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West-Central Florida Coastal Transect # 3: Sand 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 #3 crosses Sand Key just north of the Indian Rocks Beach headland (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. Additionally, bottom samples were collected during the cruises using an underway grab sampler at 4-km intervals along track. Offshore core locations were selected based upon seismic data and were focused in areas likely to contain sufficient sediment thickness for core retrieval. 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.

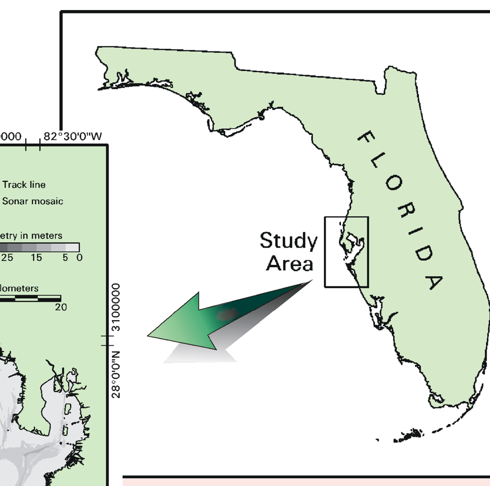
Geologic History and Morphodynamics of Barrier Islands

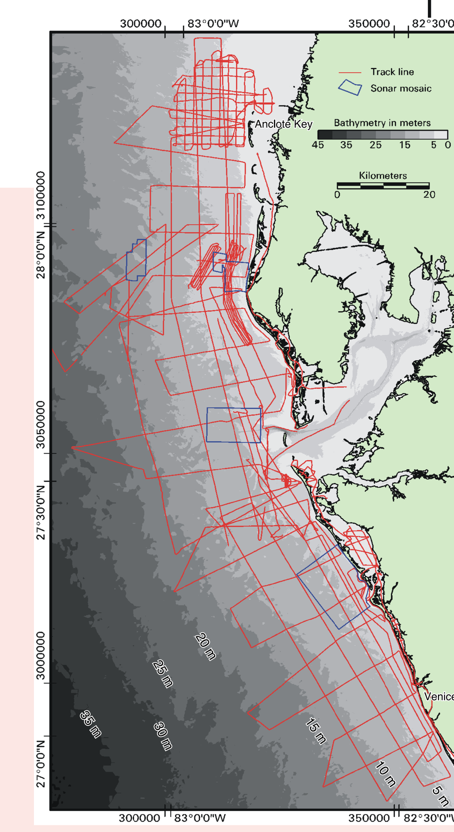
Barrier islands on the west-central Gulf coast of Florida display a wide range in morphology along the most diverse barrier/inlet coast in the world (Davis, 1994). In addition, the barriers have formed over a wide range of time scales from decades to millennia. The oldest of the barriers have been dated 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.

Sand Key

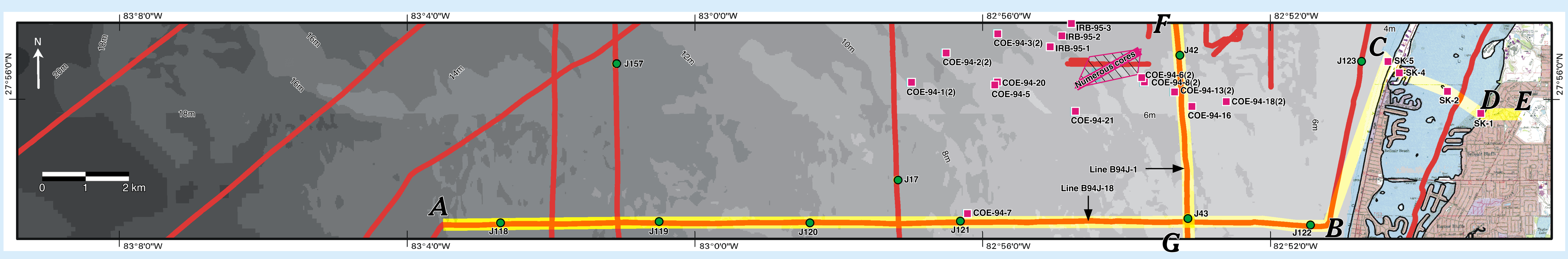
Sand Key is the longest barrier island in the study area and is distinctly wave-dominated. Its gross morphology is similar to a barrier spit that emanates both to the north and south from the Indian Rocks headland. It is probable that the barrier was never in contact with the headland although much of the sediment from which it is composed came from reworking of the headland by the Holocene transgression. Longshore transport diverges from the Indian Rocks area with a significant sediment flux to the north, as is shown by the large accumulation of sediment on the north end of Sand Key at the jetty that was completed in 1975. To date, the shoreline has prograded 500 m accumulating a volume of nearly 500,000 m^3 in only a couple of decades.

