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West-Central Florida Coastal Transect # 7: Longboat Key

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Introduction

A major goal of the West-Central Florida Coastal Studies Project was to investigate linkages between the barrier-island system along the west coast of Florida and offshore sedimentary sequences. High population density along this coastline and the resultant coastal-management concerns were primary factors driving the approach of this regional study. Key objectives were to better understand sedimentary processes and accumulation patterns of the modern coastal system, the history of coastal evolution during sea-level rise, and resource assessment for future planning. A series of nine "swath" transects, extending from the mainland out to a depth of 26 m, was defined to serve as a focus to merge these data sets, and for comparison of different coastal settings within the study area.

Transect #7 extends seaward from Longboat Key (see location map to right). Information from seismic and vibracore studies is combined to derive a 2-D stratigraphic cross section extending from the offshore zone, through the barrier island, and onto the mainland. This stratigraphic record represents the late Holocene evolution of the coastal-barrier system and inner shelf following the last sea-level transgression and present highstand conditions. A comparison to surface-sediment distribution patterns indicated by side-scan sonar imagery and bottom grab samples illustrates the importance of spatial variability in sediment-distribution patterns offshore when considering stratigraphic interpretations of seismic and core data.

Methods

The primary data sets used in this study were collected from 1993 to 1998. Geophysical surveys included high-resolution single-channel "boomer" seismic data and 100-kHz side-scan sonar imagery (Locker and others, 2001). Most of the reconnaissance seismic and side-scan sonar data were acquired during two offshore cruises in 1994. Bottom sediments (N series) were collected during the 1994 cruises using an underway grab sampler at 4-km intervals along track. Additionally, a continuous-coverage side-scan sonar mosaic in the inner-shelf area, 3.5 kHz subbottom profiles and numerous underway bottom samples (M series) were collected in 1995 (Twichell and Paskevich, 1999; Twichell and others, 2000). Offshore core locations were selected based upon seismic data and were focused in areas likely to contain sufficient sediment thickness for core retrieval (Brooks and others, 1999). Vibracores and probe data provided stratigraphic control in the barrier-island and bay areas.

The four panels showing location and side-scan sonar imagery, seismic data, and a stratigraphic cross section are at the same horizontal scale. The seismic profile and cross-section panels are constructed by fitting the data between the labeled cross-section turns (location map panel) that have been projected downward to the straight cross-section line. Subtle differences in the horizontal scale of segments in the cross section due to this projection are minimal. The horizontal scale, as well as vertical exaggeration of the seismic profile and cross section, are the same for all nine transects in the map series in order to facilitate comparison among transects.

Geologic History and Morphodynamics of Barrier Islands

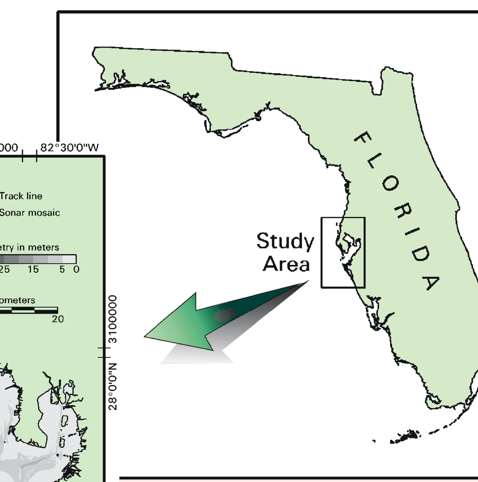
Barrier islands on the west-central Gulf coast of Florida display a wide range in morphology along the most diverse barrier/inlet coast in the world (Davis, 1994). In addition, the barriers have formed over a wide range of time scales from decades to millennia. The oldest of the barriers have been dated at 3,000 years (Stapor and others, 1988) and others have formed during the past two decades. The barrier system includes long, wave-dominated examples as well as drumstick barriers that are characteristic of mixed wave and tidal energy. Historical data on the very young barriers and stratigraphic data from coring older ones indicate that the barriers formed as the result of a gentle wave climate transporting sediment to shallow water and shoaling upward to intertidal and eventually supratidal conditions. The barriers probably formed close to their present position and several have been aided in their location and development by antecedent topography produced by the shallow Miocene limestone bedrock (Evans and others, 1985). The two most important variables that control barrier-island development along the coast are the availability of sediment and the interaction of wave and tidal energy.

