SAND RESOURCES, REGIONAL GEOLOGY, AND COASTAL PROCESSES FOR THE RESTORATION OF THE BARATARIA BARRIER SHORELINE

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EXECUTIVE SUMMARY

Louisiana's barrier shorelines are rapidly eroding due to high rates of relative subsidence combined with sea-level rise, repeated storm impacts, and a diminishing sand supply. Due to these factors Louisiana's barrier shorelines are the fastest eroding shorelines in the Nation. In places, the erosion of barrier islands exceeds 65 ft/yr (20 m/yr). One of the best methods for protecting Louisiana's coastal resources from encroachment from the sea is shoreline restoration using coastal and nearshore sediment sources. The key to restoring barrier shorelines is to find large volumes of high-quality sand and developing cost-effective shallow delivery systems to move these materials.

The first major barrier shoreline restoration project proposed by Coast 2050 planners is for the Barataria Basin barrier shoreline that stretches 50 mi (80.5 km) from Belle Pass east to Sandy Point. Many of the barrier shoreline areas in Barataria Basin have become fragmented, low mounds of sand, that are easily washed over by minor storm events, that provide less available habitat than fully developed barrier islands.

The objective of this study is to provide information about sand resources, coastal processes, and regional geology which can be collectively used to restore the Barataria Basin barrier shoreline. The focus of this study is the identification of sand resources for the restoration of beaches and creation of backbarrier marshes along this portion of the coast.

Many coastal and geologic studies have been conducted in Louisiana leading to our present understanding of the geologic framework and processes of the Barataria study area. Although these reports and inclusive data were an invaluable resource, the lower resolution of the available technology and more widely spaced data points limited the results of earlier studies.

Sand resource targets for this study had to meet basic criteria defined by the U.S. Army Corps of Engineers, New Orleans District. The parameters for economical sand-mining operations were that sand deposits: (1) contain more than 60% sand; (2) sand deposit thickness minimally be 3 ft (0.9 m) for surficial deposits or 5 ft (1.5 m) or more for sand deposits with sediment overburden; and (3) depth of sand deposits below mean sea level must not exceed 60 ft (18.3 m).

The U.S. Geological Survey, University of New Orleans, and U.S. Army Corps of Engineers – New Orleans District cooperative project collected 652.5 line-mi (1,050 line-km) of high-resolution single-channel seismic sonar reflection profiles using ‘Boomer’ and ‘CHIRP’ sources. In combination these two sources provide a good cross-sectional profile of shallow geology. Potential sand deposits were identified from seismic and sonar data. More than 250 sediment cores and borings were collected to confirm the sand deposits identified and to provide subsamples for textural analysis.

We found during this study that the basic geologic framework agrees with the findings of previous geologic reports. The data density within this new data set provides a high level of detail not normally available from previous geologic framework studies. Geologic interpretations of these data indicate a very high degree of lateral variability within the strata and facies.

Seismic and sonar interpretations verified with geologic samples (vibracores and borings) indicate that there are 9 sand targets within the Barataria study area that meet or exceed the minimum criteria for potential mining sites. The Western section of the study area has no targets that meet the criteria, 6 targets are found in the Central section and 3 targets in the Eastern section. The sand units are associated with geologic depositional systems such as ebb-tidal deltas, distributary mouth bars, and channel fill (undifferentiated fluvial or tidal inlet channels). Individual sites range from small compact surficial deposits (Caminada) to large buried deposits with large volumes of overburden (Sandy Point). In this study, we identified 396 to 532 mil yd^3 (305.8 to 410.8 mil m^3) of sand that has the potential to be used for shoreline restoration.

The 9 potential sand targets found by this study consist primarily of fine sand and can be delineated into 3 surficial and 6 buried targets. The surficial targets (Caminada, Barataria Inshore, and Quatre Bayou Shallow) contain approximately 10% of the total sand resources identified. A full 90% of the sand body areas found will need overburden sediment removed; almost 570 mil yd^3 (438.5 mil m^3) of overburden will need to be removed if the entire resource is mined.

This report recommends using the sand for shore face restoration and the overburden to build back-barrier platforms for marsh restoration. The result will provide better barrier shoreline protection. Due to the sparse sand resources of this coastal system, Ship Shoal (a large clean surficial sand deposit) should be considered as an alternate resource, even though it is located outside the immediate study area.

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INTRODUCTION

Louisiana's barrier islands and headlands are rapidly eroding and disappearing (Williams and others, 1992). The nation's shorelines are receding at an average rate of slightly more than 1 foot (ft) per year (yr) (0.3 m/yr), but rates vary significantly across regions and shoreline types (Leatherman, 1993). According to Leatherman (1993), 80 to 90 percent of the sandy beaches in the United States are eroding. The East Coast erosion rate averages 2 to 3 ft/yr (0.6 to 0.9 m/yr). However, these rates can vary over short distances (e.g., 1 mile – 1.6 km or less) because of geology, inlets, and engineering structures. Due to high rates of relative subsidence combined with repeated storm impacts and a diminishing sand supply, Louisiana's barrier shorelines are the fastest eroding shorelines in the Nation. In places, the erosion of barrier islands exceed 65 ft/yr (20 m/yr) (Penland and Boyd, 1981; McBride and others, 1992). Humans have contributed to this erosion problem building coastal structures that disrupt natural patterns of sediment dispersal and coastal evolution. Louisiana's barrier shorelines form the seaward boundaries of the major estuarine basins within the Mississippi River delta plain. For the interior delta plain these barrier shorelines form the first line of defense against winter storms and hurricanes. As barrier shorelines retreat, the tremendous natural, and human resources lying landward are at an increasing risk of destruction and loss. The key to restoring barrier shorelines is to find large volumes of high-quality sand and developing cost-effective shallow-delivery systems to move this material.

This study is sponsored under the Coast 2050 Management Plan. Coast 2050 is a collective effort among Federal, State, and local governments to describe, maintain and restore Louisiana's barrier shoreline and coastal resources. The effort has been affirmed by the adoption of the plan by the Louisiana Coastal Wetlands Conservation and Restoration Task Force and the Wetlands Conservation and Restoration Authority as their official restoration plan, the transmission of this plan to the U.S. Department of Commerce by the State of Louisiana to incorporate it into the Louisiana Coastal Resources Program Guidelines, and resolutions of support from 20 coastal parish councils and police juries. The first major barrier shoreline restoration project proposed by the Coast 2050 Management Planning Team is the Barataria Basin barrier shoreline that extents 50 mi (80.5 km) from Belle Pass east to Sandy Point (Fig. 1). This barrier shoreline forms the southern boundary of the Barataria Basin which is one of the richest and most viable estuaries in Louisiana (Gosselink, 1984). The objective of this report is to provide necessary information on the available sand resources to restore this barrier shoreline. The US Geological Survey (USGS) in partnership with the Coastal Research Laboratory at the University of New Orleans (UNO) and US Army Corp of Engineers, New Orleans District (USACE – NO) conducted a detailed analysis of the Barataria Basin barrier shoreline in support of the restoration effort for the barrier shoreline.

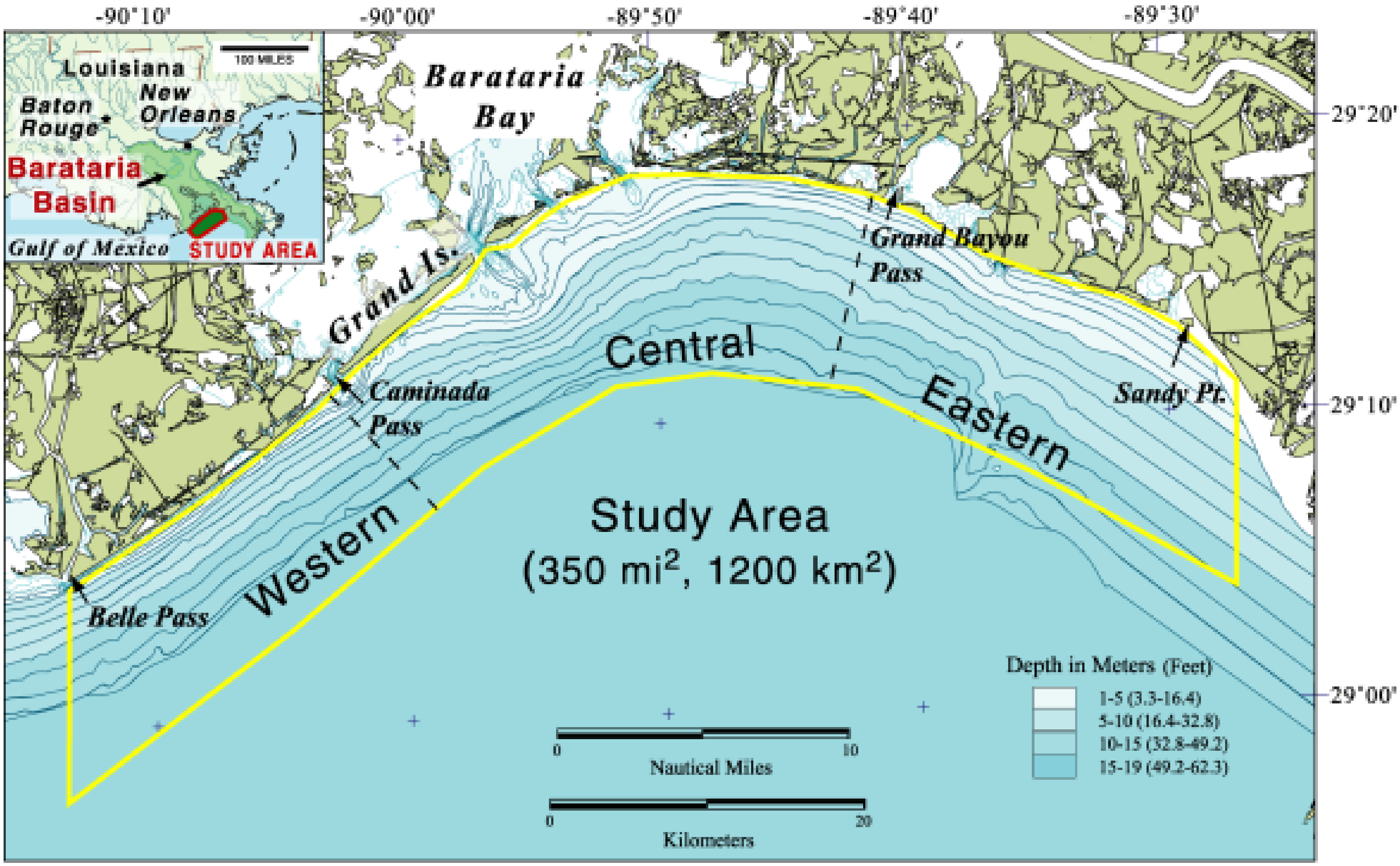


Figure 1. Map showing Barataria Shoreline Restoration Study Area from Belle Pass to Sandy Point to 7 n mi (13 km) offshore. Insert shows location of study area in relation to southern Louisiana.

SCOPE OF STUDY

The objective of this study is to provide information on sand resources, coastal processes, and the regional geology to aid in the decisions on restoration of the Barataria Basin barrier shoreline. The focus of this study is the identification of sand resources for restoring the beaches and islands along this coast as well as the creation of backbarrier marshes. Additional information on shoreline changes, sea floor changes, coastal processes, and regional geology is provided to support the planning and engineering design of the Coast 2050 Management Planning Team.

STUDY AREA

Barataria Basin barrier shoreline is located in south central Louisiana on the west side of the Mississippi River delta plain. The study area described in this report includes the shoreline of Belle Pass at Bayou Lafourche eastward to Sandy Point to an offshore distance of 7 nautical miles – n mi (13 kilometers – km) (Fig. 1). The limits of the area are 90˚11'00" to 89˚29'00"W. and 29˚05'00" to 29˚18'00"N. The study area encompasses barrier islands including Grand Isle (the only barrier island with a permanent settlement in Louisiana), Grand Terre Isles and tidal inlets such as Caminada, Barataria, and Quatre Bayou Passes. To promote a systematic discussion of the results, the area has been partitioned into Western, Central, and Eastern sections (Fig. 1). The Western section extents from Belle Pass to Caminada Pass, Central section from Caminada Pass to Grand Bayou Pass, and Eastern section is from Grand Bayou Pass to Sandy Point. The study area is approximately 350 n mi^2 (1200 km^2).

SEDIMENT BUDGET AND DISPERSAL

SEA FLOOR CHANGE 1880 TO 1980's

Much of the following discussion extracts information from the Barrier Island Coastal Erosion Study completed by List and others (1994). Their study documented sea-floor elevation along the western Mississippi River deltaic coast of Louisiana and presented the patterns of sea-floor erosion and accretion necessary to understand large-scale processes of sediment transport. Readers are referred to that publication for a thorough discussion of sea-floor change analysis.

In the Bayou Lafourche region (Western section in this study), erosional and depositional patterns assume a much larger scale than the rest of the study area. The dominant aspect in this area is the massive erosion of the Bayou Lafourche shoreface from the eastern end of Timbalier Island (west of Belle Pass) to Caminada Pass. This erosion extends to at least the 42.6 ft (13 m) depth contour offshore, and between 1880 and 1980 reached a maximum of over 19.7 ft (6 m) of vertical change seaward of Bay Champagne. In the 1880's to 1930's comparison, 571.2 mil yd^3 (439.4 mil m^3) of sediment were eroded (area 25.1, p.18; and area 25.2, p.19, List and others, 1994). Similarly, in the 1930's – 1980's comparison, 599.7 mil yd^3 (461.3 mil m^3) of sediment were eroded (Fig. 2). Patterns of accretion suggest several pathways of sediment transport away from this rapidly eroding headland. An area of deposition probably derived at least in part from erosion of the Bayou Lafourche headland is located to the east, on the shoreface between Caminada and Quatre Bayou Passes.

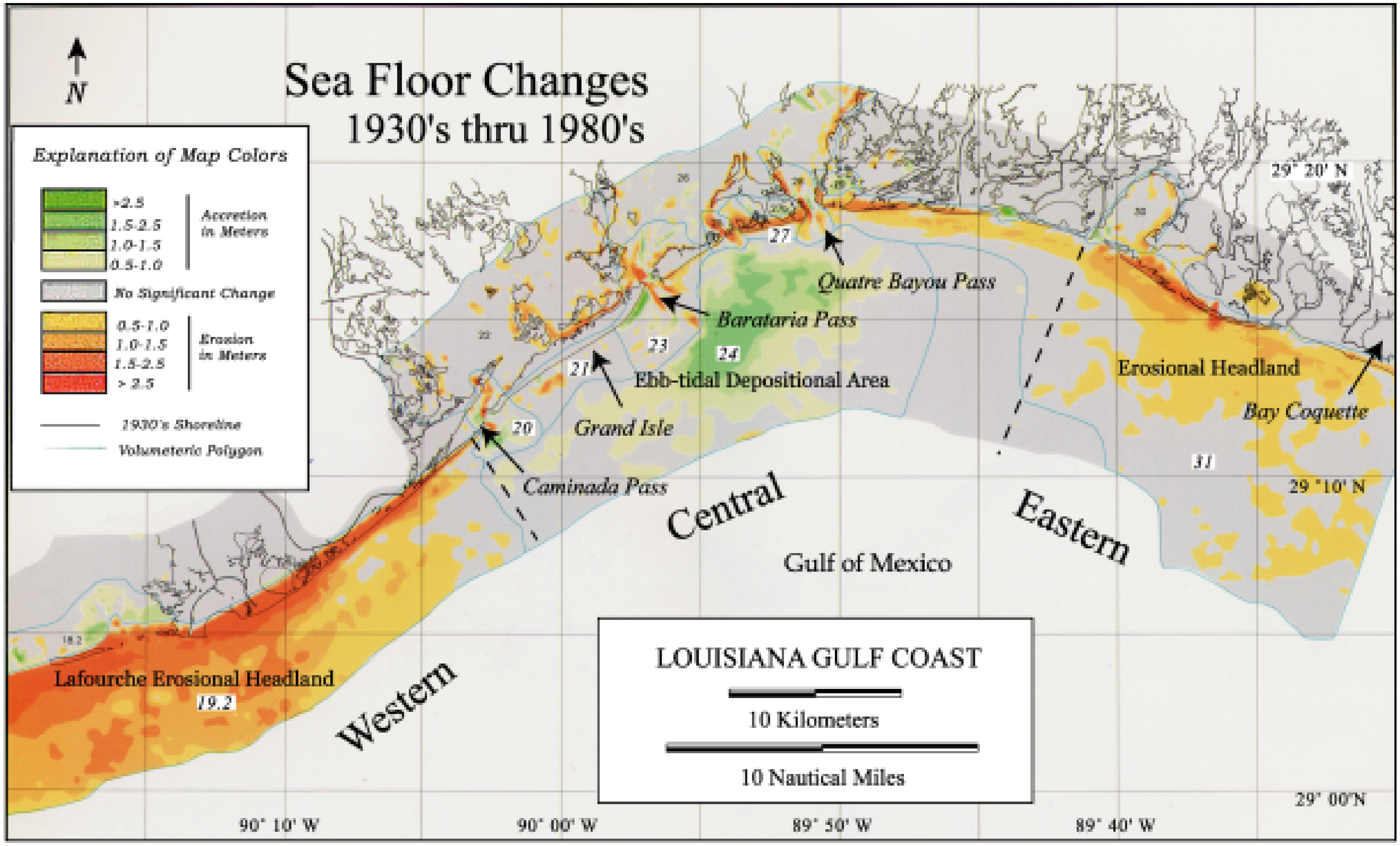


Figure 2. Map showing sea floor erosion and accretion by comparing the 1930's bathymetry to the 1980's bathymetry from Belle Pass to Sandy Point. The yellow to red colors represent erosion with the lighter yellow 0.0 to 1.64 ft (0.0 to 0.5 m) and the dark red represent 16.4 to 32.8 ft (5.0 to 10.0 m) and greater. The green colors represent accretion with the lighter green 0.0 to 0.5 m, dark green 8.2 to 16.4 ft (2.5 to 5.0 m) (Modified from List and others, 1994).

The changes within the Barataria region are dominated by one very large-scale process: erosion of headland areas with subsequent deposition on the shoreface adjacent to tidal inlets connecting the Gulf of Mexico to Barataria Bay (Fig. 2). These headlands include the Bayou Lafourche headland in the western section of this study and the coastline east of Quatre Bayou Pass to Bay Coquette in the Eastern section of this study.

The depositional area offshore from the inlets connecting Barataria Bay to the Gulf of Mexico (area 30, p.19 for the 1880's – 1930's comparison (List and others, 1994) and area 24, for the 1930's – 1980's comparison, Fig. 2) contains the largest volume of deposited sediment in this area (191.6 mil yd^3 – 147.4 mil m^3 for the earlier period and 145.6 mil yd^3 – 112.0 mil m^3 for the latter period). In the 1930's – 1980's comparison, this depositional body coincides with what appears to be a series of large, coalesced ebb-tidal deltas between Barataria and Quatre Bayou Passes (Fig. 2). List and others (1991) investigated the volume of sediment stored in these ebb-tidal deltas using the method of Dean and Walton (1975). They found changes in ebb-tidal delta volume during the last 100 years closely correspond with changes in the Barataria Bay tidal volume, according to the empirically derived relation of Walton and Adams (1976).

The depositional area 24 (Fig. 2), as described by List and others (1994) investigation, lies within a region where the ebb-tidal deltas are in equilibrium with the local tidal volume. Visual estimates of grain size from sediment cores taken by the Louisiana Geological Survey (LGS) preliminarily indicate that this deposit contains a small fraction of sand, but predominantly composed of silt- and clay-size material. List and others (1994) inferred that the depositional processes within area 24 are different from those generally assumed for sandy coastal systems in which sand is cycled between the ebb-tide delta and littoral zone by a combination of wave-induced and tidal currents (Oertel, 1988).

List and others (1994) concluded that volumetrically, the material could have been derived from the massive erosion of adjacent headlands, although no mechanism, even of a conceptual nature, is known by which such fine material could have been eroded from these headlands and deposited in the ebb-tidal delta region. Another potential source, the erosion of adjacent shorelines and the deepening of nearby inlet channels, must be largely discounted due to the lack of a sufficient volume of sediment (in the 1930's – 1980's comparison, in Fig. 2 for example, a total of only 30.6 mil yd^3 (23.5 mil m^3) was eroded from areas 21, 23, 23, 27a, and 28). Another source may be fine sediment flushed from Barataria Bay on the ebb-tidal flow. However, this process assumes a net export of sediment from Barataria Bay, and, again, a mechanism by which such fine sediment could be deposited in the form of an ebb-tidal delta. Clearly, research is needed on the transport and deposition of fine-grained sediment in this area.

SHORELINE SEDIMENT TRANSPORT

List and others (1994) used the sea-floor change data to examine coastal evolution in terms of the balance or budget of eroding and accreting sediments. Again we extract much of the following information from the Barrier Island Coastal Erosion Study done by List and others (1994). Overall, they reported only 35% as much deposition (380.1 mil yd^3 – 293 mil m^3) as erosion (1084 mil yd^3 – 834 mil m^3) throughout their central Louisiana study area in the 1930's – 1980's comparison. However, sediment cores collected during the Barrier Island Coastal Erosion Study suggested that only about 31% of the sediment eroded from the retreating shoreline was of sand size, whereas most of the sediment deposited in the nearshore is sand size except in area 24 for where the material deposited is composed of silt- and clay-size sediment (Fig. 2). Estimating (roughly) that deposition in area 24 was 20% sand whereas other depositional bodies were 100% sand, there was a net sand deposition of 266.6 mil yd^3 (203.8 mil m^3) versus a net erosion of 371.2 mil yd^3 – 258.5 mil m^3 (31% of total erosional volume). Within the error estimated for volumetric calculations, this produces a net sand balance. List and others' (1994) bathymetric comparisons appear to encompass the majority of the sea-floor changes in the study area. However, they did not discount the possibilities that sand was transported offshore beyond the depth limit of the hydrographic survey or dispersed widely such that the elevation change was within the error of the bathymetric comparisons.

Assuming that the comparisons had not missed major bodies of deposited sand, the patterns and volumes of deposits can be used to better understand and perhaps predict the future erosion of certain coastal reaches. This approach was taken by List and others (1991), who examined the erosion of the Bayou Lafourche shoreline in terms of an equilibrium shoreface profile following the "Bruun Rule" (Bruun, 1962) and a modified Bruun Rule (Everts, 1985). In summary, the Bruun Rule states that if the shoreface profile retains the same form (the equilibrium assumption) during shoreline retreat, and if the profile maintains a constant elevation in relation to a rising sea level, then the rate of shoreline retreat can be predicted from the sea-level rise during a certain time period.

For the Bayou Lafourche shoreline, List and others (1991) showed that despite an extremely high rate of relative sea-level rise in the study area (approximately 0.4 in/yr – 1 cm/yr; Penland and Ramsey, 1990), only about one-third of the observed shoreline retreat was directly attributable to sea-level rise. The difference could be made up by accounting for the sediment removed in the longshore direction as determined through sediment-budget analysis.

List and others (1994) have shown that the equilibrium profile approach of hindcasting shoreline erosion works well in other highly erosive headland areas, such as along the Isles Dernieres but does not work where deposition occurs on the shoreface, such as between Barataria Pass along the Grande Terre Isles shoreline to Quatre Bayou Pass. In these areas, where the shoreface is being nourished and yet the shoreline is still eroding, the equilibrium assumption fails. Clearly a more process-based approach will be required to hindcast shoreline erosion in these areas.

Predictions of shoreline erosion with changing future conditions can also be made for headland areas using the equilibrium approach. List and others (1991) predict that a 100% increase in the rate of relative sea-level rise along the Bayou Lafourche headland would increase the shoreline erosion by only about 35%. However, this prediction assumes that the rate of longshore sand removal from the headland will remain constant under the scenario of a doubled sea-level-rise rate, which currently cannot be verified.

COAST 2050

> Wetland loss in coastal Louisiana has reached catastrophic proportions, with current losses of 25 to 35 square miles per year. Since the magnitude of the problem was identified in the 1970s, we have gained much insight into the processes that lead to wetland creation and destruction. The disappearance of Louisiana's wetlands threatens the enormous productivity of its coastal ecosystems, the economic viability of its industries, and the safety of its residents. (Coast 2050: Toward a Sustainable Coastal Louisiana, 1998)

In 1998, the State of Louisiana and its Federal partners approved a coastal restoration scoping study entitled Coast 2050: Toward a Sustainable Coastal Louisiana. That document presented strategies jointly developed by Federal, State, and Local interests to address Louisiana's massive coastal land-loss problem. While the long-term goal for coastal restoration under the Coast 2050 plan is to implement projects throughout coastal Louisiana, the Barataria Basin is in dire need of immediate attention (Fig. 1). Barataria Basin has a very high rate of wetland loss, estimated at about 9 square statute miles – mi^2 (28.5 km^2) for the 7-year interval from 1983 to 1990 (Dunbar and others, 1992).

The barrier shoreline in Barataria Basin from Belle Pass to Sandy Point has undergone significant movement and reduction in size during the past 100 years. While some lateral movement of the shoreline is expected as sand is reworked in the nearshore environment, the shoreline has retreated rapidly. Tidal passes that have opened in the islands during the passage of storms have not resealed in fair weather. The tidal volume increase of Barataria Bay that has occurred as a result of wetland losses in the Barataria Basin has amplified the barrier shoreline loss rate.

Many of the barrier shoreline areas in Barataria Basin have become nothing more than fragmented, low mounds of sand, that are easily washed over by minor storm events, and provide less available habitat than fully developed barrier islands. For example, it is predicted that Grand Terre Island may be gone by 2008 (Reed and others, 1995). The Barataria barrier islands have decreased in area by 47 percent from the 1890s to 1988 (Williams and others, 1992). As the barrier shorelines become narrower and fragmented, bays and wetlands behind them become more directly connected with the Gulf of Mexico. This fragmentation exposes the more fragile back-barrier environments to increased wave action and higher salinity water.

Behind Barataria Basin barrier shorelines are wetlands that are also disappearing rapidly. Reed and others (1995) calculated land loss for the Barataria basin from available habitat data to be 7.8 mi^2 per yr (20.2 km^2 or 0.74% per yr) for the period from 1958 to 1978. They also reported that for the period from 1978 to 1988/90 the land-loss rate was 11.1 mi^2 per yr (28.75 km^2 or 1.3 to 1.5 % per yr). This area is one of only a few in coastal Louisiana where marsh loss rate has continued to increase. Because of its proximity to the Gulf of Mexico, high relative subsidence rates, and high loss rates, most of the remaining wetlands behind the barrier shorelines are expected to be lost in coming years.

Calculations from the Coast 2050 plan show that with no restoration efforts the environments behind the barrier shorelines could lose from 47% to 95% of the 1990 area by 2050. Within 100 years much of the Barataria shoreline (shoreline of the study area, Fig. 1) will be gone and a series fragmented islands will remain. Without these island barriers impact of storm waves will increase. Most of the marsh present today will be gone thus exposing hurricane protection levees to open water, increasing maintenance costs of the levees and leaving area residents more vulnerable to wave energy, storm surge, tidal inundation and hurricane damage.

REGIONAL GEOLOGY
OF THE LOUISIANA DELTAIC PLAIN

The Barataria shoreline is located in the Mississippi River delta plain, which is a very complex depositional system with considerable vertical and lateral variability. Previous researchers have demonstrated that with close examination of deltaic sedimentary facies predictable patterns of deposition can be discerned. Understanding the regional geologic framework provides an exploration strategy to locate appropriate sand resources within complex geologic systems.