The stratigraphy of the northern part of Sand Key (Yale, 1997) shows a discontinuous Pleistocene (Stage 5e) muddy sand overlying the Miocene limestone. The sand is covered throughout by an organic-rich, muddy sand that represents a vegetated paralic environment. The next unit is a thick muddy and shelly sand that occupies the present back-barrier environment. This unit originated largely as washover deposits that were then bioturbated in a protected, low-energy setting. The barrier itself is composed of clean sand and shelly sand that represent the beach, supratidal washover fans, and dunes. The narrow barrier apparently migrated landward as evidenced by apparent back-barrier deposits that are present about 200 m offshore (Brooks and others, 1999).





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 areas. The bathymetry shown in 5-m intervals by gray shading is modified from Gelfenbaum and Guy (1999).

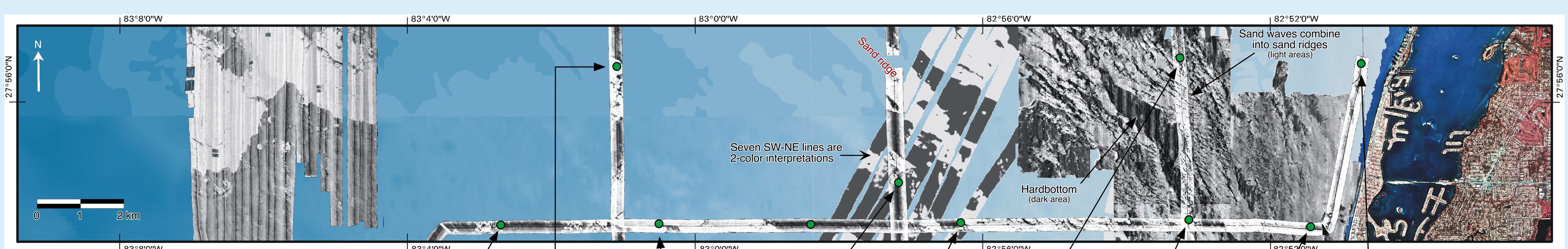


Location map

Location map showing bathymetry, cruise-track coverage, core and bottom sample locations, and location of figures. The area marked "numerous cores" is too densely sampled to display here and is reported in Harrison (1996) and Edwards (1998). The full transect cross section A-E is presented below. An expanded view of the island portion of the transect C-D is shown at lower right. Line F-G 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).

