The St. Bernard Shoals: an Outer Continental Shelf Sedimentary Deposit Suitable for Sandy Barrier Island Renourishment

Chapter G of

Sand Resources, Regional Geology, and Coastal Processes of the Chandeleur Islands Coastal System: an Evaluation of the Breton National Wildlife Refuge

Scientific Investigations Report 2009–5252

U.S. Department of the Interior
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Edited by Dawn Lavoie

In cooperation with the U.S. Fish and Wildlife Service

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Chapter G. The St. Bernard Shoals: an Outer Continental Shelf Sedimentary Deposit Suitable for Sandy Barrier Island Renourishment

By Bryan Rogers[1] and Mark Kulp[1]

Abstract

The St. Bernard Shoals are a group of 61 individual subaqueous sand bodies 25 km southeast of the Chandeleur Islands, La. The shoals are estimated to contain 200 × 10^6 m^3 of fine-grained, well-sorted, moderate yellowish brown sandy sediment. Individual shoals consist of as mush as 97 percent quartz sand. The shoals are the result of transgressive reworking of St. Bernard Delta distributary channels and have sedimentary characteristics similar to other beach sands and shoal deposits in the Mississippi River Delta. Two separate datasets were used to establish the sedimentary framework of the St. Bernard Shoals. The first of these datasets, which consists of subbottom seismic profiles and vibracores, was acquired in 1987 to characterize the stratigraphic architecture of the eastern Louisiana shelf. The other dataset was obtained in the summer of 2008 to update previous interpretations by using modern surveying technology and to establish whether the shoals had undergone any major modifications during the intervening 20-year lapse of investigations. The 2008 dataset consists of seismic profiles, side scan imagery, and sea floor grab samples. The 2008 seismic and side scan data show a sea floor morphology that is suggestive of large-scale erosional reworking but reveal a shoal system that has not substantially migrated since the 1980s. The St. Bernard Shoals have a sedimentary texture that is similar to that of the Chandeleur Islands, making them an ideal borrow site for renourishment of the Chandeleur Island system.

Introduction and Background

There are four widely spaced, shore-parallel shoals (subaqueous sand bodies) on the Louisiana continental shelf (Fisk, 1944; Kolb and Van Lopik, 1958; Ludwick, 1964; Frazier, 1967). These sandy sedimentary bodies are found beyond the edge of the modern subaerial Mississippi River Delta marshes and barrier islands and form the modern sea floor where they are located (fig. 1). These shoals are as much as 6 m thick and locally consist of as much as 100 percent fine to very fine grained sand. One of these shoal systems, known as the St. Bernard Shoals, is located approximately 25 km southeast of the Chandeleur Islands, La. (fig. 2). As is the case for the other shoals on the Louisiana shelf, the St. Bernard Shoals have been suggested as a sedimentary body that could be mined and used to renourish a deteriorating sandy barrier island system such as the Chandeleur Islands. The purpose of this chapter is to outline the general framework and sedimentary composition of the St. Bernard Shoals and provide an understanding of the potential use of the shoals as renourishment sediment for the Chandeleur Islands.

Many regional studies of stratigraphic relations, deltaic evolution, and Louisiana continental shelf geology have contributed toward a generally acceptable evolutionary model for the Louisiana shelf shoals (for example, Fisk, 1944; Frazier, 1967, 1974; Penland and others, 1988). These models ascribe their formation to transgressive submergence of an abandoned deltaic headland that was formerly active and advancing seaward (Penland and others, 1988; Miner and others, this volume). Kindinger and others (1982), Pope and others (1993), and Brooks and others (1995) completed studies describing in detail the fundamental sedimentology and stratigraphic characteristics of the St. Bernard Shoals. The work by Pope and others (1993) provided a range of sedimentary data necessary to fully evaluate the use of the St. Bernard Shoals as a continental shelf borrow site. The following sections provide an overall summation of previous work regarding the shoals, describe their stratigraphic framework, and provide answers to questions regarding the extent and recent evolution of the shoals.