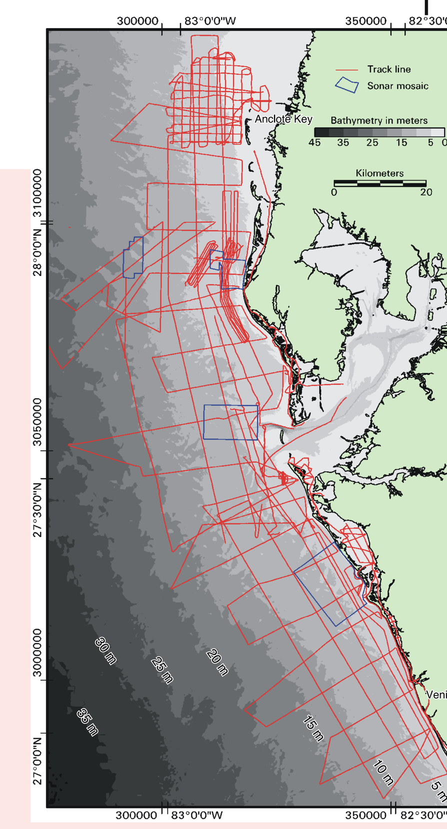
Longboat Key

The transect at Longboat Key is located across a relict tidal inlet that connected two islands in pre-historical time (FitzGerald, 1995; Barnard, 1998). The island is now a wave-dominated barrier although the southern portion was a drumstick barrier when it was separated from the northern portion. The stratigraphic cross-section across this area includes portions of both of the former barriers and Buttonwood Sound, the former tidal inlet.

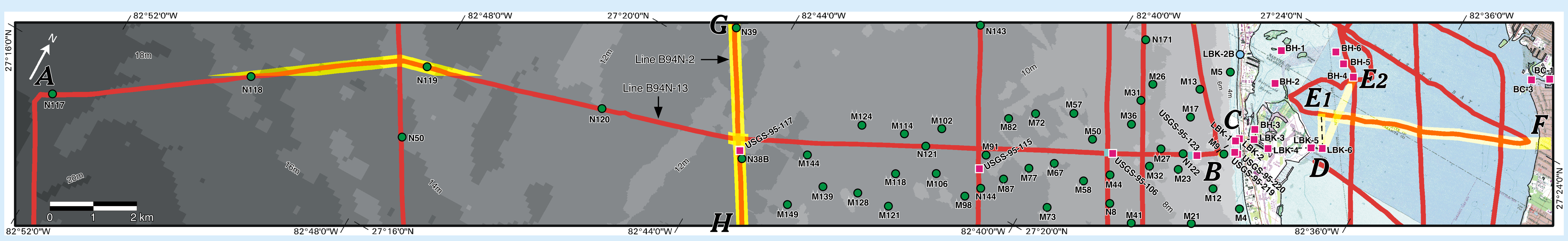
None of the vibracores reached the Miocene carbonate strata. However, cores from the relict inlet and from Sarasota Bay did contain limestone clasts. A core taken by Knowles (1983) from just landward of the cross section shown here encountered limestone at 6.5 m below sea level. Cores from Sarasota Bay and Bowlees Creek (FitzGerald, 1995) penetrated Pleistocene sediments, which are muddy, well-sorted sand interpreted to have accumulated on an eolian strandplain.

The deepest strata penetrated in this cross section are shelly sands interpreted to represent channel deposits (FitzGerald, 1995; Yale, 1997), most likely associated with the relict inlet and its previous positions. Abundant washover deposits are present over the channel deposits and are also laterally equivalent to the same facies. The typical nearshore, beach, and dune deposits of sand and shelly sand comprise the present barrier facies.





Location of study area along the west-central Florida coastline showing cruise-track coverage in red. Data types include high-resolution seismic-reflection data, side-scan sonar imagery, surface-sediment samples, and vibracores. Blue-box areas identify continuous-coverage side-scan sonar mosaic area. The bathymetry shown in 5-m intervals by gray shading is modified from Gelfenbaum and Guy (1999).



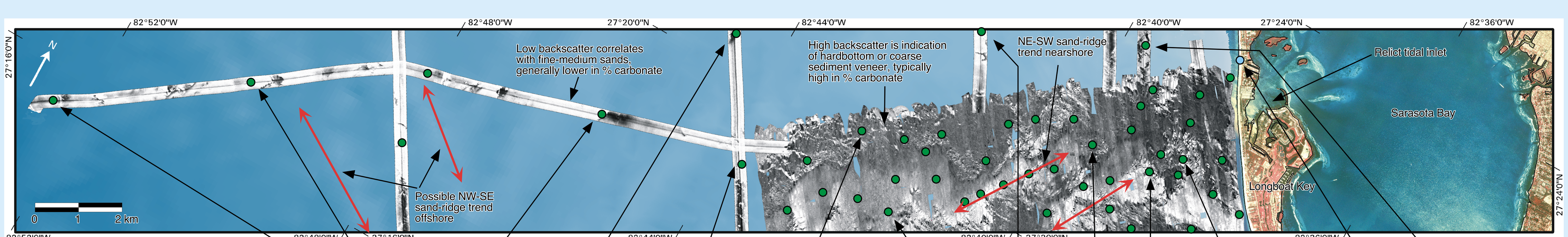
Location map

Location map showing bathymetry, cruise-track coverage, core and sample locations, and location of figures. The full transect cross section A-F is presented below. An expanded view of the island portion of the transect C-D-E2 is shown at lower right. Line G-H locates the seismic profile shown at lower left.

