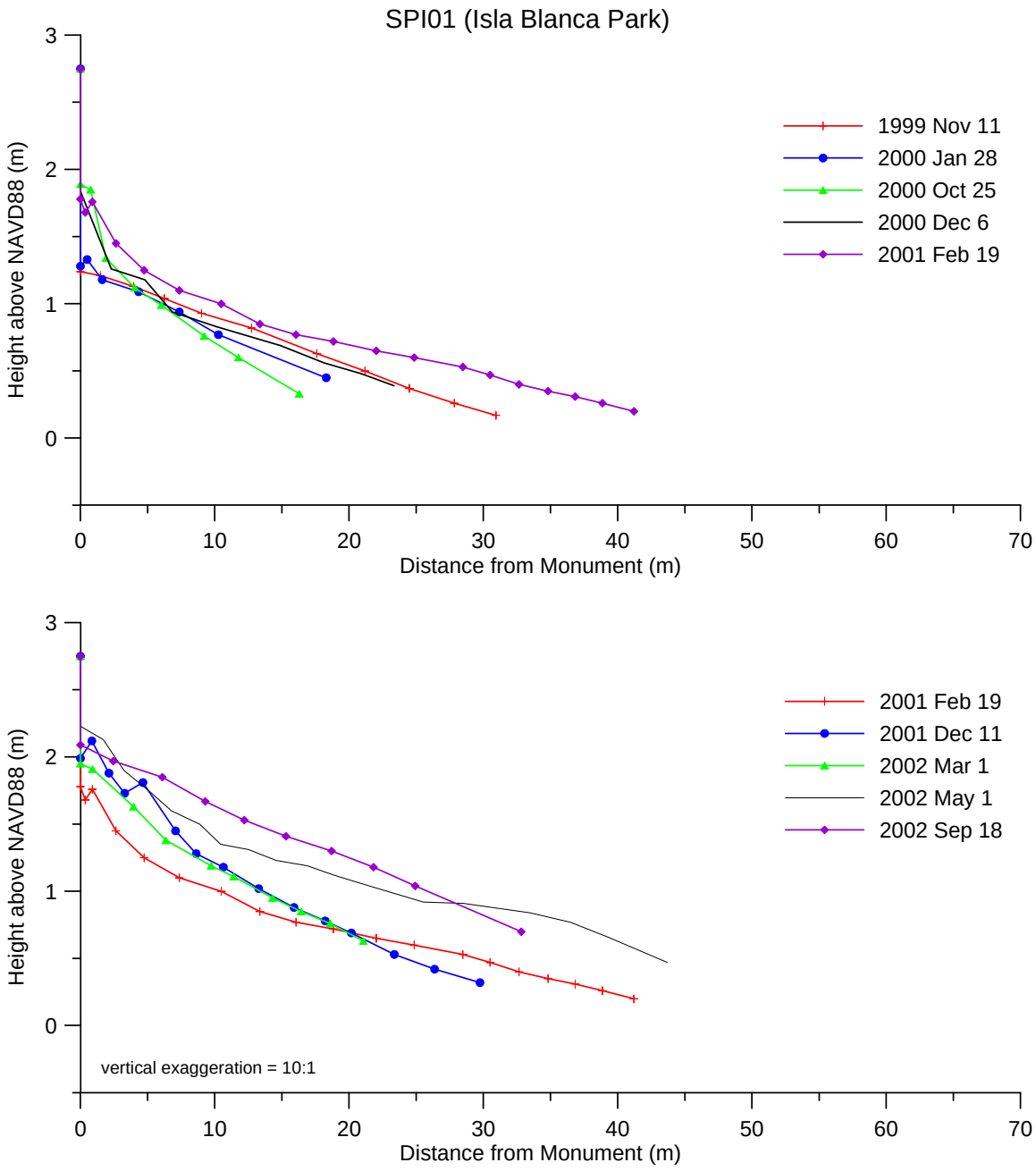

Height above NAVD88 (m)
Distance from Monument (m)
2002 Mar 19
2002 Oct 11
2003 Jan 23
2003 Sep 15
2004 Jan 30