Methods of Investigation

Two separate datasets were used to establish the sedimentary framework of the St. Bernard Shoals. The first

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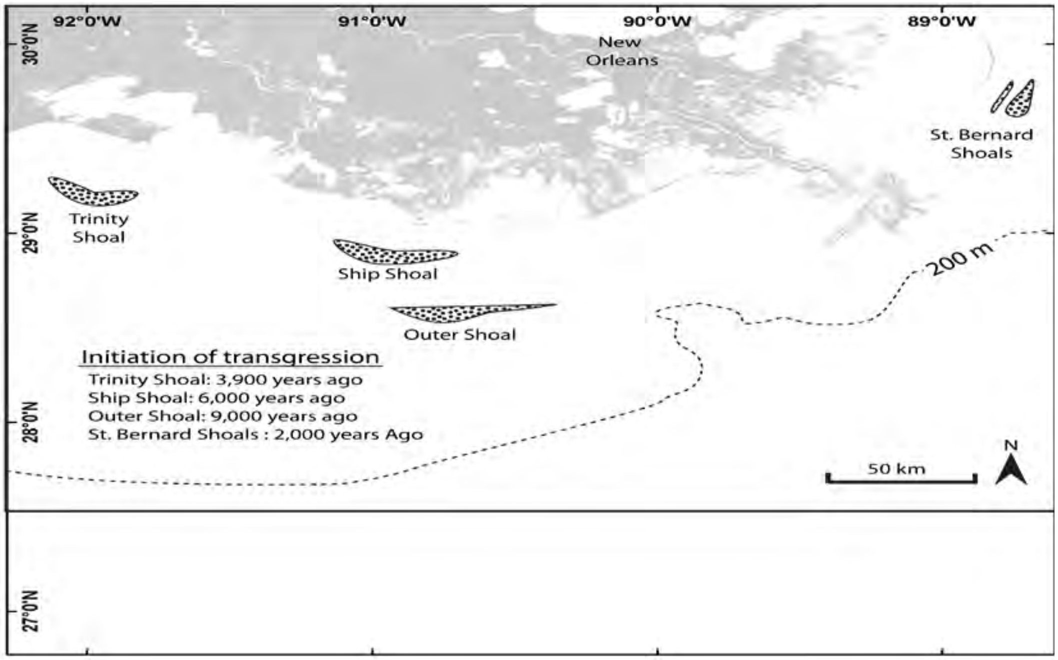

Figure 1. Location of the primary Holocene-age sand shoals on the Louisiana continental shelf. The St. Bernard Shoals represent the distal edge of a depositional platform that was built through progradation of distributaries from the more westward located modern deltaic plain.