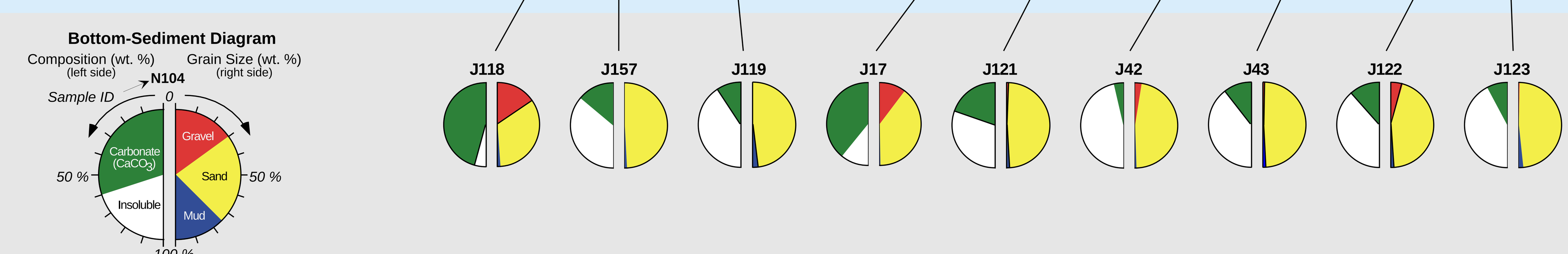
Projection: UTM, GRS 1980, NAD83, Zone 17. Coordinates: Geographic. Bathymetry in 2-m intervals starting at 4 m. Land areas represented by USGS 7.5-Minute Topographic Map.



Side-scan sonar data

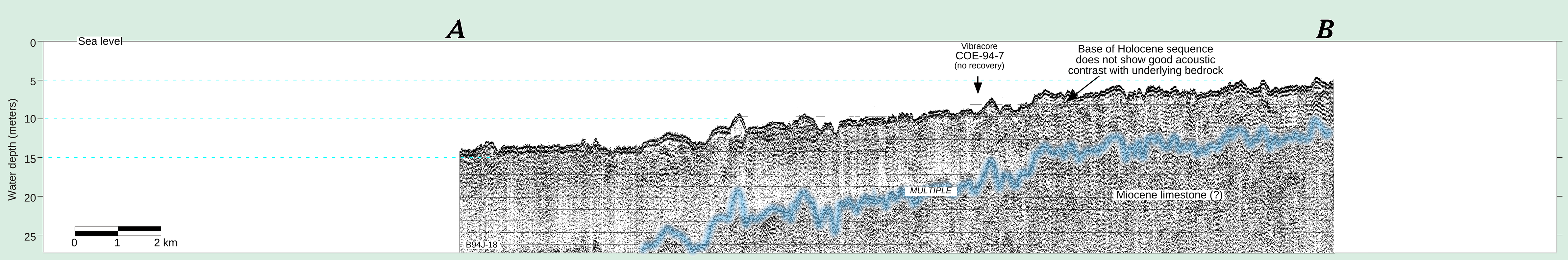
Side-scan sonar imagery available in this area includes reconnaissance surveys (Locker and others, 2001), sand resource surveys (Gelfenbaum and others, 1995) and those collected from 1995-1996 (Harrison, 1996, 1999 [nearshore mosaic]; Hafen and others, 1997 [offshore mosaic]). Low backscatter (light gray) areas correspond to sand ridges and flats dominated by siliciclastic sand. The dark (high backscatter) areas are largely coarse sediment veneer with increased carbonates (primarily shell material), or are hardbottoms. The imagery together with bathymetry reveals a northwest-trending sand-ridge morphology on the inner shelf in this region (inner mosaic). A closer look shows these features to be composed of smaller scale sand waves. Surface-sediment cover is thin (1 to 3 m) and exhibits a patchy and discontinuous distribution. Farther offshore (outer mosaic), sediment cover is thinner, more compacted, and more uniform - apparently lacking the sand-wave architecture found on the inner shelf. A series of northeast-trending swaths in the vicinity of 82°56' W longitude are presented as gray-scale interpretations only.

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).