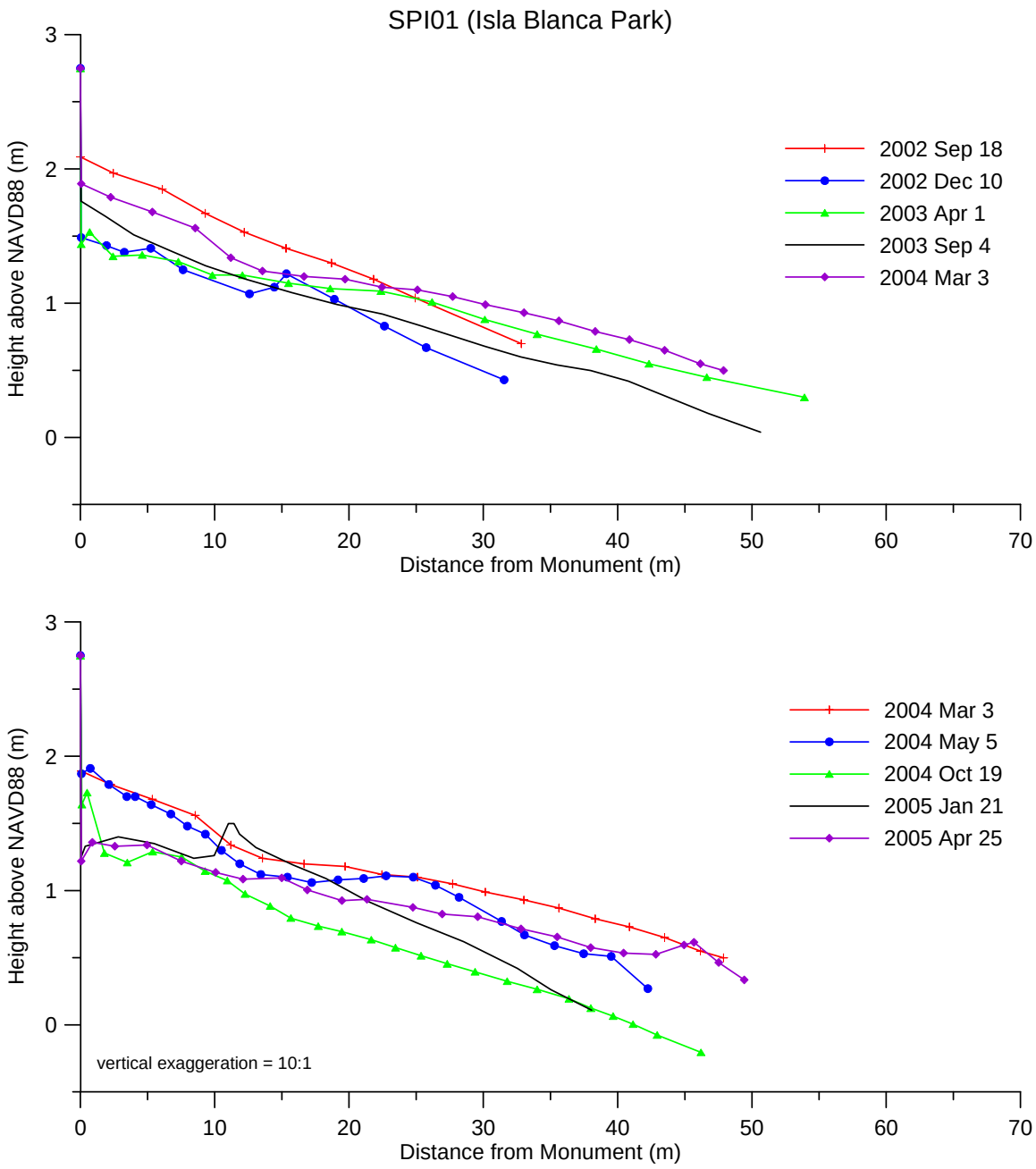

Height above NAVD88 (m)
Distance from Monument (m)
2004 Jan 30
2004 Apr 19
2004 Sep 8
2004 Dec 9
2005 May 3
vertical exaggeration = 10:1