- Vibracore
- Underway surface-sediment sample
- Surface-sediment grab sample

Cruise track in red with yellow highlight indicating line of cross section or seismic profiles (below).

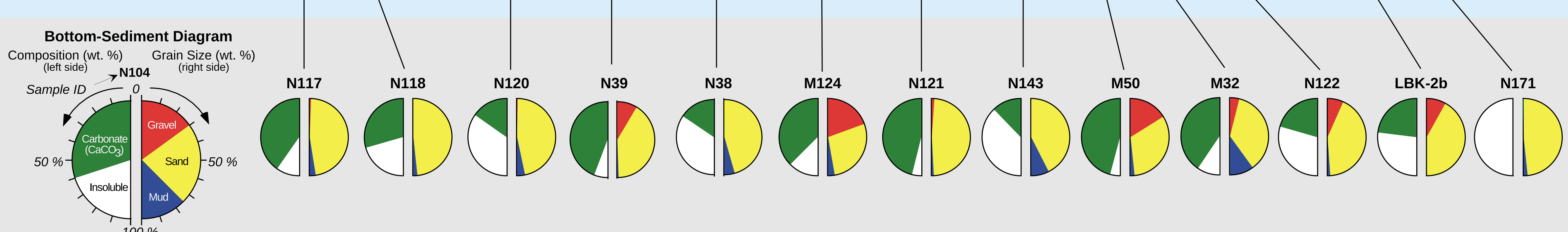
Projection: UTM, GRS 1980, NAD83, Zone 17. Coordinates: Geographic.
Bathymetry in 2-m intervals starting at 4 m.
Land areas represented by USGS 7.5-Minute Topographic Map.



Side-scan sonar data

Side-scan sonar imagery overlain on bathymetry reveals widespread high backscatter (dark) in the inner half of the transect and lower backscatter (light grey) in the outer half of the area. Low-relief sand ridges in the inner area are oriented NE-SW and encompass both high and low backscatter bottom types due to changes in grain size across the ridges (Twichell and Paskevich, 1999; Twichell and others, 2000). Offshore of this mosaic area, thicker sand waves or ridges are more common and appear more uniformly as low backscatter (sandy) bottom types. The sand ridges in the inner portion of this transect area are dominated by a NE-SW trend with apparently no second-order smaller bedforms (sand waves). This contrasts with the northwest-trending sand ridges off Indian Rocks Beach north of Tampa Bay that contain numerous secondary sandwave fields (Harrison and others, 2000). The bathymetric-surface model to the right (Gelfenbaum and Guy, 1999), however, suggests sand-ridge trends may shift to the NW-SE trend in the outer portion of the transect area.

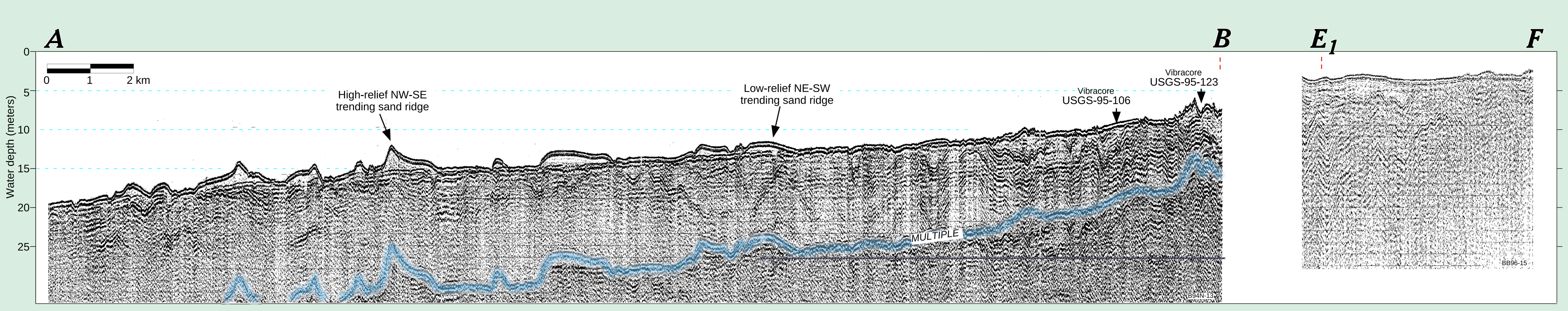
Projection: UTM, GRS 1980, NAD83, Zone 17. Coordinates: Geographic.
Bathymetry (areas > 4 m) after Gelfenbaum and Guy (1999).
Coastal areas (< 4 m) represented by Digital Orthophoto Quarter Quadrangle (1995).