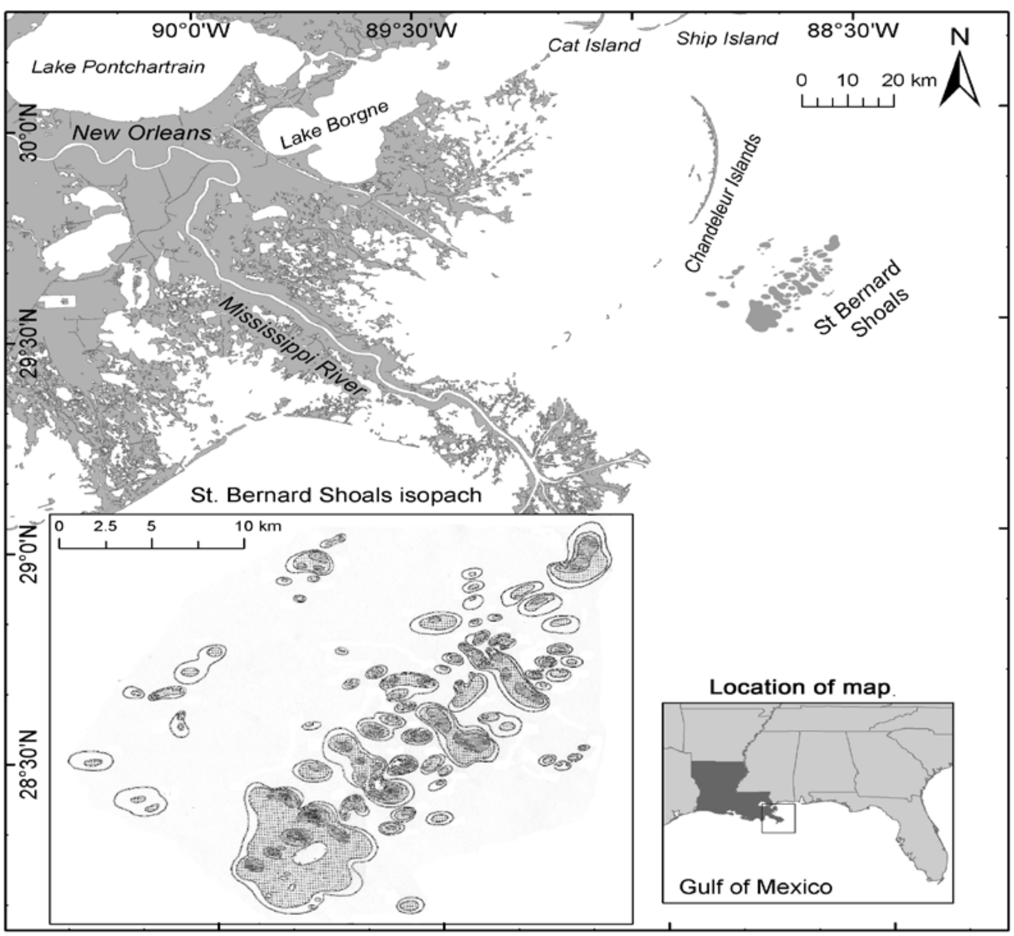

Figure 2. Map of the eastern Louisiana shelf showing the distribution of the St. Bernard Shoals relative to the Chandeleur Islands, La. Shoal contour map is from Pope and others (1993).

dataset was acquired in the late 1980s. The second dataset was obtained in the summer of 2008 to update previous interpretations by using modern surveying technology and to establish whether the shoals had undergone any major modifications during the intervening 20 years.

1987 Datasets

The first dataset (herein referred to as the CI-87 dataset) consisted of high-resolution seismic-reflection profiles and vibracores collected in 1987 by the U.S. Geological Survey, in cooperation with the Louisiana Geological Survey and the Louisiana Department of Natural Resources, to investigate shallow geologic framework of the Louisiana-Mississippi shelf (fig. 3). These 1987 seismic profiles were collected by Alpine Ocean Seismic Survey (Norwood, N.J.) from the Louisiana Universities Marine Consortium's *R/V Acadiana* by using a 5-kHz transducer and a Ferranti Ocean Research Equipment (ORE) Geopulse boomer. Navigation at that time was accomplished by using a Northstar 600 LORAN-C receiver and a Morrow XYP-200 real-time LORAN-C plotter. The original digital seismic data from the survey are no longer available, but a complete analog dataset and the digital navigation data are archived by the University of New Orleans Coastal Research Laboratory. In this study, as in most studies of the Louisiana continental shelf stratigraphy, an acoustic velocity of 1,500 m/s was used for determining the depth of stratigraphic units imaged in the seismic-reflection data.

After the completion of the seismic survey in 1987, vibracores were collected across the eastern Louisiana shelf by Alpine Ocean Seismic Survey from aboard the *M/V Blue Streak* (fig. 3). Fourteen of the vibracores from the CI-87 dataset were taken in the area of the St. Bernard Shoals and were used by Pope and others (1993) to map the shoals and