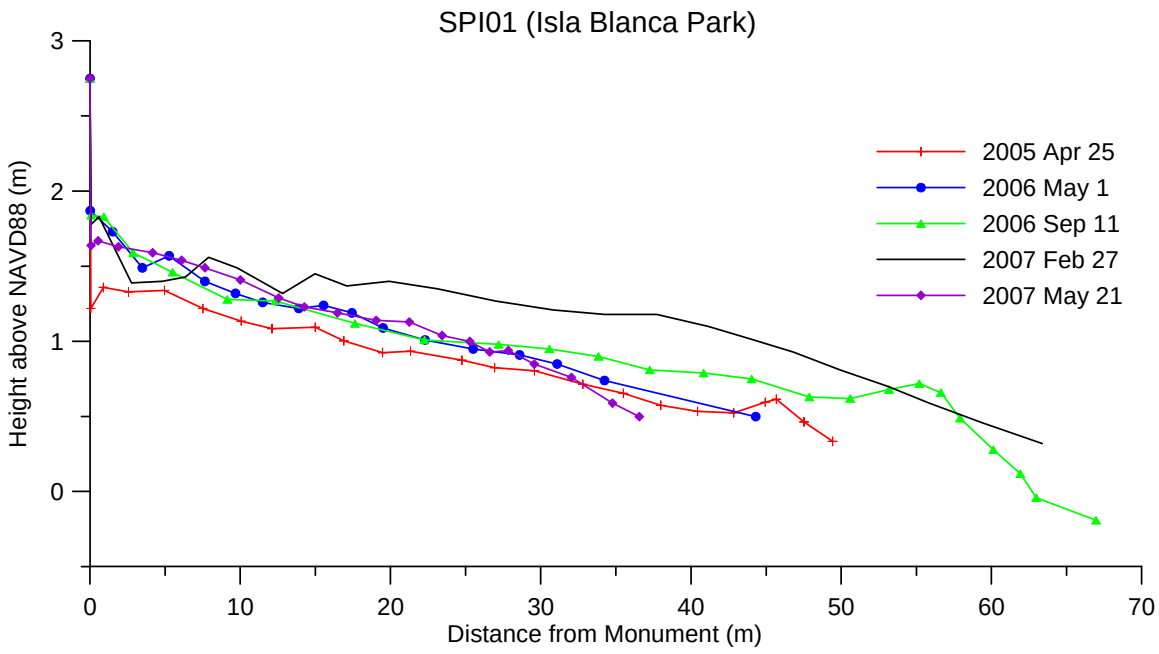

MUI03 (Mustang Island)
2005 May 3
2005 Sep 20
2006 Jan 19
2006 Mar 21
2006 Sep 14
Height above NAVD88 (m)
Distance from Monument (m)
0
1
2
3
4
5
0
25
50
75
100
125