HOLOCENE GEOLOGY

The 300-km-wide deltaic plain is the product of continuous sediment accumulation deposited by the Mississippi River and its distributaries during the last 7,000 to 8,000 years as sea-level rose to within -10 m of its present position. Assembled as overlapping, stacked sequences of unconsolidated sands and muddy sediments, the deltaic plain is composed of six major delta complexes (Fig. 3) consisting of at least 18 smaller deltaic lobes. Many classic studies, (e.g. Fisk, 1955, 1961; Kolb and van Lopik, 1958; Coleman and Gagliano, 1964; Frazier, 1967) have focused on the regressive phase of Mississippi delta sedimentation. For the corresponding transgressive component of the Mississippi delta there are relatively few discussions except for those of Boyd and Penland (1981) and Boyd and others (1989). Using geophysical data, results from deep sediment boreholes, and careful mapping of surficial landforms, van Andel (1960), van Andel and Poole (1960), Frazier (1967), Coleman (1988), Boyd and Penland (1988), and Boyd and others (1989) discussed the evolutionary history of the delta plain. The spatial relation of ancestral and active deltas are shown in Figure 3.

Processes controlling deltaic plain development consist of the establishment of the prodelta platform in shallow water followed by progradation of the delta and bifurcation of the distributary channel. The delta construction phase continues until the channel becomes so distended that it is no longer hydrologically efficient. Channel shifting and then abandonment of the old channel occurs in favor of the shorter and more efficient course to the coast. Cut off from its sediment source, the abandoned delta subsides by compaction. Marine coastal processes erode, winnow, and rework the seaward margin of the abandoned delta. Sandy headlands and barrier beaches result from the reworking process and continue to undergo transgression, resulting in segmented barriers separated by tidal inlets, backed by shallow bays and lagoons.

Along with periodic shifts in the course of the Mississippi River, sea-level rise also has influenced the development of the deltaic plain. From maximum lowstand at approximate depths of -360 to -490 ft (-110 to -150 m) at the end of the Pleistocene epoch (Curray, 1969; Frazier, 1974; and Suter and others, 1986), relative sea-level rose rapidly (> 0.065 ft/yr, > 0.02 m/yr) during the early Holocene to a sea level around -30 ft (-10 m) of present day levels by 7,500 years BP (Coleman, 1988; Penland and others, 1988). Since the middle Holocene, relative sea level has continued to rise, primarily due to compaction and subsidence of thick Holocene sediments (> 300 ft – > 100 m).

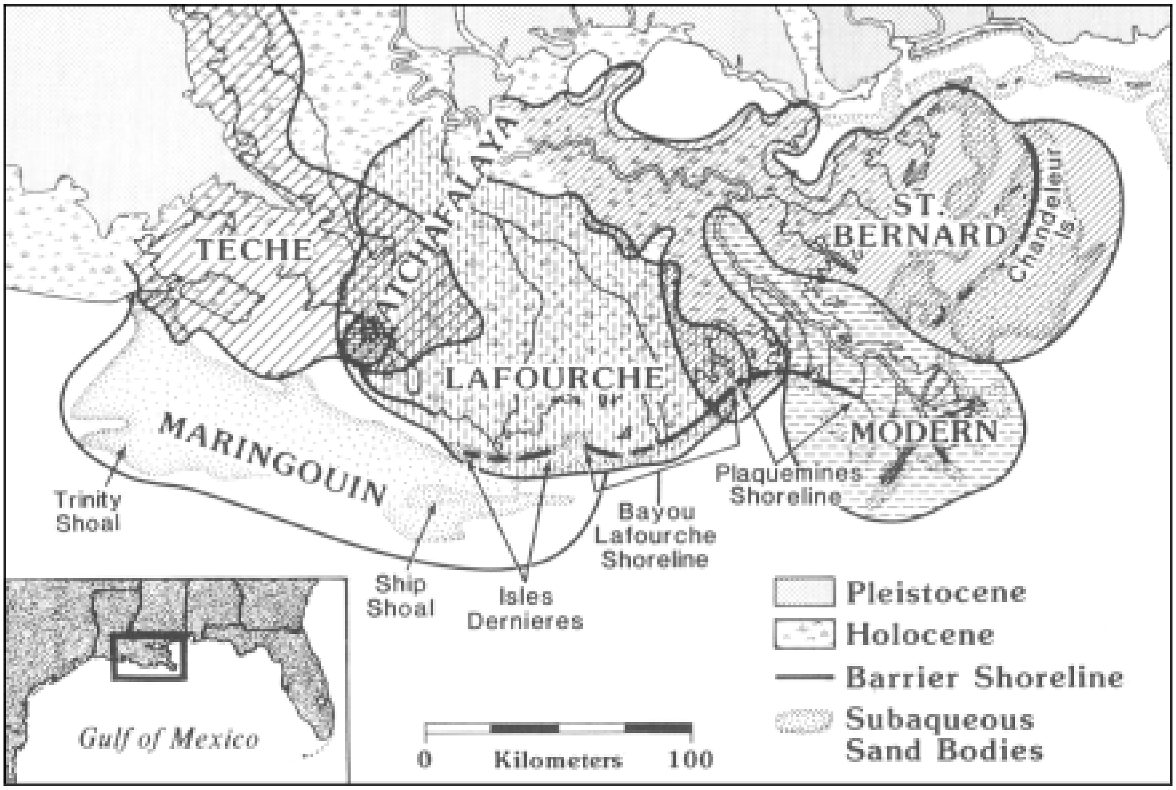


Figure 3. Holocene Mississippi River delta plain showing the distribution of transgressive barriers and shoals. From ~7,000 years to present the Mississippi River has built a delta plain consisting of six delta complexes; four are abandoned (Maringouin, Teche, St. Bernard, and Lafourche), and two are active (modern and Atchafalaya) (From Penland and others, 1988).

COASTAL GEOMORPHOLOGY

Western and Central Sections - Bayou Lafourche Coastline

The late Lafourche coastline consists of the erosional headland of Bayou Lafourche fronted by the Caminada-Moreau coast and two nearly symmetrical sets of flanking barriers; Caminada Pass Spit and Grand Isle to the east and the Timbalier Islands to the west (Fig. 4). This discussion extracts information from publications by Boyd and Penland (1988) and Penland and others (1988). We refer readers to these publications for more details. Fifty-two percent of the late Lafourche delta shoreline is composed of a low barrier beach in the form of a thin continuous washover sheet approximately 3 ft (1 m) above mean sea level (Boyd and Penland, 1981). Salt marsh has replaced freshwater marsh and is expanding landward of the beach and also crops out in the surf zone seaward of the beach, indicating a negative sediment budget and rapid shoreline retreat. The eastern half of the erosional headland (Fig. 4) consists of a beach ridge plain (Ritchie, 1972; Gerdes, 1985). Shore face retreat is actively occurring along the Caminada-Moreau coast reworking the distributary sand bodies of Bayou Lafourche and Bayou Moreau and the beach ridge plain of Cheniere Caminada. The dominant wave approach direction to the Caminada-Moreau coast is from the southeast. This together with the convex shoreline produces a longshore sediment transport divergence from the central erosional headland. Moving away from the central erosional headland, increasing downdrift sediment abundance leads to the development of small washover fans and low, hummocky dune fields which eventually coalesce further downdrift to form a higher, more continuous washover terrace, and eventually, a foredune ridge (Ritchie and Penland, 1985). Downdrift flanking barrier islands migrate laterally, in the direction of long-shore sediment transport, by erosion at the updrift ends and accretion downdrift. Washover sheets and multiple shallow breaches are common on the updrift or erosional ends of these islands. Downdrift, longshore bars become more prominently developed in the nearshore zone and, toward the end of the system, bars become shore attached. In these downdrift zones, lateral building of recurved spits is taking place. Recurved-spit morphology formed during the growth of both Timbalier Island and Grande Isle indicates the importance of an updrift sand source in the late Lafourche erosional headland. In the erosional headland and flanking barrier stage, the greatest shoreline erosion has occurred within the erosional headland itself 33 to 65 ft/yr (10 to 20 m/yr) on the Caminada Moreau coast and on the updrift ends of the flanking barrier islands. Maximum accretion rates of 30 to 65 ft/yr (10 to 20 m/yr) are found on the downdrift ends of the Timbalier Islands-Grand Isle flanking barriers.

During regressive deltaic sedimentation, interdistributary bays separate active delta complexes. Following delta abandonment, sand moving along shore from the erosional headland source into flanking barriers builds across the mouth of the interdistributary bays. Bay volume and hence potential tidal exchange volume is continually increasing in response to delta-plain subsidence and land loss, creating an environment suitable for tidal-inlet generation. Tidal inlets are formed during storm events and especially during hurricanes when elongated flanking barrier spits are breached by overwash processes. The increasing tidal volume of the interdistributary bay is then sufficient to maintain permanent water exchange through the barrier, resulting in the production of flood and ebb tidal deltas (Howard, 1985). The result of flanking barrier island growth and tidal-inlet generation is to produce a restricted interdistributary bay with intermediate salinities. This environment accumulates bioturbated

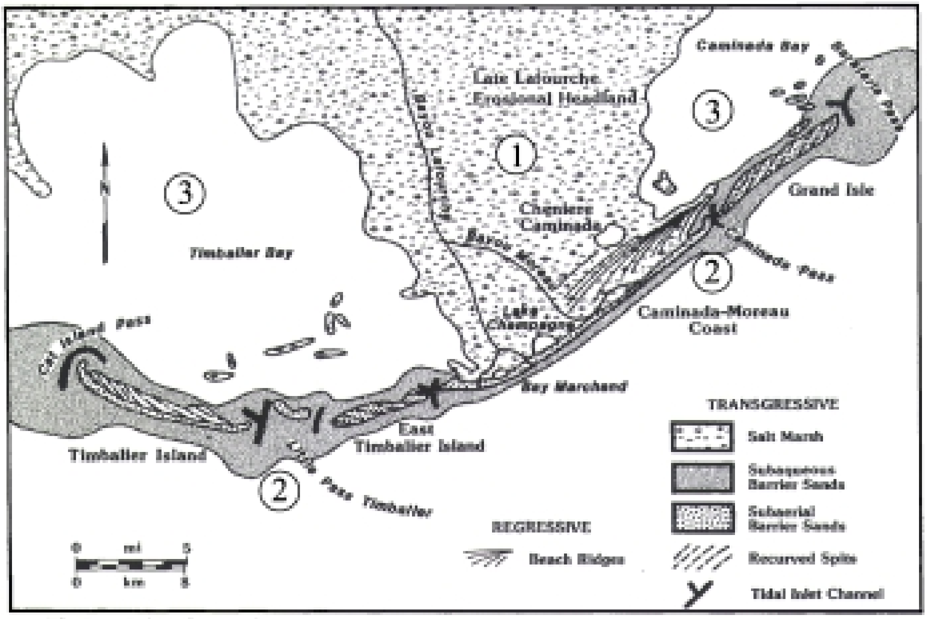


Figure 4. The late Lafourche coastline consists of: 1) the Lafourche headland containing Cheniere Caminada, 2) the flanking barriers of Caminada Pass spit and Grand Isle (east) and the Timbalier Islands (west), and 3) the restricted interdistributary bays of Caminada Bay and Timbalier Bay (Modified from Boyd and Penland, 1988).

muds often accompanied by prolific oyster reef growth (Coleman and Gagliano, 1964; Van Sickle and others, 1976). Modern examples of restricted interdistributary bays on the late Lafourche coastline are Timbalier and Barataria Bays (Fig. 4, 5).

Eastern Section - Plaquemines Coastline

The Plaquemines delta (Fig. 5) was actively receiving river-borne clastics between approximately 905 and 350 yr BP (Boyd and Penland, 1988) and prograded southeastward, building a delta between Barataria Bay and Sandy Point (Fig. 5). As Bayous Grand and Robinson built seaward, they intercepted sediment moving from the eroding Bayou Blue headland of the Lafourche delta complex forming the westward flaring Cheniere Ronquille beach ridge plain. The remainder of the Plaquemines lobe prograded from Grand, Long, and Dry Cypress Bayous, with each accumulating minor beach ridges in the regressive phase.

Following abandonment, the distributary mouth bars and beach ridges of the Plaquemines delta were transformed into numerous small erosional headland sand sources. Sediments derived from the Robinson Bayou headland were transported predominantly westward into the Grand Terre and Chaland Pass flanking barriers. The Bayou Grand erosional headland supplied the Bay Joe Wise spit (west) and Bastian Island (east) flanking barriers while the Bayou Long-Dry Cypress Bayou headland supplied the Shell Island (west) and Sandy Point (east) flanking barriers.

Sand deficiency and low wave energy due to the a sheltering effect provided by the Balize delta influenced the transgression of the Plaquemines delta. As a result, shoreline erosion patterns do not reflect a single coalesced Stage 1 headland as in exposed locations, but a series of small individual headlands experiencing high erosion rates of about 49 ft/yr (15 m/yr) with intervening flanking barriers eroding at slower rates (Penland and others, 1988).

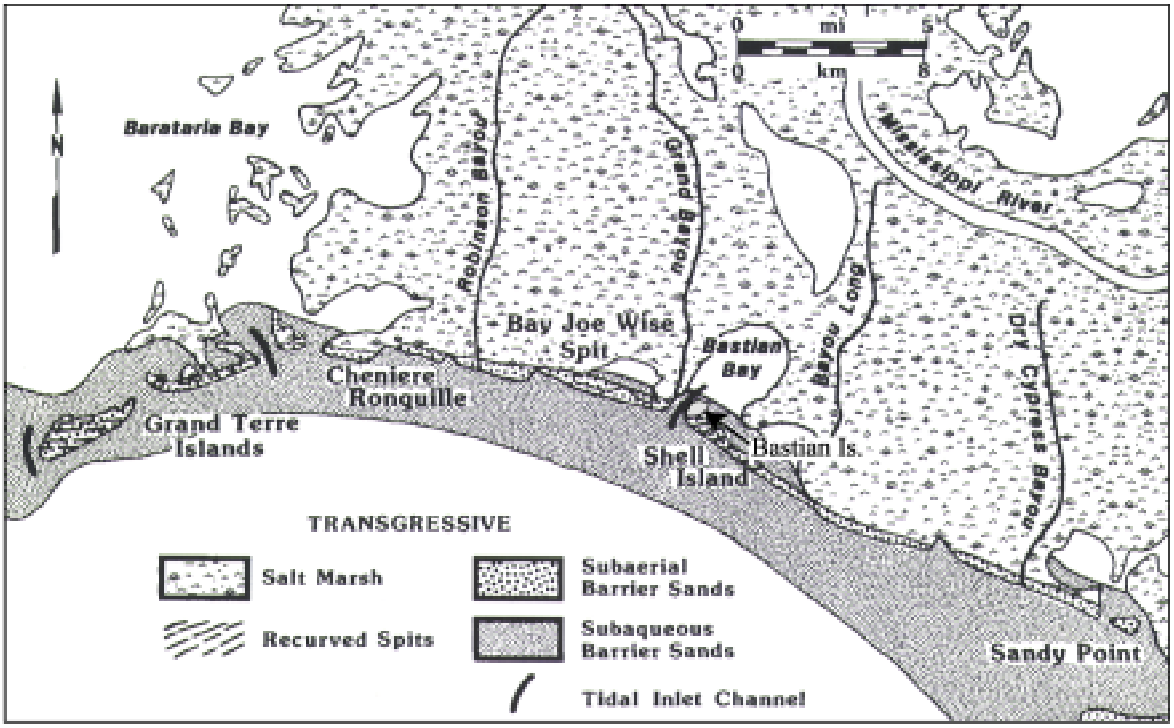


Figure 5. The Plaquemines coastline stretches from the Grand Terre Islands to Sandy Point. It consists of numerous small erosional headlands each associated with a Plaquemines distributary such as Grand Bayou or Robinson Bayou. Flanking barriers such as Shell Island or Grand Terre are attached to each headland (Modified from Penland and others, 1988).

BARATARIA SHORELINE RESTORATION
SAND RESOURCES INVESTIGATION

PREVIOUS STUDIES

There have been many coastal and geologic studies conducted in Louisiana to pave the way for our present understanding of the geologic framework and processes of the Barataria study area (see Regional Geology this report). One study that is directly related to this study is a technical report written by Suter and others (1991). In their 1991 report, Suter and others, conducted a regional nearshore sand resource inventory from Marsh Island to Sandy Point. From 1982 to 1986 approximately 4660 line-mi (7,500 line-km) of high-resolution single-channel seismic reflection profiles and 152 vibracores were collected (Fig. 6). Using this database, Suter and others (1991) defined 55 nearshore sand resource targets in the area between Marsh Island and Sandy Point. These targets were identified as many different types of sedimentary deposits including distributary channel, inner-shelf shoal, recurved spit, tidal delta, tidal channel, submerged beach ridge, and barrier-shore face deposits. The targets ranged in area from 0.8 mi^2 (2 km^2) to greater than 155 mi^2 (400 km^2) with estimated sand volumes of less than 2.6 mil yd^3 (2.0 mil m^3) to greater than 20.8 mil yd^3 (16.0 mil m^3). While these data and the report were an invaluable resource, the lower resolution of the available technology and more widely spaced data points limited the authors' interpretations. Regardless, their report was an excellent starting point.

Another study that greatly influenced our planning, the Louisiana Barrier Island Erosion Study (Sallenger and others, 1987) was conducted cooperatively by the USGS and LGS. Sallenger and others (1987) discussed in general the geologic framework, historical changes, and modern processes affecting the barrier islands of Louisiana, but the final product of the Barrier Erosion Study was the production of the Shoreline Change Atlas (Williams and others, 1992) and the Sea-Floor Change Atlas (List and others, 1994). The atlases were designed to give a comprehensive overview of the shoreline change and sea-floor evolution. These two atlases cover an area from the Isles Dernieres to the Modern delta lobe. Williams and others (1992) describe the geologic history of the study area, and provide detailed series of shoreline maps with accompanying data analysis documenting the evolution of the barrier island systems since the first shoreline surveys in 1853. List and others (1994) document sea-floor elevation along the deltaic coast and present the patterns of sea-floor erosion and accretion necessary to understand large-scale processes of sediment transport, see Figure 2 example. Together the atlases provide excellent background information about this rapidly changing coastline.

COAST 2050 – SAND RESOURCE CRITERIA

Sand resource targets for this study had to meet basic criteria defined by the USACE–NO District. These criteria were developed as parameters for economical sand mining operations. For sand deposits to be considered as potential sand resource targets they must meet these basic criteria: (1) contain more than 60% sand; (2) sand deposit thickness must be 3 ft (0.9 m) or more for surficial deposits or 5 ft (1.5 m) or more for sand deposits with sediment overburden; and (3) depth of the sand deposits must not be exceed -60 ft (-18.3 m) below mean sea level (MSL).

The exploration for sand suitable for beach nourishment is carried out in three phases. The first

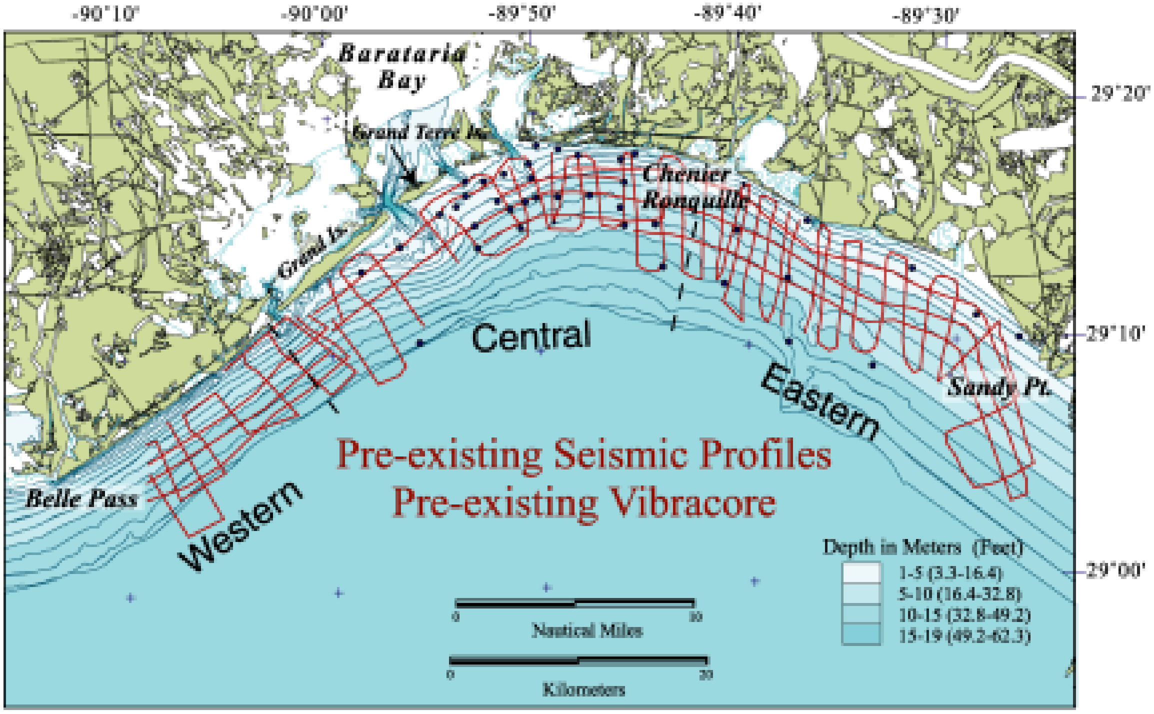


Figure 6. Pre-existing high-resolution single-channel seismic (Boomer) profiles and 40 ft (12.2 m) vibracores within the Barataria study area (from Suter and others, 1991).

is acquiring and reviewing as much background data as possible from the previous studies in the exploration area and identifying potential sand resource sites. Second is locating the potential deposit and mapping areal extent and distribution. This phase is accomplished using high-resolution seismic reflection profiling techniques (see Methods this report). Phase three is verification or 'groundtruth' of distribution and quality of the resource by collecting sediment cores and conducting texture analysis. Interpretations and analyses are finalized by integrating the data from each phases into maps (such as distribution and isopach) and volume estimates of sand resources.

As seismic profiles were acquired, a coastal geologist on board the vessel would immediately conduct preliminary interpretations of the profiles to identify potential targets for sediment sampling. Potential targets were duly recorded and transmitted to project scientists. Using this method a backlog of selected targets was developed. After two weeks of seismic surveying the field crews switched to sediment core sampling. After vibracore collection, the cores were shipped to the UNO core facility for description and analysis. Once a backlog of cores was in the lab, the field crews switched back to seismic surveying. This field technique effectively shortens the duration of the study by many weeks.

METHODS

High-Resolution Single-channel Seismic and Sonar Reflection Profiling (HRSP)

The USGS/UNO collected 652.5 line-mi (1,050 line-km) of high-resolution single-channel seismic and sonar reflection profiles – HRSP (Fig. 7) using two sources: 'Boomer' and 'CHIRP' (the sound of the outgoing pulses, not an acronym) (Fig. 8, 9). Both systems are broadband systems: the Boomer is an acoustic source with a range from 2.0 to 6.0 kHz and the CHIRP is a FM sonar source with a range from 4.0 to 24.0 kHz. Resolution of the Boomer is approximately 3.28 ft (1.0 m), whereas the CHIRP provides resolutions of approximately 0.65 to 2.0 ft (0.2 to 0.6 m). The combination of these two sources typically provides a good cross-sectional profile of the shallow geology that makes interpretation and mapping possible. When collecting HRSP data, a critical element is marine weather. As sea state changes so does the quality of the HRSP data. A sea state of greater than 2 to 3 ft of wave chop renders unusable profiles. The raw acoustic signal was recorded digitally in the field and post-processed to provide the best working copies. The profiles were interpreted using standard seismic stratigraphic techniques and mapped horizons were digitized into a computerized contouring program from which contour maps of the data are produced. The HRSP data along with previous data were used to identify potential sand targets and to pick core-sampling sites needed for verification and analysis.

Boomer

The seismic reflection data acquisition system consisted of an Applied Acoustics AA200 boomer plate (sound source, Fig. 8, 9) driven by an Applied Acoustics CSP 300 power supply running between 100 and 300 joules. The seismic wave return was received by a towed ITI ST-5 10 element hydrophone array. A Kontron Lite PC running TEI Delph Seismic version 4.02, under the Windows 98 operating system, triggered the sound source. This same system collected the seismic return from the ITI hydrophone, logged it, and formatted the data in SEGY (Society of Exploration Geophysicists Y)/Integer/Motorola format. The initial shot rate was 500 milliseconds (ms) with a 100-ms acquisition window. Paper plots were produced using EPC HSP 100 plotter, OYO 608 plotter, and an Alden 9315 plotter.

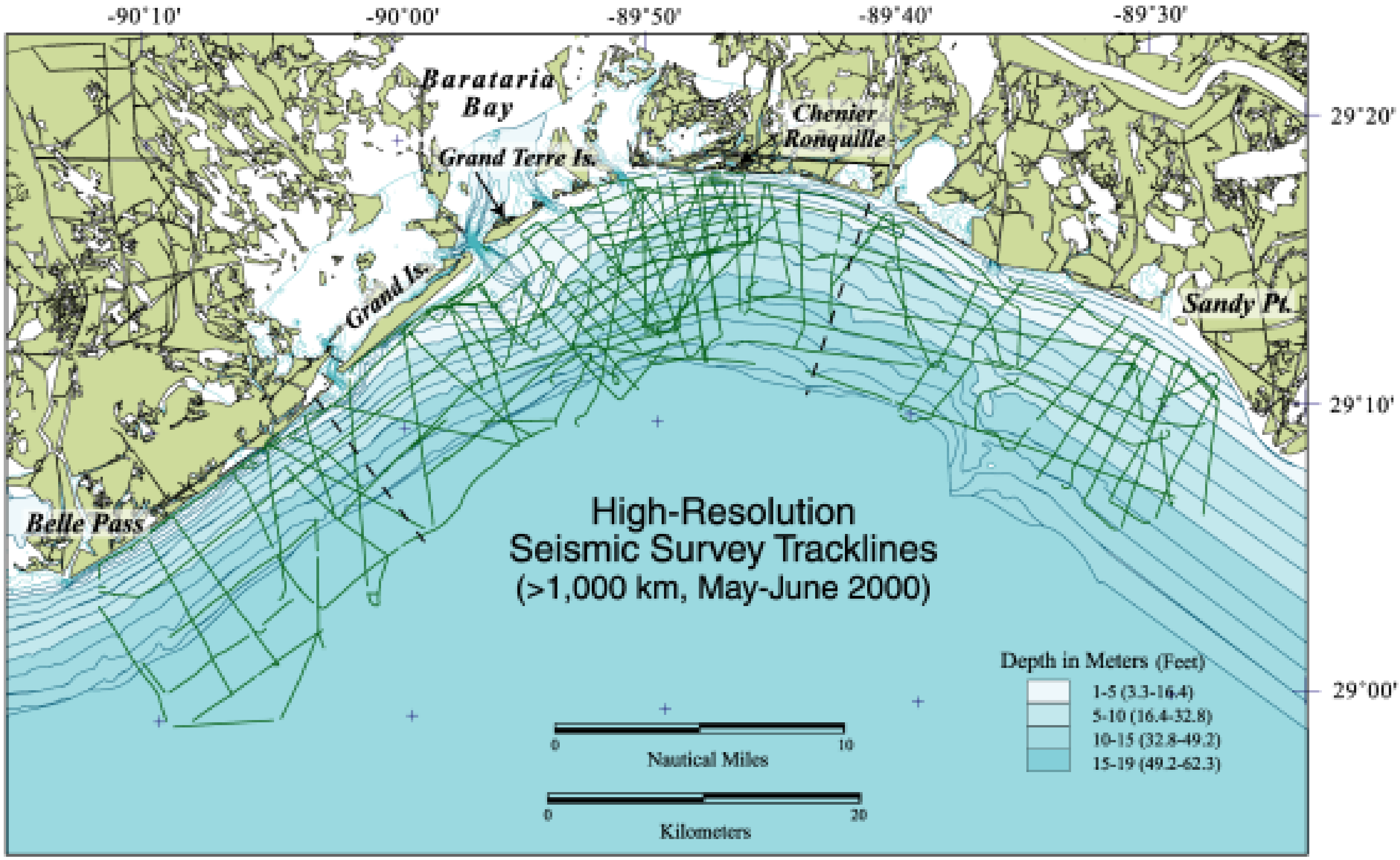


Figure 7. Seismic and sonar survey tracklines collected during summer of 2000. More than 1,000 km (540 n mi) of high-resolution single-channel seismic and sonar data (Boomer and CHIRP) were collected. Sea state and the need to collect the best data possible dictated trackline directions. See Appendix A - Plate 1 (insert) for detailed navigation and survey tracklines.