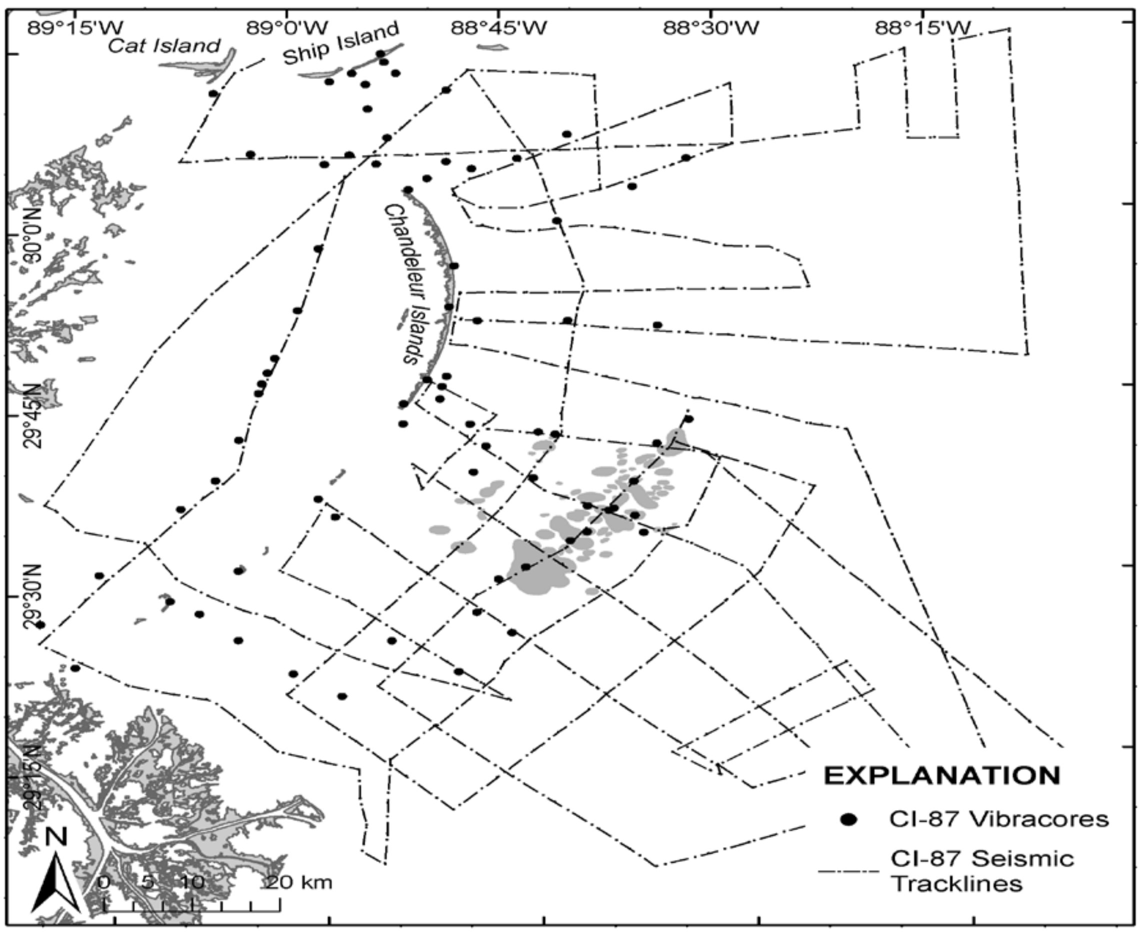

Figure 3. Map showing the distribution of the 1987 seismic tracklines and vibracores collected by the Louisiana Geological Survey on the eastern shelf of Louisiana. The subset of cores used in this study comes from this much larger and expansive 1987 dataset (which is also described in chap. F of this report).

describe their sedimentary characteristics. The vibracore barrels used to collect the cores had an outside diameter of 10 cm and a length of 9 m. Total lengths of the retrieved vibracores ranged between 6 and 12 m. The longest cores were obtained by vibracoring in one 9-m pipe to completion and then jetting down a second pipe to begin vibracoring where the previous pipe had stopped. A total of 19 sediment samples obtained from the cores were analyzed, and the results were published by Pope and others (1993). Details of the collection methods for all of the 1987 data can be found in Pope and others (1993) and Brooks and others (1995).

2008 Datasets

A second, less extensive dataset consisting of subbottom seismic profiles, side scan imagery, and eight sea floor grab samples (referred to herein as the SBS-08 dataset [fig. 4]) was collected in the summer of 2008 by the University of New Orleans from aboard the *R/V Acadiana*. This dataset was collected specifically for the purposes of confirming whether the shoals had changed substantially in form, location, or character since the work completed in the late 1980s, but the data were also used to more fully evaluate the origin and