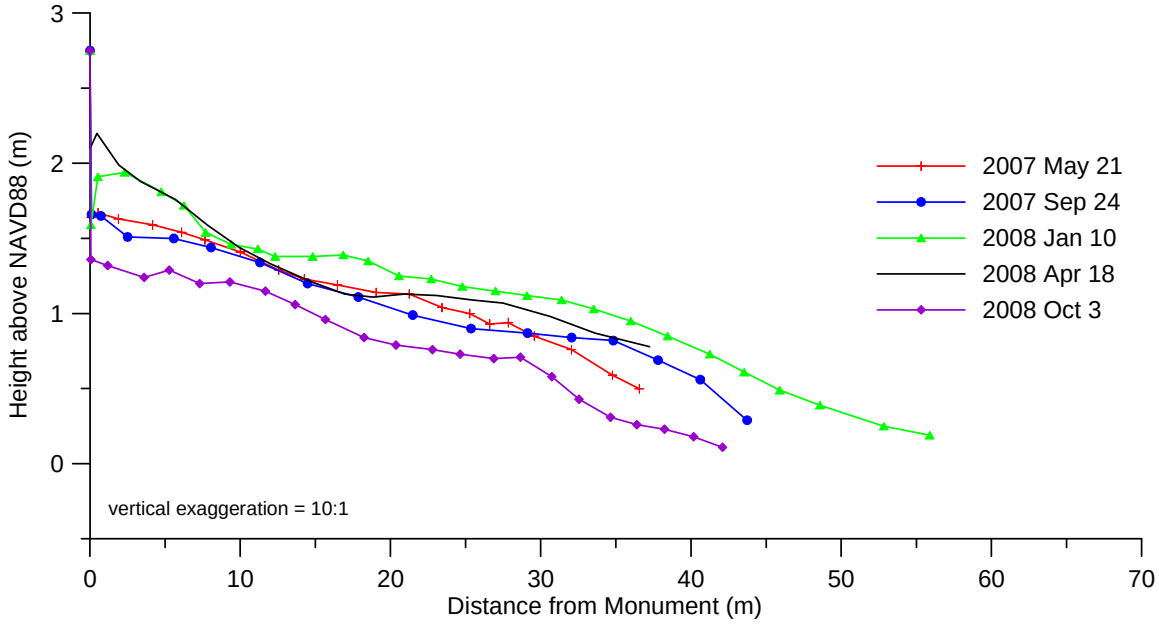

2006 Sep 14
2007 Jan 12
2007 May 1
2007 Sep 21
2008 Jan 17
Height above NAVD88 (m)
Distance from Monument (m)
0
1
2
3
4
5
0
25
50
75
100
125

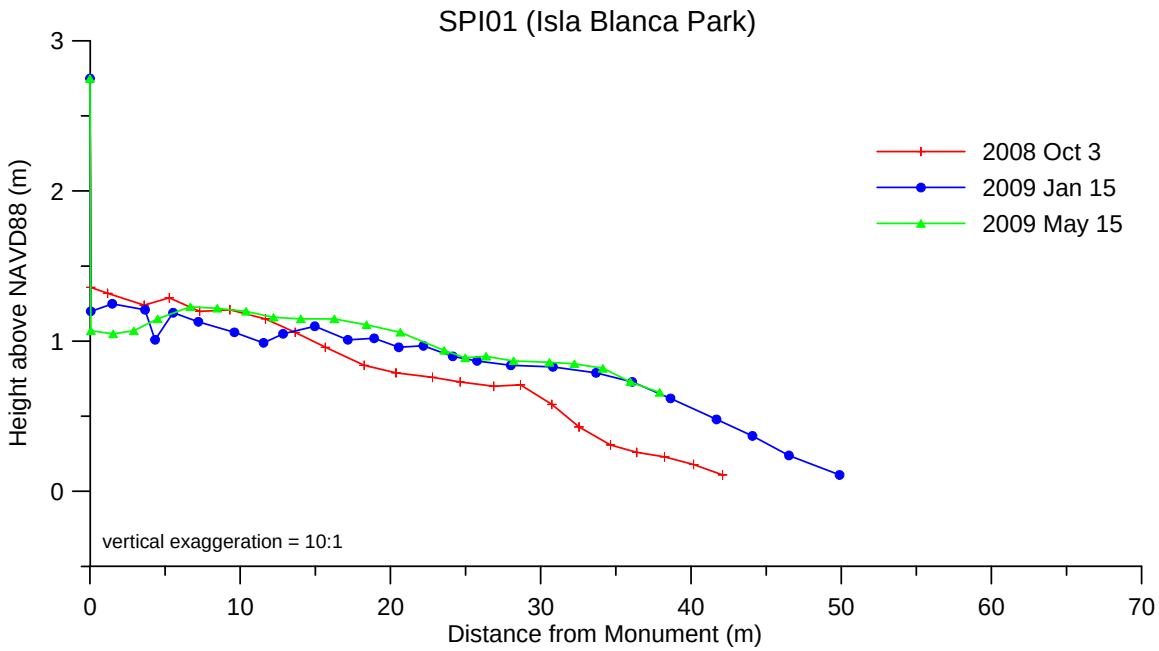

2008 Jan 17
2008 May 14
2008 Sep 24
2009 Jan 21
2009 Apr 15
vertical exaggeration = 10:1
Height above NAVD88 (m)
Distance from Monument (m)
0
1
2
3
4
5
0
25
50
75
100
125