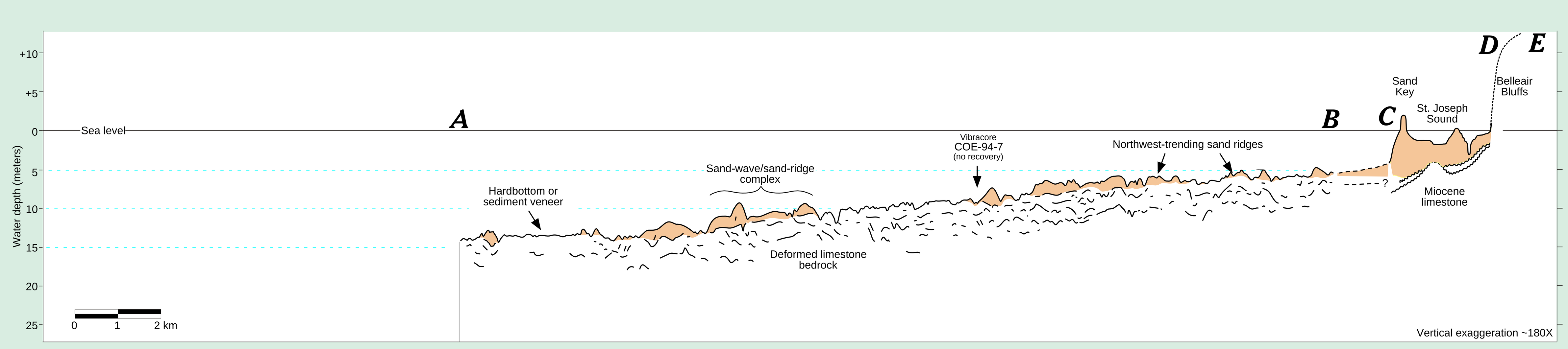
Surface sediments

Grain-size and composition data for bottom grab samples are presented below the sonar imagery. Samples generally consist of quartz-rich sand nearshore with increasing amounts of gravel and mud offshore. Sand-ridge deposits contain medium to fine siliciclastic sand with minor carbonate grains, which in turn correspond to low acoustic backscatter in the side-scan sonar imagery. The higher backscatter areas correlate with coarse grain size and increased carbonates. The coarse-grained facies is thin and typically exhibits ripple crests running N-S with a 40- to 70-cm spacing.