Surface sediments

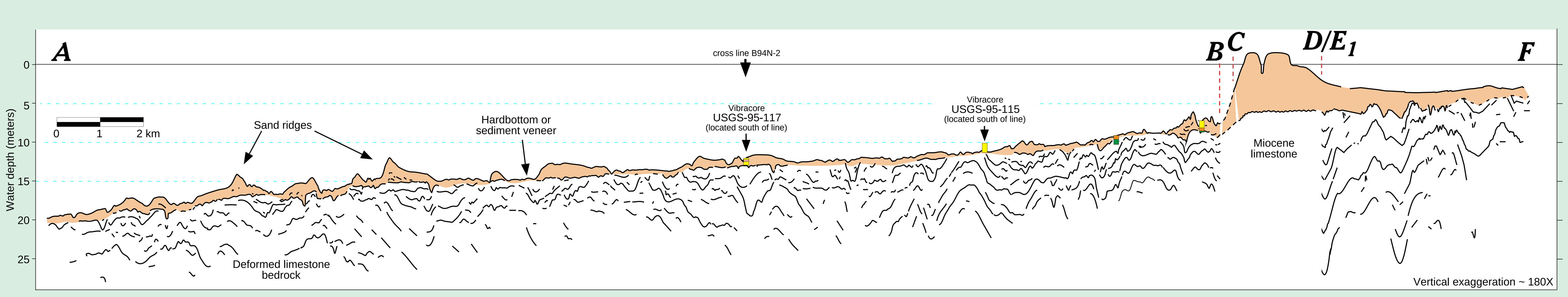
Grain-size and composition data for bottom grab samples are presented below the sonar imagery (see Brooks and others, 1998). Samples generally consist of quartz-rich sand and carbonate gravel and mud. Carbonate-rich sand and gravel are found immediately adjacent to shore.

Low backscatter correlates with medium to fine siliciclastic sand with minor carbonate grains and is associated with the thicker sand-ridge deposits. The higher-backscatter areas correlate with coarse grain size and increased carbonate.



Seismic-profile data

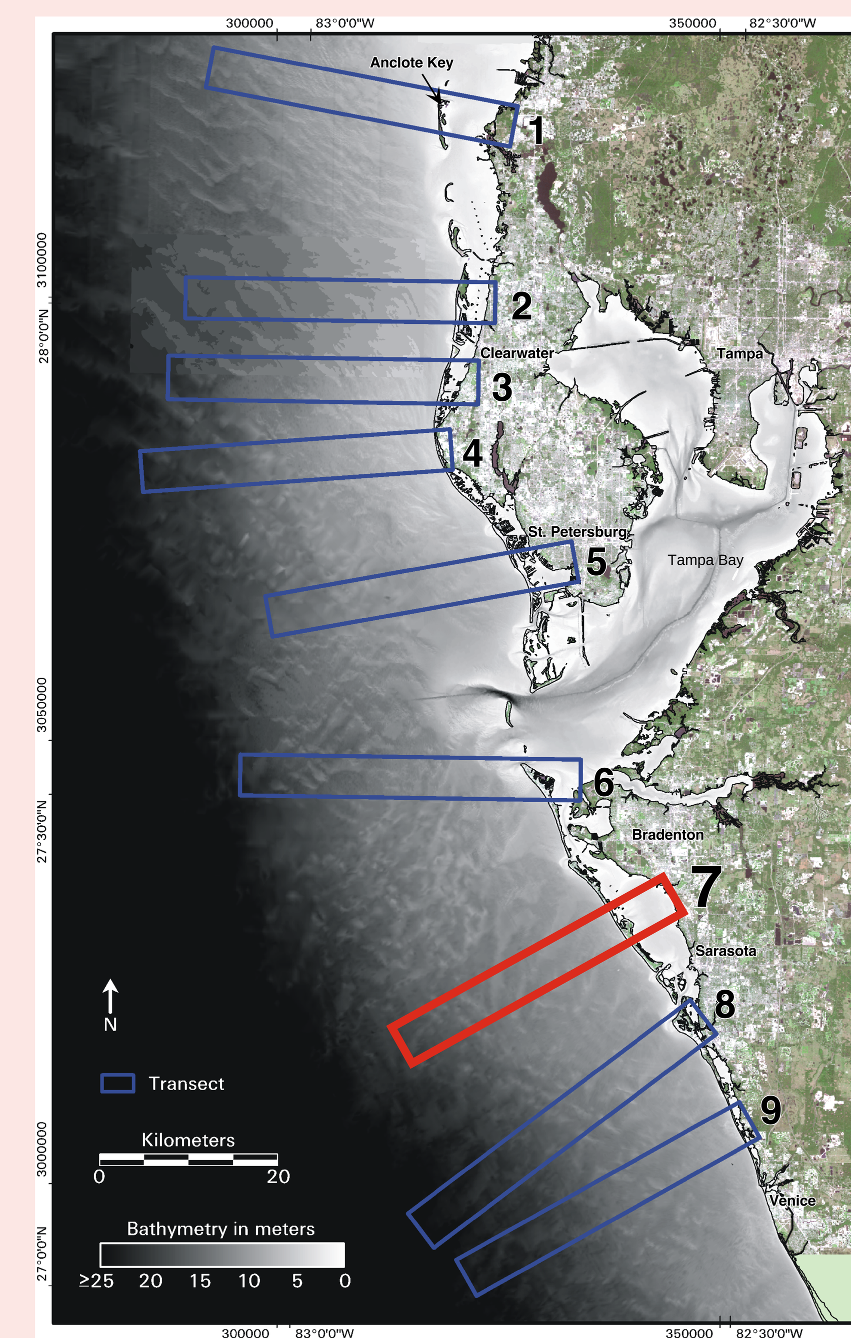
Uninterpreted "boomer" seismic-reflection data reveal distinct sand bodies offshore reaching over 3 m in thickness, and a much thinner section nearshore. A well-defined, high-amplitude reflection marking the base of the Holocene section (confirmed by vibracores) is easily identified beneath the sand ridges. Low-relief sand ridges in the nearshore area trend NE-SW (Twichell and others, 2000) in contrast to NW-SE sand ridge trends off Indian Rocks Beach (Harrison and others, 2000). Both types of sand ridges are oblique to the coastline and commonly show asymmetry, with the steeper lee slope facing SW (Harrison) or NW (Twichell). Also evident at 5- to 10-m depth in the subsurface are wavy reflections attributed to karst deformation in the Miocene limestone bedrock and infilled shelf valleys that are common below the inner shelf south of Tampa Bay.