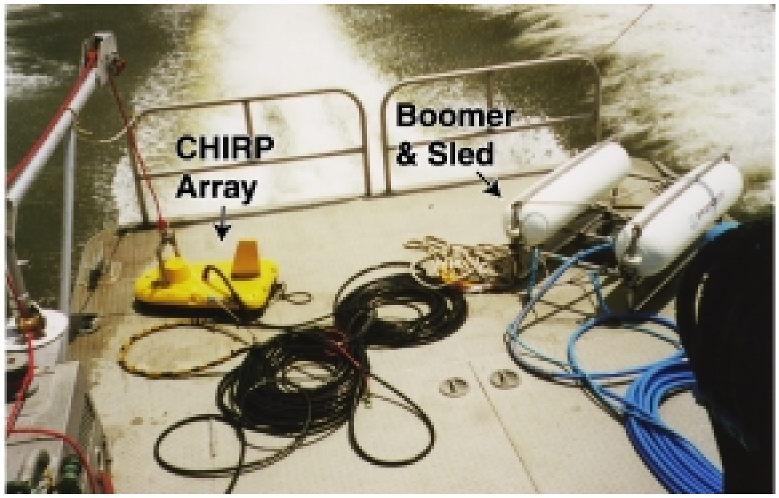


Figure 8. Catamaran (sled) mounted Boomer and CHIRP Array shown on the aft deck of the *R/V GK GILBERT*.

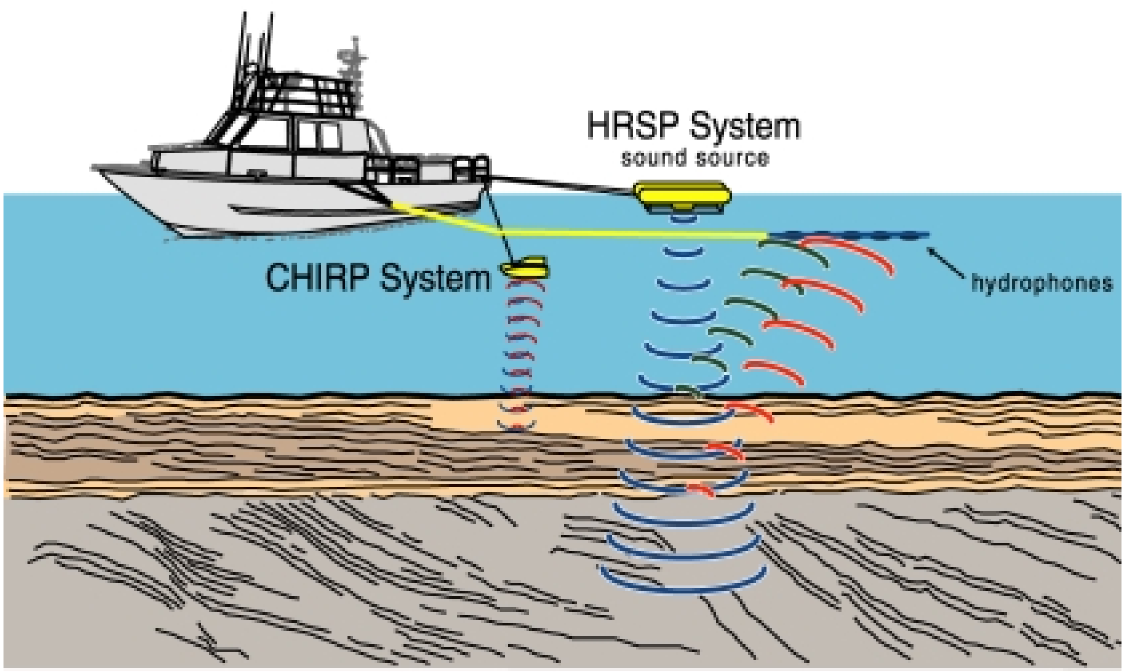


Figure 9. Illustration of towing configuration of the CHIRP and Boomer (HRSP) Systems from the R/V GK GILBERT. The Boomer is a surface-towed catamaran. The CHIRP, a mid-water towfish, was towed at depth ~6 to 15 ft (~2 to 5 m) above the sea floor when possible and in shallow water towing was very near the water surface at a depth of ~1.6 ft (~0.5 m depth).

Navigation was input and logged to the HRSP system from a Trimble Centurion P code GPS receiver and a Trimble Navgraphic XL Differential GPS system at a rate of 1 to 2 fixes per sec. Depth data were collected from an Innerspace Model 448 depth sounder during the second half of the HRSP survey (June 2000). The depth output rate equaled the sweep rate of the sounder. This depth data were fed into a Rocky PC running Fugawi software, under Windows 95. The GPS positioning data being fed to the seismic system were split off (using a Black Box RS232 Splitter) into the depth system and logged at its input rate along with corresponding depth data. All raw seismic, depth, and navigation data were archived onto DVD discs, Jazz discs and Exabyte tape.

The Applied Acoustics boomer plate was towed from the port stern quarter at a distance of approximately 20 m. The ITI ST-5 hydrophone was towed from a 3-m boom amidship the starboard side. The active elements were approximately 20 m from the stern and approximately 3 m from the starboard side of the boat. A sea anchor, approximately 20 m back from the center of the stern, was used to dampen boat oscillation. Equipment was towed at a boat speed of 3 to 4 knots depending on sea state.

CHIRP

CHIRP sonar systems are defined as systems that transmit calibrated, swept FM waveforms and process the data using matched filter sonar DSP algorithms. The data acquisition system components that were employed consisted of an EdgeTech X-Star CHIRP with a 2 kWh power amplifier, mated to an EdgeTech SB-424 towed body (Fig. 8, 9). Output pulse length was 10 ms over a frequency range of 4 to 24 kHz. This system is capable of sub-bottom layer and object resolution of 4 to 8 cm.

Acquisition windows were ranged from 20 to 30 ms. Processed CHIRP data was sent from the EdgeTech X-Star unit, real time, via LAN to a Kontron Lite PC running TEI Delph Seismic FSSB version 4.02, under the Windows 98 operating system. The TEI system did further processing, data formatting (SEGY/Integer/Motorola format) and storage. Paper plots were produced using an EPC HSP 100 plotter, an OYO 608 plotter, and an Alden 9315 plotter.

The SB-424 body was towed from the starboard stern corner with approximately 50 m of cable deployed. It was flown at a height of 2 to 5 m above the sea floor. Boat speed was 3 to 4 knots.

Navigation data were input and logged to the CHIRP system from a Trimble Centurion P code GPS receiver and a Trimble Navgraphic XL Differential GPS system at a rate of 1 to 2 fixes per second. All raw CHIRP and navigation data were archived onto DVD discs, Jazz discs, and Exabyte tape.

Boomer and CHIRP provide continuous, non-invasive profiles of the subsurface using acoustic and sonar reflections. Stacked amplitude plots that represent velocity changes across textural and stratigraphic variations of varying impedance in the sediments provided two-dimensional images of the near surface sedimentary sequences. Operating at higher frequencies, CHIRP provides increased resolution of the uppermost meters of sediment, but cannot resolve features as deep into the subsurface as Boomer. When used together, the two techniques provide a high-quality characterization of the subsurface. Invasive sediment sampling techniques such as vibracores are required to ground-truth the HRSP data. Once stratigraphy is established, the reflection data serve as a continuous sediment characterization tool.

Sediment Sampling

Potential sand deposits were identified from previous studies and HRSP data. Sediment cores were collected to confirm the sand deposits identified from the newly acquired reflection profiles and to provide subsamples for textural analysis. Whether the identified targets can be used as a productive sand resource depends upon their textural character. The preferred method (tested by many years of successful sampling) for acquiring sediment samples is vibracoring, in which a vibrating head pushes a core barrel into the sediment. This technique preserves the sedimentary structures necessary for accurate interpretation of depositional environments and verification of sand resources. Interpretations of reflection profiles correlated with sediment analysis can help identify the extent of sand resources beyond only using sediment cores.

Vibracore Collection Methods – 20 foot (6.1 meter) cores

The primary vibracoring apparatus used during this study was operated from aboard the USGS coastal *R/V GK GILBERT* (Fig. 10). During this project more than 200 vibracores were collected in the Barataria study area (Fig. 11).

Vibracores were obtained using a Bradford pneumatic vibrator powered by two air compressors delivering 35 cfm at 100 psi each. The vibracore rig is capable of handling aluminum barrels with a diameter of 3.0 in (7.6 cm) and up to 20 ft (6.1 m) in length. Brass core-catchers were riveted at the base of each barrel to ensure complete recovery of the sediments. An electric wire line was attached to the top of the rig and connected to a voltmeter on board to measure penetration of the barrel into the sea floor. A Hiab hydraulic crane onboard the Gilbert was used to position and recover the coring rig (Fig. 10). Upon recovery, the barrel was removed from the rig and cut to the core sample length. The ends of the core sample barrel were capped and the length measured. The measured length was compared to the wire line reading to estimate compaction. A complete instructional course on the construction, preparation, and use of the vibracore rig used in this survey, as well as barrel preparation and curation, is available on CD-ROM and can be obtained from the USGS Center for Coastal and Regional Marine Studies.

USACE 2000 - 40 foot (12.2 meter) borings

In order to fully penetrate deeper sand deposits, partially identified by the 20 ft (6.1 m) vibracores, 38 borings approximately 40 ft (12.2 m) deep were obtained (Fig. 11). These borings were taken with a Failing 1500 truck-mounted drill rig on a jack-up barge. The sampling procedure involved two techniques, one for clay strata, and one for sand strata. When in clay, a 3 inch (0.76 m) diameter, 4.0 ft (1.2 m) Shelby tube was driven 3.5 ft (1.1 m) with a 1.5 ft (0.5 m) washout between drives. The 3.5 ft (1.1 m) samples were extruded and logged in the field. When sand was encountered, either in the sample or seen in the cuttings during washout, the sample technique was changed to driving a 3 inch (0.76 m) split spoon sampler 1.5 ft (0.5 m) with a 1.0 ft (0.3 m) washout between samples. The split spoon samples were also logged in the field.

Representative samples of the clay and sand from each drive were jarred and delivered to the USACE–NO with the field logs. The field log data were imported into the USACE BORPLOT program, which allows the boring data to be viewed and plotted graphically. Representative sand samples from each sand strata identified on the logs were submitted to UNO for grain-size analysis.

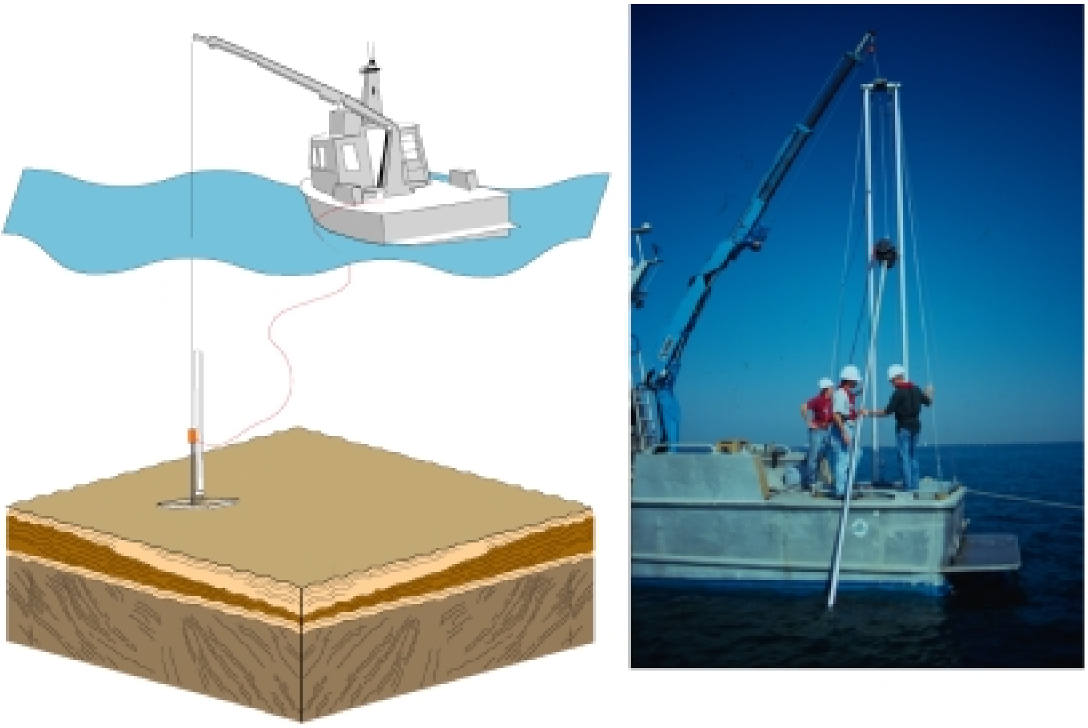


Figure 10. Vibracoring from the *R/V GK GILBERT* shows typical deployment.

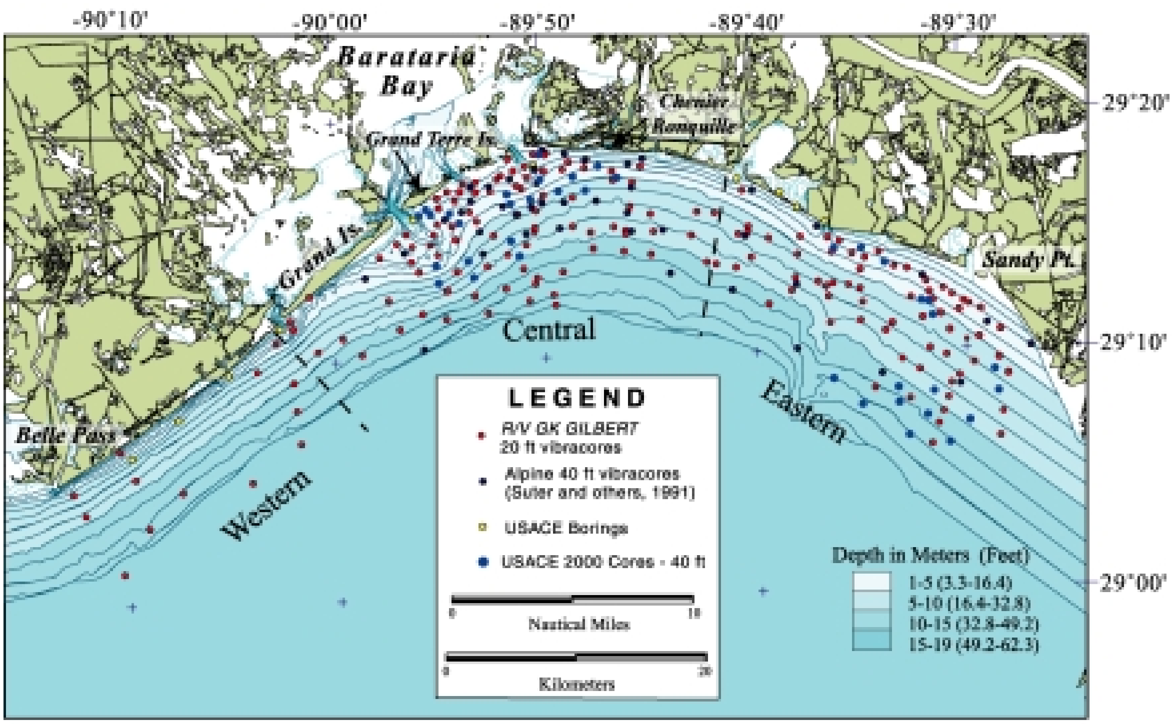


Figure 11. Location of vibracores used in this study. More than 250 cores and borings from this study and previous studies were used to verify sand resources and subbottom lithology. See Appendix A – Plate 1 and 2 (inserts) for detailed location and relative position of tracklines cores and boreholes.

Vibracore Analysis

UNO Coastal Research Laboratory personnel analyzed vibracores acquired during this study. The procedure involved splitting each vibracore in half. One half was visually described using standard sediment logging methods and sampled at 1.0 ft (0.3 m) intervals for textural analysis. Additional samples were taken from the top and bottom of sand-rich intervals greater than approximately 2.0 ft (0.6 m) thick to allow for more effective textural classification of such sedimentary packages. Each vibracore log includes a description of sedimentary texture, sedimentary structures, percent sand, physical characteristics, stratification type, sample type, and sample location. Descriptive sheets were scanned and saved as PDF© files for digital access (CDROM Appendix), the hardcopy description sheets are archived at the UNO Coastal Research Laboratory. The remaining half of each split vibracore was cut into 3.28 ft (1.0 m) intervals, photographed in detail, wrapped in plastic sleeves, and archived at the UNO Department of Geology and Geophysics Chevron core warehouse. The sampled halves (destroyed during sampling) of the vibracores were discarded.

Grain-size Analysis

Textural analysis of sediment samples taken from the vibracores was performed at the UNO Coastal Research Laboratory using a *Coulter LS 200* particle-size analyzer. The *Coulter LS 200* particle-size analyzer, is a state-of-the-art instrument that utilizes laser diffraction to measure the size distribution of sedimentary particles between 0.4 µm and 2 mm. The utility of the *LS 200* is the high reproducibility of measurements, rapid acquisition of results, ability to accurately and quickly provide quantitative measure of extremely small grain-size fractions, and customizable data output. Grain-size analyses were conducted by simulating the sizes that would be determined from standard ASTM 11-E sieves. Textural classification boundaries were based on the Wentworth size scale. Percent sand, silt, and clay for each sample is reported in a textural data table, depth vs. sand graphs, and grain size at cumulative frequency intervals of 5% between 0 and 100% (CDROM Appendix). Grain-size measurements were reported in mm and phi intervals for the mean and sorting, the statistical measures used in assessing the suitability of sediment for nourishment projects (USACE, 1977). The conversion of metric-based measures to the non-dimensional *phi* (ϕ) categories were completed using the equivalence:

$$phi\ (\phi) = -\log_2 \frac{d}{d_o} \qquad [1]$$

where: d = the millimeter diameter of the measured particle and d_o = a particle with a 1.0 mm diameter (Krumbein, 1938). In order to accurately establish a correspondence to grain-size data previously acquired by the UNO Coastal Research Laboratory the mean grain size (X_ϕ) was calculated using the relation:

$$\text{Mean grain size } (X_\phi) = \frac{\phi_{84} + \phi_{16}}{2} \qquad [2]$$

where: ϕ_{84} and ϕ_{16} represent the phi grain sizes for which 84 and 16% of the total sample are coarser. Sorting, a measure of the standard deviation (σ) from the mean grain size, was calculated through the equation:

$$S_\phi = \frac{\phi_{84} - \phi_{16}}{2} \quad [3]$$

(e.g. 68% of the spread of a frequency versus grain-size curve lies within $\pm 1\sigma$ of the mean grain size). The aforementioned statistics are based on procedures developed by Inman (1952) and referenced in the USACE Coastal Engineering Technical Aid No. 79-7 (Hobson, 1979). The completed textural data and core descriptions were integrated for each vibracore to create a data package. This vibracore package was integrated with existing data and the HRSP data to provide a comprehensive framework of the character and distribution of sedimentary units within the study area.

RESULTS OF METHODS

The general subsurface geology of the study area has been described in previous studies utilizing HRSP (Boomer) and vibracores. The pre-existing surface and subsurface datasets defined general areas of potential sand resource. Due to the high spatial resolution required to constrain target areas and quantify resource availability, additional HRSP surveys and vibracores were required to complement the previous coverages. To provide higher resolution of the subsurface to depths accessible for borrow recovery; CHIRP profile data was acquired in conjunction with the Boomer profiles. Examples from the Boomer and CHIRP datasets (Fig. 12) show how the two techniques when used together provide more detailed characterization of the subsurface than when used alone. In all, over 652.5 line-mi (1,050 line-km) of HRSP data, 200 vibracores, and 38 USACE 2000 borings, along with the reports and pre-existing data sets, were used to identify potential sand resource targets. The targets were constrained, using the minimum criteria described by USACE–NO, primarily by unit thickness and percent sand (see Coast 2050 – Sand Resource Criteria, this report).

Geophysical survey coverage of approximately 1.2 to 1.9 mi. (2 to 3 km) grid spacing was obtained during the first phase of field operations to provide a general reconnaissance of the study area. To resolve target areas, a tighter grid of survey lines of 0.6 mi. (1.0 km) or less enhanced the original coverage. Quality of Boomer and CHIRP data across the study area ranged from very good to poor. Typically, variation in data quality depended on sea state, however, overlapping coverages allowed for acceptable continuous correlation of subsurface features throughout much of the study area. For subsurface characterization at depths suitable for borrow recovery, CHIRP data was generally used. Boomer and CHIRP profiles were interpreted using standard geologic investigative techniques that allowed for the identification of geomorphologic features typical of shelf and nearshore sedimentary environments. Features identified from profiles are consistent with subsurface records from across the northern Gulf of Mexico that describe geology associated with sea-level fluctuations, delta progradation, and barrier-island migration (see Regional Geology, this report). Spatial mapping of the interpretations further resolved the distribution of these features.

Vibracore surveys were conducted during and after the second leg to verify the HRSP data and provide samples for geotechnical analysis of target areas. Included with the 20 ft (6.1 m) vibracores were USACE 2000 40 ft (12.2 m) borings obtained at target areas to constrain target thickness. While the vibracore data provided textural and grain-size analysis of the target areas, the geophysical surveys identified their areal extent. This allowed for volume estimates of potential sand bodies as well as sand percentages and grain size.

GEOLOGY AND SAND RESOURCE POTENTIAL OF THE BARATARIA SHORELINE

During this study it was found that the basic geologic framework of the area agrees with the findings of previous geologic reports such as Penland and others (1988), Suter and others (1991), Williams and others (1992) and List and others (1994). The data density provides a high level of detail not normally available for geologic framework studies. Geologic interpretations of these data suggest a very high degree of lateral variability within the strata and facies.

Seismic and sonar reflection profile interpretations verified by geologic samples (vibracore and boring) indicate that there are 9 large sand targets within the Barataria study area that meet or exceed the minimum criteria for potential mining sites (Fig. 13, Table 1). The Western section is devoid of targets that meet minimum criteria, 6 targets are found in the Central section and 3 targets are found in the Eastern section. The sand targets are associated with geologic depositional systems such as ebb-tidal deltas, distributary mouth bars, and channel fills. Sediments in the depositional systems or facies may contain sand but may not meet the Coast 2050 criteria for thickness or percent sand to be used as a sand resource. The sand targets and deposits shown in the figures used in this report are differentiated so as to indicate the actual sand resource. Figure 14 shows the location of cross sections and profiles used in this report.

An ebb-tidal delta represents sediment accumulation that results from the interaction of tides, waves, and currents. The morphology of ebb-tidal deltas on a micro-tidal coast, such as the Gulf of Mexico, typically has channel-margin linear bars, swash bars, lateral flood channels, a main ebb channel, and terminal lobe (Boothroyd, 1985). Sediments are typically poorly sorted fine sand with varying small amounts of shell. Bedforms found in this unit include cross bedding and parallel laminations (Moslow and Tye, 1985).

Distributary mouth-bar deposits form as an area of shoaling associated with the seaward extent of a river distributary. Morphologically the river mouth consists of channel, natural levee, distributary mouth bar, delta front, and prodelta (Coleman, 1982). Sediments deposited in the distributary mouth bar are subjected to constant reworking and winnowing of finer grain sediments. As a result distributary mouth-bar deposits are commonly well-sorted sands with varying amounts of clay and silt (Coleman, 1982).

Channel-fill deposits have been identified as cut and fill cross-bedded sand and silt beds (Coleman, 1982). While this may be valid, it is not a practical description of the variability found within channels at the seaward extent of river systems. Channel abandonment can occur making this depositional environment quit varied. With continued progradation or reactivation, the distributary reaches a point at which it can no longer maintain its gradient and the process of channel abandonment begins. Channels are commonly filled with poorly sorted sands and silts containing transported organic debris and over time the channel can be filled with fine-grained, poorly sorted sediments (Coleman, 1982) (Fig. 15, 16). In seismic or sonar profile it is impossible to distinguish between channels that are filled with sandy deposits and those filled with muddy deposits. It is necessary to obtain samples (vibracores) to identify the channels that contain usable sand resources.

The Suter and others (1991) sand resource study conducted in this area identified 21 sand targets many of which were directly associated with buried channels (Fig. 17). Their report

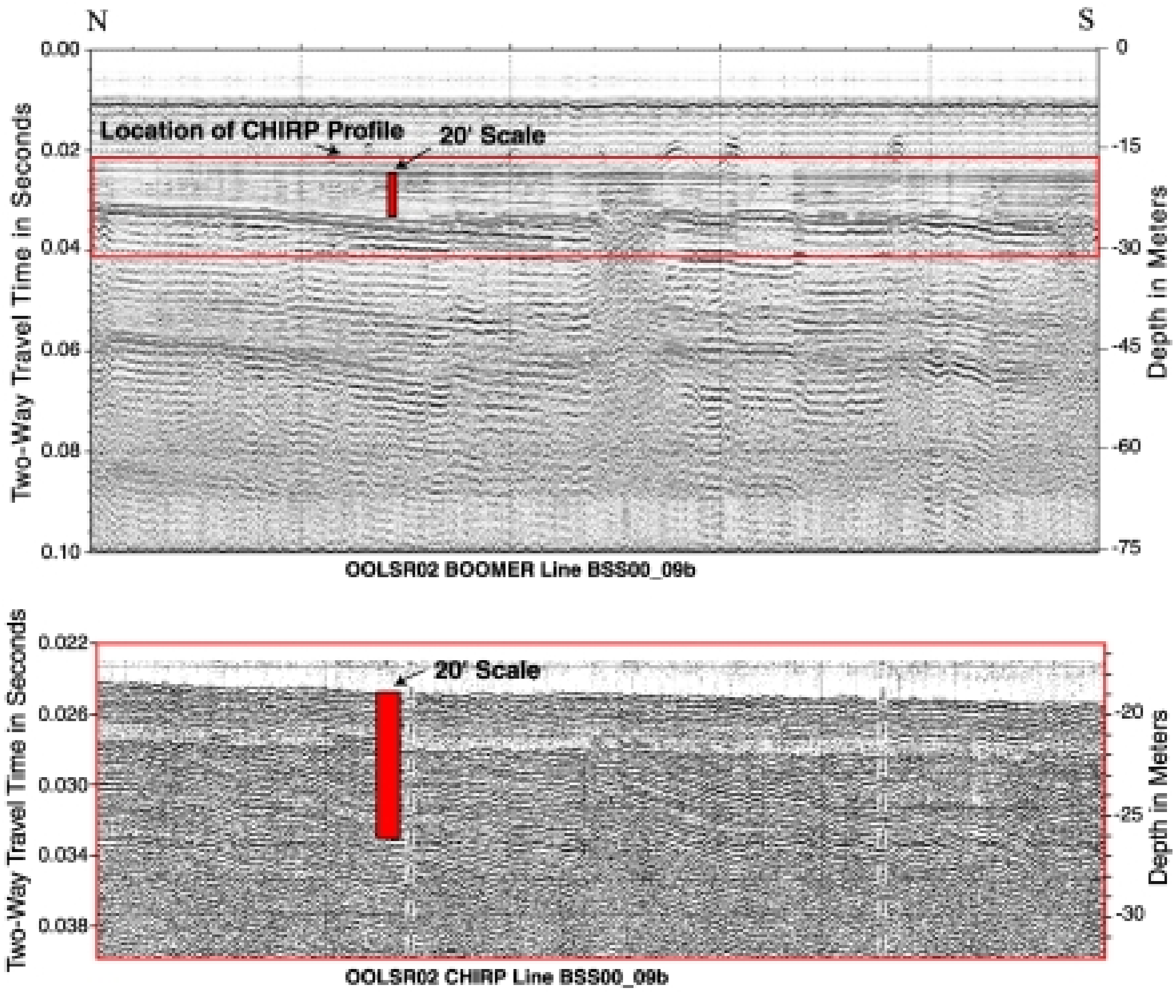


Figure 12. HRSP example Line BSS00_9b, the top panel is Boomer data with the red box showing the relative position of the CHIRP profile shown underneath. Notice the scale on left – Two-Way Travel Time in Seconds (same as Depth in Milliseconds in subsequent figures), the scale on the right – Depth in Meters, and relative depth penetration of a typical vibracore. Location of illustration shown in Figure 14.