Seismic-profile data

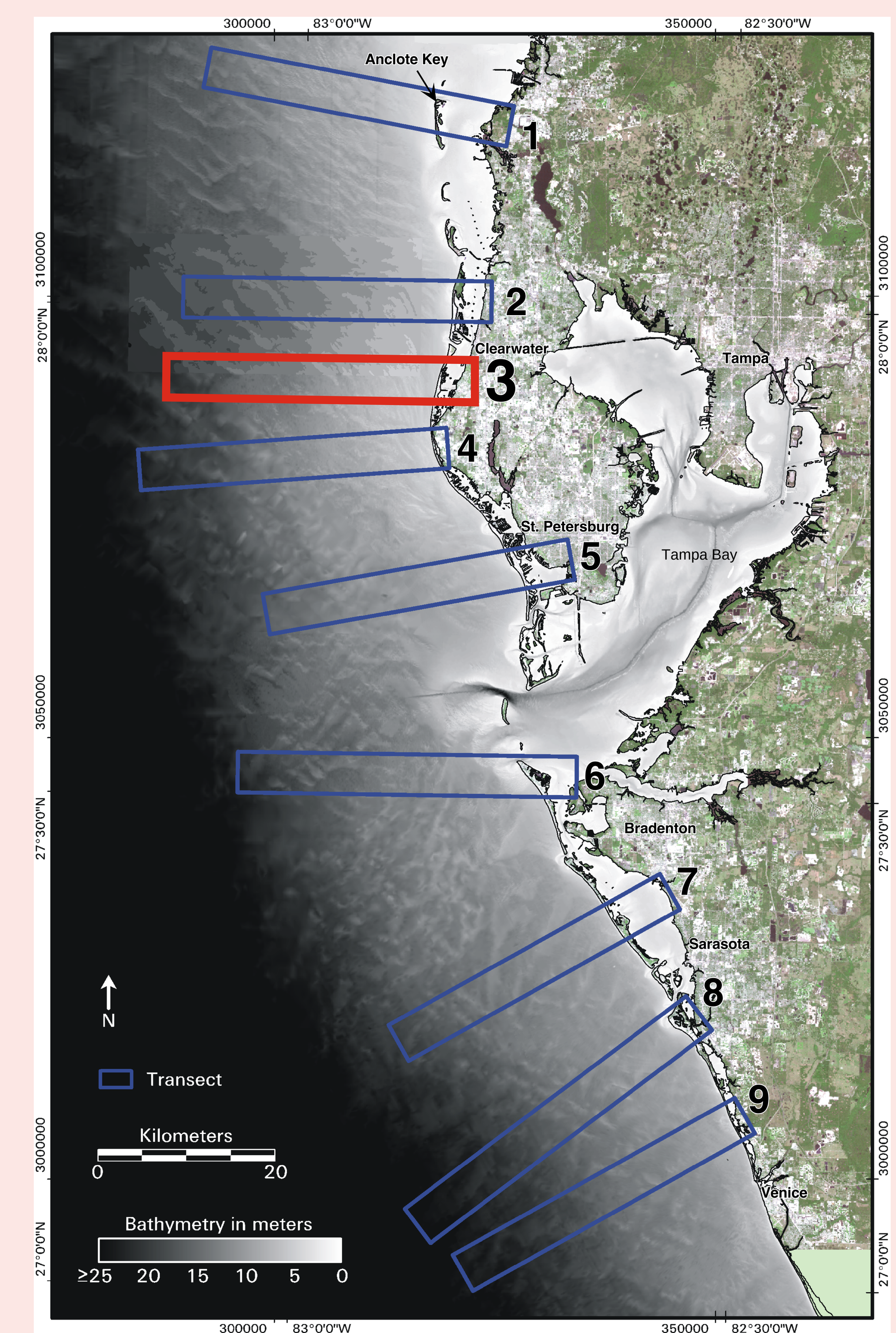
Uninterpreted "boomer" seismic profile illustrates the poor acoustic contrast between the Holocene sediment cover and the Pleistocene exposure surface. The poor contrast is typical throughout the region and is attributed to the karstic and weathered nature of the underlying pre-Quaternary bedrock. Overall, the base of the Holocene is extrapolated from vibracore data that supports the seismic interpretations. Additional evidence includes hardbottoms (pre-Holocene bedrock) and probe-rod measurements of sediment thickness. The modern sediment cover is usually less than 2 to 3 m thick, corresponding with the higher relief portions of the sand waves or ridges seen here.



Transect cross-section *A-E*

Integrated stratigraphic cross section combining line-drawn interpretation of seismic data, ground truthed by coring, with a coastal cross section based on vibracores. Cores in the offshore transect have no cross-shelf correlation potential because they often contain different ridge deposits, shown in side-scan sonar imagery and bathymetry data. Most of the sediment volume in this coastal system is found in the barrier-island section.

