

FINAL REPORT

Texas High School Coastal Monitoring Program: Ball, Port Aransas, and Port Isabel High Schools, 1999/2000

James C. Gibeaut and Roberto Gutierrez

**A Report of the Texas Coastal Coordination Council pursuant to National Oceanic
and Atmospheric Administration Award No. NA97OZ0179**

**Funding for the Texas High School Coastal Monitoring Program is provided by the
Texas Coastal Coordination Council, Conoco, the Exxon Foundation, and the Wray
Family Trust**



**Bureau of Economic Geology
Scott Tinker, Director
The University of Texas at Austin
Austin, Texas 78713-8924**

November 2000

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INTRODUCTION

The Texas Coastal Monitoring Program engages people who live along the 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 on the Texas coast. 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 1999/2000 school year. During this time, Ball High School on Galveston Island completed its third year in the program and Port Aransas and Port Isabel High Schools completed their first year (Fig. 1). All three high schools are continuing the program during the 2000/2001 school year. Discussions of the 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 1996/1997 and revised during subsequent years. A major addition to the program this year is the revised web site (<http://inet1.beg.utexas.edu/thscmp/>).

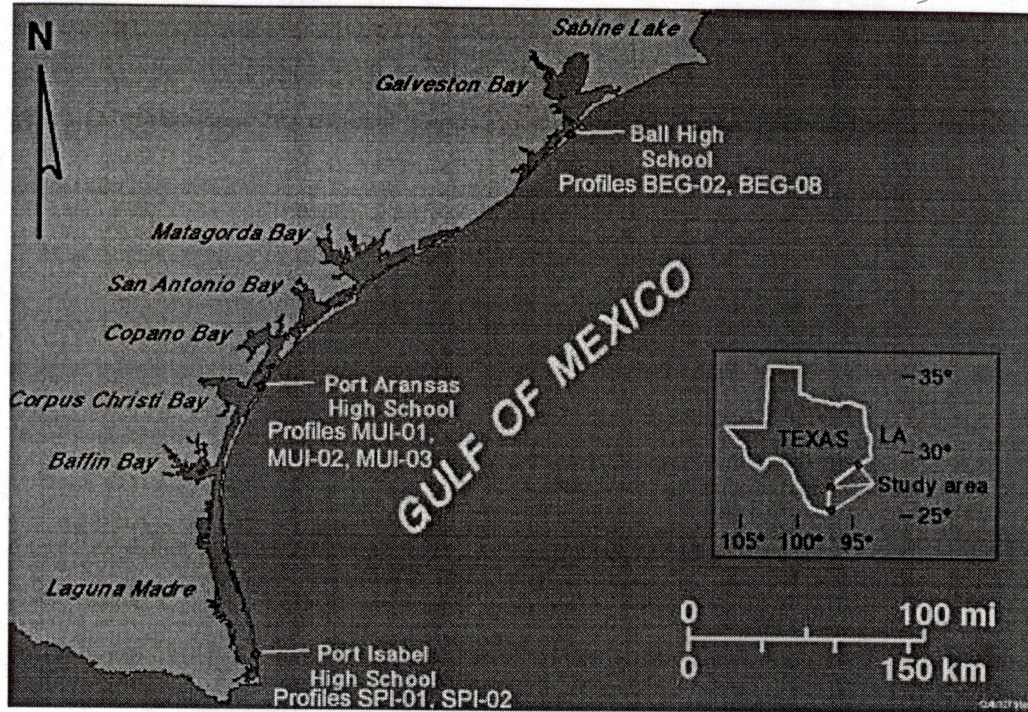


Figure 1. Participating schools.

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 to 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 the participating students will discuss the program with their parents, classmates, and neighbors, further expanding the reach of the program. We expect the program to attract media attention as well. A World Wide Web site (<http://inet1.beg.utexas.edu/thscmp/>) containing the latest information is central to the community outreach portion of the project. Coastal residents may wish to view the effects of a storm that strikes the upper coast. They will be able to do so by accessing the Texas Coastal Monitoring Program web site to view maps, graphs, and photographs collected by Ball High School. Curiosity may drive this inquiry at first, but eventually there is an increased awareness and appreciation of coastal processes and how future storms could affect one's community.

(3) Obtain 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 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 measure beach morphology and make observations on beach, weather, and wave conditions. These procedures were developed during the program's pilot year (1997/98) and are presented in detail in a manual that 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 the foredunes to the waterline. 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.

(2) Shoreline 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 shoreline change.