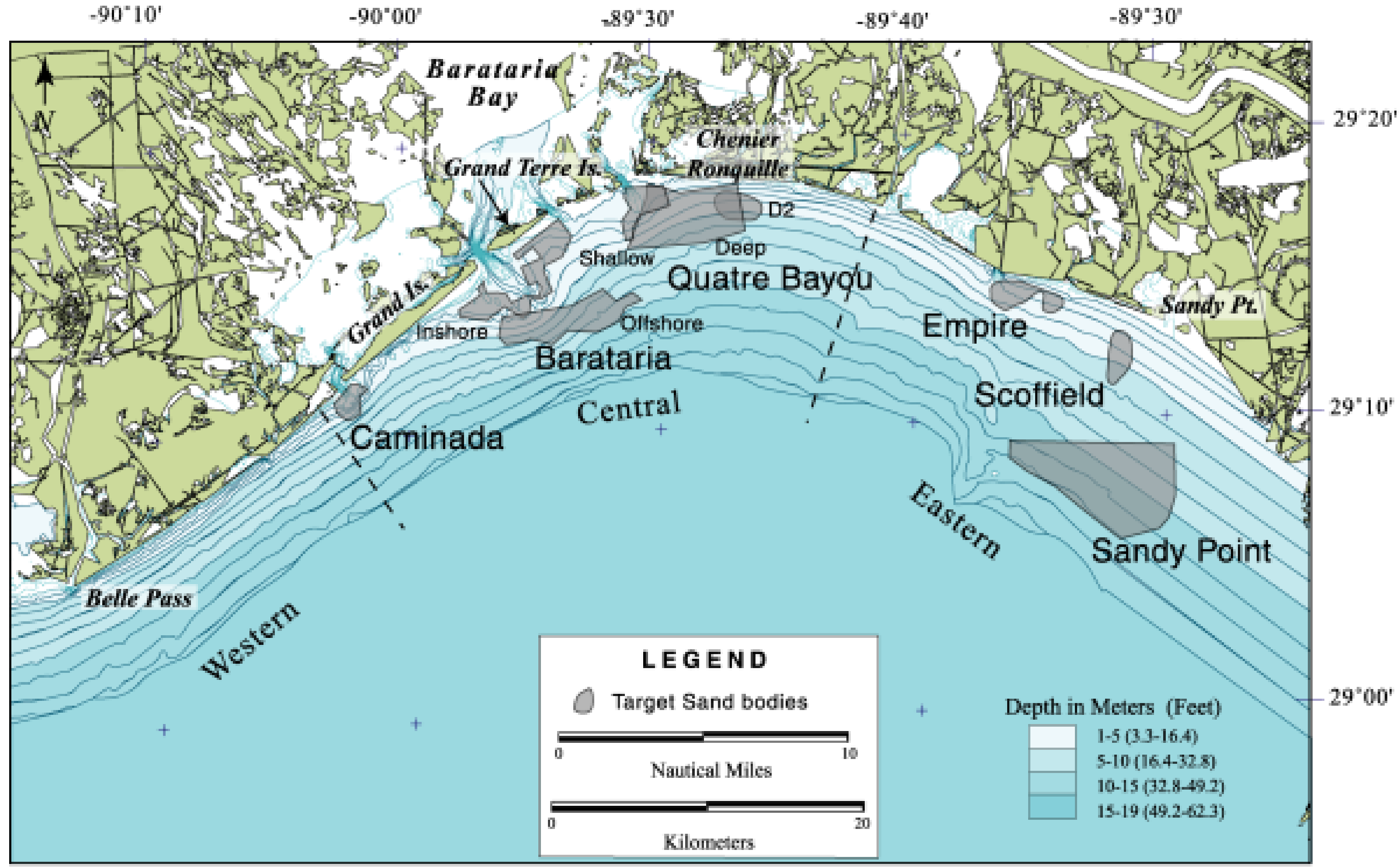


Figure 13. Location of the nine potential sand resource targets for Barataria shoreline restoration identified from seismic and sonar profiles and verified by vibracore and borings. Also shown is the study area partitioned into three sections: Western, Central, and Eastern. See Appendix A - Plate 5 (insert) for detailed locations of sand targets.

Target Site	Surface Area (mi.^{2})	Depth to Top of Target (ft below MSL)	Thickness of Overburden (ft)	Est. Target Thickness (ft)	Percent Sand %	Grain size range (phi)	Est. Vol. Sand (low) (yd^3)	Est. Vol. Sand (high) (yd^3)	Est. Vol. Overburden (yd^3)
Caminada	1.13	5-10	0	4	60-80	2.5-4.7	3,796,844	5,062,458	0
Barataria Inshore	5.93	5-10	0	4-9	60-85	2.5-4.7	18,412,746	26,084,723	0
Barataria Offshore	6.07	25-40	10-15	7-9	60-80	2.5-5.5	34,726,502	46,302,003	78,640,178
Quatre Bayou Shallow	2.04	10	0	5-10	60-80	2.5-4.7	6,084,670	8,112,893	0
Quatre Bayou Deep	8.85	22-45	7-15	5-22	70-100	2.0-5.5	92,815,154	132,593,078	156,028,517
Quatre Bayou D2	1.70	45-47	30-40	7+	50-80	3.0-5.0	7,372,288	9,829,717	61,611,264
Empire	2.10	17-25	3-10	3-6	60-80	2.0-3.5	5,854,464	7,805,952	14,961,408
Scoffield	1.50	30	9	6+	80-90	2.5-5.5	7,434,240	8,363,520	13,939,200
Sandy Point	16.95	40-48	8-13	20-30	60-80	2.5-5.5	220,635,383	294,180,511	244,848,543
Ship Shoal	96.60	13-29	0	16	80-100	2.3-4.0	1,276,706,816	1,595,883,520	0

Table 1. Comparison of the nine sand targets found within the Barataria Shoreline Restoration Study and Ship Shoal, a well known sand shoal west of the study area. Ship Shoal data are from Suter and others (1991). The combined estimated volume of sand found in the nine targets of this study equal half of the sand volume found in Ship Shoal.

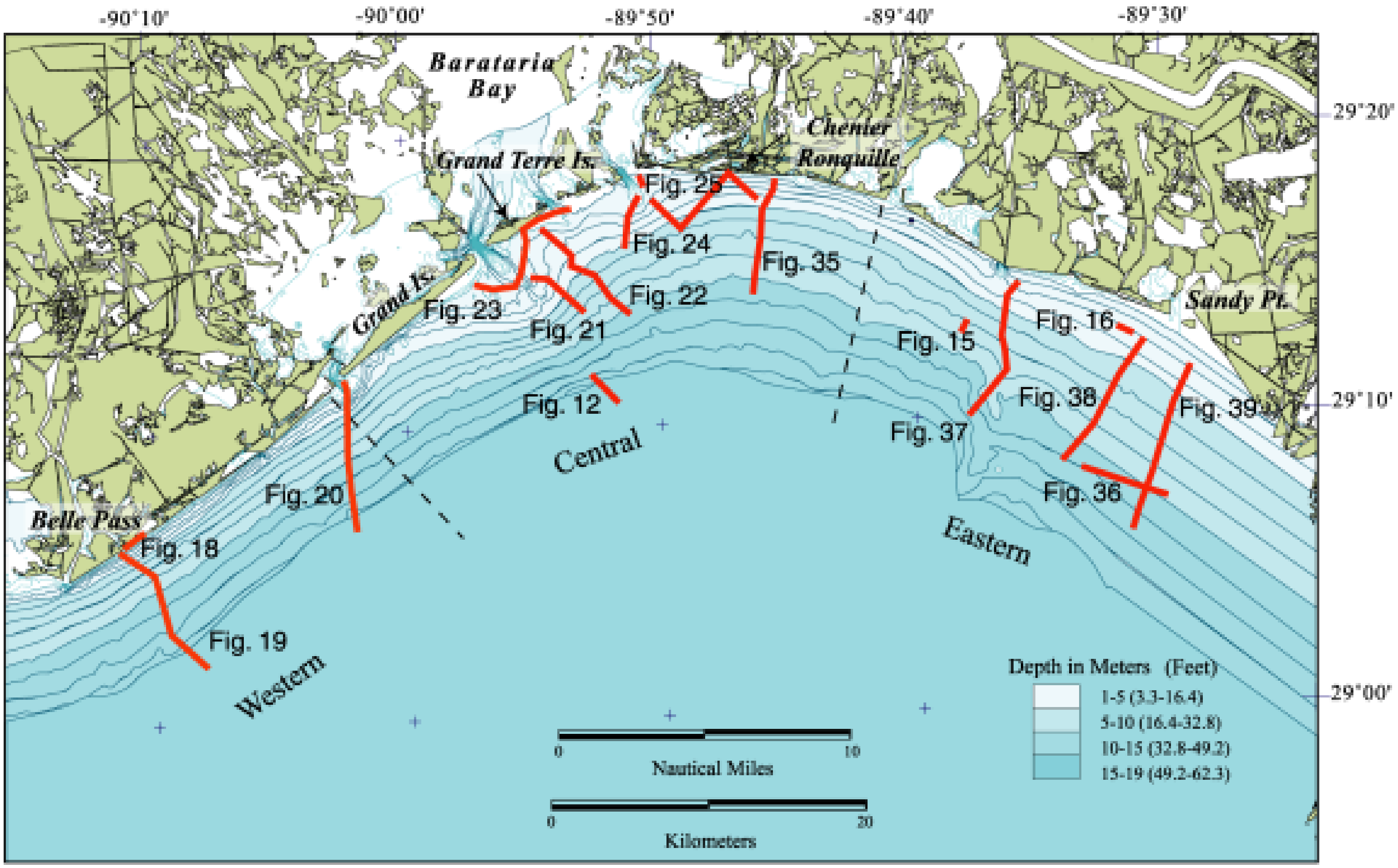
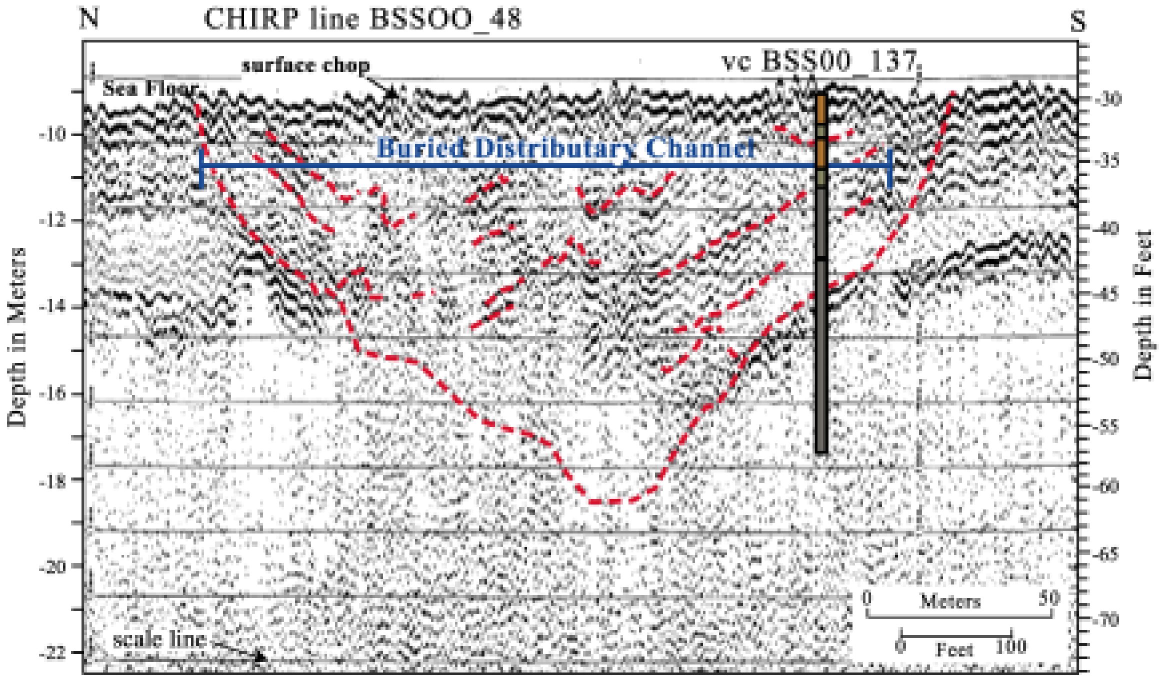


Figure 14. Location of cross section and profile illustrations used in this report. See Appendix A - Plate 3 (insert) for detailed locations.



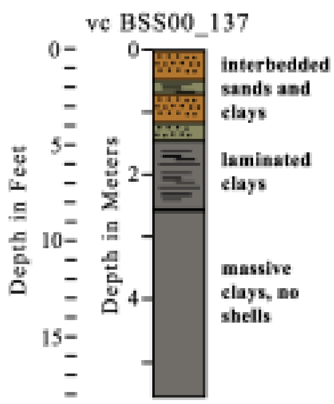


Figure 15. Subbottom CHIRP profile showing cross section of a distributary channel. Vibracore BSS00_137 shows the interbedded sands and clays, laminated clays, and massive clays that might be found in interdistributary cores. Horizontal lines across the profile are for vertical scale in milliseconds and were converted to meters and feet using the velocity of sound through sea water (1500 m/sec, 4920 ft/sec). Surface chop produces the wavy look of the profile and is caused by the up & down motion of ocean waves as seen in seismic profile. Location of illustration is shown in Figure 14.

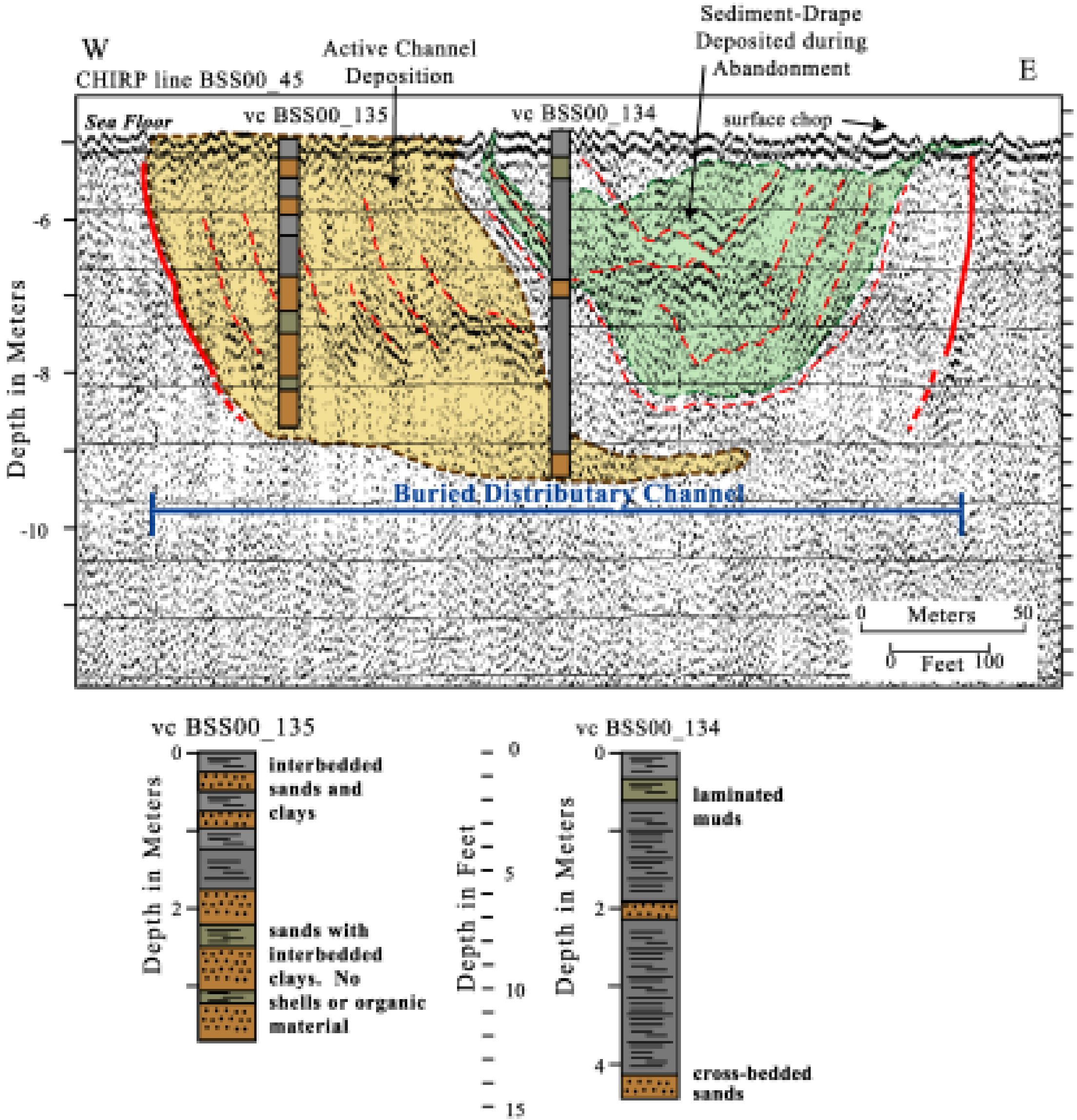


Figure 16. A combined illustration of subbottom CHIRP profile and vibracore interpretations demonstrating the variability of sediments found in distributary channels. This example shows internal channel-fill structures, such as cross bedding, indicating lateral migration of active channel deposition and draping fill of channel abandonment.

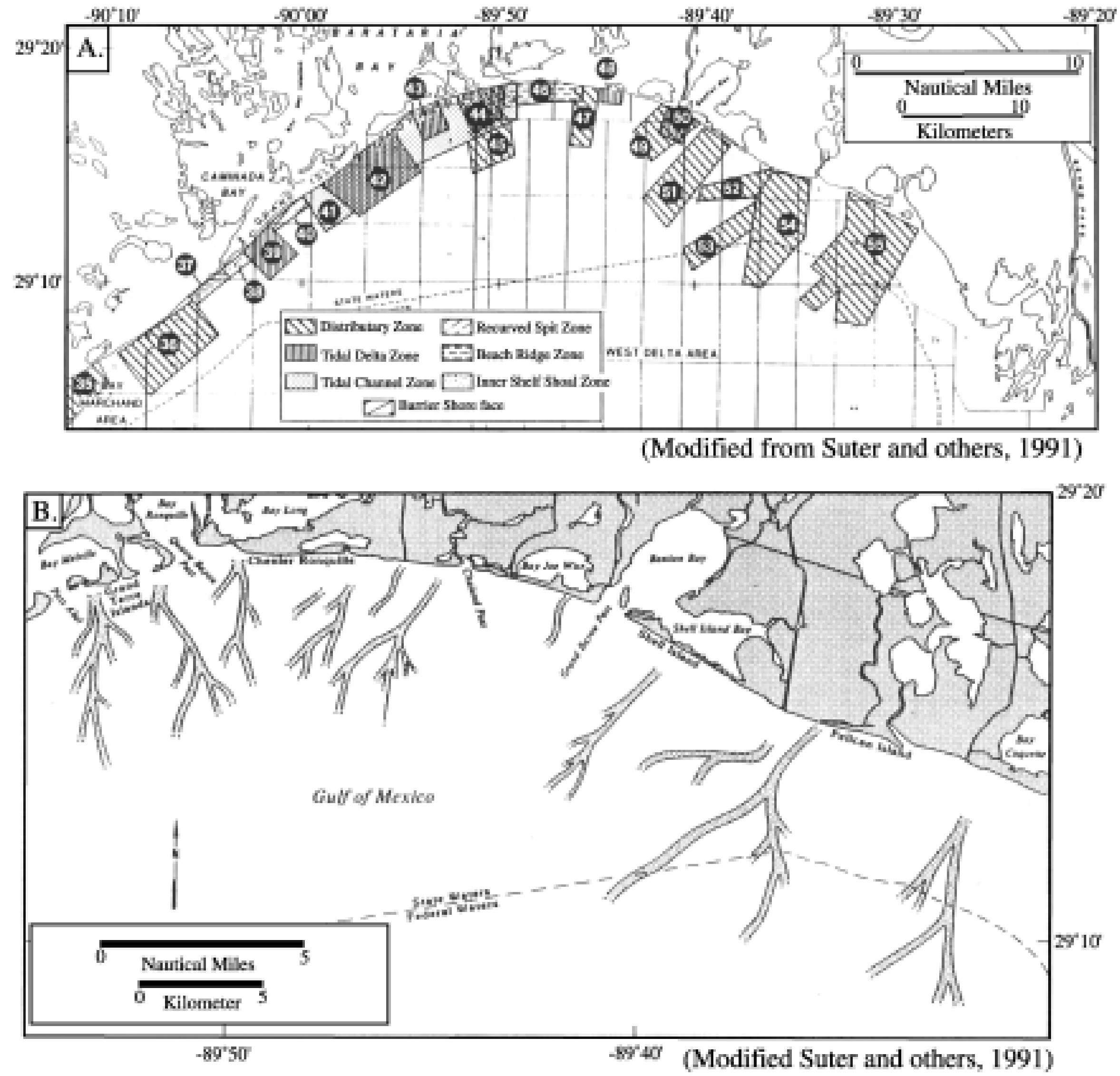


Figure 17. Potential sand resource zones and buried channels reported by Suter and others (1991). (A.) Zones reported as potential sand resources. (B.) Buried channels identified from seismic profiles as an indication of potential channel-fill sands (Suter and others, 1991).

was a reconnaissance survey of a very large area with the inherent variability of a very complex depositional system. There is considerable discrepancy in estimated sand volumes when comparing Suter and others (1991) 21 targets to the 9 targets reported in this study. This discrepancy is a directly due to Suter and others (1991) over estimating of sand resources associated with buried channels. An example is that many of the zones shown in Figure 17-B as sand targets (especially those near Bayou Lafourche to the west end of the study area) are outside the parameters given for this reports survey. Comparing the results of Suter and others (1991) with those of this study indicates that to realistically characterize sand resources, a dense-grid spacing is required and it is necessary to have abundant ground truthing data.

WESTERN SECTION - BELLE PASS TO CAMINADA INLET:

CHIRP profiles from the Western section of the study area show generally horizontal reflections with few interruptions. Infrequent dipping or truncated reflections occur nearshore, adjacent to Belle Pass. This pattern of reflections, characteristic of small, buried distributary channel, are more commonly elsewhere in the study area. Vibracores acquired in this portion of the study area contain a stratification and sediment type that can be described as sand-poor with laminated to massive clays and silts and suggests a predominantly prodelta depositional environment. (Fig. 18). The only exception to this pattern is found at the extreme nearshore where shore face sands are found (Fig. 19). There is a relatively thin (0.9 ft, 0.30 m) surficial silty-fine sand resulting from erosion and marine reworking of the sea floor. Our interpretations are similar to those of List and others (1994) and Penland and others (1988) that indicate this area consists of an erosional headland and flanking barriers of the Bayou Lafourche delta lobe of the Lafourche delta complex. They also reported that the headland's shoreline is composed of prodelta muds and beach ridge sands. In the offshore area, the beach ridge sands have been reworked to form a thin transgressive sand layer overlaying the prodelta sediment. In the Western section there appears to be limited sand beyond the shore face and no sand bodies that meet basic minimum criteria for this survey (see Coast 2050 – Sediment Resource Criteria this report).

CENTRAL SECTION - CAMINADA INLET TO GRAND BAYOU PASS:

The predominant processes influencing sediment accumulation and distribution in this area are inlet dynamics associated with Caminada, Barataria, Quatre Bayou Passes, and Pass Abel. Ebb-tide delta and shore face/barrier deposits provide sandy material that is readily characterized in both the geophysical data and sediment cores (Figs. 20, 21, 22, 23, 24). These deposits produce distinct sand packages in otherwise fine-grained shelf and deltaic deposits. The location of 3 potential surficial resource deposits Caminada, Barataria Inshore, and Quatre Bayou Shallow are shown in Figure13. The geometry of these coarser deposits is typically lenticular, dipping and pinching out offshore. Vibracores that penetrate these units have fine-grained sand to silty sand, typically massive with abundant shell material. Ebb-tide delta deposits at Barataria and Quatre Bayou Passes are the most significant of these deposits (Figs. 21, 23, 24) and can be more than 6.6 ft (2.0 m) thick. Thin, cross-bedded to wavy bedded sands below the nearshore deposits are interpreted to be abandoned tidal-inlet deposits.

Deeper buried depositional features are evident in HRSP and some deeper penetrating cores offshore of Barataria and Quatre Bayou Passes. The target sites are identified as Barataria Offshore, Quatre Bayou Deep and Quatre Bayou D2 in Figure 13. Cores acquired from these

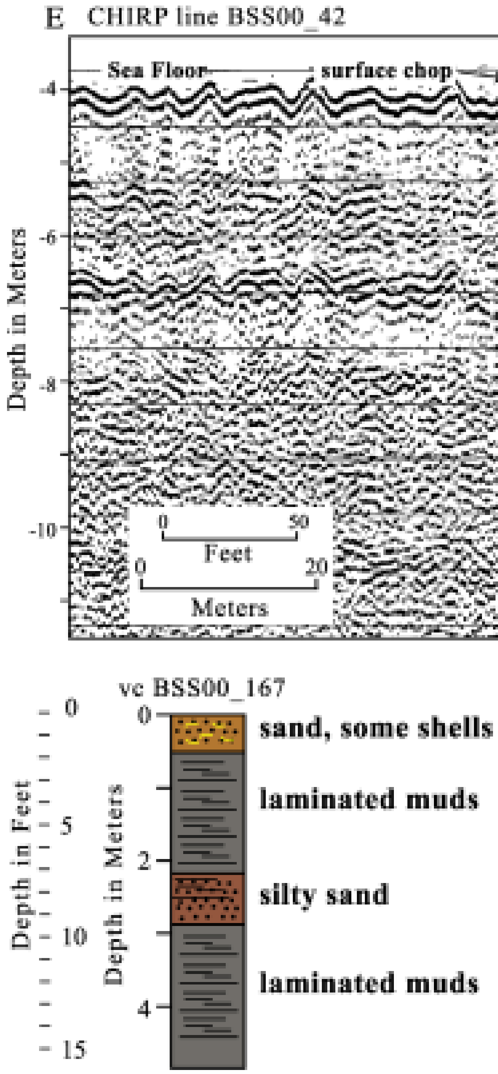


Figure 18. Vibracore BSS00_167 superimposed on a CHIRP profile collected from the western end of the study area (see Fig. 14 for location). The laminated muds indicate a prodelta depositional environment. There is a veneer of surficial silty-fine sand resulting from erosion and marine reworking of the sea floor, (see Western section, Figure 2).