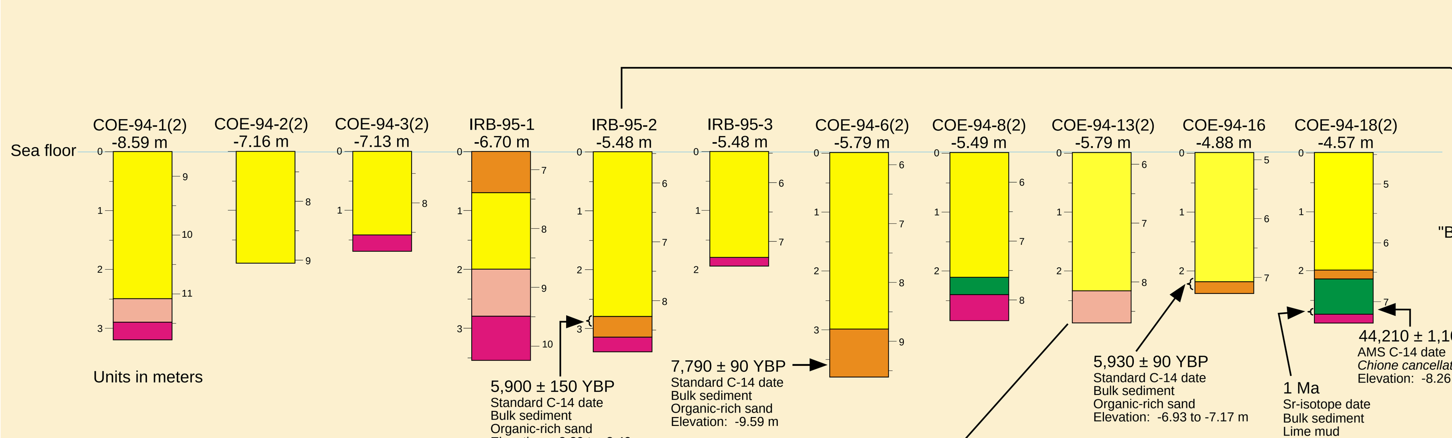
- Holocene sediment

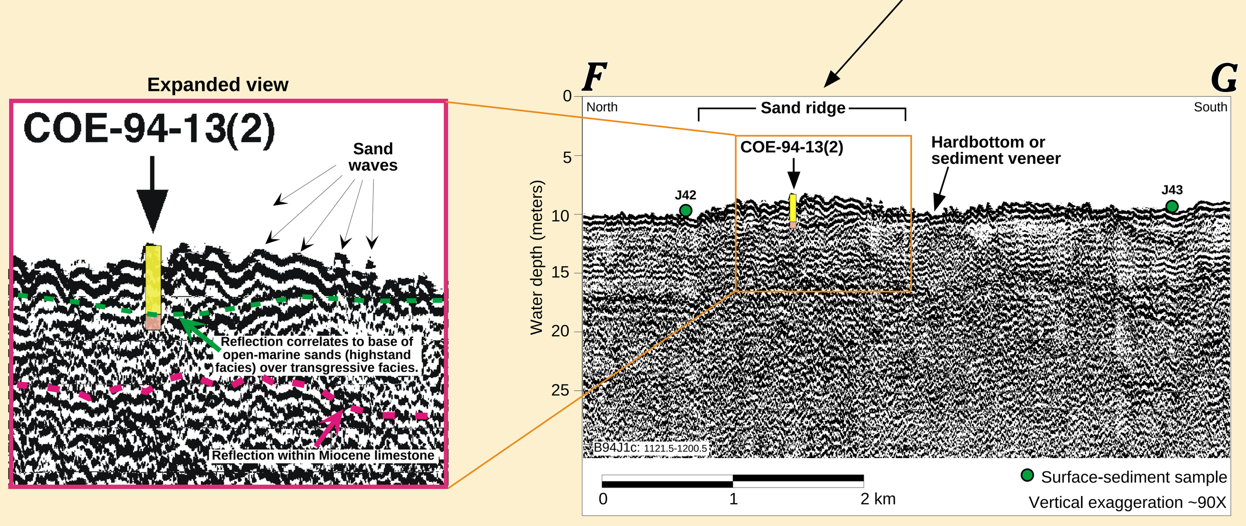


Location of west-central Florida coastal-transect maps with Transect #3 shown in red. 1997 LANDSAT TM imagery of Florida's west coast is merged with a bathymetric-surface model (Gelfenbaum and Guy, 1999). Bathymetric trends offshore in part reflect sediment-distribution patterns. The study area extends from Anclote Key to Venice, FL.