(3) Sediment sampling

Students 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

Students measure wind speed and direction, estimate the width of the surf zone, and observe the breaker type. They note the wave direction, height, and period and estimate the longshore current speed and direction using a float, stop watch, and tape

measure. 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.

Training

UT scientists provide the teachers with all the training, information, field forms, and equipment needed to conduct the field and lab measurements. During the school year, UT scientists accompany the students on at least one of the field trips and make at least two classroom visits that may be joined with the field trips. The classroom visits provide students with even 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 the scientists with an opportunity to ensure the quality of the data.

Data Management, Data Analysis, and Dissemination of Information

The World Wide Web is central to the dissemination of data collected for this program. A web site, which resides on a UT server, was implemented toward the end of the 1998/1999 school year. The web site 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 web site to post its data and observations, including photos taken by an electronic camera. UT scientists manage the data in an electronic database and make it available to the public. UT scientists also evaluate the data in light of coastal management problems. During 1999/2000, the web site was upgraded to allow students to enter data through the web site. Students and the public can now interactively plot beach profiles and retrieve the data through the web site.

STUDENT, TEACHER, AND SCIENTIST INTERACTIONS DURING THE 1999/2000 SCHOOL YEAR

UT scientists, Drs. Gibeaut and Gutierrez, worked with teachers Ms. Shawna Riddle of Ball High School, Mr. Billy Slingerland of Port Aransas High School, and Mr. Kevin Tenison of Port Isabel High School. Ms. Riddle chose one of her Aquatic Sciences

classes to participate in the program. Mr. Slingerland had one Aquatic Sciences class, and he chose it to participate in the program. Mr. Tenison's Advanced Placement Environmental Sciences class participated in the program. Approximately 50 students in the 10th, 11th, and 12th grades participated during the 1999/2000 school year.

Drs. Gibeaut and Gutierrez conducted a teacher workshop on October 22 and 23 in Port Aransas. The workshop provided the teachers with the background and experience to prepare their students for the first field trip to the beach. Teachers received background information on the project and learned about coastal processes. They also received instruction in field, laboratory, and data analysis techniques. They were provided equipment, lecture notes, graphics, instruction manuals, and other curriculum materials. The workshop included a trip to the beach to conduct the measurements. We had originally planned a 3-day workshop but because of teacher schedules during the school year we shortened it to 2 days. Two days were adequate for the seminar, and the third day was used for individual instruction at each school during the year.

UT scientists visited each school at least twice. These visits usually coincided 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, the students were divided into 2 or 3 teams. One team measured the profile and took sediment samples while the other team collected data on the 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 would have an opportunity to conduct all measurements. Sediment sampling was conducted only if the teacher planned to use the sediments in a lab exercise.

Dividing students into two five- to seven-member teams, one that conducts the profile and sediment sampling and the other that measures the processes and the shoreline, works well. Each team finishes at about the same time, although for short profiles, the profiling

team may finish early. In this case, an extra task can be assigned to the profiling team. 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.

It was originally planned that the students would measure 4 profiles on each field trip. Although it may be possible to visit four locations and return by the end of the school day (2:30), it is clear that this is too much work for the students. Little time would be allowed for lunch, and the quality of the data and learning experience for the students would suffer. Furthermore, managing and analyzing data from four profiles would require more time in the classroom than is available. It was therefore decided to measure 2 or 3 locations during each trip. Doing so allows ample time for careful data collection and gets the students back to school about 1 hour before the end of the day. During this hour, equipment and samples are stored, and data are filed or transferred to the computer.

During the 1999/2000 school year, weather, other classroom commitments, and scientists commitments allowed Ball and Port Isabel High Schools to make only 2 field trips. If a field trip is cancelled it can be difficult to reschedule, especially if it involves a full day. This is another reason to keep the trips shorter than the full school day. Following are details on the activities at each school.

Ball High School

Ms. Shawna Riddle's Aquatic Sciences class at Ball High School conducted their first beach measurements on November 18, 1999. They conducted surveys at the same 2 locations as previous Ball High classes, one at the Galveston Island State Park and one on Follets Island southwest of San Luis Pass. The Bureau has also measured these profiles since the 1980's. Dr. Gutierrez accompanied the class and provided further training and background information to the students. The second and last field trip of the year was conducted on February 7, 2000 at the same two locations as the first trip. Dr. Gutierrez

accompanied the class on this trip as well. Unfortunately, only the February profiles are valid. Apparently mistakes were made during the November field trip.