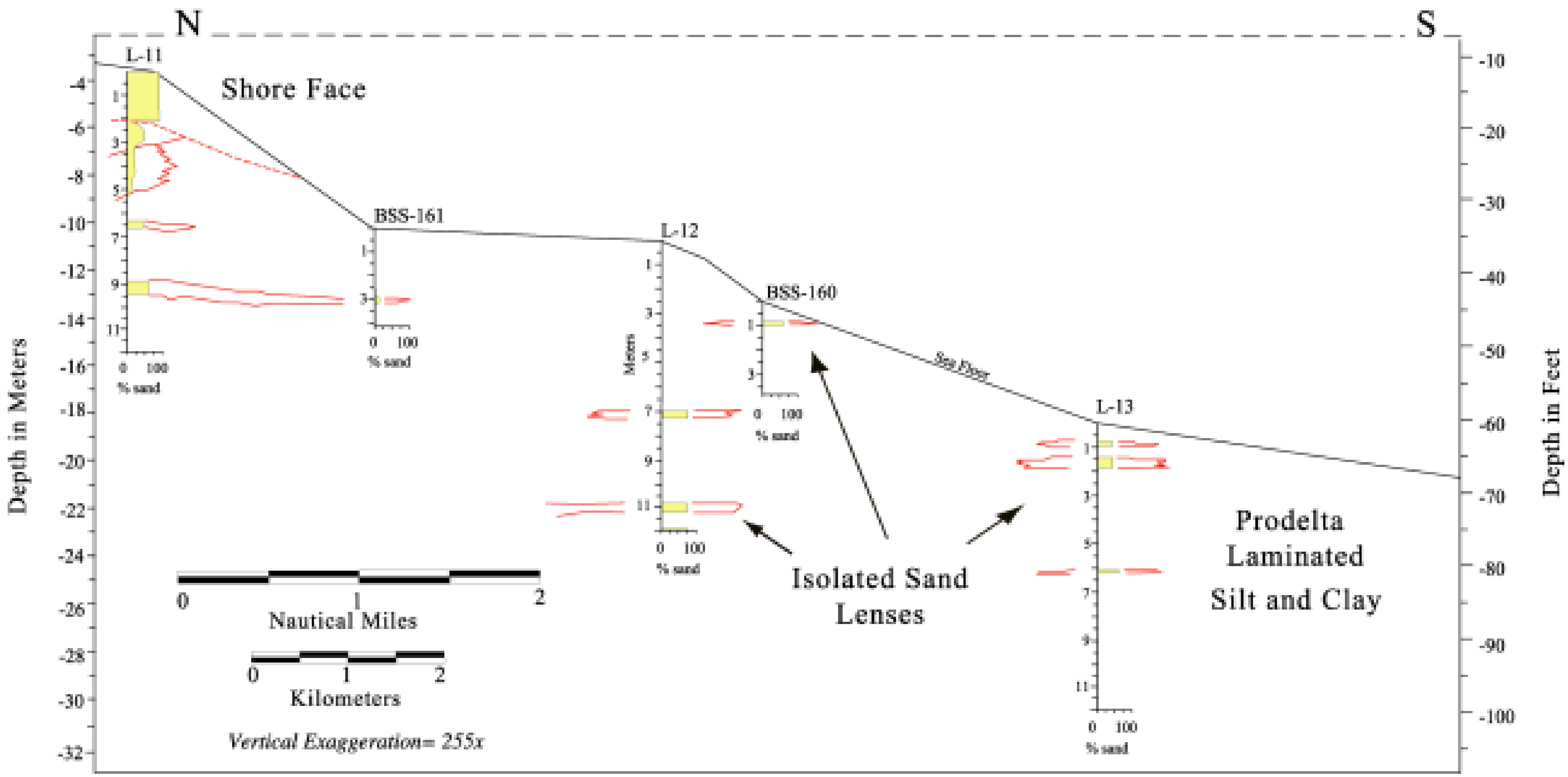


Figure 19. Vibracore transect from the Western section of the study area indicating that there is minimal sand available in the system. Vibracore descriptions indicate massive laminated muds with minimal variation, except along the nearshore where shore face sands are found. Location of illustration shown in Figure 14.

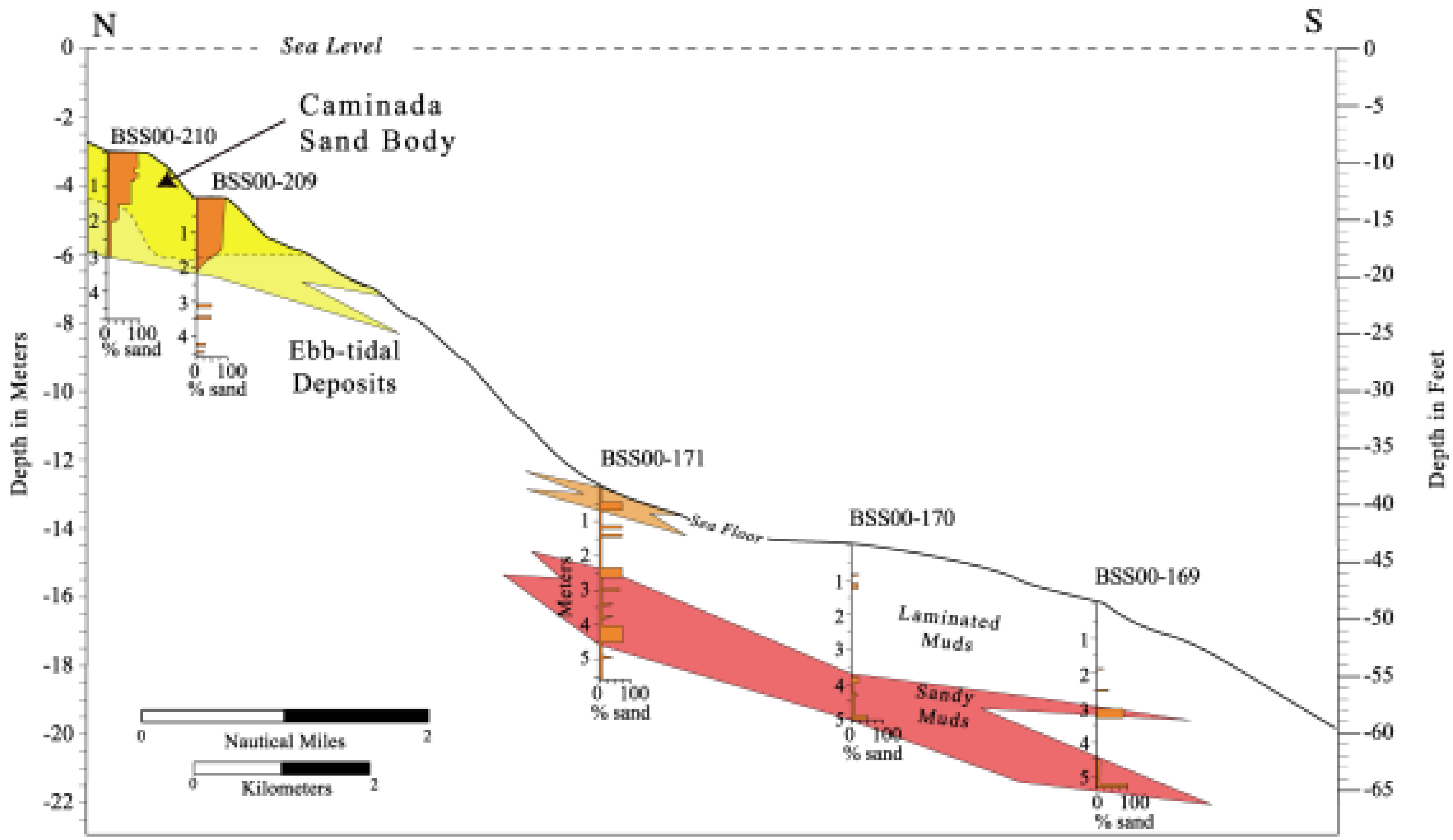


Figure 20. Line drawing of a vibracore transect across Caminada Sand Body ebb-tidal delta deposits. The Caminada Sand Body is part of the ebb-tidal delta and meets the Coast 2050 criteria as a sand resource. The remaining portion of the ebb-tidal delta contains less percent sand and does not meet the basic criteria. The smaller sand units shown in cores BSS00_171, _170, and _169 are too thin to meet basic sand resource criteria. Location of illustration shown in Figure 14.

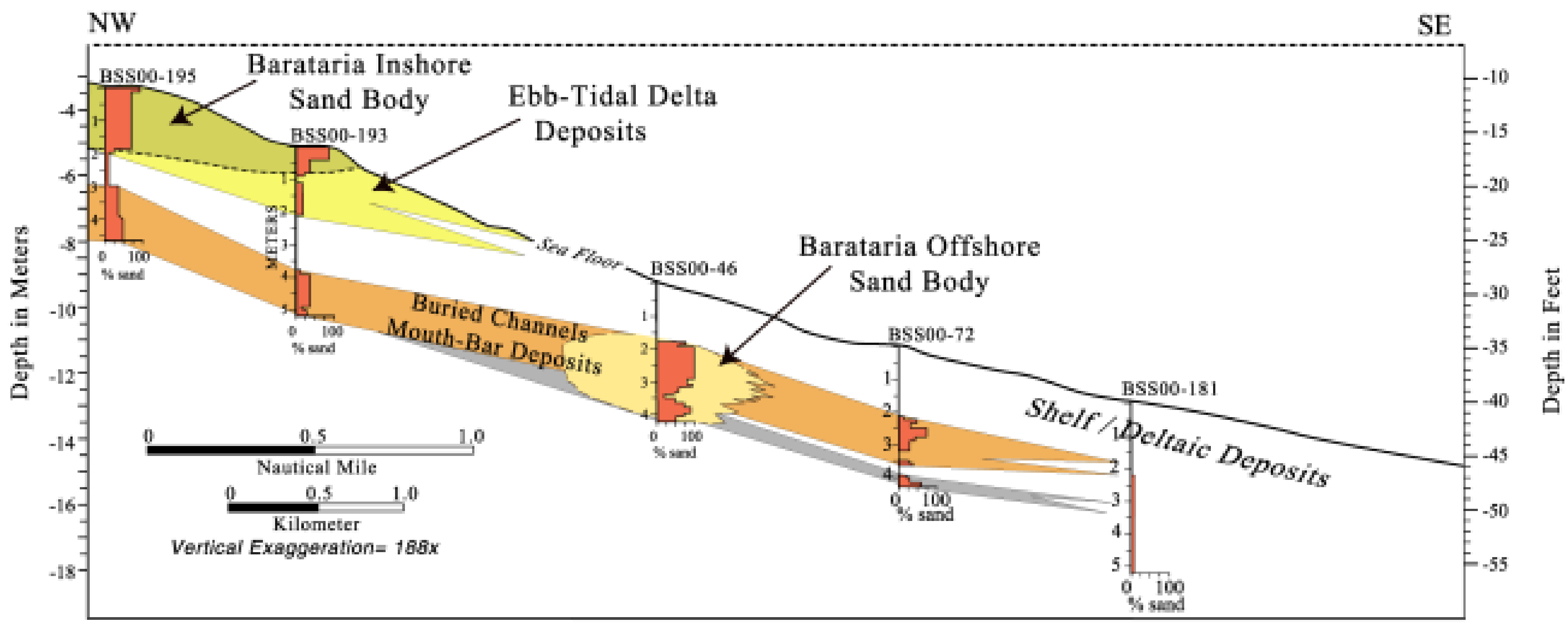
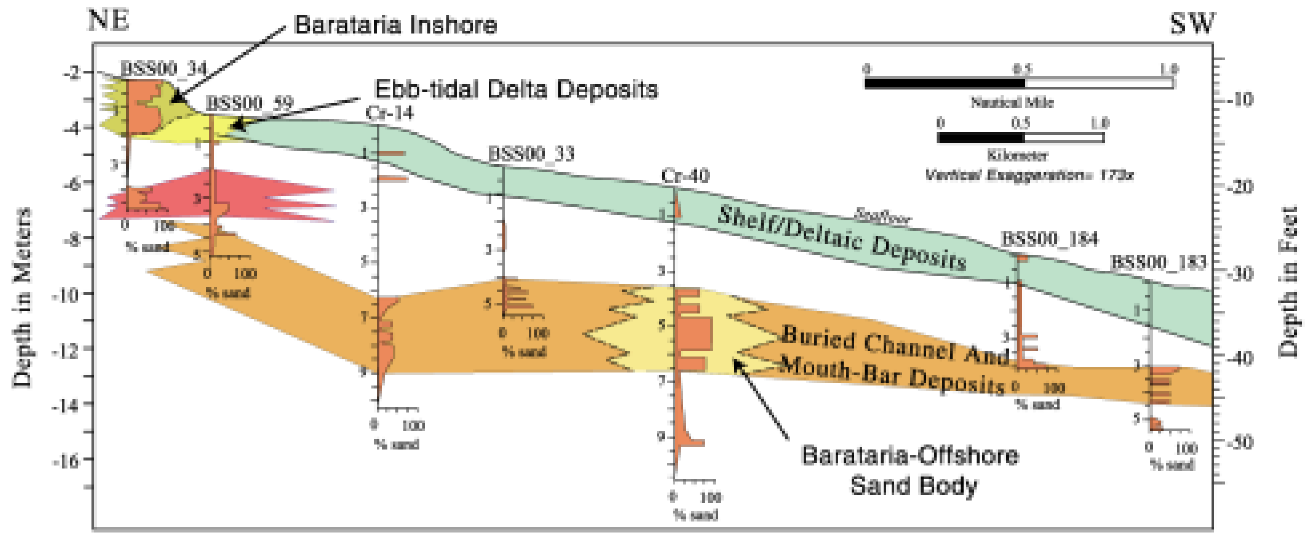


Figure 21. Vibracore cross section A-A’ from Barataria Pass to the south edge of the study area. The sand deposits shown are Barataria Inshore and Offshore with percent sand from vibracore descriptions. Barataria Inshore is part of the ebb-tidal delta facies deposit and Offshore is found within the buried channel and mouth-bar facies deposit. Location of illustration shown in Figure 14.



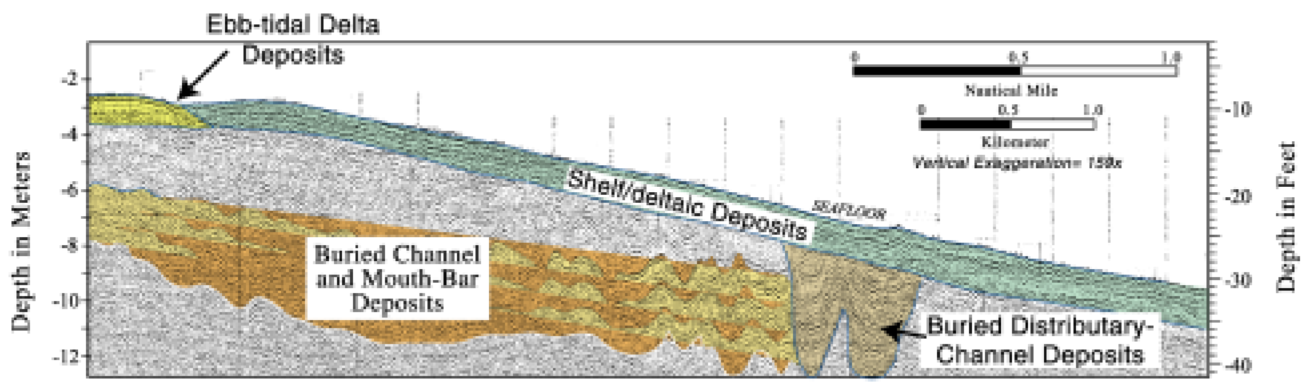


Figure 22. Line drawing of vibracore transect (above) and interpreted subbottom CHIRP profile (below) showing Barataria Inshore and Offshore sand deposits. CHIRP profile shows buried distributary channel not sampled by vibracores. Barataria Inshore is part of the ebb-tidal delta facies deposit and Offshore is found within the buried channel and mouth-bar facies deposit. Location of illustration shown in Figure 14.

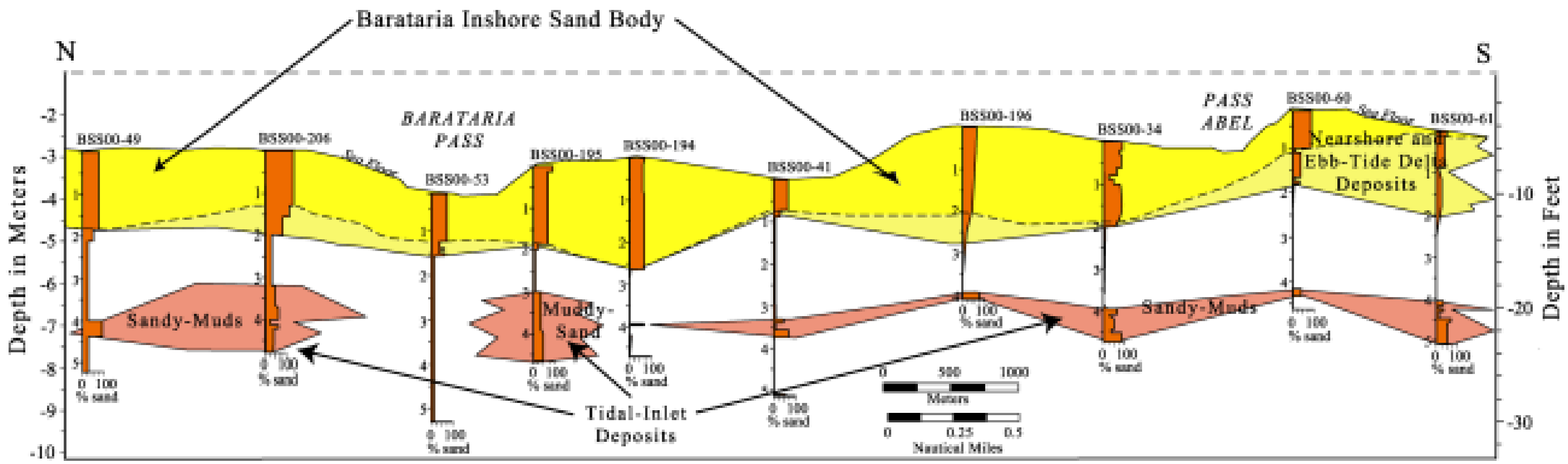


Figure 23. Line drawing of east to west vibracore transect across Barataria Pass to Pass Abel. Cross section shows the surficial Barataria Inshore ebb-tidal delta sand deposits. Barataria Inshore Sand Body is part of the ebb-tidal delta facies deposit. Location of illustration is shown on Figure 14.

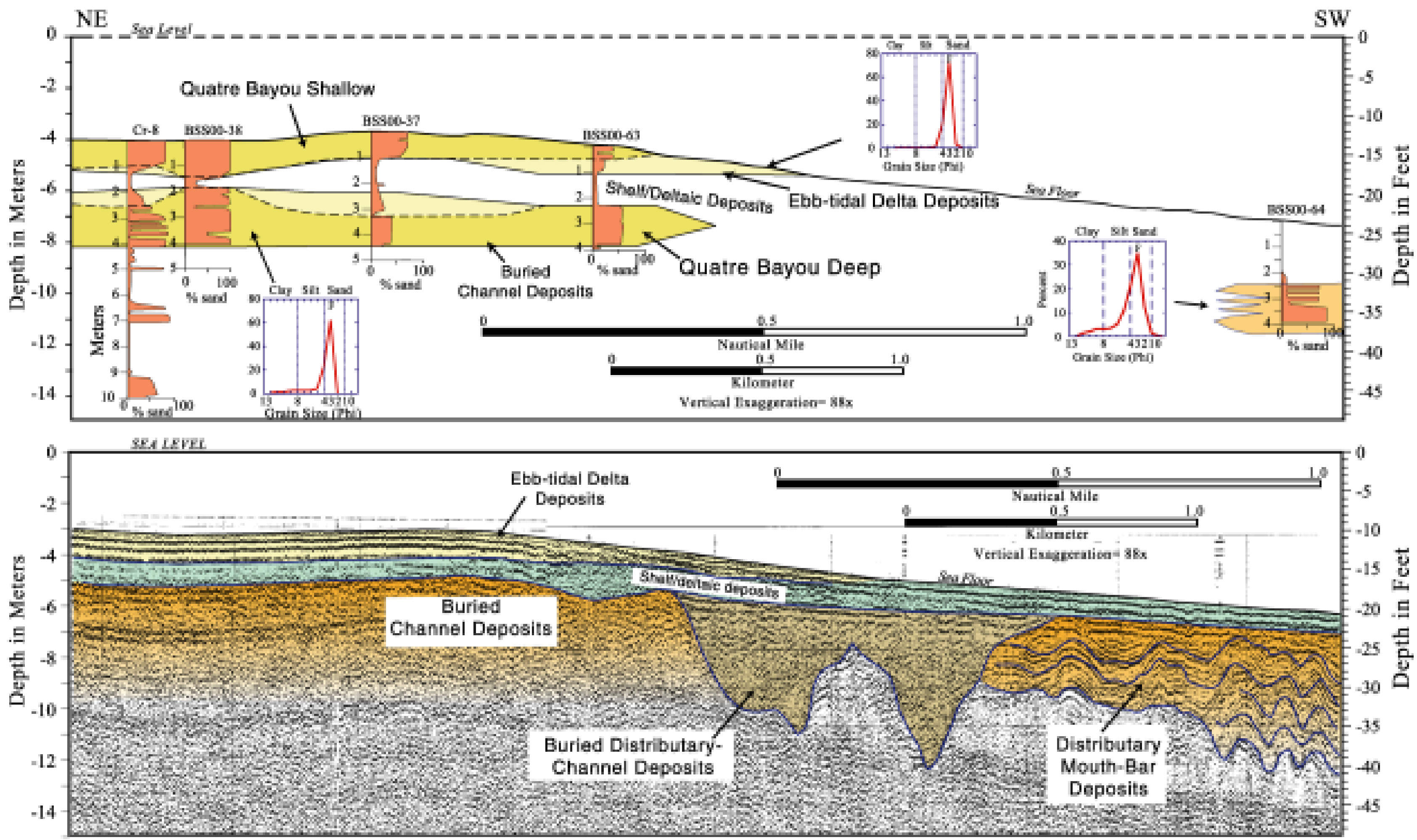


Figure 24. Line drawing of vibracore transect and subbottom CHIRP profile showing position of Quatre Bayou Shallow and Deep Sand Bodies within respective sedimentary facies. Quatre Bayou Shallow is found within ebb-tidal delta deposits. Quatre Bayou Deep is found within the buried channel deposits. In this cross section the two deposits clearly overlap. Location of illustration shown in Figure14.

deposits show massive to laminated sands, devoid of shell material. The deposits are lenticular, elongate parallel to shore and can be more than 14 ft (4 m) thick. These features are interpreted to be buried distributary mouth-bar or channel-fill deposits. USACE 2000 40 ft (12.2 m) borings were acquired to determine thickness of these deeper deposits (Fig. 25). The cores correlated well to horizons interpreted from CHIRP profiles, which provided areal extent.

Caminada

The Caminada Sand Body is a relatively small (1.13 mi^2, 2.0 km^2) surficial unit on the west side of Caminada Pass, which is located at the west end of Grand Isle (Fig. 13, 14, 26). The sand body is located in water depths of 5 to 10 ft (1.5 to 3.0 m) below MSL. The Caminada Sand Body is an ebb-tidal delta associated with Caminada Pass (Fig. 20) and is a surficial deposit with no overburden. This sand body has an estimated average thickness of 4 ft (1.2 m) and consists of 60 to 80 % fine sand with a grain-size range of between 2.5 to 4.7 phi. Estimated sand volume is 3.7 to 5.0 mil yd^3 (2.9 to 3.9 mil m^3) (Table 1).

Barataria Inshore

Barataria Inshore is an irregularly shaped surficial sand unit with the largest areal extent of the ebb-tidal sand bodies within the study area (Fig. 13, 27). This sand body has a surface area of 5.93 mi^2 (15.4 km^2) and is found in a water depth of 5 to 10 ft (1.5 to 3.0 m) below MSL (Fig. 27). As shown in Figures 21, 22, 23, and 27, Barataria Inshore has an estimated thickness ranging from 4 to 9 ft (1.2 to 2.75 m) and is 60 to 85% fine sand with a grain-size range of 2.5 to 4.7 phi (Table 1). This asymmetrical sand deposit does not have an overburden and has an estimated sand volume of 18.4 to 26.1 mil yd^3 (14.2 to 20.1 mil m^3). Asymmetry of the Barataria Inshore is caused by the central portion of the deposit being reworked and eroded by the incision of Barataria Pass tidal inlet due to the increasing tidal volume exchange from Barataria Bay through Barataria Pass to the Gulf of Mexico (Fig. 28).

Barataria Offshore

Barataria Offshore is one of the larger sand bodies in the study area and has a surface area of 6.07 mi^2 (15.7 km^2) and thickness of 7 to 9 ft (2.1 to 2.7 m) (Fig. 13, 29, 30, Table 1). This unit of 60 to 80% sand was deposited in migrating distributary channels and as reworked distributary mouth-bar sediments (Fig. 21) with sand-grain size values of 2.5 to 5.5 phi. The estimated volume of usable sand is 34.7 to 46.3 mil yd^3 (26.7 to 35.6 mil m^3). Barataria Offshore is a buried deposit 25 to 40 ft (6.1 to 12.2 m) below MSL with 10 to 15 ft (3.0 to 4.6 m) overburden equaling 78.6 mil yd^3 (60.5 mil m^3) (Fig. 29, 30). The overburden material consists of massive to laminated clayey-silt beds with occasional sand lenses and some shell.

Quatre Bayou Shallow

Quatre Bayou Shallow is a moderate size ebb-tidal delta with an areal extent of 2.04 mi^2 (5.3 km^2) (Fig. 13, 31). This is a surficial deposit with an average water depth of 10 ft (3.0 m). The deposit has a thickness ranging between 5 and 10 ft (1.5 to 3.0 m) with an estimated sand volume of 6.1 to 8.1 mil yd^3 (4.7 to 6.2 mil m^3). Sand concentration is 60 to 80% with a sand grain-size range of 2.5 to 4.7 phi (Table 1). The Quatre Bayou Shallow Sand Body partially overlies the Quatre Bayou Deep Sand Body and they are separated by intercalated beds of clay and silt ranging from 3 to 10 ft (0.9 to 3.0 m) thick (Fig. 25, 32 B-B').

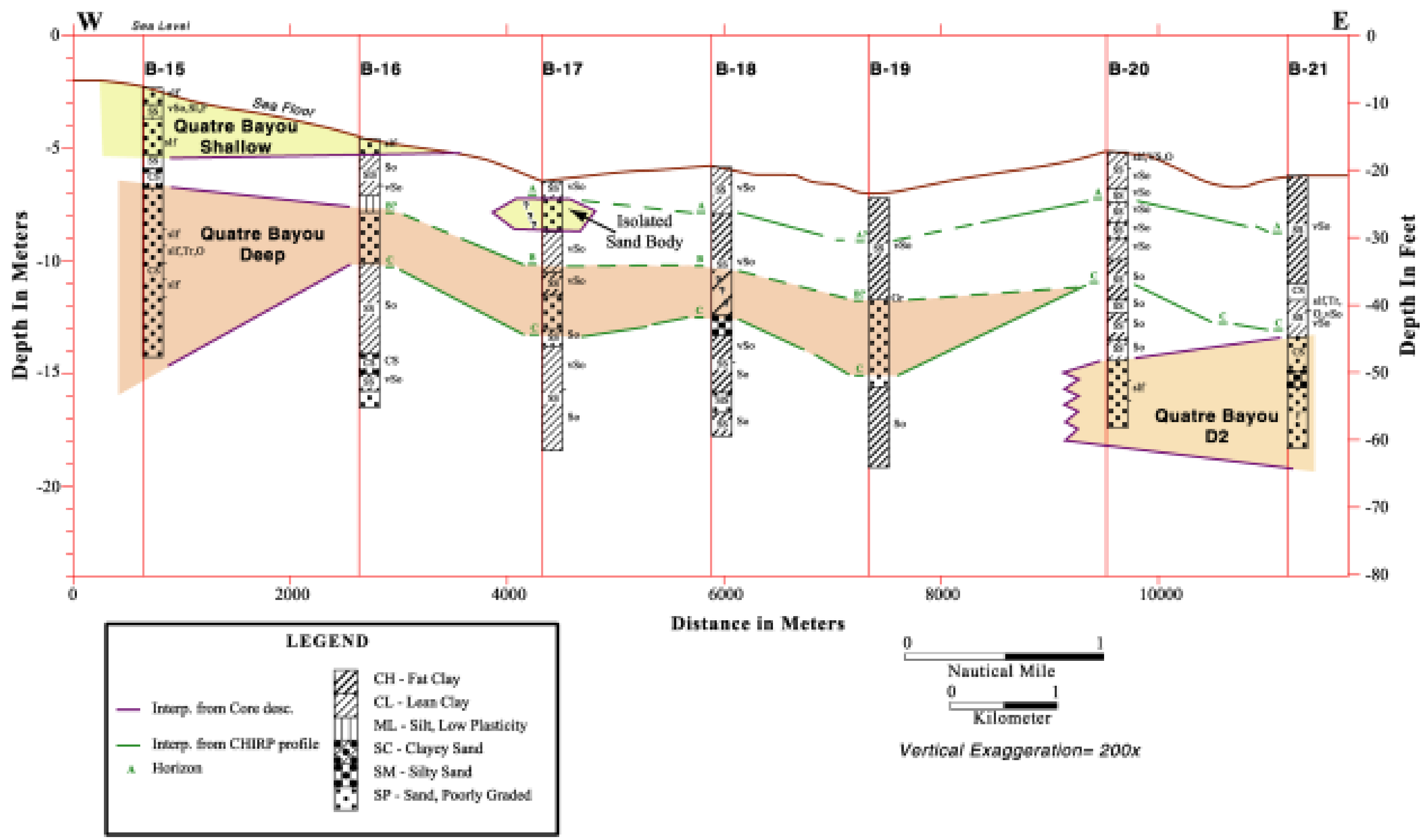


Figure 25. Line drawing of USACE 2000 borehole transect showing the overlying position of Quatre Bayou Shallow, Deep, and D2 sand targets. Bore hole B-17 samples indicate the presence of a small isolated sand body that maybe a buried channel sand, but does not meet the criteria as a target. Location of illustration shown in Figure14.