Transect cross-section *A-F*

Integrated stratigraphic cross section combining line-drawn interpretation of seismic data, ground-truthed by coring, with a coastal cross section based on vibracores. At point D the line of section is offset to point E1 to pick up the seismic control crossing the bay. Cores in the offshore transect have low cross-shelf correlation potential because they sample different ridge deposits as shown by side-scan sonar imagery and bathymetry data. Offshore sediment thickness reaching over 3 m contrasts with the thinner (<2 m) section nearshore. Over 7 m of Holocene sediment comprises the barrier-island section at this location - reflecting a thicker lower section of channel fill that once occupied this location. In spite of this potential channel erosion, a 2- to 3-m rise in the bedrock relief below Longboat Key at this location suggests that antecedent topography of the bedrock surface may play a key role in barrier-island location and the presence of a wide bay environment landward of the island. Offshore, a relatively flat unconformity between Holocene sediments and the deformed Miocene bedrock suggests little or no antecedent bedrock control on the offshore pattern of sandbody morphologies.

Holocene sediment

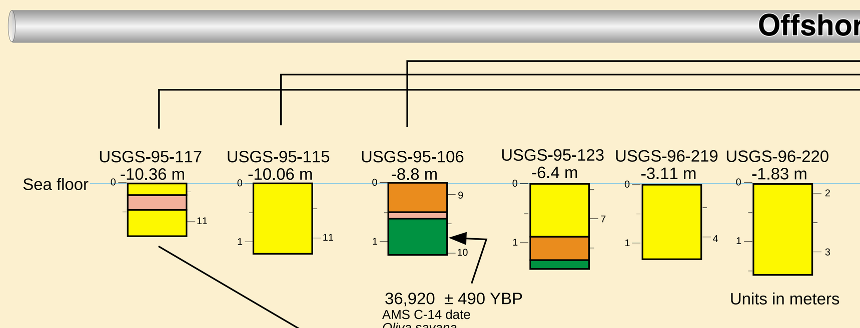


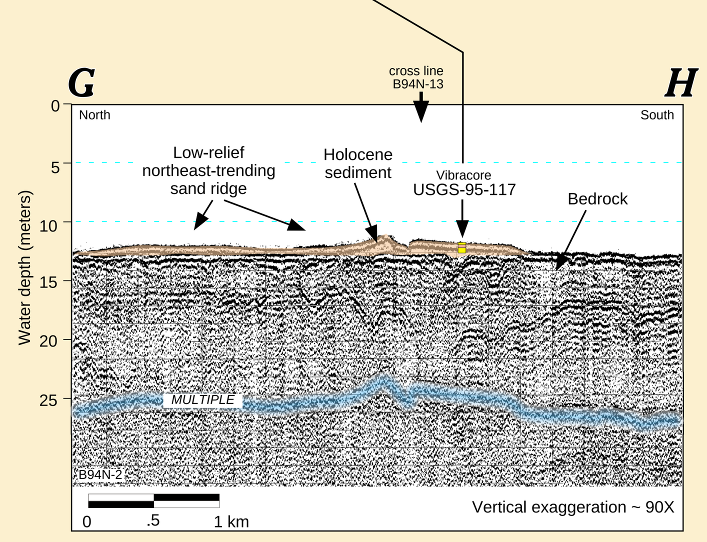
Location of west-central Florida coastal-transect maps with Transect #7 shown in red. 1997 LANDSAT TM imagery of Florida's west coast is merged with a bathymetric-surface model (Gelfenbaum and Guy, 1999). Bathymetric trends offshore in part reflect sediment-distribution patterns. The study area extends from Anclote Key to Venice, FL.