Port Aransas High School

Unlike along the upper Texas coast, the Bureau did not have an established beach-profiling network in the vicinity of Port Aransas on Mustang Island. The profiles measured by Port Aransas students were the first in what will hopefully be a long time series. One profile (MUI-01), within walking distance of the high school, was established and measured during the teacher seminar. On November 4, 1999 Mr. Slingerland's class conducted their first measurements at this location on the north end of Mustang Island. Dr. Gutierrez accompanied the students on this trip.

On February 1, 2000, Mr. Slingerland and Dr. Gibeaut decided on locations for 2 additional profiles, one in Mustang Island State Park (MUI-02) and another between the park and the school at beach access road #2 (MUI-03). A student field trip was planned to measure all 3 profiles on February 2, but a wet cold front caused the trip to be cancelled. Although the trip was cancelled Dr. Gibeaut presented a classroom lecture describing the project, coastal science, and research in general. The students were also introduced to the web site. The February 2 field trip was rescheduled and conducted on February 23. No UT scientists accompanied the students on this trip. The students measured 3 profiles (MUI-01, MUI-02, and MUI-03) along Mustang Island during this trip. On May 3, Dr. Gibeaut accompanied Mr. Slingerland's class on the third and last field trip of the year. The three, earlier established locations were measured during this trip.

There was some confusion on the locations of the MUI-02 and MUI-03 profiles on the February 23 and May 3 trips. This confusion has been removed, but the first 2 profile measurements at these locations are not useful. Apparently errors were made at the MUI-01 site during the February 23 and May 3 field trip. We believe these errors are correctable, and we will eventually incorporate them into the time series.

Port Isabel High School

Unlike along the upper Texas coast, the Bureau did not have an established beach-profiling network on South Padre Island for Port Isabel High School to measure. The profiles measured by Port Isabel students were the first in what will hopefully be a long time series. On November 10, Dr. Gibeaut established a new profile site (SPI-01) in Isla Blanca County Park just north of Brazos-Santiago Pass. On November 11, Mr. Tenison's class conducted their first set of measurements at this location. Dr. Gibeaut accompanied the class on this field trip.

Port Isabel students conducted their second and last beach measurement at SPI-01 on January 28, 2000. They surveyed the location in the park north of Brazos-Santiago Pass; a strong, wet cold front prevented the surveying of more sites. Television Channel 4 and a local newspaper reporter filmed and interviewed the students and teacher on the beach. In lieu of surveying more sites, Dr. Gibeaut and Mr. Tenison led the class on a field trip of the Gulf beaches of South Padre Island. Coastal processes and coastal management issues were discussed.

EFFECTS ON SCIENCE CURRICULUM

The Texas High School Coastal Monitoring Program addresses several requirements of Texas Essential Knowledge and Skills (TEKS) for science. The program was relevant in the following 1999/2000 Texas high school courses: (1) Environmental Systems; (2) Aquatic Science; and (3) Geology, Meteorology, and Oceanography. TEKS 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 that 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.

With the upgrade of the web site, students next year will gain more experience using the Internet for research. We also intend to expand the site to make it more of a national resource useful to teachers and students not directly involved in the program. The ability to enter data through the web site and to make immediate comparisons with earlier data is expected to increase the interest of students in their measurements and observations.

EFFECTS ON SCIENTIFIC RESEARCH, COASTAL MANAGEMENT, AND PUBLIC AWARENESS

During the 1999/2000 academic year, Ball High School students measured a profile at a location in Galveston Island State Park (BEG02, Fig. 1) two times. They also measured a profile on Follets Island to the southwest of Galveston Island (BEG08, Fig. 1) two times. Only the February 2000 beach profiles are valid because mistakes were made during the November 1999 field trip. Ball High School students had measured these same locations the previous year, 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 per 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 the time series at these key locations are continued.

Port Aransas and Port Isabel High Schools started new beach profile time series at new locations. The Bureau did not have established profile sites along Mustang Island or South Padre Island before this program, and these new sites are the beginning of a wider network. The profiles and process 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.

Although it will take time to incorporate the 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 increased public awareness through the students. Based on inquiries from people

wishing to enter their school or group in the THSCMP, we think the program is reaching the public. Television reports, presentations at conferences, and newspaper articles have helped. The web site will continue to be instrumental in extending the reach of the program and increasing public awareness of coastal processes.

Scientific Results of 1998/1999 Studies

Profile data were entered into the public domain software package called "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 and profile plots were created using BMAP. Students plotted their data and made volume calculations as class exercises, but UT scientists generated the tables and graphs presented here.