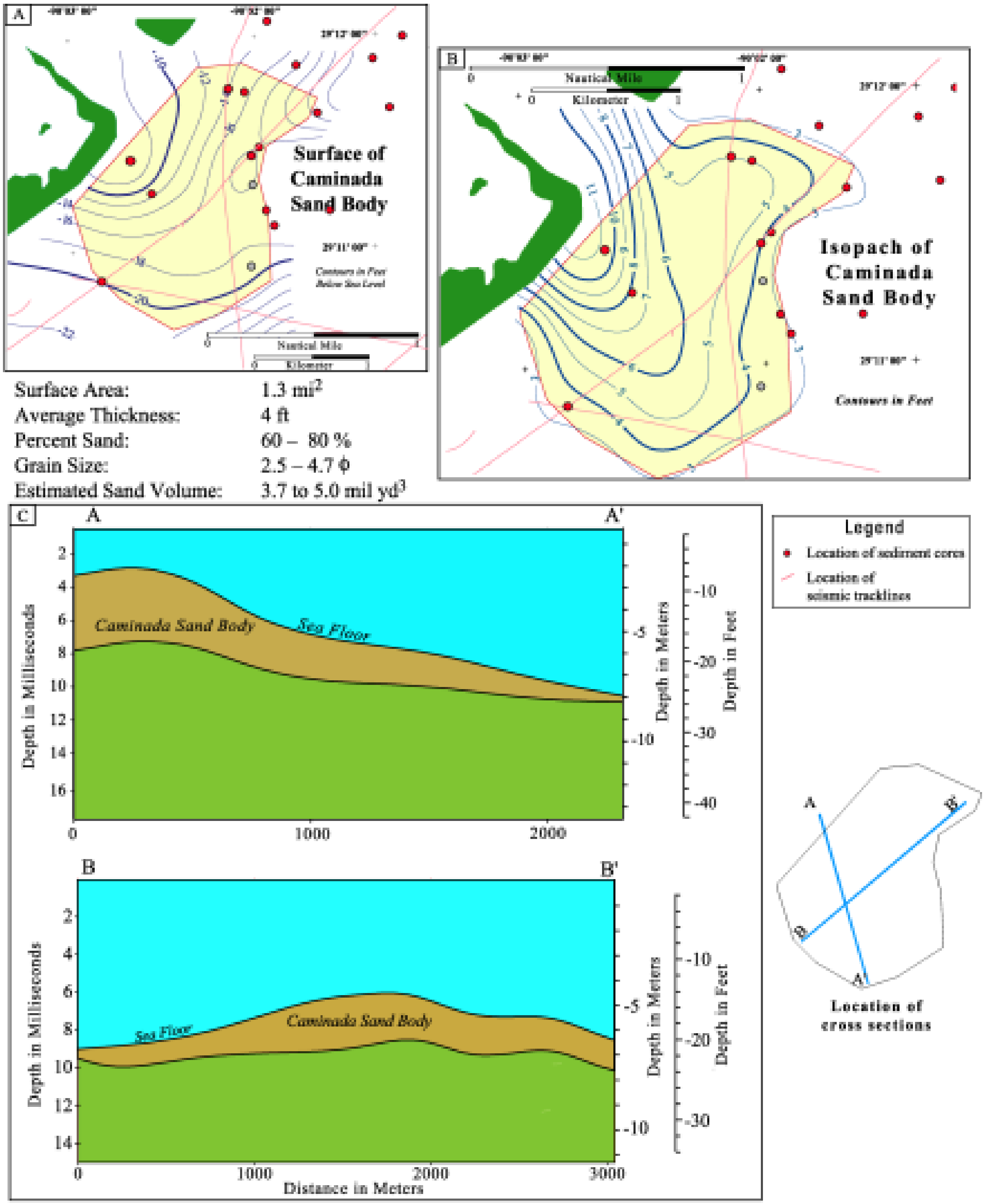
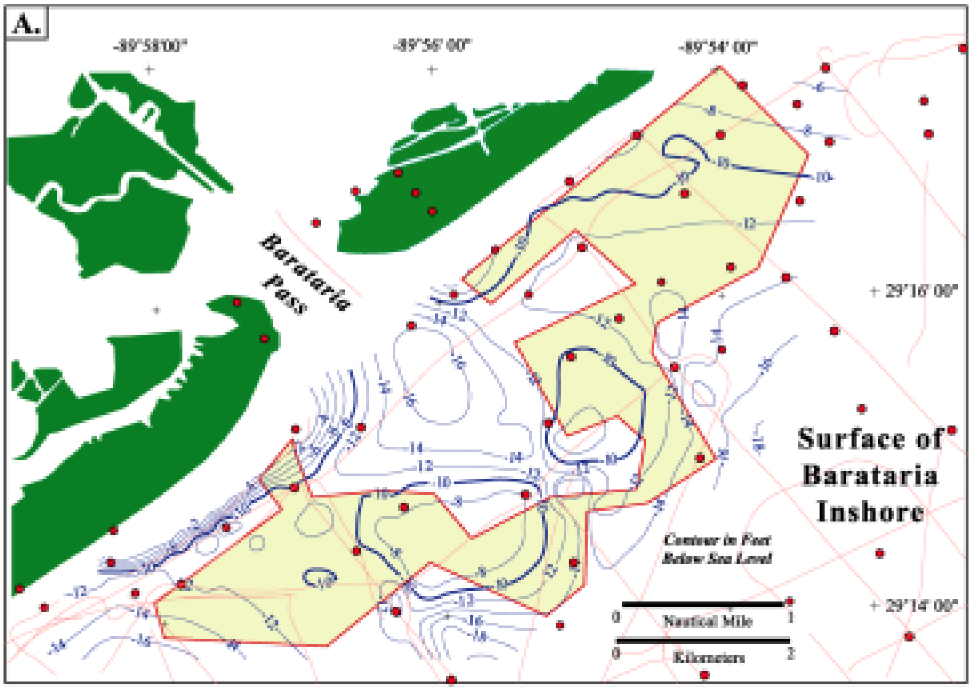


Figure 26. Caminada Sand Body is a surficial sand resource with 1.3 mi2. The surficial sand body has an average thickness of 4 ft (1.2 m) and an estimated sand volume of 3.7 to 5.0 mil yd3. (A) Surface structure map; (B) Caminada Sand Body Isopach is constrained by the thickness of unit and percent sand; (C) Cross sections A-A' and B-B' show the lateral variability of the sand unit thickness.



Surface Area:	5.93 mi^2
Average Thickness:	4 -9 ft
Percent Sand:	60-85 %
Grain Size:	2.5 – 4.7 ϕ
Estimated Sand Volume:	18.4 to 26.1 mil yd^3

Legend

- Location of sediment cores
- Location of seismic tracklines

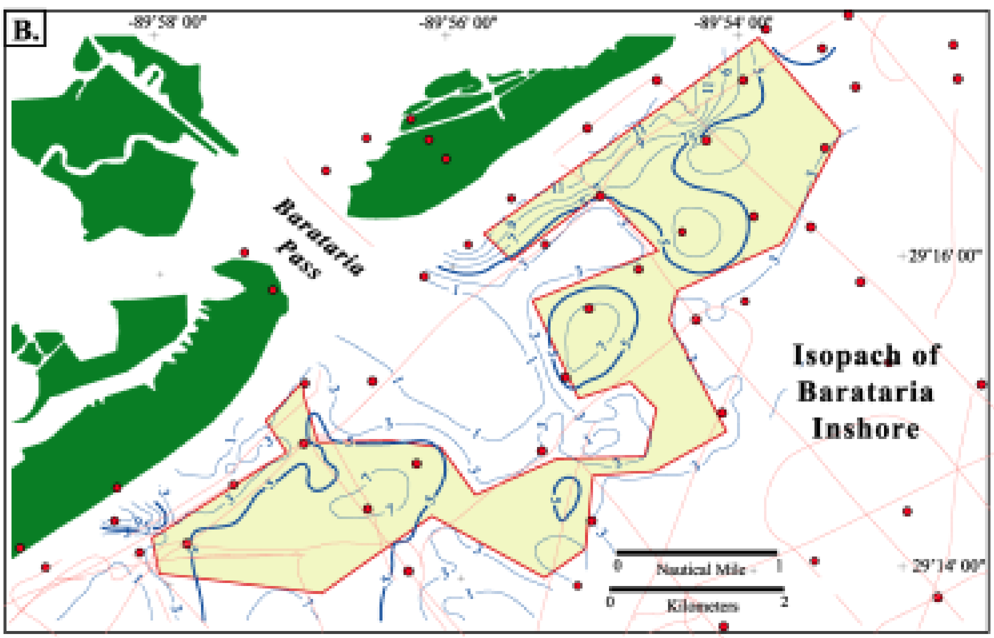


Figure 27. Barataria Inshore Sand Body is a very irregular shaped ebb-tidal sand body. The irregular shape is produced by the presence of the Barataria Pass tidal inlet. (A) Structure contour of Barataria Inshore Sand Body surface overlain by deposit outline and location meeting the basic criteria. (B) Barataria Inshore Sand Body Isopach is constrained by thickness and percent sand criteria.

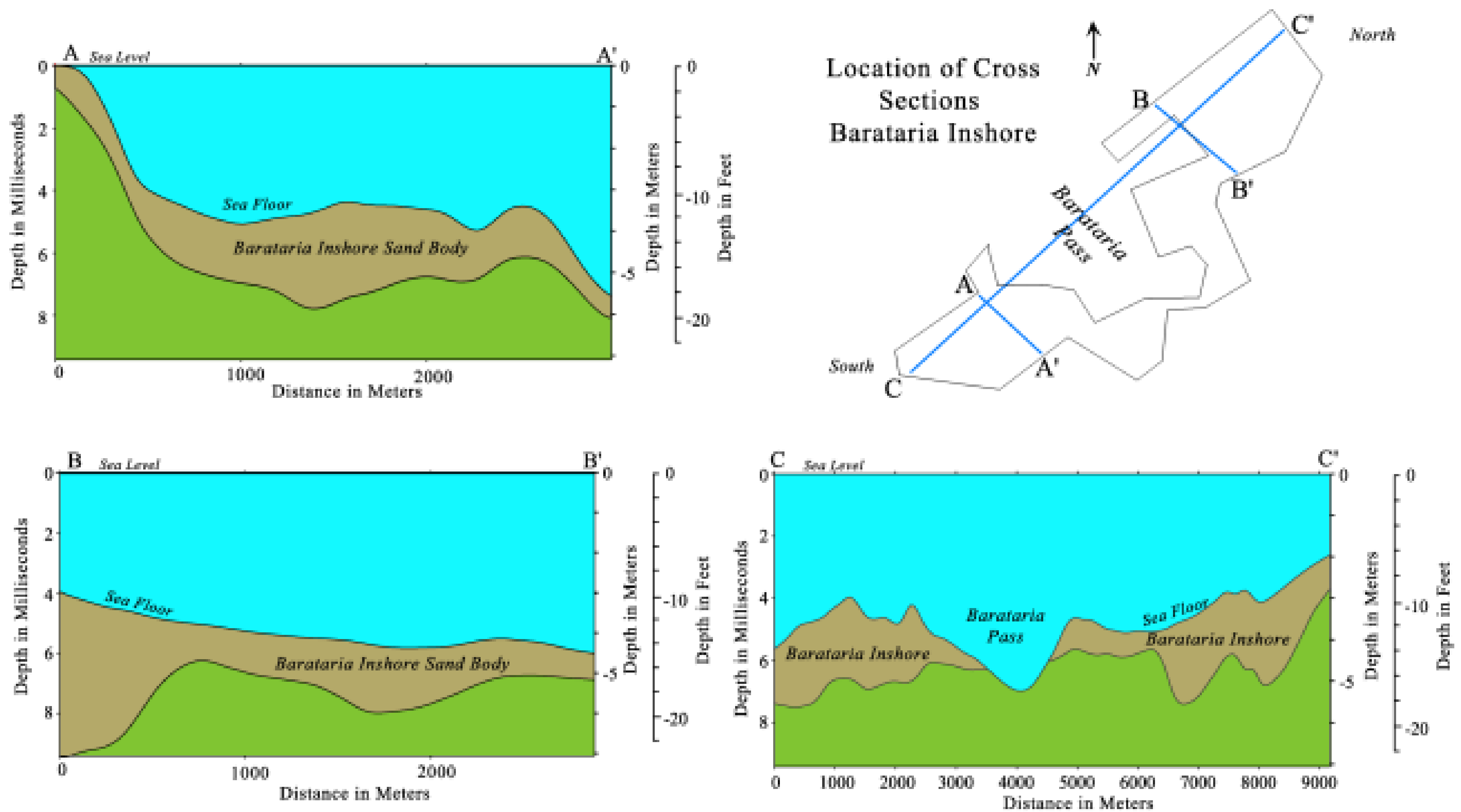


Figure 28. Cross section of Barataria Inshore showing thickness and sand body distribution. A-A' (western lobe) and B-B' (eastern lobe) cross sections of sand body on opposite sides of Barataria Pass. C-C' is a southwest to northeast cross section showing sea floor and deposit irregularities due to incision by Barataria Pass inlet.

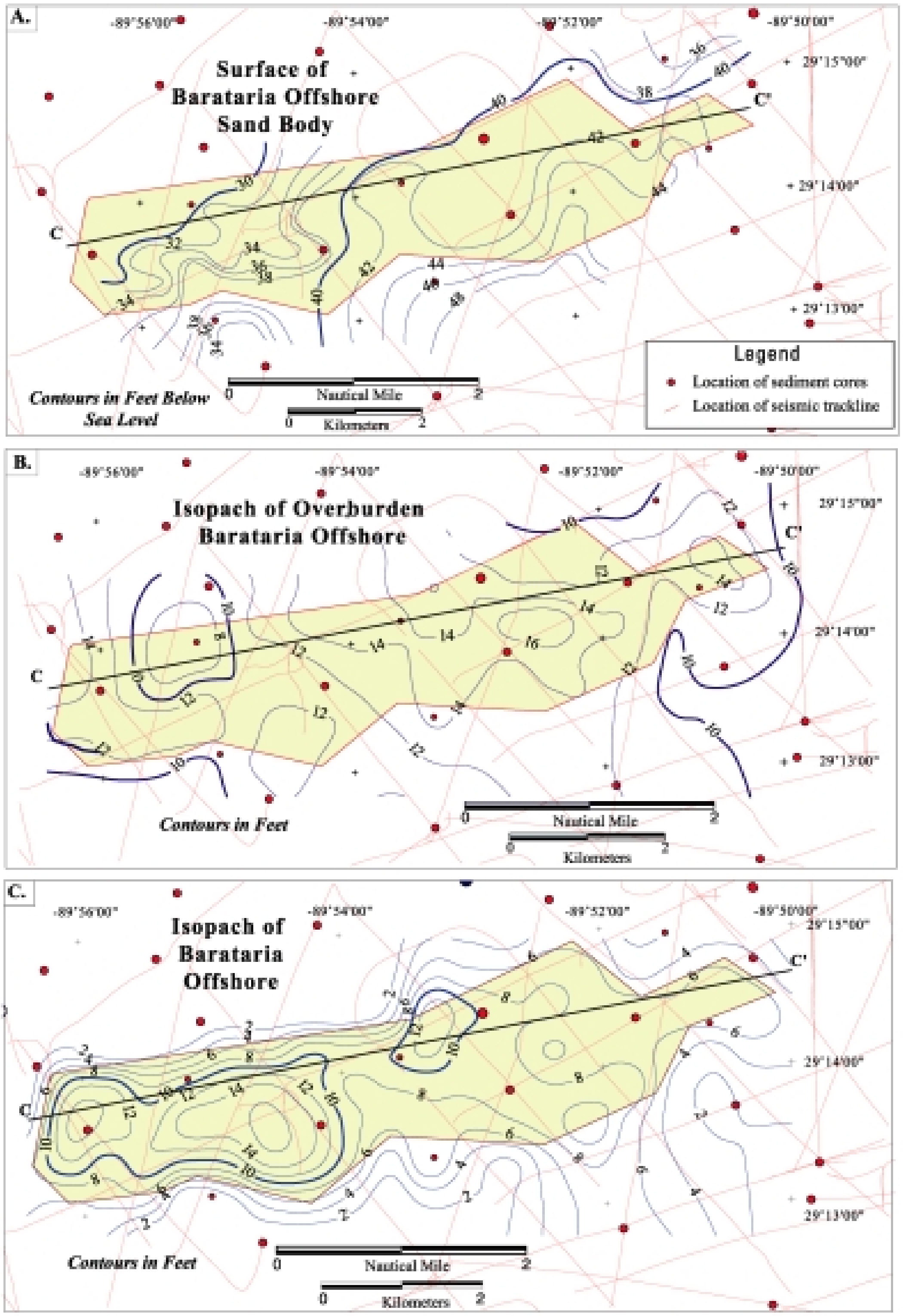


Figure 29. The Barataria Offshore Sand Body is a buried sand deposit with 10 – 15 ft (3.3 to 4.6 m) of sediment overburden. Outline of sand deposit is shown in red. (A) Structure contour map of Barataria Offshore Sand Body surface; (B) Isopach of overburden covering the sand body; and (C) Isopach of the Barataria Offshore Sand Body. See cross section C - C' in Figure 30.

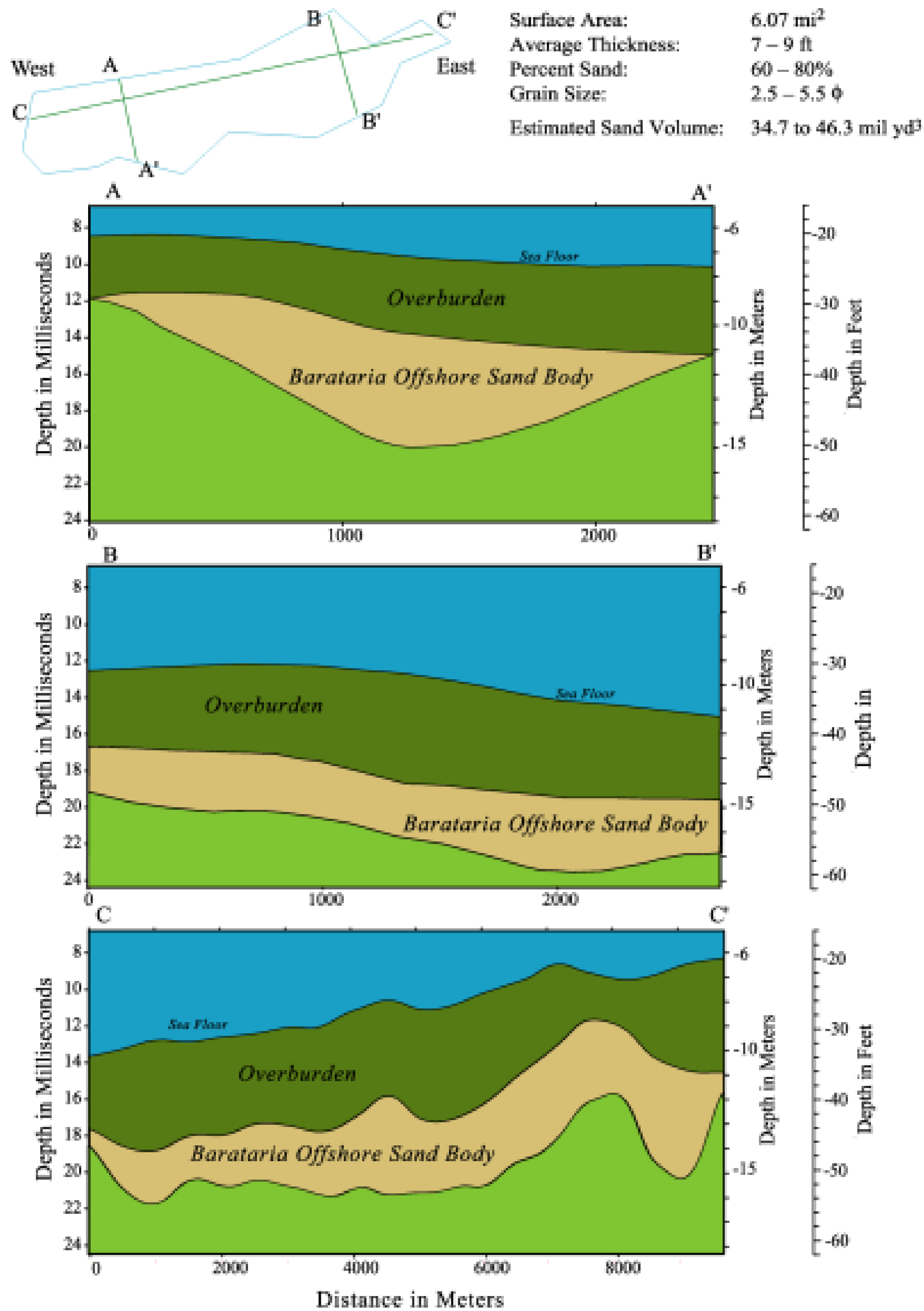


Figure 30. Barataria Offshore Sand Body is a buried sand resource covering an area of 1.3 mi2. The overburden thickness is 10 – 15 ft (3.3 to 4.6 m). A - A' and B - B' are north to south cross sections across the narrow portion of the sand body. C - C' is a west to east cross section along the axis of the sand body. See Isopach contours in Figure 29.

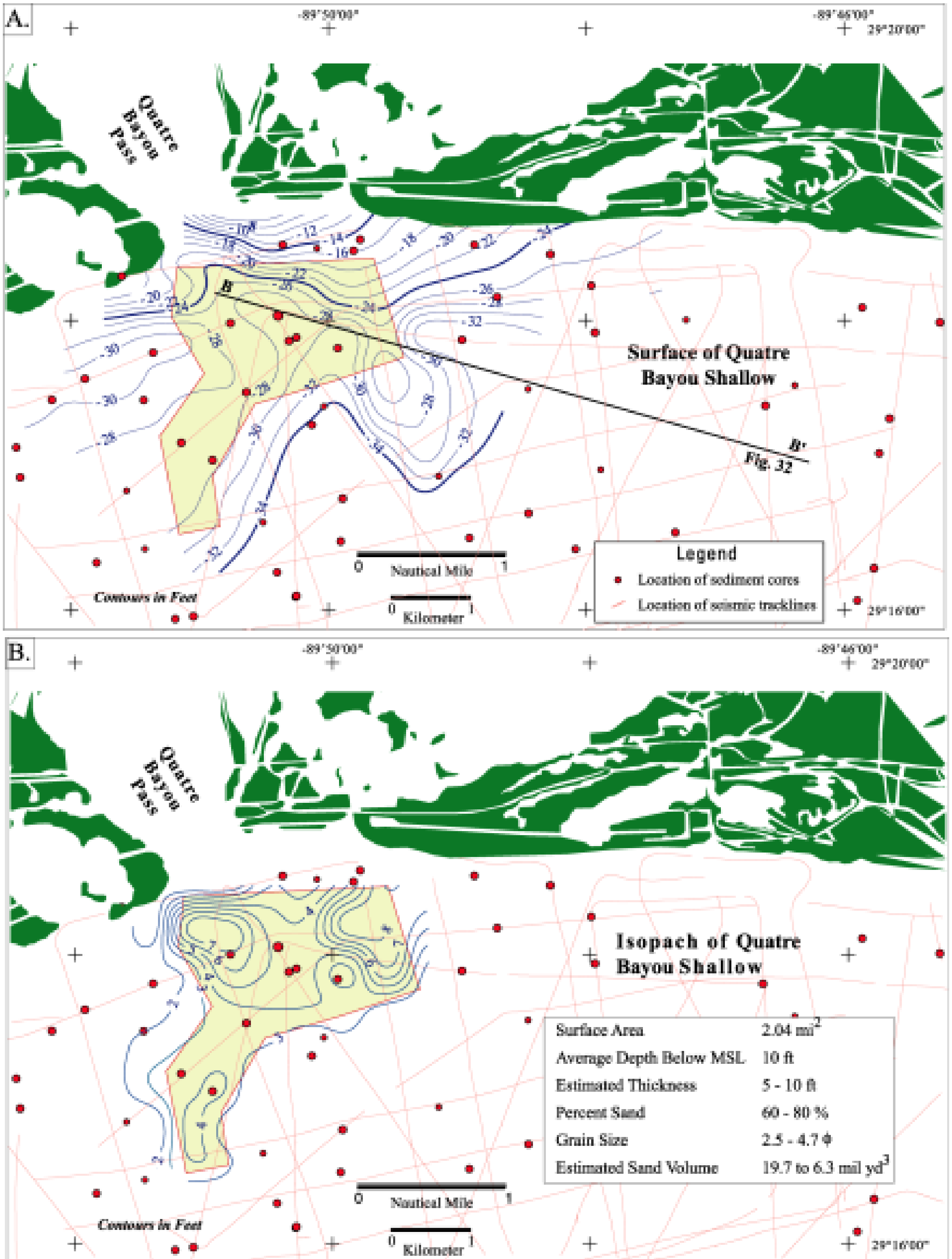


Figure 31. Quatre Bayou Shallow Sand Body is part of a surficial ebb-tidal delta. (A) Structure contour of sand body surface. B-B' is the cross section shown in Figure 32. (B) Isopach of sand body showing a bi-modal sediment distribution.