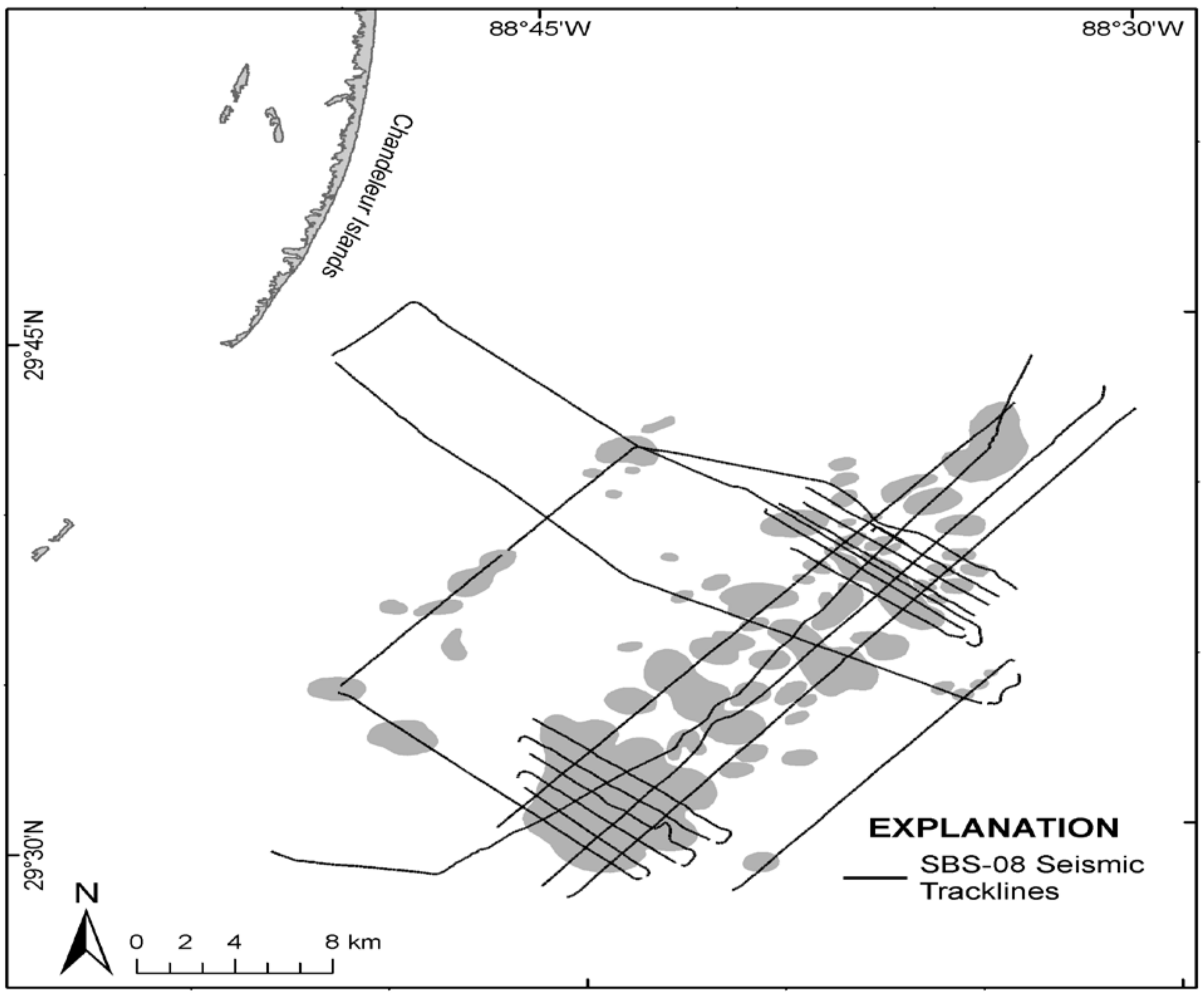

Figure 4. Distribution of the survey tracklines collected for this study by the University of New Orleans during summer 2008 aboard the *R/V Acadiana*. The tightly clustered tracklines represent runs that were intended to provide greater detail on shoal morphology than that which was available from other datasets. The northward extension of the tracklines was completed to tie together the data of this effort with the 2008 data described in chapter F of this report.

evolution of the shoals and to link to the datasets of chapter F in this report. A total of 384 line-km of CHIRP seismic profiles and side scan images were collected by the University of New Orleans in 2008. CHIRP data were collected with an EdgeTech SB-216S towfish (EdgeTech Marine, West Wareham, Mass.) capable of 6-cm vertical resolution. Side scan imagery was collected by using an L-3 Klein Systems 3000 digital side scan sonar (L-3 Communications Klein Associates, Inc., Salem, N.H.) with a frequency range of 25–100 ms. A 200-m horizontal swath of sea floor was imaged. Additionally, eight sea floor samples were collected along an axis of a larger shoal by using a grab sampler. Sites for sediment sampling were selected by analyzing the side scan profiles. Samples were bagged and numbered and returned to UNO for sediment analysis. Grain size and sorting coefficients were determined by using a Beckman Coulter LS200 (Beckman Coulter Inc., Fullerton, Calif.) particle size analyzer. Differential Global Positioning System (DGPS) positioning was acquired by using a Thales dual frequency Z-Max GPS receiver with a 1.00 s update rate (Thales Navigation, San Dimas, Calif.). Hypack hydrographic survey software (Hypack, Inc., Middletown, Conn.) was used to record navigation and to serve the GPS signal to the CHIRP and side scan systems. CHIRP and side scan software systems recorded the positioning data, which were then imbedded into the data files.