SPI01 (Isla Blanca Park)
Height above NAVD88 (m)
Distance from Monument (m)
1999 Nov 11
2000 Jan 28
2000 Oct 25
2000 Dec 6
2001 Feb 19
2001 Feb 19
2001 Dec 11
2002 Mar 1
2002 May 1
2002 Sep 18
vertical exaggeration = 10:1

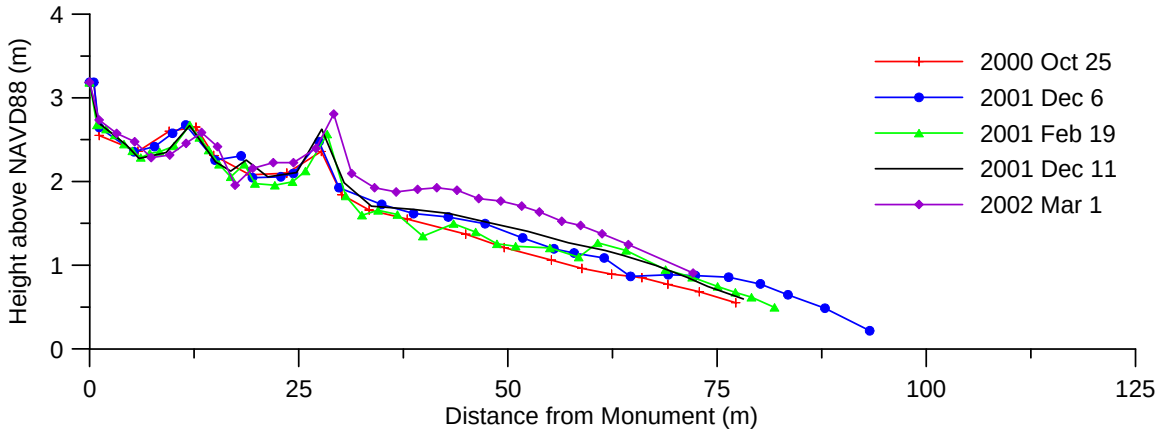

SPI01 (Isla Blanca Park)
Height above NAVD88 (m)
Distance from Monument (m)
2002 Sep 18
2002 Dec 10
2003 Apr 1
2003 Sep 4
2004 Mar 3
2004 Mar 3
2004 May 5
2004 Oct 19
2005 Jan 21
2005 Apr 25
vertical exaggeration = 10:1

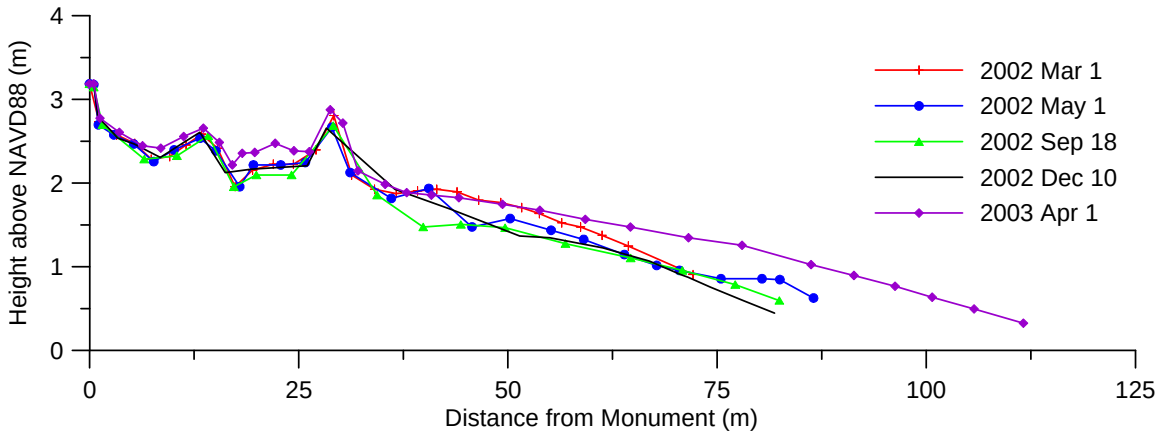

SPI01 (Isla Blanca Park)
Height above NAVD88 (m)
Distance from Monument (m)
2005 Apr 25
2006 May 1
2006 Sep 11
2007 Feb 27
2007 May 21