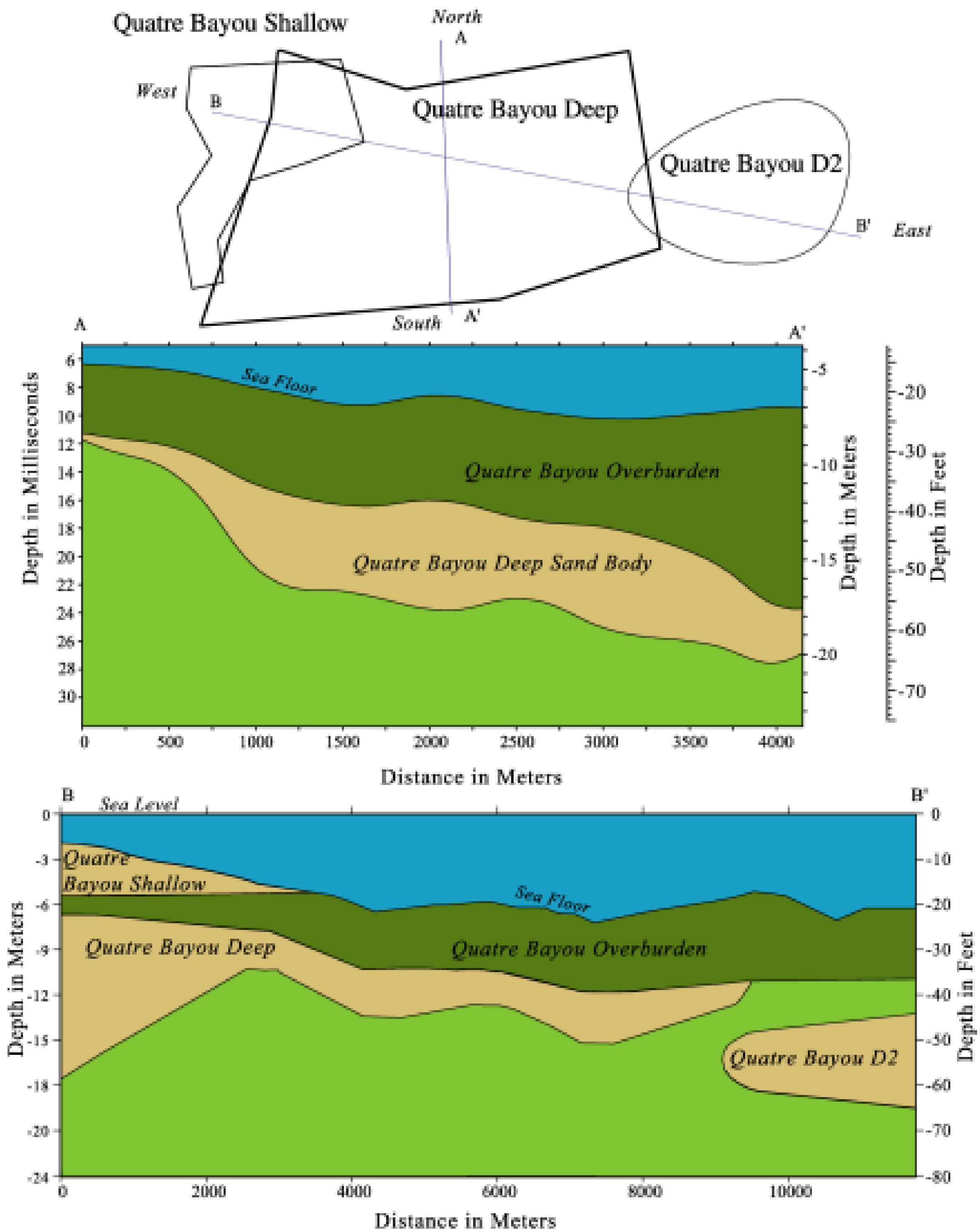


Figure 32. Line drawing cross sections that transect Quatre Bayou Shallow, Deep, and D2 sand targets. A-A' is a north to south transect interpreted from boomer and CHIRP profiles interpreted from borings showing overburden and Quatre Bayou Deep and D2 Sand Bodies. B-B' is a west to east transect showing the geometric relation of the three sand bodies.

Quatre Bayou Deep

The Quatre Bayou Deep Sand Body (Fig. 33) is 8.85 mi^2 (22.9 km^2), 5 to 10 ft (1.5 to 3.0 m) thick with an overburden of 7 to 15 ft (2.01 to 4.6 m). The deposit is characterized as 70 to 100% poorly to moderately sorted fine sand (2.0 to 5.5 phi) that was deposited in migrating distributary channels and as reworked distributary mouth-bar sediments (Fig. 24). This sand body has an estimated sand volume of 92.8 to 132.6 mil yd^3 (71.4 to 101.9 mil m^3) (Table 1). Depth to the target unit is 22 to 45 ft (6.7 to 13.7 m) below MSL. The Quatre Bayou Deep deposit has an overburden of 156 mil yd^3 (120.0 mil m^3) with a portion of the overburden consisting of the Quatre Bayou Shallow deposit (Fig. 25, 32-B, 34). The remaining overburden is comprised of horizontally laminated clay and silt with occasional lenticular sands.

Quatre Bayou D2

The deepest buried sandy body identified during this study was the Quatre Bayou D2 deposit. This deposit has a relatively small surface area of 1.7 mi^2 (4.4 km^2) (Fig. 13) and a thickness greater than 7 ft (2.1 m) (Table 1). Depth to the top of the target ranges from 45 to 47 ft (13.7 to 14.3 m) below MSL with an overburden thickness of 30 to 40 ft (9.2 to 12.2 m) and an estimated overburden volume of 61.0 mil yd^3 (46.9 mil m^3) (Table 1). The west end of the Quatre Bayou D2 sand deposit is partially overlain by the east end of the Quatre Bayou Deep separated by 7 to 10 ft (2.1 to 3.1 m) of clay, silt, and sand overburden (Fig. 32). The remaining overburden consists of alternating laminae of clays and silt with an infrequent sand lens. The D2 sand deposit consist of 50 to 80% sand with grain-sizes ranging from 3.0 to 5.0 phi. Quatre Bayou D2 is technically beyond the depth parameters of this study and was not fully penetrated by any of the coring methods employed. Given that the total thickness is unknown, an estimate was calculated using the sampled 7 ft (2.1 m) thickness resulting in an estimated volume of 7.4 to 9.8 mil yd^3 (5.7 to 7.6 mil m^3) (Table 1).

EASTERN SECTION - PASS ABEL TO SANDY POINT:

CHIRP profiles from the Eastern section show horizontal reflections extend throughout much of the area demonstrating similarities between the erosional headlands of the Western and Eastern sections. In contrast to the Western section, in this section the horizontal reflections are disrupted by the presence of distributary channels. Cores reveal that these horizontal reflections consist of alternating massive and laminated soft muds. Buried distributary channels are more prevalent in the Eastern section than elsewhere, as characterized in CHIRP and cores (Fig. 35, 36). As discussed above, buried distributary channels would make likely sand targets for borrow material, however, sediment cores in these distributary channels show some bedded sands, whereas others are mud-filled (Fig. 15, 16). The channel sands are isolated packages and are not necessarily borrow-quality material without detailed, site-specific investigations. Three target sand bodies were identified in the Eastern section: Empire, Scoffield, and Sandy Point (Fig. 13).

Empire

The first targeted sand unit in the Eastern section is the Empire Sand Body located offshore of the Empire jetties (Fig. 13). This sand body has a surface area of 2.1 mi^2 (5.4 km^2) with 3 to 10 ft (0.9 to 3.1 m) of overburden (Table 1). The target is 17 to 25 ft (5.2 to 7.6 m) below MSL and has a thickness of 3 to 6 ft (0.9 to 1.8 m). This sand body is 60 to 80 % fine sand

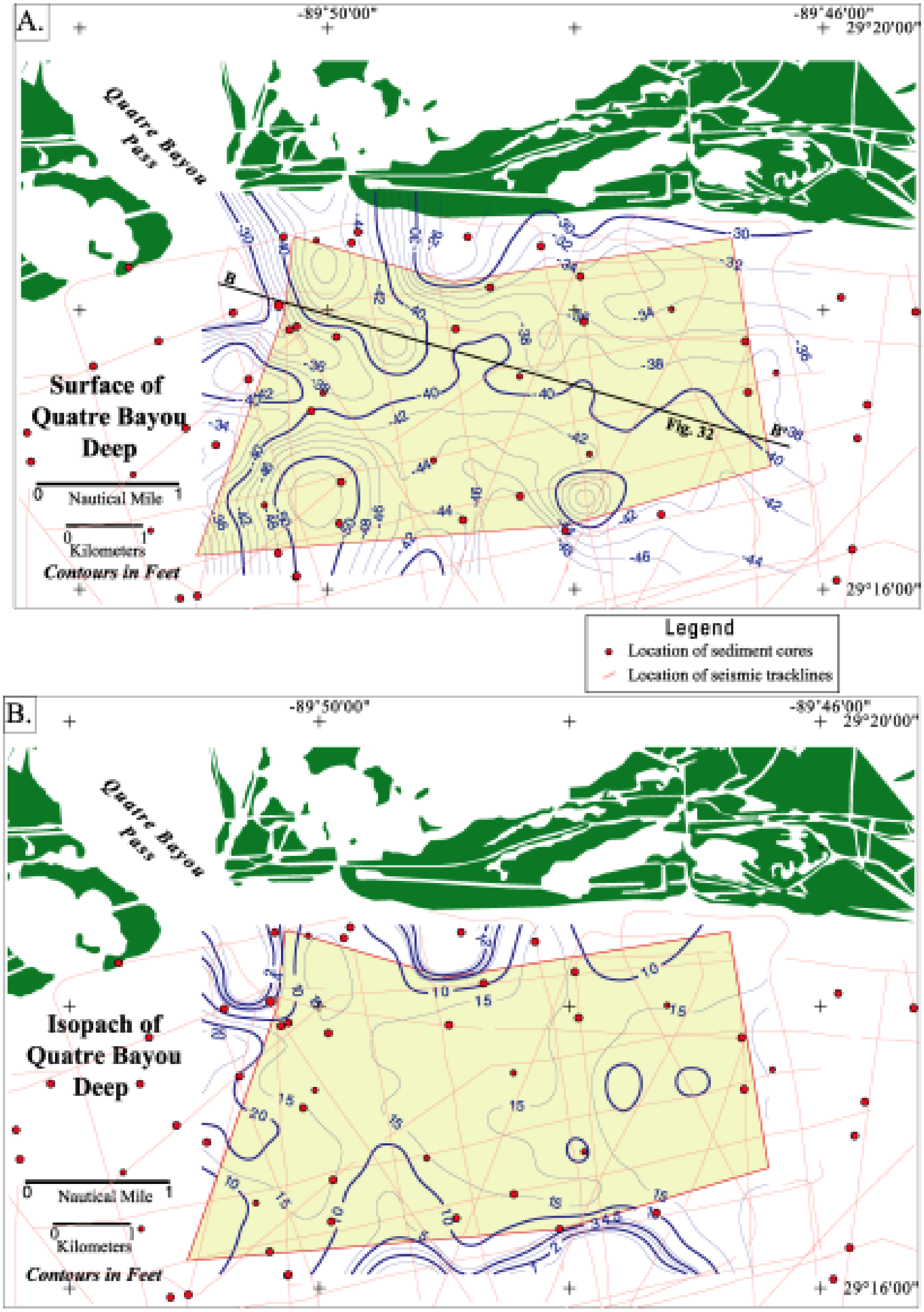


Figure 33. Quatre Bayou Deep Sand Body (outlined in red). (A.) Structure contour of Quatre Bayou Deep Sand Body surface. (B.) Isopach of Quatre Bayou Deep Sand Body showing distribution of the relatively even sand unit. B-B' cross section shown in Figure 32.

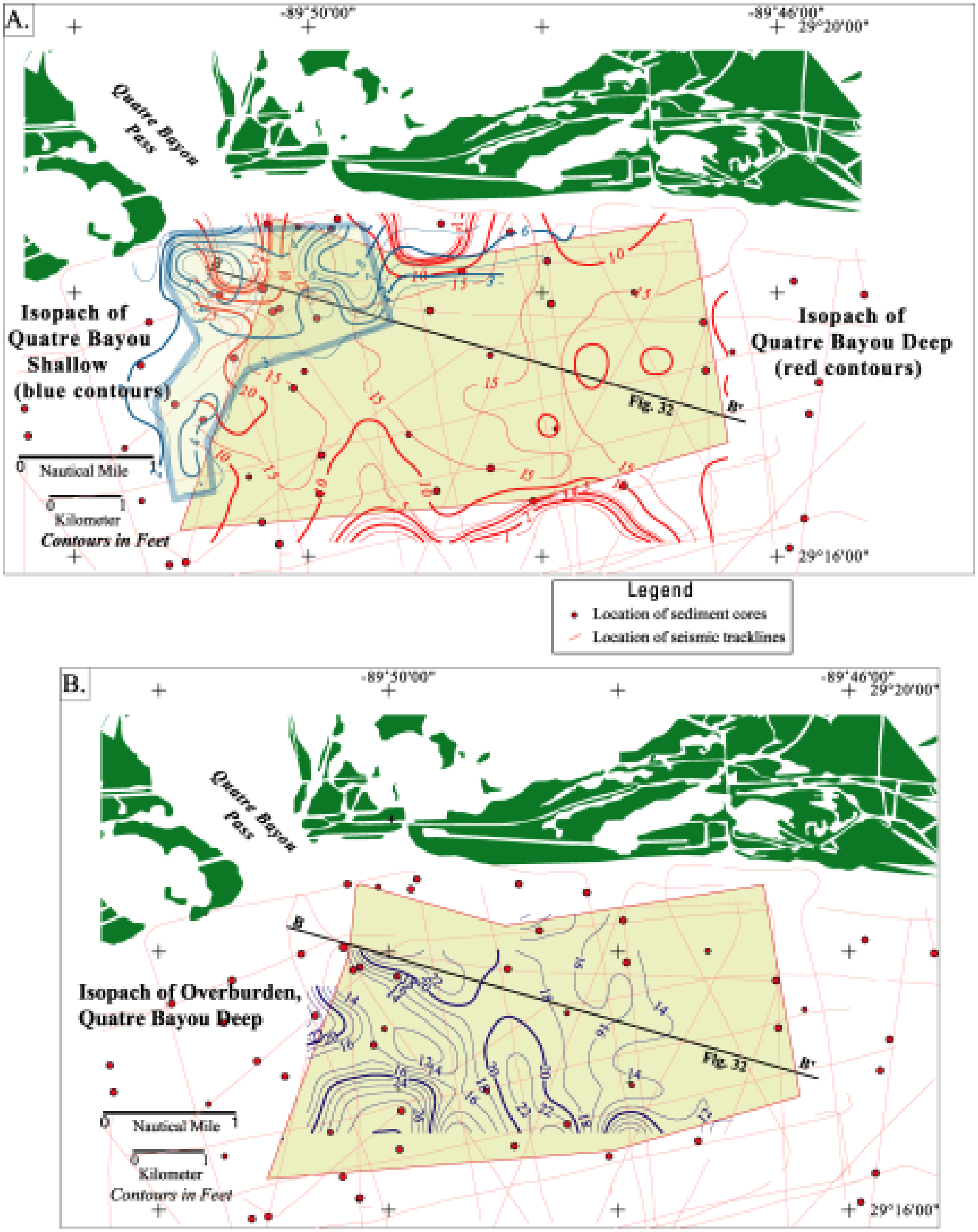


Figure 34. Isopach maps of Quatre Bayou Shallow (outline and contours in blue) and Deep (outline and contours in blue) Sand Bodies. (A.) Isopach map shows relative position of Quatre Bayou Shallow to Quatre Bayou Deep. (B.) Isopach of overburden above the Quatre Bayou Deep Sand Body showing distribution of the 7 to 15 ft (2.1 to 4.6 m) of muds and sand (Quatre Bayou Shallow). B-B' cross section shown in Figure 32.

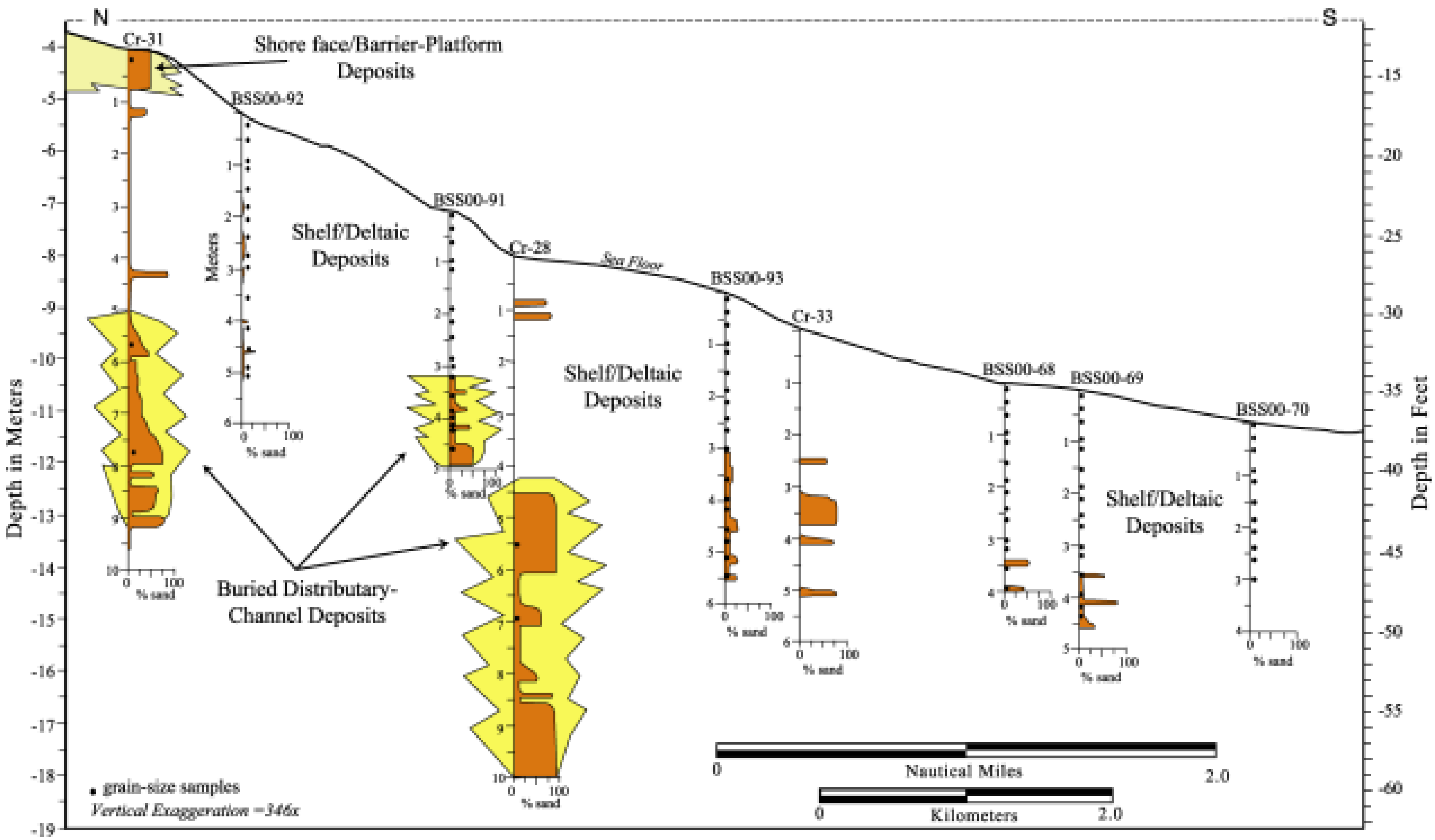


Figure 35. Line drawing of north to south vibracore cross section of the study area Eastern section showing distributary deposits as described from vibracores. Shelf/deltaic deposits (predominately laminated beds of silts and clay) overlie the channel deposits. See location of illustration in Figure 14.

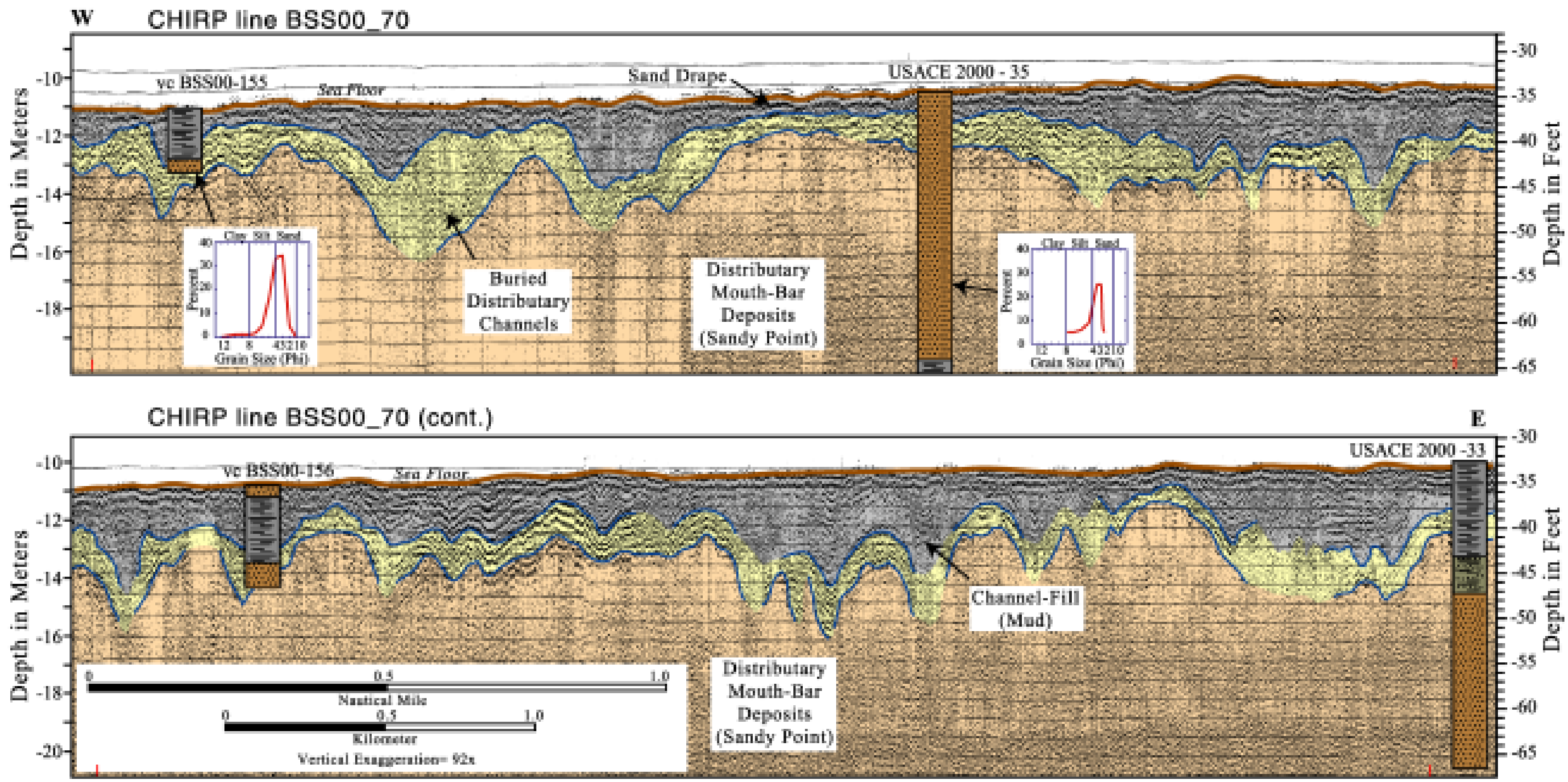


Figure 36. Interpreted subbottom CHIRP profile showing the irregular surface caused by dissection of distributary channels over the Sandy Point Sand Body. Vibracores and borings show the sand and clay portions of the section. See location of illustration in Figure 14.

with a phi range of 2.0 to 3.5 and an estimated volume of 5.8 to 7.8 mil yd^3 (5.7 to 7.6 mil m^3). Empire is characterized from vibracores as massive to laminated sands and muddy sands, with no apparent bioturbation or shell material (Fig. 37). The lack of invertebrates and organic material suggest fluvial origin rather than tidal-inlet processes. Sonar reflection character in CHIRP profiles is similar to that of the Scoffield Sand Body, with high-angled and chaotic reflections indicative of channel fills. The overburden has an estimated volume of 14.9 mil yd^3 (11.5 mil m^3) and consists of laminated muds grading to fine sands.

Scoffield

The Scoffield Sand Body is located offshore of Scoffield Bay (Fig. 13). This potential sand target is one of the smaller targets with a surface area of 1.5 mi^2 (3.9 km^2). This buried sand body is 30 ft (9.2 m) below MSL and is covered by an average of 9 ft (2.7 m) of overburden (Table 1). The overburden has an estimated volume of 13.9 mil yd^3 (10.7 mil m^3) and consists of laminated muds with small amounts of sand. Interpretation of CHIRP profile cross sections reveals steeply dipping reflections within an incised channel indicating that the sand body is a channel-fill deposit. Two vibracores acquired from this target show interbedded sands and clays within the buried channel (Fig. 38). The cores bottom into a clean sand at the base of the channel and USACE 2000 cores near this same location indicate that this sand is thicker than 6.5 ft (2 m). The Scoffield Sand Body consists of 80 to 90% fine sand with grain-size range between 2.5 to 5.5 phi (Table 1). The Scoffield Sand Body, as sampled, has an estimated volume of 7.4 to 8.3 mil yd^3 (5.7 to 6.4 mil m^3).

Sandy Point

Sandy Point Sand Body is the largest and geomorphically complex potential sand target identified during this study. Numerous buried distributary channels that are filled with interbedded sands and clays (Fig. 36) overlie the sand body. These distributary channels bisect the shallow subsurface in the eastern portion of the study area. The sands that occupy the base of the channels are laminated and devoid of shell material or bioturbation (Fig. 39) a possible indication of a fluvial source. A thin, sandy drape is present at the sea floor or covers interdistributary areas outside of the channels (Fig. 36). Below these channels is the large main sand body of Sandy Point. Using geometry and textural descriptions we suggest that the sand body was deposited within a distributary mouth-bar environment. The Sandy Point Sand Body has an irregular surface due to incision by the overlying sand body of Sandy Point (Fig. 40). Excluding the overlying channels the sand body is 40 to 48 ft (12.2 to14.6 m) below MSL (table 1) and covers an areal extent of 16.95 mi^2 (43.9 km^2) with 8 to 13 ft (2.4 to 3.7 m) of overburden (Fig. 40, 41). USACE 2000 cores taken within the target area indicate that there is 20 to 30 ft (6.1 to 9.2 m) of 60 to 80% fine sand (2.5 to 5.5 phi). These dimensions make the Sandy Point Sand Body the largest target in the study area, with an estimated volume of 220.6 to 294.2 mil yd^3 (169.7 to 226.3 mil m^3) of sand. The fine-grain overburden (excluding the channels) consists primarily of laminated clayey-silt. Including channel-fill material and fine-grain components, the estimated overburden volume is 244.8 mil yd^3 (188.3 mil m^3).

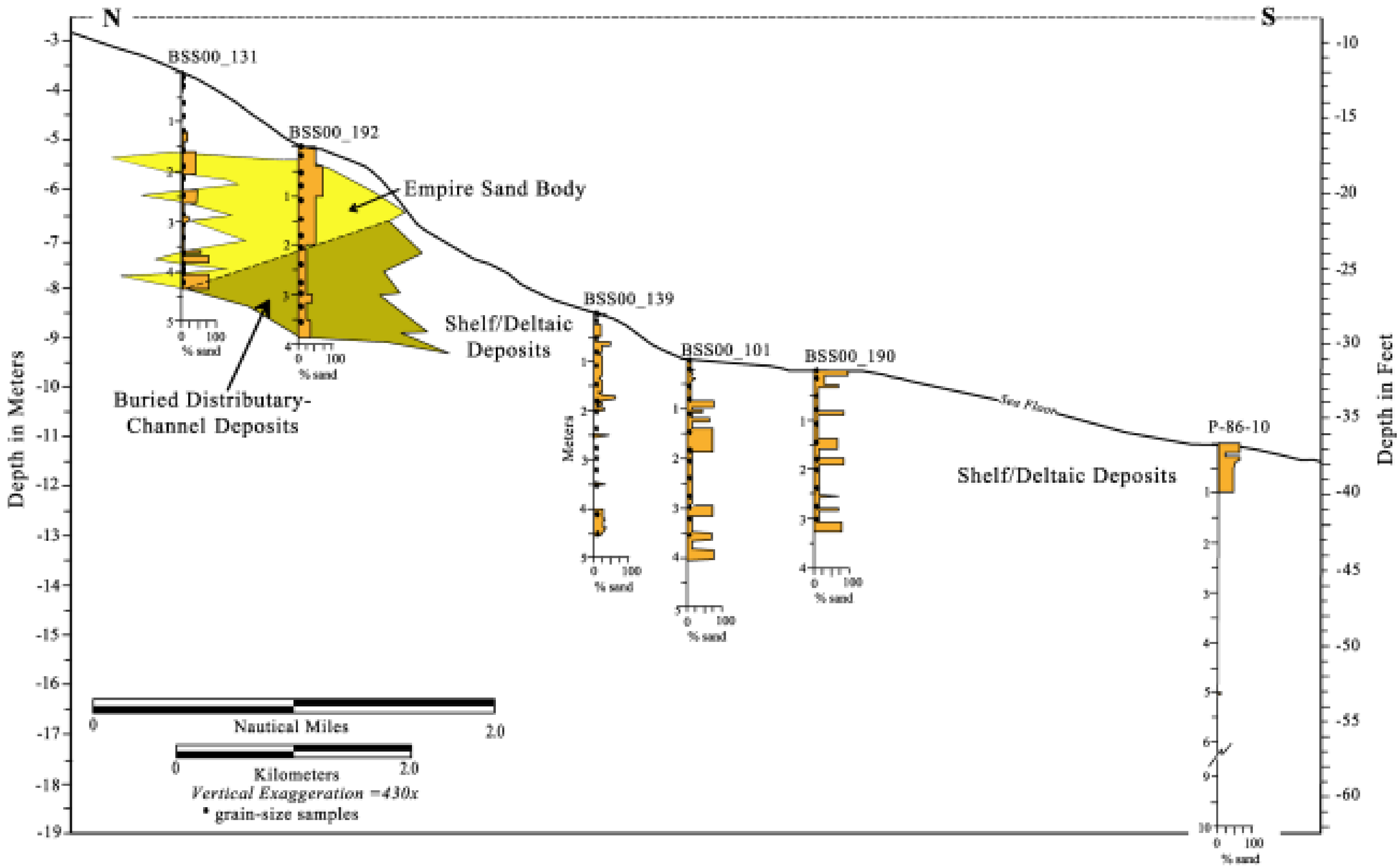


Figure 37. Line drawing vibracore cross section of Empire Sandy Body. This sand body consists of distributary-channel deposits with the percent sand descriptions in BSS00_131 and _132 showing the variability of the sediments. The sand deposits rest on and overlain by shelf/deltaic deposits. See location of illustration in Figure 14.