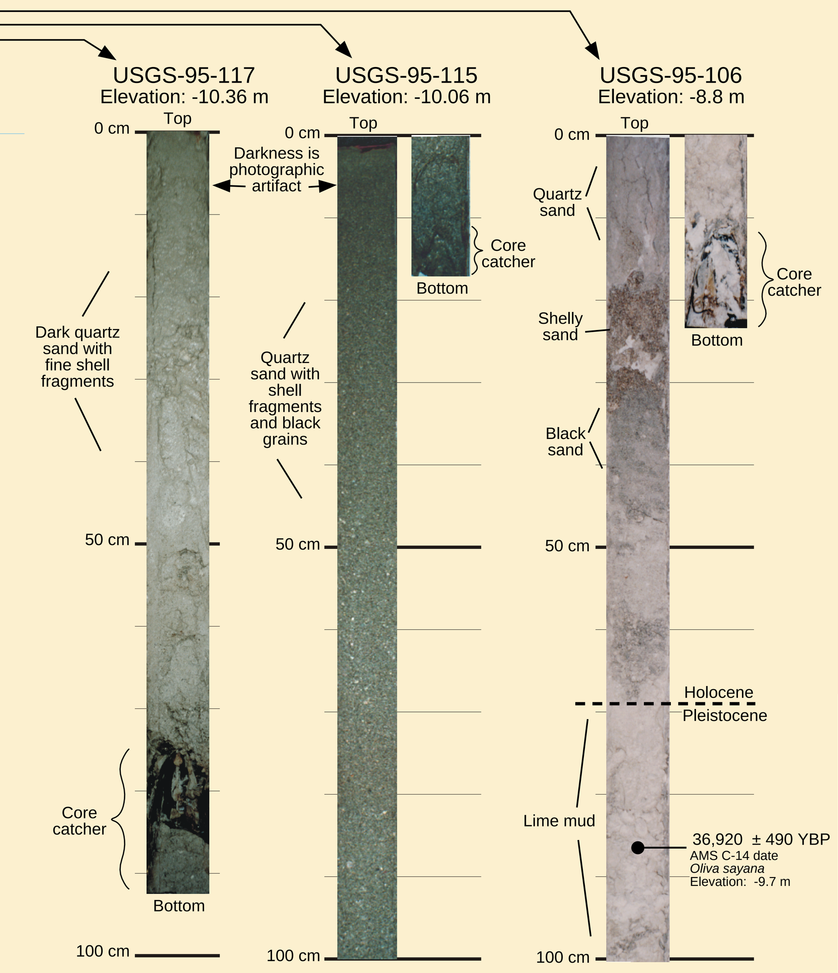
Oblique aerial photograph of Longboat Key taken in 1994. The sinuous Buttonwood Harbor lagoon is a relict tidal inlet. Extensive channel deposits recovered in vibracores are now overlain by washover, beach, and dune deposits (see stratigraphic section C-D below).

Core Data

Offshore Cores







Seven generalized sedimentary-facies types were defined for a unified comparison of core data from the entire study area. All seven color-coded facies for the entire study are shown in the Explanation below. However, not all facies necessarily are present on each transect. Core photographs present individual cores cut into 1-m sections from top (upper left) to bottom (lower right). Discrepancies in core length between the photographs and the diagrams are due to compaction during the coring process. Offshore cores (left) are aligned at core tops. Core locations were chosen to sample thicker Holocene sections and to aid in determining pre-Holocene stratigraphy. Elevations were determined from the photographs and tide tables. The datum for the barrier-transect cores is the mean lowest low water (MLLW).

Offshore vibracore retrieval was consistently less than 1.5 m in length. Even though none of the underlying platform deposits were collected, the contorted nature of the barrel bottoms suggests the entire sediment thickness was penetrated. Offshore cores consistently contain a thin surface layer of sand-size material overlying pre-Holocene deposits. Sands contain a large amount of blackened grains believed to have been derived from the pre-Holocene stratigraphy. Core observations from these sites indicate that there is little significant sediment influx to this part of the study area.