Tropical Storm Frances struck the southeast (upper) Texas coast September 7 through 13, 1998, and caused extensive beach and dune erosion and damage to structures. The storm surge peaked at only 1.4 m above mean sea level, but extreme water levels ($> .78$ m) lasted for 64 hours. Although peak wave height was 4.09 m during the storm, extreme wave heights (>2.30 m) lasted for 73 hours. Beach-profile data collected by students at Ball High School, along with data collected by the Bureau, quantify the storm erosion and 2 years of post-storm recovery at BEG-02 and BEG-08 (see Appendix A for profile plots).

The beaches at Galveston Island State Park (BEG-02, Fig. 1) lost 40 m^3 of sand per meter of shoreline during Frances. Before the storm, this beach had a prominent foredune and a smaller incipient foredune seaward of the foredune. These dunes were completely removed with a portion of the sand deposited landward (see profiles in Appendix A). The shoreline and vegetation line retreated landward 20 m during the storm. Recovery of the beach proceeded quickly, however, with a steady return of sand over the winter. By March 2, the beach had regained 92 percent of the volume eroded by Frances (Fig. 2). The shoreline advanced steadily and regained its prestorm position over the winter. The vegetation line, however, moved only 6 m seaward and this advance was aided by a human-made artificial foredune that consists of washover sand bulldozed from the picnic

area. The bulldozed washover sand also contributed to the volume recovery of the beach/dune system. Recovery continued over the summer and winter of 1999/2000. By February 2000 the profile volume had reached the pre-Frances amount and the shoreline was 6 m farther seaward of its pre-storm position. The back beach had raised, and an incipient foredune formed along a sand fence.

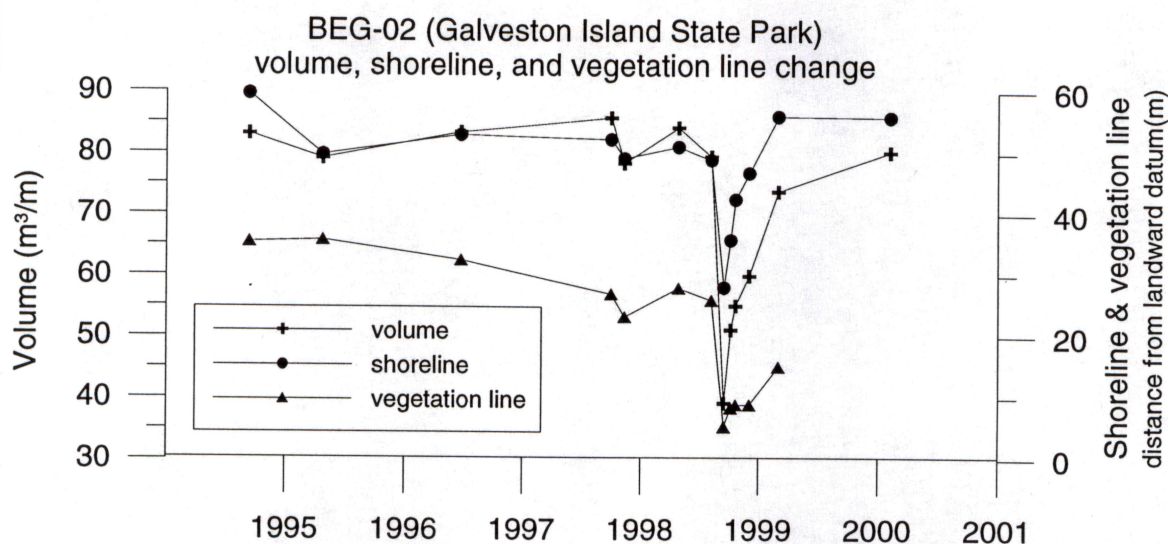


Figure 2. Profile volume, shoreline, and vegetation line changes at Galveston Island State Park.

At BEG-08 on Follets Island southwest of San Luis Pass (Fig. 1), Frances eroded 33 m³/m of sand. The foredune was removed, leaving a former secondary dune as the foredune (see profiles in Appendix A). Only a small amount of washover sand was deposited through low areas in the former secondary dune. The shoreline retreated 23 m, and the vegetation line retreated 21 m. As at the Galveston Island State Park, this beach began recovering soon after the storm, with one-half of the sand eroded returning by October 22, 6 weeks later (Fig. 3). By the end of the winter (March 1999), the beach contained the same amount of sand as before the storm. The shoreline also advanced to its pre-storm position, but the vegetation line had not moved from its post-storm position. By February 2000, the beach and dune had slightly more volume than it had before Frances. The shoreline, however, had not advanced farther, and the vegetation line

remained in its post-storm position showing no recovery. An incipient foredune had been established by February 2000.