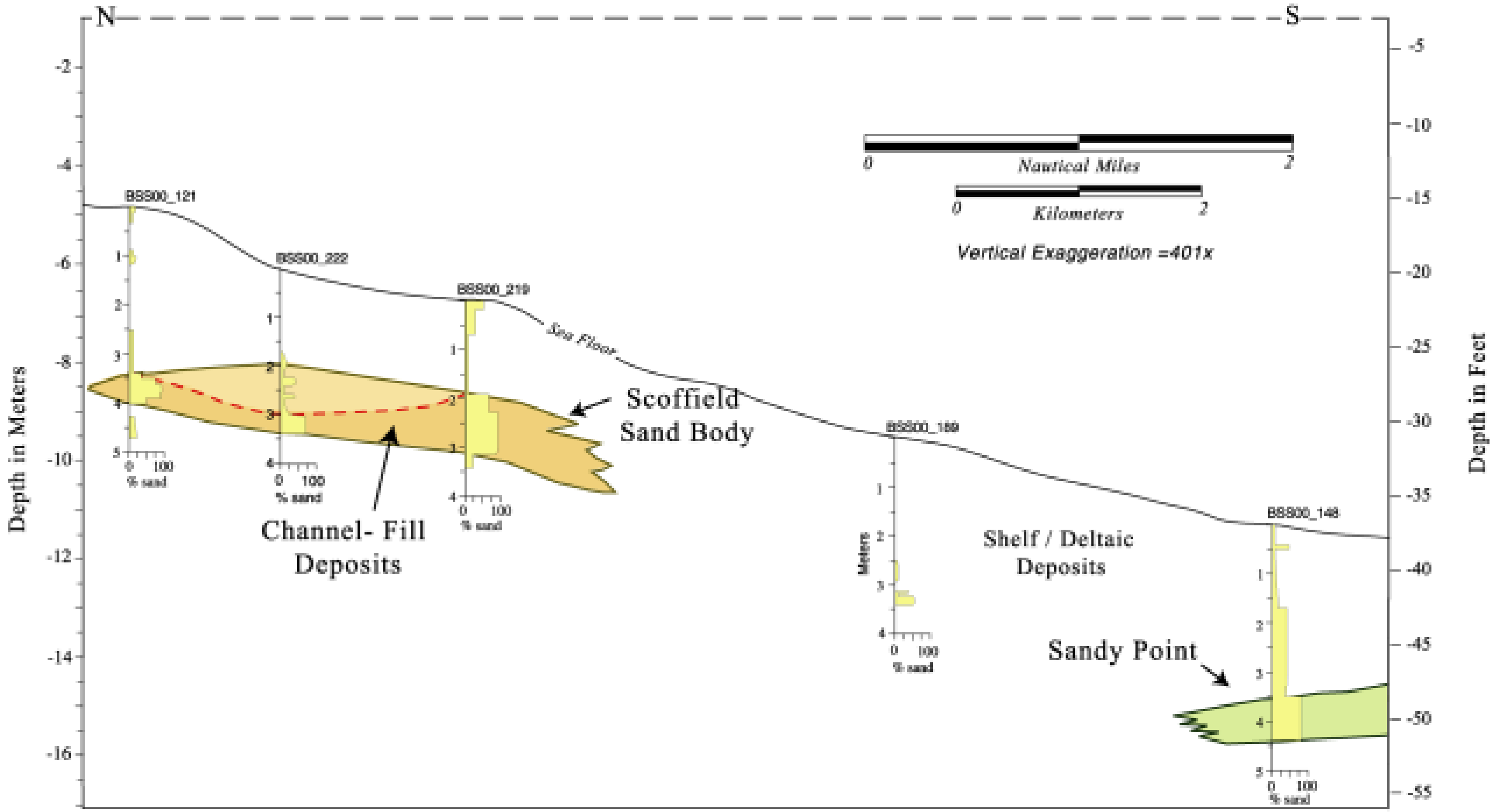


Figure 38. Line drawing of vibracore cross section of Scoffield Sand Body identified as distributary channel-fill with interbedded sands and clays. Portions of the sand body fall below the minimum percent sand criteria for this study and are not included as part of the sand resource

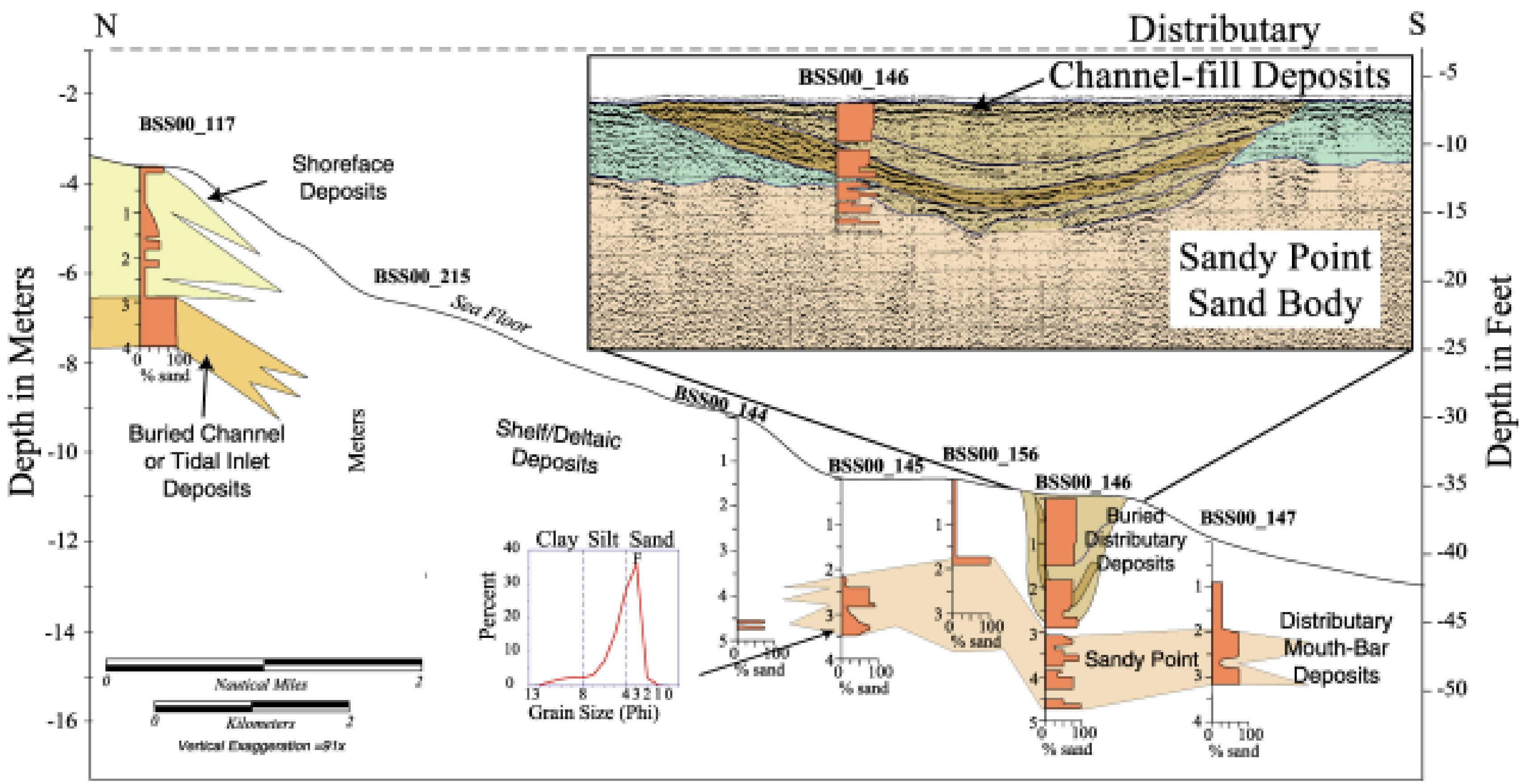


Figure 39. Line drawing of vibracore cross section of Sandy Point Sand Body. Sand body is distributary mouth-bar deposits overlain by shelf/deltaic deposits and distributary channel-fill deposits. The subbottom CHIRP profile (inset) shows the Sandy Point Sand Body overlain by buried channel-fill deposits. The vibracore description of BSS00_146 superimposed on the CHIRP profile demonstrates the sediment variability that may be found within the channel-fill. Location of illustrations shown in Figure 14.

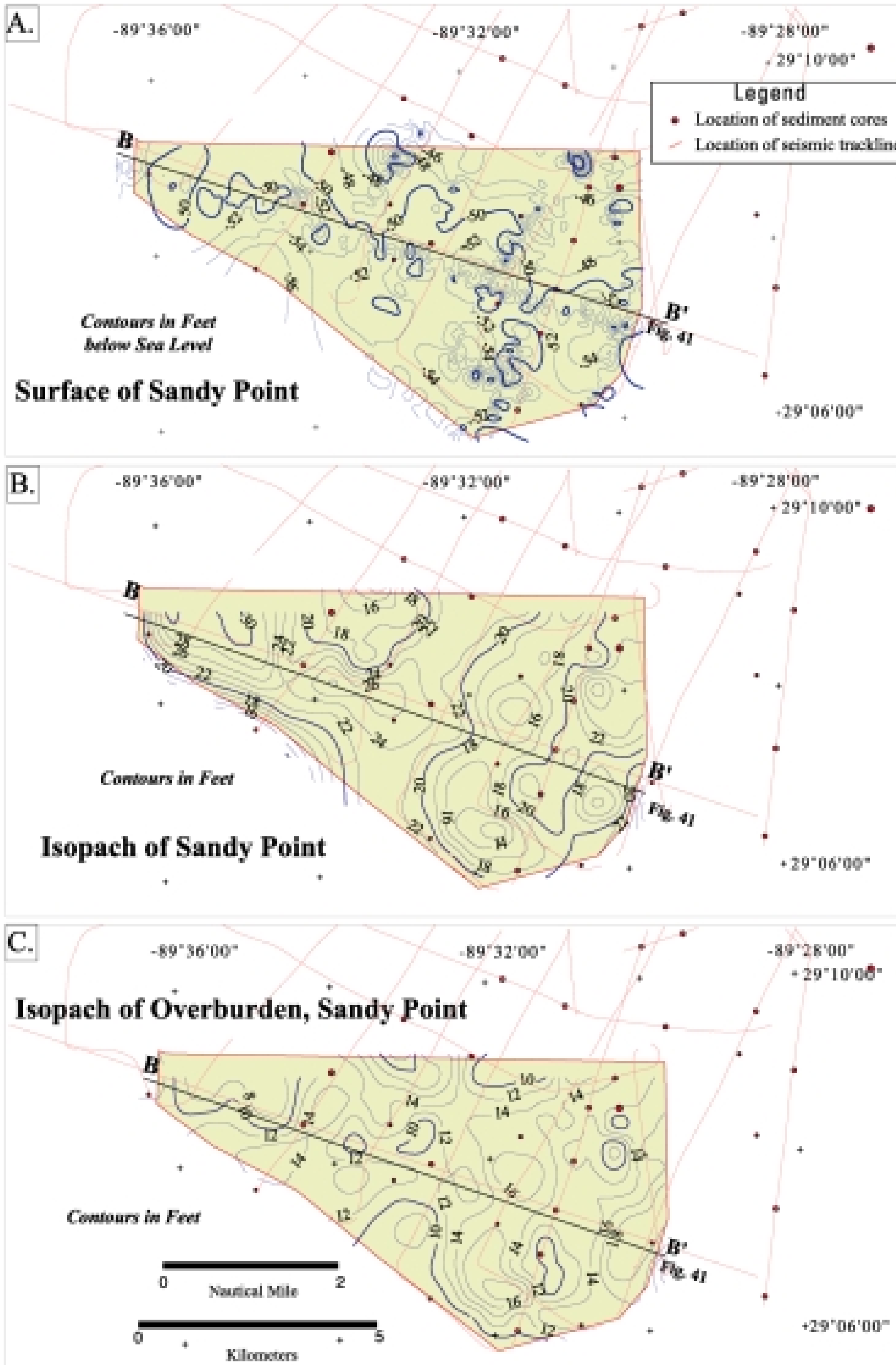


Figure 40. Sand Point Sand Body: (A.) Structure contour of the sand body surface, contours are in feet below MSL; (B). Isopach of the Sandy Point Sand Body shows the distribution of the 20 to 30 ft (6.1 to 9.2 m) sand body; and (C.) Isopach of overburden sediments shows distribution of the 8 to 13 ft (2.4 to 4.0 m) sandy mud. Transect B-B' is shown in Figure 41.

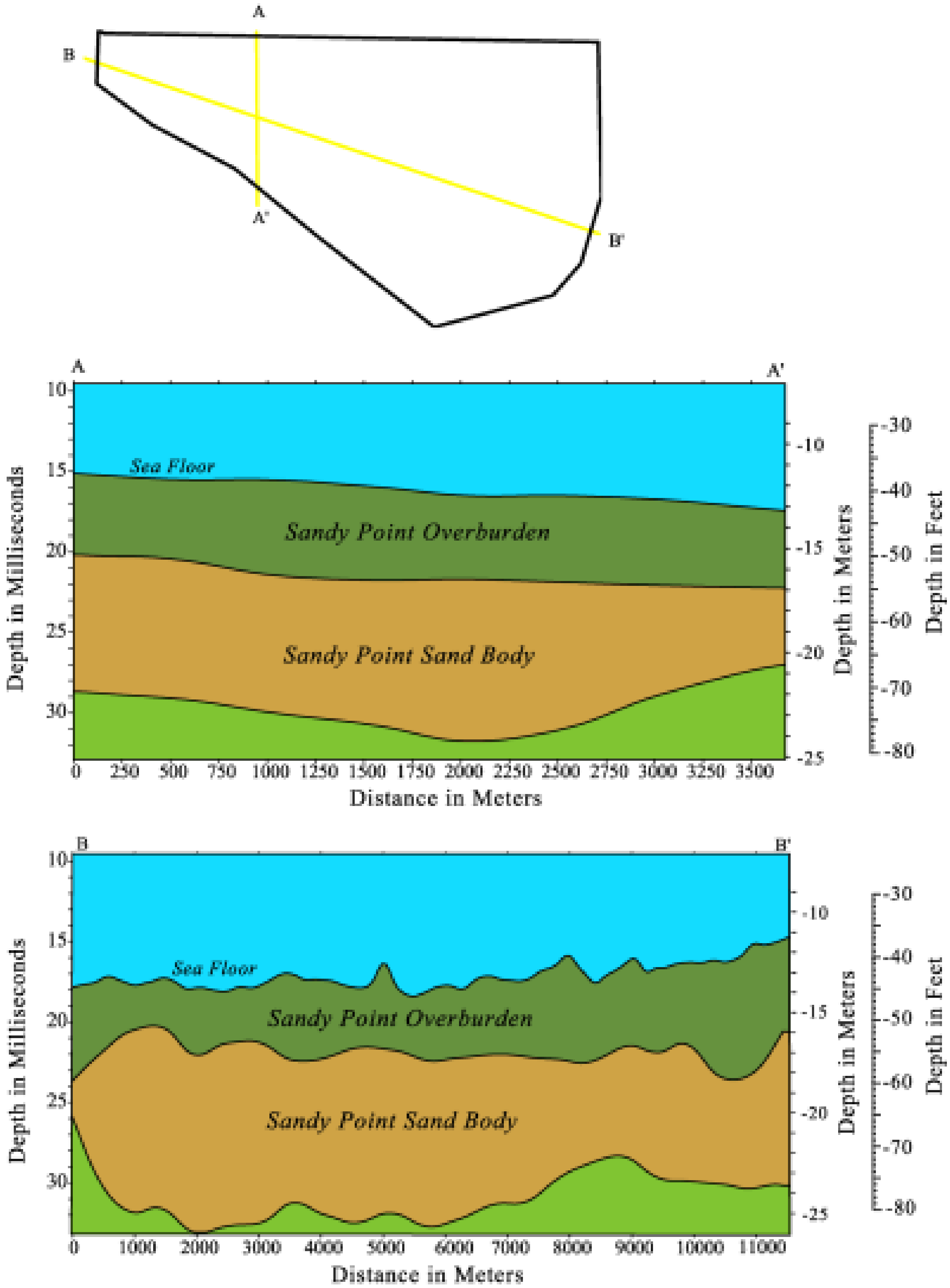


Figure 41. Line drawing cross sections of Sandy Point Sand Body. A-A' is a north to south transect showing thickness of Sandy Point overburden relative to Sandy Point Sand Body. The west to east B-B' transect shows the roughness due to channel incisions across the top of the Sandy Point Sand Body. Structure contour, isopach of sand body, and isopach of overburden are shown in Figure 40.

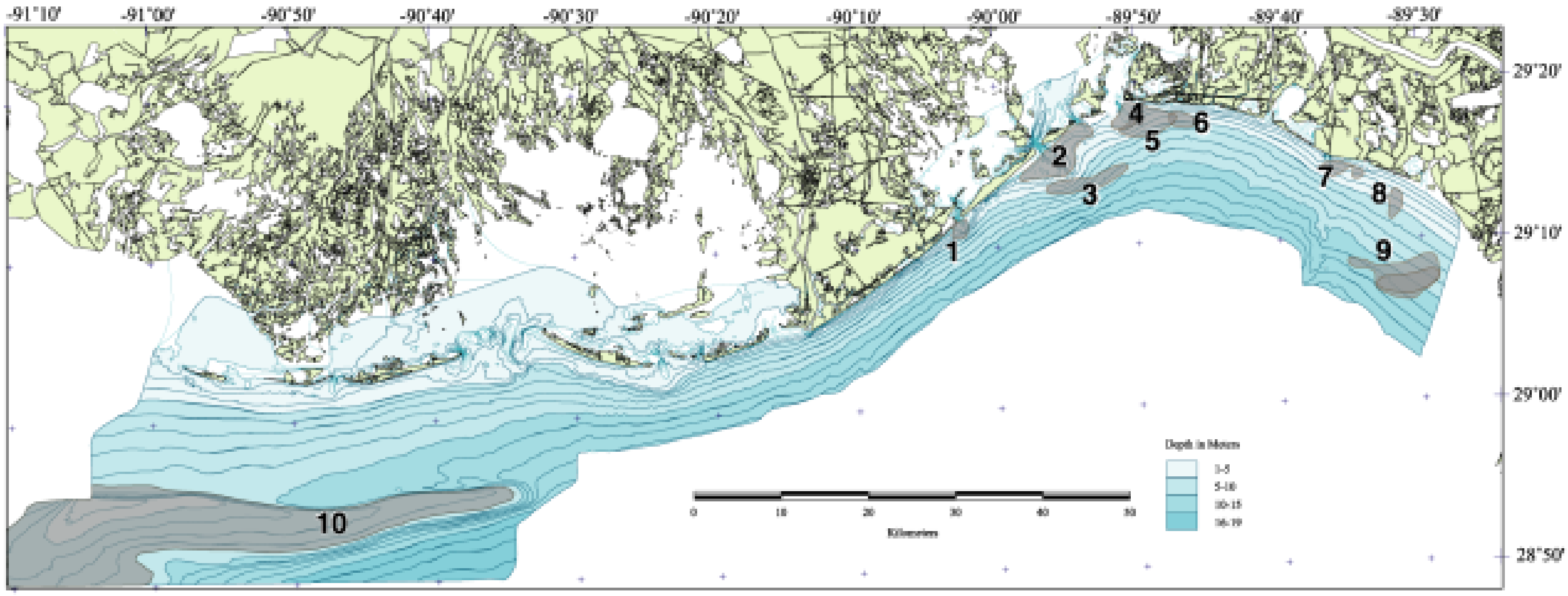
DISCUSSION AND RECOMMENDATIONS

After close examination of previous studies and collection of very dense data sets consisting of high-resolution seismic and sonar reflection profiles, cores, and borings from the present study, we identified 9 potential sand resource sites. Individual sites range from small compact surficial deposits (Caminada) to large buried deposits with large volumes of overburden (Sandy Point). In this study we identified a total of 396 to 532 mil yd^3 (305.8 to 410.8 mil m^3) of potential sand for shoreline restoration. Suter and others (1991) in this same area using a much less dense data set identified 1152 mil yd^3 (886 mil m^3) of sand from 21 sites. The discrepancy between the two estimates can be explained by the tremendous variability of channel-fill deposits found during this study. Over 80% of the sand estimated by Suter and others (1991) was identified from seismic profiles as distributary channel-fill deposits. The inherent variability of channel-fill deposits can give estimates with as much as 50% error.

The 9 potential sand targets found by this study are 3 surficial and 6 buried targets. The surficial targets Caminada, Barataria Inshore, and Quatre Bayou Shallow contain approximately 10% of the total sand resources identified. A full 90% of the sand found will need overburden material removed, almost 570 mil yd^3 (438 mil m^3) if the whole resource is mined. The sand in these sites is primarily fine sand ranging from 2 to 5.5 phi.

Due to the relatively small number of sand targets identified during this study another sand resource such as Ship Shoal located west of the Barataria Basin barrier shoreline should be mentioned as a possible resource. Ship Shoal is a shore-parallel sand body located approximately 9.3 mi (15 km) offshore of Isle Dernieres Islands and 40 mi (64 km) west of Belle Pass (Fig. 42). Ship Shoal is the remnant of a former deltaic headland and barrier shoreline that has been progressively inundated by marine waters due to relative sea-level rise and transgressive submergence (Penland and others, 1988). Not considering the presence of oil and gas industry infrastructure, previous estimates of recoverable sand from Ship Shoal have been 1.56 bil yd^3 (1.2 bil m^3, calculated using data from Suter and others, 1991).

Due to the sparse sand resources of the Barataria coastal system, Ship Shoal should be considered as an alternate or supplemental sand resource. Ship Shoal is twice as large as the 9 sites reported in this study combined (96.6 mi^2, 250 km^2), has better quality sand (80 to 100% sand, 2.3 to 4.0 phi), and twice the volume (1,276 to 1,595 mil yd^3, 982 to 1227 mil m^3).



Target Site	Surface Area (mi²)	Depth to Target (ft below MSL)	Thickness of Overburden (ft)	Est. Target Thickness (ft)	Percent Sand %	Grain Size Range (phi)	Est. Vol. Sand (low) (yd³)	Est. Vol. Sand (high) (yd³)	Est. Vol. Overburden (yd³)
1. Caminada	1.13	5-10	0	4	60-80	2.5-4.7	3,796,844	5,062,458	0
2. Barataria Inshore	5.93	5-10	0	4-9	60-85	2.5-4.7	18,412,746	26,084,723	0
3. Barataria Offshore	6.07	25-40	10-15	7-9	60-80	2.5-5.5	34,726,502	46,302,003	78,640,178
4. Quatre Bayou Shallow	2.04	10	0	5-10	60-80	2.5-4.7	6,084,670	8,112,893	0
5. Quatre Bayou Deep	8.85	22-45	7-15	5-22	70-100	2.0-5.5	92,815,154	132,593,078	156,028,517
6. Quatre Bayou D2	1.70	45-47	30-40	7+	50-80	3.0-5.0	7,372,288	9,829,717	61,611,264
7 Empire	2.10	17-25	3-10	3-6	60-80	2.0-3.5	5,854,464	7,805,952	14,961,408
8. Scoffield	1.50	30	9	6+	80-90	2.5-5.5	7,434,240	8,363,520	13,939,200
9. Sandy Point	16.95	40-48	8-13	20-30	60-80	2.5-5.5	220,635,383	294,180,511	244,848,543
10. Ship Shoal	96.60	13-29	0	16	80-100	2.3-4.0	1,276,706,816	1,595,883,520	0

Figure 42. Location map showing comparative sizes of the 9 target sand bodies of the Barataria Barrier Shoreline Restoration Study to the large Ship Shoal sand deposit. As the table shows the 9 deposits combined equal about half of the sand available in Ship Shoal.

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SUMMARY OF USGS/UNO/USACE PROJECT WORK ACTIVITIES

Since 1986, the USGS has successfully worked in cooperation with UNO/LSU investigating coastal erosion and wetland loss in Louisiana. This cooperative research has made significant advancements in understanding the impact of sea-level change on coastal erosion and wetlands. During this project the USGS worked closely with UNO and USACE to complete each of the proposed phases of the study.

PHASE I - PROJECT DEVELOPMENT (SPRING 2000)

Initiate inventory of existing data. Using existing data, possible borrow areas were identified prior to the field effort. This task used existing information to determine the most likely location for potential borrow site and summarized information relative to the quantity and quality of sand available for use on the islands. USGS/UNO compiled and did quality control (QC) on available existing high-resolution seismic and core description data and reviewed existing technical reports to identify the most likely location for borrow site.

PHASE II - DATA COLLECTION, PROCESSING, AND INTERPRETATION (SUMMER AND FALL 2000)

Compiled existing data and collect new data to meet data needs identified in Phase I. New information was incorporated into the report as it became available. Data included shallow geology, geotechnical, and physical parameters incorporated into a later modeling effort.

Conducted surveys of the potential borrow areas. Information collected on borrow areas included high-resolution seismic (subbottom profiler and CHIRP) and bathymetry data. In addition, 20’ vibracores were taken and analyzed to verify seismic data and acquire sediment textual data. USGS/UNO conducted high-resolution seismic surveys from Bell Pass to Sandy Point to seven miles offshore and used this data to select coring sites. This interpreted data provided the data needed to prepare sand resource maps (such as isopach maps) and texture maps used to identify the best borrow locations. Data (raw and preliminary interpretations) were made accessible to USACE New Orleans District, as it became available.

PHASE III – PRODUCTS (2001)

Existing data and newly acquired data were integrated to produce final products. During Phase II as data collection was in progress, interim maps and data (raw and preliminary interpretations) were made accessible to USACE New Orleans District. The seismic and sediment data were used to construct sand resources maps (i.e. sand isopach and percent sand) as needed by the USACE. These maps and data are to be used to make final decisions on the usability, exact location, and quantity of the sand in the borrow sites.

Appendix A. Folded Map Plates

Appendix B. Barataria Shoreline Restoration Sand Resource Study, Louisiana, CD-ROM (Insert)

Open-File Report (PDF)
Browser Index (Netscape or Microsoft Explorer)
Cross Sections (PDF)
Grain-Size Data (Microsoft Excel)
Navigation Files (ASCII)
Vibracore Descriptions Sheets (PDF)

Appendix C. High-Resolution Seismic Profiles - CD-ROM (Insert)

Boomer Seismic Reflection Data Collected during USGS Cruise 00SCC02 and 00SCC04, Barataria Sand Resource Study, Louisiana, 12 May - 31 May and June 17 - 3 July, 2000, U.S. Geological Survey (CD-ROM, Insert)