Morphology and Sedimentary Framework of the St. Bernard Shoals

The St. Bernard Shoals were identified at least as early as 1778 in a British naval survey map of coastal Louisiana and Mississippi (fig. 5). Bathymetric measurements at that time indicated the presence of a crudely defined bathymetric high, relative to the adjacent shelf. Presumably some sea floor sediment sampling completed at that time was the basis for the indication of a sandy sea floor in the location of the bathymetric high (fig. 5). It was not until the middle of the 20th century, however, that the shoals became a topic of scientific inquiry and were recognized for their importance in reconstructing regional geologic evolution and their possible use as sediment for shoreline renourishment projects.

The St. Bernard Shoals are a system of individual shoals that have a common sedimentary framework and origin. The individual shoals rise as much as 4 m above the surrounding sea floor and sit on a well-defined northeast-striking bathymetric platform that extends from 15 m to about 20 m water depth (fig. 6). This bathymetric platform, referred to herein as the "St. Bernard Bathymetric High," covers an area of 530 km^2 and is characterized by an irregular internal bathymetry that is a result of the location, morphology, and height of individual shoals on the larger platform. The internal morphology of the St. Bernard Bathymetric High is quite different from that of the other primary shoal platforms of the central and western Louisiana continental shelf. Whereas the other shoal systems are represented by large, shore-parallel elongated bodies of sand that can be continuous for kilometers, the St. Bernard Bathymetric High contains a group of 61 individual discontinuous shoals. Individual shoals within the system range in size from 0.05 km^2 to 44 km^2. On the basis of individual shoal size, the shoal platform can be differentiated into two well-defined shoal fields. The most expansive set of shoals is located between 16 and 20 m of water, whereas the smaller shoal field is 5 km northwest of the larger field in approximately 15 m of water (fig. 7).

Stratigraphy of the Shoals

Two stratigraphic cross sections were developed on the basis of sedimentary interpretations presented in the CI-87 vibracore descriptions (fig. 8). These cross sections provide a two-dimensional representation of the stratigraphy and serve to identify the lateral extent of some of the shoals, their thickness, and relations to the underlying stratigraphy. On the basis of the sedimentary characteristics presented in the 1987 vibracore descriptions, five progradational lithofacies were identified in the area: prodelta, delta front, distributary channel, interdistributary bay, and bay fill. Five transgressive lithofacies were also identified, including sand sheet, shoal, barrier shoreface, tidal channel, and tidal delta. The two stratigraphic sections show the distribution of these sedimentary units within the study area (fig. 9). One of the most noticeable features of the shoal stratigraphy is that the shoals are very closely correlated with the distribution of sedimentary facies that are interpreted to be the result of deposition by fluvial channels. As has been previously suggested by Pope and others (1993) and Brooks and others (1995), the close correlation of subsurface distributary channel deposits to the distribution of shoals suggests that the distributary and shoal environments are very closely genetically linked to the longer term evolution of this shelf environment. Frazier (1967) suggested that a lobe of the larger St. Bernard Delta Complex extended into the area of the current St. Bernard Shoals at some time between 2,480 and 1,800 years before present (BP). The character and distribution of sedimentary facies mapped in the area by using vibracores and seismic reflection, along with the chronology of past deltaic depositional events, suggest that the St. Bernard Shoals are the remnants of an abandoned deltaic headland. Since the time of abandonment this headland has been transgressively submerged and reworked by marine processes to create the shoals as they exist today on the continental shelf (see Penland and others, 1988). More details on the chronology of their evolution are presented in Rogers and others (2009).