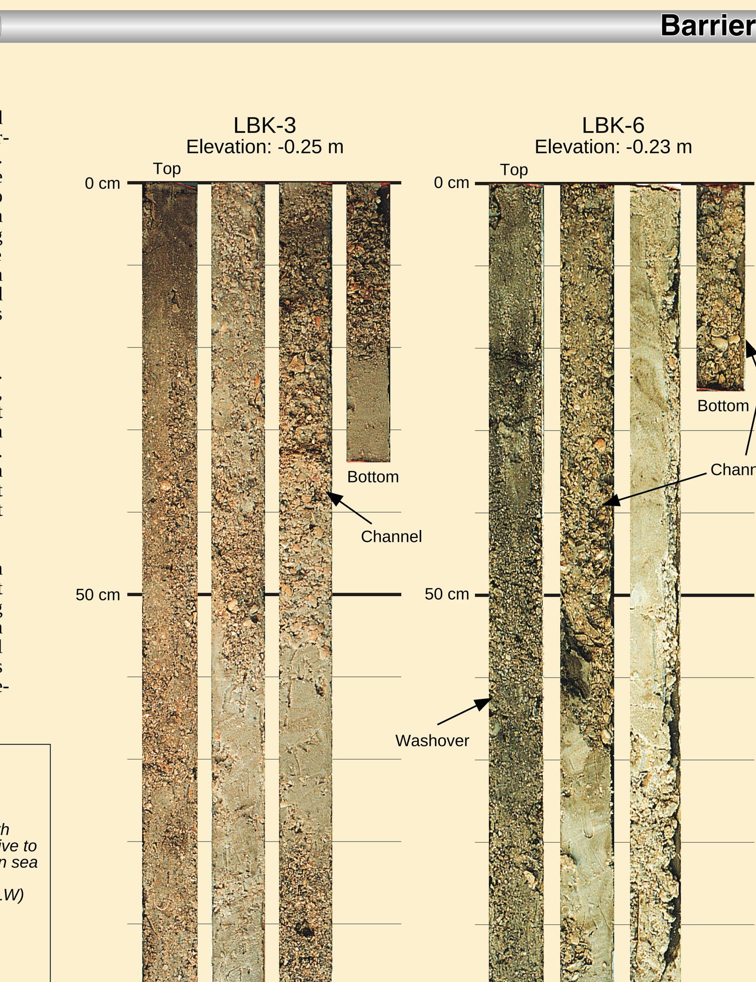
Cores from the barrier island revealed somewhat coarser sands associated with Longboat Key, grading to muddy sands below Sarasota Bay. Abundant channel deposits reflect the dynamic history of coastal change, including inlet closure, over the past few thousand years. The island cross section shown to the right (Yale, 1997) is located in widest section of central Longboat Key, once occupied by an open tidal inlet. On cross sections where cores do not penetrate to bedrock, the data is based on probe-rod data.

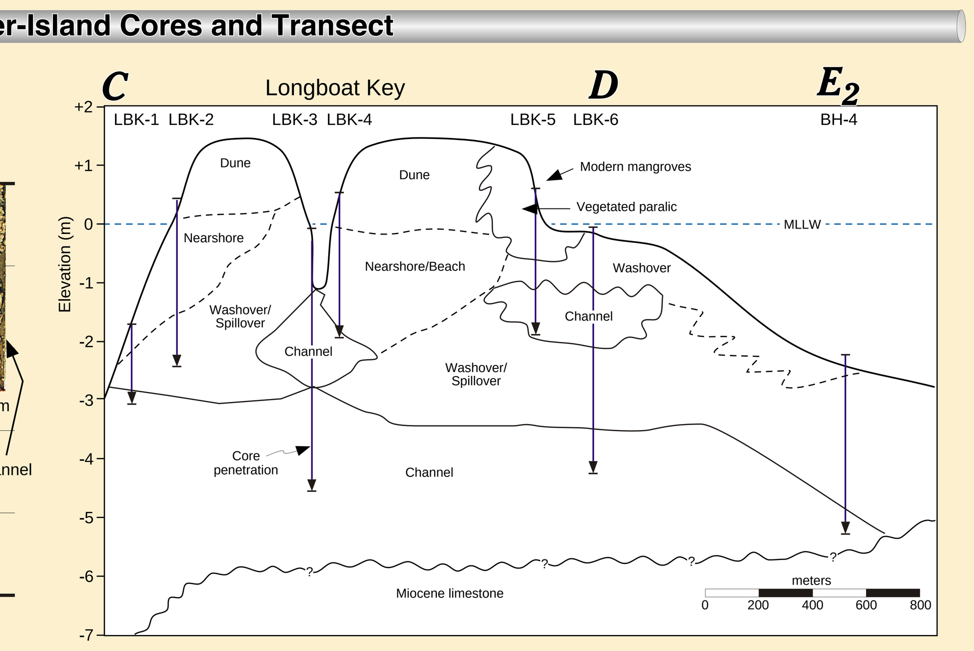
Explanation: core logs and sedimentary facies

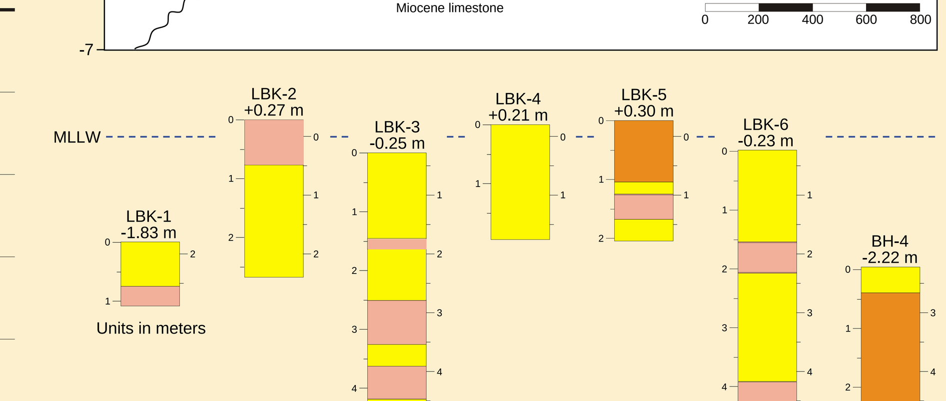
- gravel (> 60% gravel)
- gravelly sand (< 3% mud and 25-60% gravel)
- sand (< 3% mud and < 25% gravel)
- muddy sand (3-50% mud)
- mud (>50% mud)
- Pleistocene facies
- Miocene (limestone and blue-green clay)