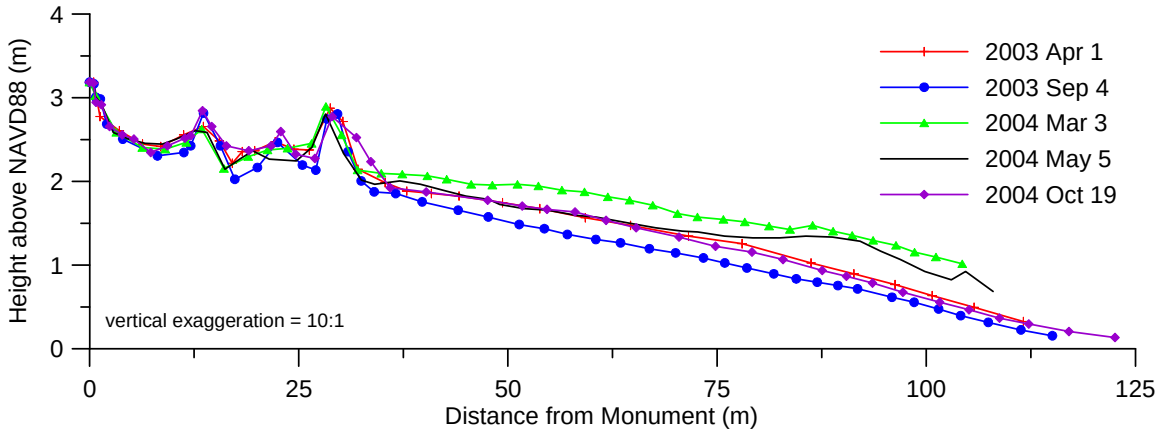

Height above NAVD88 (m)
Distance from Monument (m)
2007 May 21
2007 Sep 24
2008 Jan 10
2008 Apr 18
2008 Oct 3
vertical exaggeration = 10:1


SPI01 (Isla Blanca Park)
Height above NAVD88 (m)
3
2
1
0
vertical exaggeration = 10:1
0
10
20
30
40
50
60
70
Distance from Monument (m)
2008 Oct 3
2009 Jan 15
2009 May 15

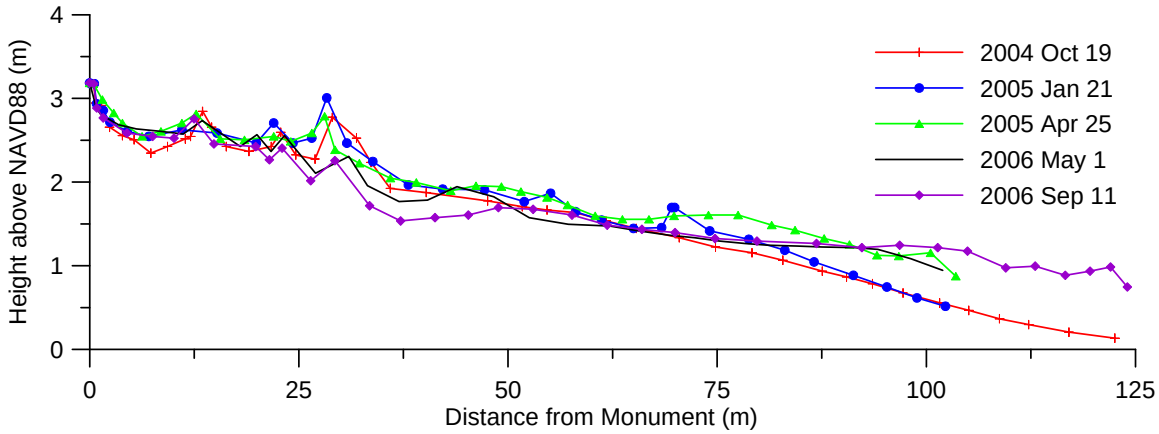
SPI02 (South Padre Island)