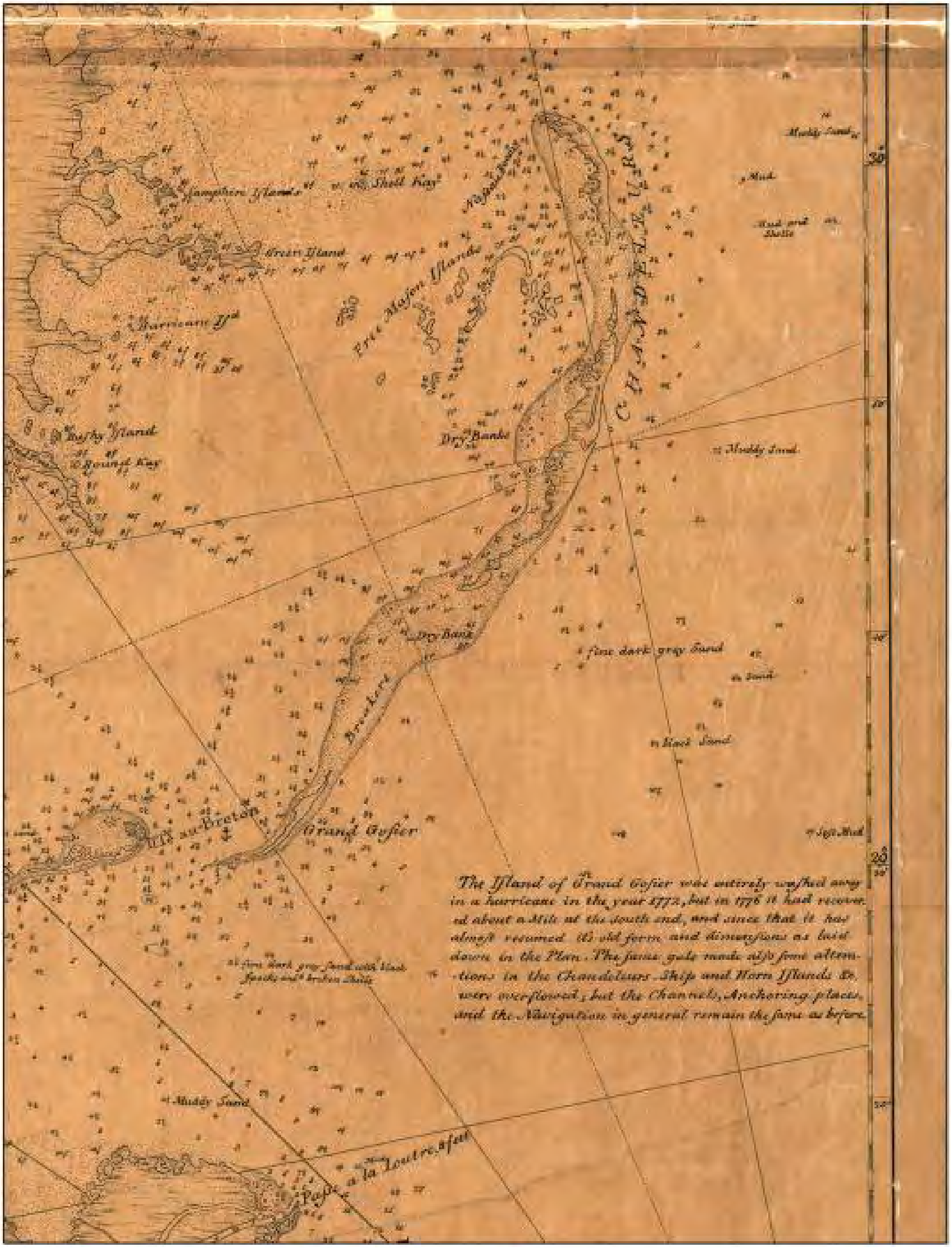

Figure 5. 1778 British naval survey map of the Louisiana coast with depth measurements in fathoms (1 fathom = 1.8 m). This portion of the map shows the Chandeleur Island, Grand Gosier, Biloxi Marsh, and the St. Bernard Shoals. The shoals are acknowledged by the soundings with labels “Sand” and “Black Sand” southeast of the Chandeleur Islands.