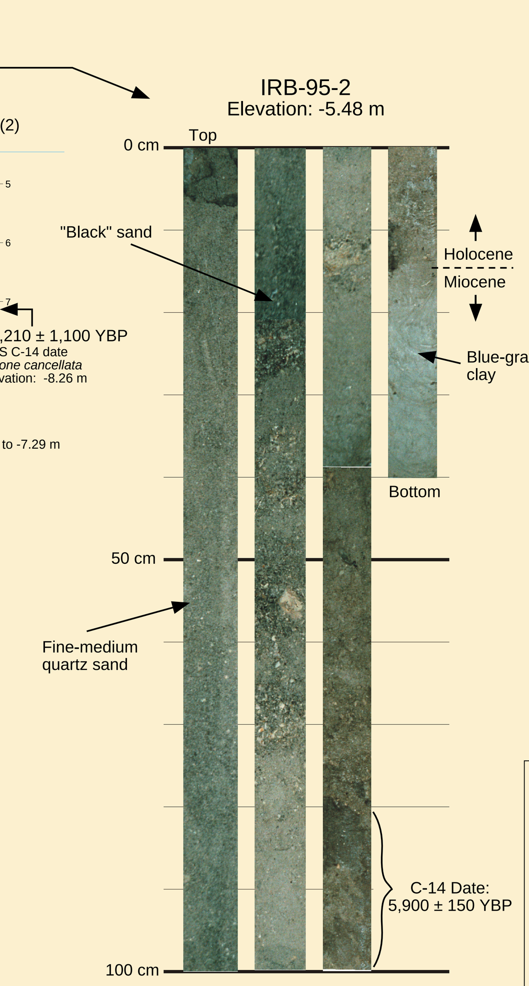
Oblique aerial photograph of Sand Key taken in 1983. Note that the beach has eroded back to the seawall, which extends beyond the width of the photo. Extensive beach nourishment has been done here in recent years. This area also represents one of the narrowest points along Sand Key. The island-transect portion (C-D) is shown with vibracore locations and descriptions below.

Offshore Cores





Core Data



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 identifying pre-Holocene stratigraphy. Core elevations were determined from water depth and tide tables. The datum for the barrier-transect cores is the mean lowest low water (MLLW). Core photographs are shown for IRB-95-2 (offshore sand ridge) and SK-4 (back barrier).

Offshore vibracore retrieval ranged from 1 to over 3 m in the sand ridges. The contact between Holocene sand and Miocene limestone and clay was recovered in numerous cores (see IRB-95-2 photo). Vibracore COE-94-13(2) shown at left with seismic section F-G shows good agreement with acoustic stratigraphy. A reflection beneath the sand ridge coincides well with a sedimentary facies change from a fine-medium quartz sand above, to a gravely sand containing mud lenses, black grains, shell debris, and limestone fragments.

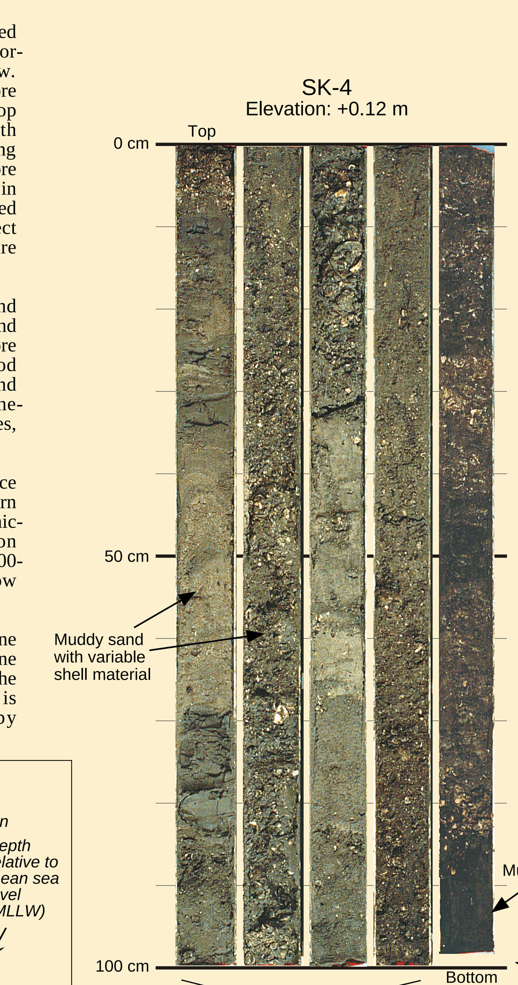
All cores contain a surface layer dominated by quartz sand. The surface layers are interpreted to be of open-marine origin and represent modern marine conditions. Uncorrected standard radiocarbon dates on organic-rich sands (bulk sediment) near the base of the Holocene section indicate the transition to open-marine conditions occurred about 5,900-7,790 years before present (YBP) at approximately 7 to 9 m below present sea level, respectively (Brooks and others, 1999).