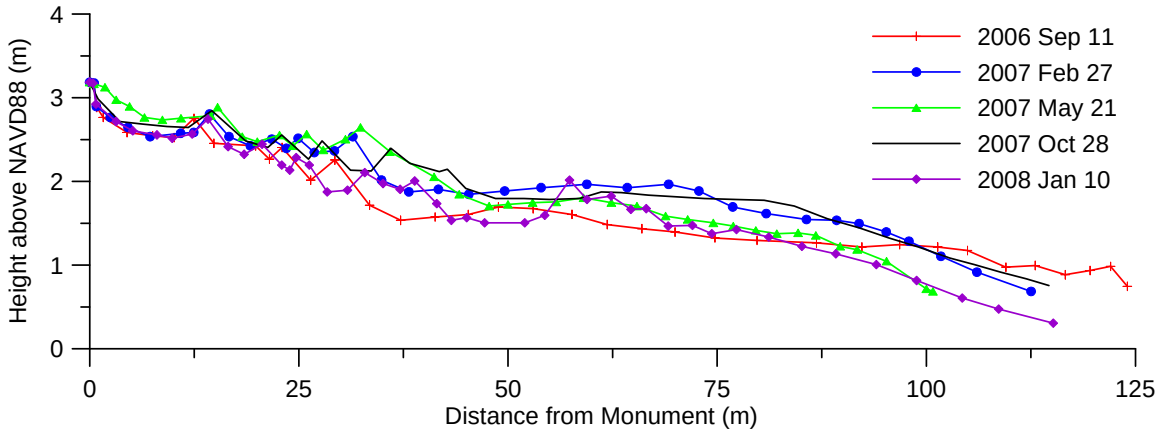


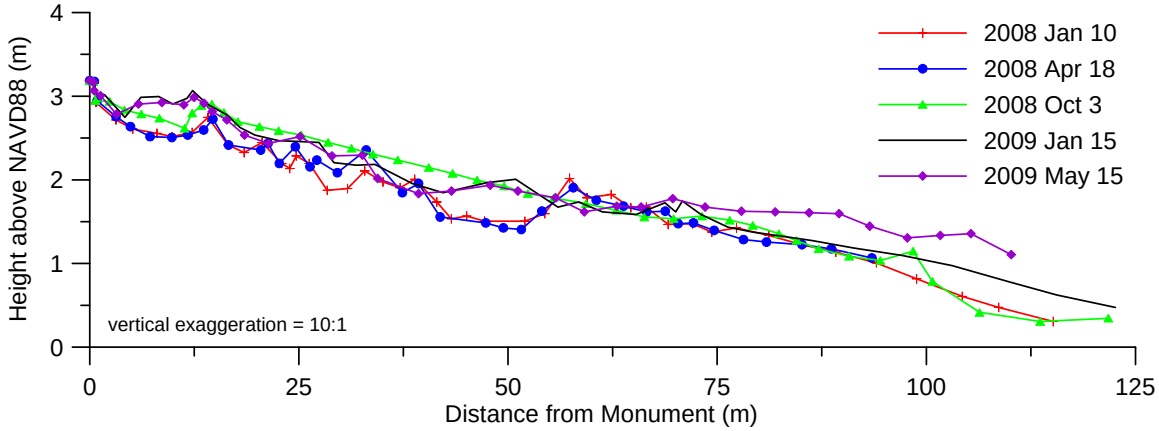


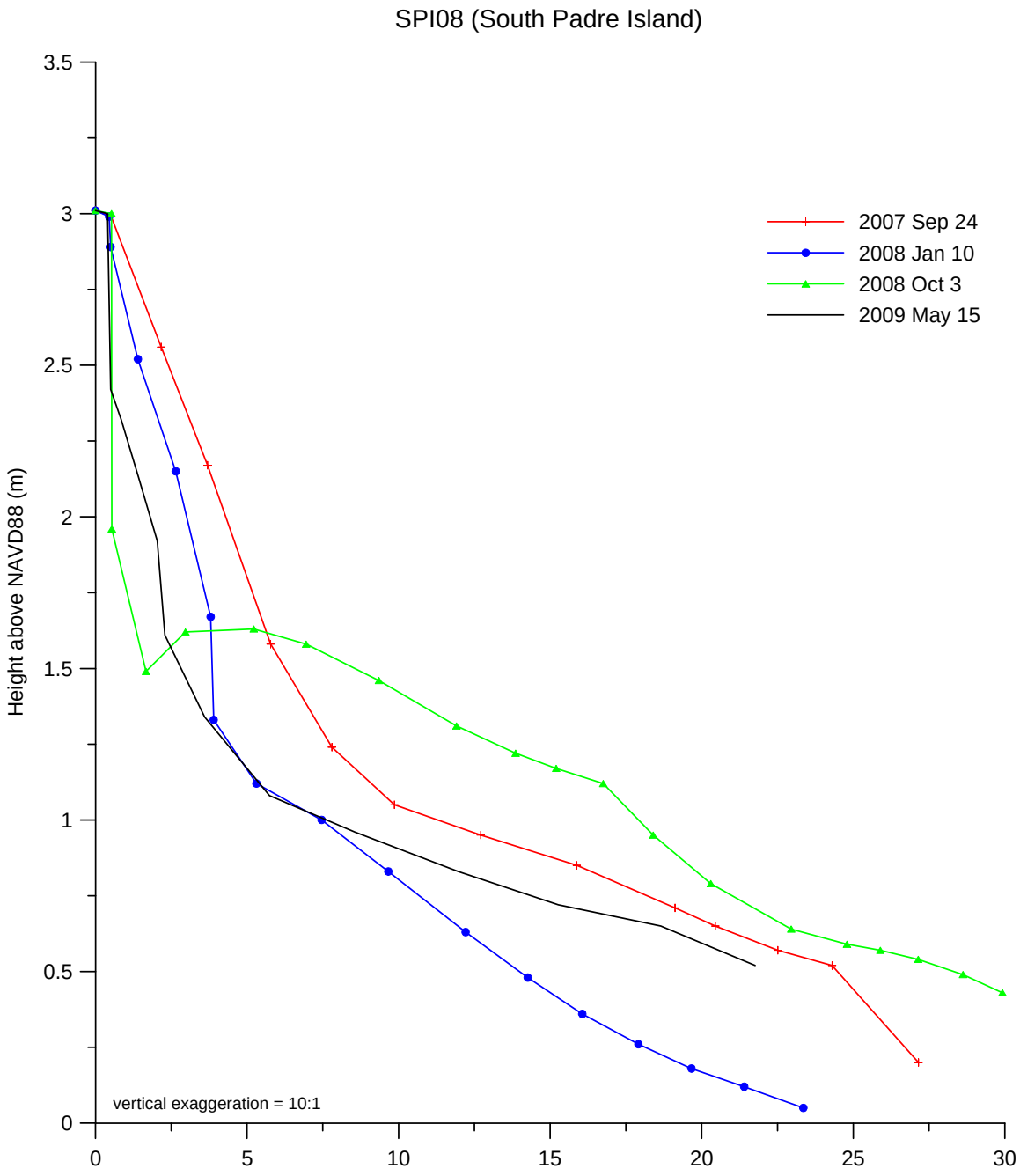


SPI02 (South Padre Island)








SPI08 (South Padre Island)
Height above NAVD88 (m)
3.5
3
2.5
2
1.5
1
0.5
0
0
5
10
15
20
25
30
2007 Sep 24
2008 Jan 10
2008 Oct 3
2009 May 15
vertical exaggeration = 10:1