Core ID & Elevation; Depth from top of core; Depth relative to mean sea level (MLLW); CAL-5 +0.82 m; Units in meters

Barrier-Island Cores and Transect







References Cited

Barnard, P.L., 1998, Historical morphodynamics of inlet channels: West-Central Florida: St. Petersburg, University of South Florida, unpublished M.S. thesis, 179 p.

Brooks, G.R., Doyle, L.J., DeWitt, N.T., and Suthard, B.C., 1999, Inner West-Central Florida Shelf: Surface sediment characteristics and distribution: U.S. Geological Survey Open-File Report 98-37, 177 p.

Davis, R.A., 1994, Barriers of the Florida Gulf peninsula, *in* Davis, R.A., ed., Geology of Holocene Barrier Island Systems: Heidelberg, Springer-Verlag, p. 167-206.

Evans, M.W., Hine, A.C., Belknap, D.F., and Davis, R.A., 1985, Bedrock control on barrier island development: West-Central Florida coast: Marine Geology, v. 63, p. 263-283.

FitzGerald, M.V., 1995, Stratigraphy of tidal and fluvial paleochannel sequences beneath West-Central Florida Gulf coast barrier islands: St. Petersburg, University of South Florida, unpublished M.S. thesis, 134 p.

Gelfenbaum, G. and Guy, K.K., 1999, Bathymetry of West-Central Florida: U.S. Geological Survey Open-File Report 99-417, CD-ROM.

Harrison, S.E., Locker, S.D., Hine, A.C., and Twichell, D.C., 2000, Side-scan sonar mosaic, Indian Rocks Beach, FL: U.S. Geological Survey Open-File Report 99-444, CD-ROM.

Knowles, S.C., 1983, Holocene geologic history of Sarasota Bay, Florida: St. Petersburg, University of South Florida, unpublished M.S. thesis, 128 p.

Locker, S.D., Brooks, G.R., Hine, A.C., Davis, R.A., Twichell, D.C., and Doyle, L.J., 2001, Compilation of geophysical and sedimentological data sets for the West-Central Florida Coastal Studies Project: U.S. Geological Survey Open-File Report 99-539, CD-ROM.

Stapor, F.W., Mathews, T.D., and Lindfors-Kerns, F.E., 1988, Episodic barrier island growth in southwest Florida: A response to fluctuating Holocene sea level?: Miami Geological Society, Memoir 3, p. 149-202.

Twichell, D.C., Cross, V.A., Paskevich, V.F., Parolski, K.F., Brooks, G.R., Gelfenbaum, G.R., Hine, A.C., and Locker, S.D., 2000, Side-scan sonar mosaic, Indian Rocks Beach, FL: U.S. Geological Survey Open-File Report 99-443, CD-ROM.

Twichell, D.C. and Paskevich, V.F., 1999, Bathymetry, sidescan sonar imagery, surface sediments, and surficial geologic map of the inner shelf off Sarasota, Florida: U.S. Geological Survey Open-File Report 99-396, CD-ROM.

Yale, K.E., 1997, Regional stratigraphy and geologic history of barrier islands, West-Central Florida: St. Petersburg, University of South Florida, unpublished M.S. thesis, 180 p.

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Data references:

Color Infrared Digital Orthophoto Quarter Quadrangles (CIR DOQQ), (1994, 1995), USGS EROS Data Center, Sioux Falls, SD 57198. CD-ROMs.

Landsat TM Image, February 18, 1997, path 17, row 40. USGS EROS Data Center, Sioux Falls, SD 57198. CD-ROM.

7.5-Minute Series (Topographic) Quadrangles, U.S. Geological Survey, Reston, VA 22092.

List of west-Florida coastal-transect series maps (1 sheet each):

Transect #1: Anclote Key, USGS Open-File Report 99-505
Transect #2: Caladesi Island-Clearwater Beach, USGS Open-File Report 99-506
Transect #3: Sand Key, USGS Open-File Report 99-507
Transect #4: Indian Rocks Beach, USGS Open-File Report 99-508
Transect #5: Treasure Island-Long Key, USGS Open-File Report 99-509
Transect #6: Anna Maria Island, USGS Open-File Report 99-510
Transect #7: Longboat Key, USGS Open-File Report 99-511
Transect #8: Siesta Key, USGS Open-File Report 99-512
Transect #9: Casey Key, USGS Open-File Report 99-513