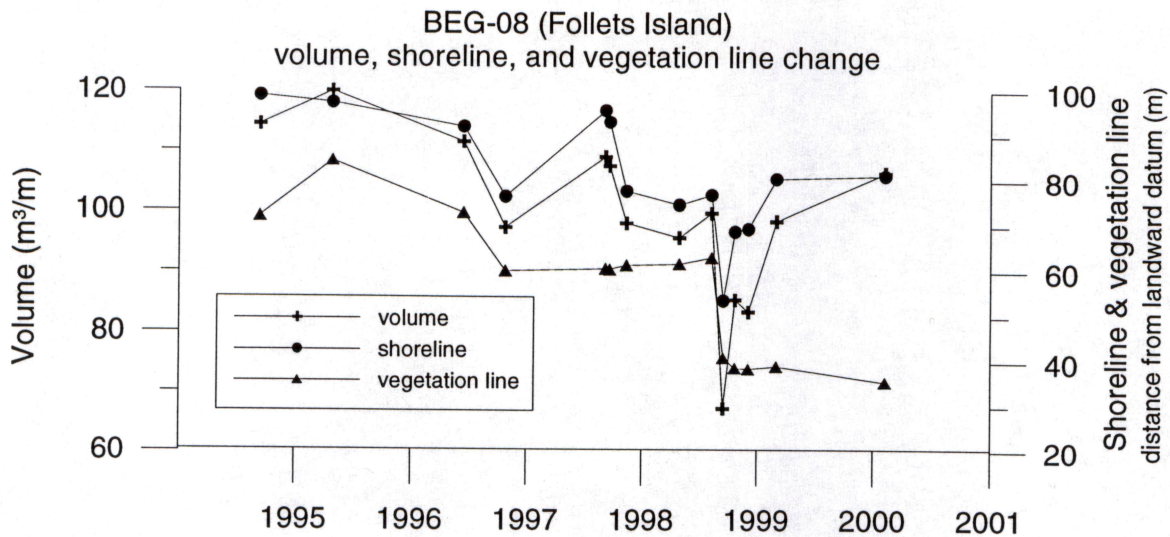


Figure 3. Profile volume, shoreline, and vegetation line changes on the northeast end of Follets Island.

Even though most of the sand removed by Frances returned to the beaches during the following winter, the shapes of the beaches have not recovered (see profiles in Appendix A). Dune formation and seaward advance of the vegetation line may take several years, and in some areas, the vegetation line may never return to its pre-storm position before long-term erosion begins again. People are forming an artificial foredune at BEG-02, whereas the BEG-08 beach is natural. The human manipulation will have a significant impact on the beach and dune recovery, and continued monitoring of BEG-02 and BEG-08 will provide insight into the processes of natural and enhanced post-storm beach recovery.

Profiles measured by Port Aransas and Port Isabel students are the first in their time series. The beaches are distinctly different from each other and from the Ball High beaches. The Port Aransas profile (MUI-01) on Mustang Island has a high foredune, and a seawall backs the Port Isabel profile (SPI-01) (see profile plots in Appendix A). Future measurements will not only show change through time at each location but will also show spatial variation along the Texas coast.

RECOMMENDATIONS

We consider the third year of the coastal monitoring program a conditional success and offer the following recommendations for continuance and expansion of the program.

- (1) Emphasize to the 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. Students' not being asked to conduct experiments that have no real consequence seems to make a difference to many students, and it probably improves the quality of the data.
- (2) Clearly tell the 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. The students are also learning a different way to view their surroundings.
- (3) Survey a reasonable number of beaches, which in most cases means two. 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 much data as possible. That approach, however, would not allow time for discussions on the beach that are not directly related to the measurements. It would also hinder the development of observation skills and keep the 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. Cancelled trips can be very difficult to reschedule. Therefore, some freedom must be allowed in the program regarding the number of trips and sites measured. Even if just one good data set is collected during the year this 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) When adding additional schools to the program, a 2- to 3-day seminar before the school year begins and including all the teachers is desirable. Instruction would be more efficient, and teachers and scientists would benefit by exchanging ideas.
- (6) A web site adds an important dimension to the project, especially when multiple schools are participating. A web site at which students can exchange observations with other schools in Texas will increase the educational value of the program by allowing students to observe differences in the processes acting along the coast. A web site would also introduce the Internet to students and illustrate how it can be used to conduct research. Furthermore, the Internet is important in increasing public awareness of coastal processes. Providing immediate feed back to students through the Internet is important. The students want to see their data and photographs on the web, and this increases their interest in the project.

APPENDIX A: GRAPHS OF BEACH PROFILES