The cross section shown to the right (Yale, 1997) reveals the Holocene section onlapping non-marine paralic deposits and Miocene limestone bedrock. On cross sections where cores do not penetrate to bedrock, the control is based on probe-rod data. Most of the stratigraphy here is dominated by washover deposits that have been reworked by bioturbation to the muddy sand facies.

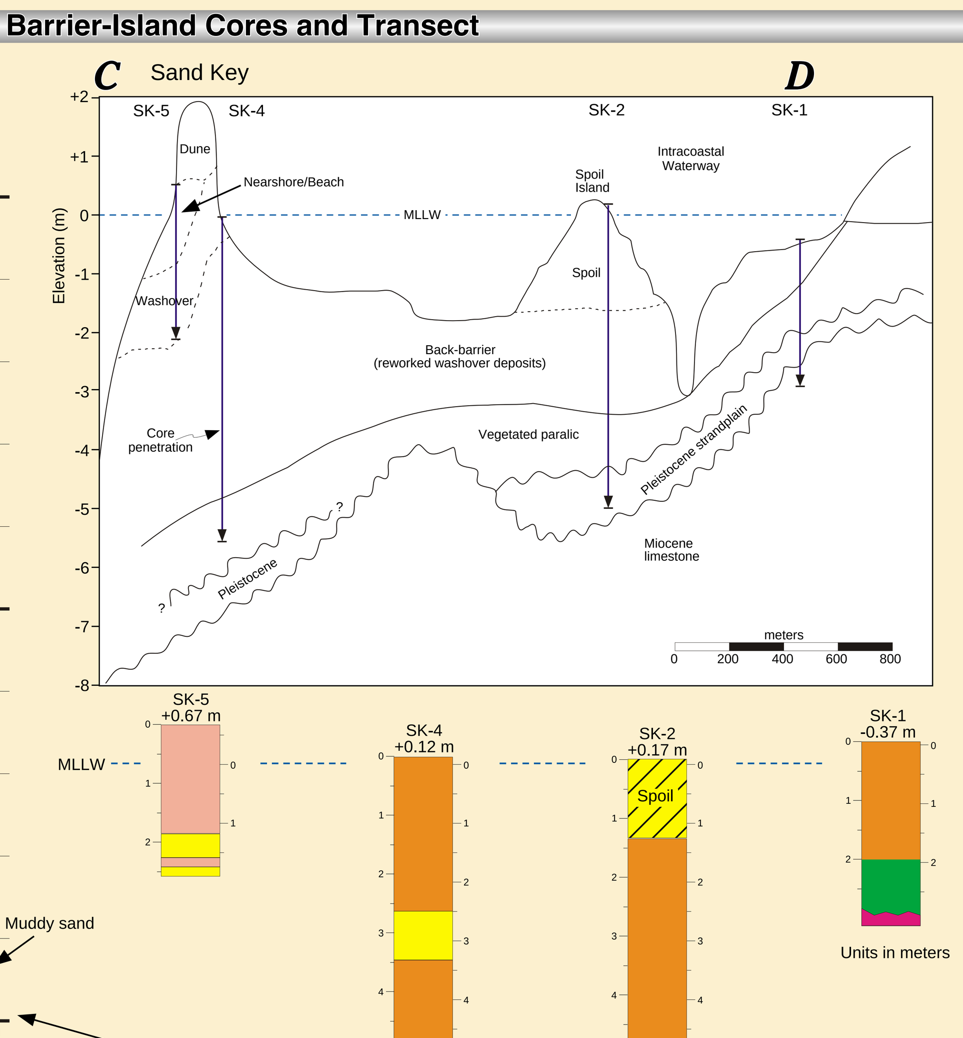
Explanation: core logs and sedimentary facies

- 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



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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