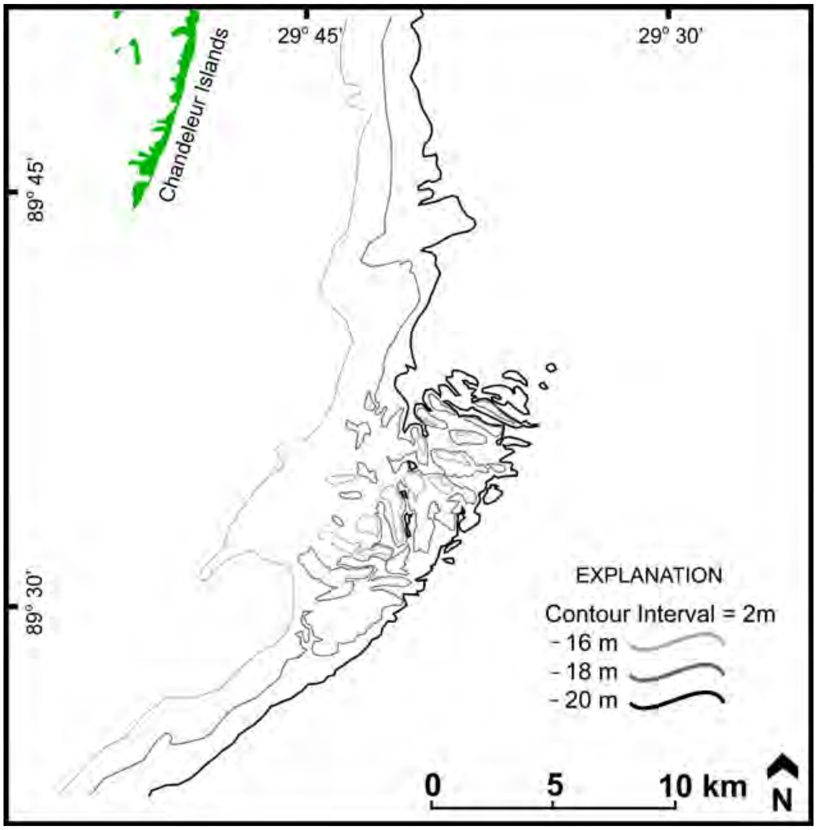

Figure 6. Bathymetry map of the St. Bernard Shoals, La., from 2004. The map shows the St. Bernard Bathymetric High as a platform that is broadly identified by the surrounding 15- to 20-m isobaths. Note the irregular morphology of the contours within the bathymetric high.

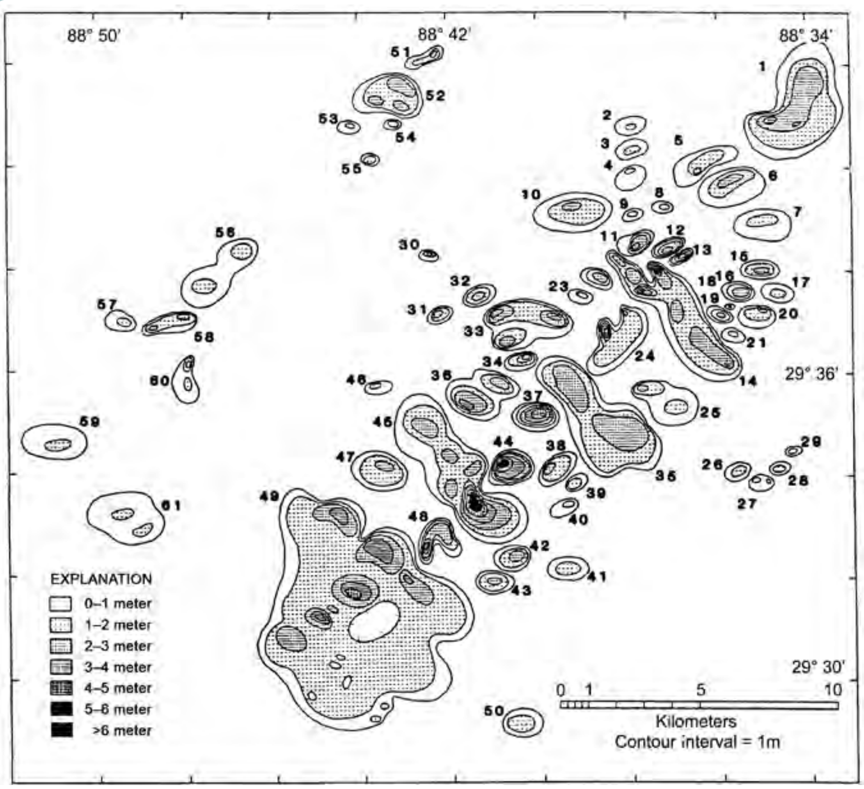

Figure 7. Isopach map of the St. Bernard Shoals, La., from Pope and others (1993). Note that the overall thickness of shoal deposits is greater in the outermost shoal field and that a general alignment of thickness trends exists. One large trend runs approximately northeast across the platform with smaller scale shoal axes trending northwest.

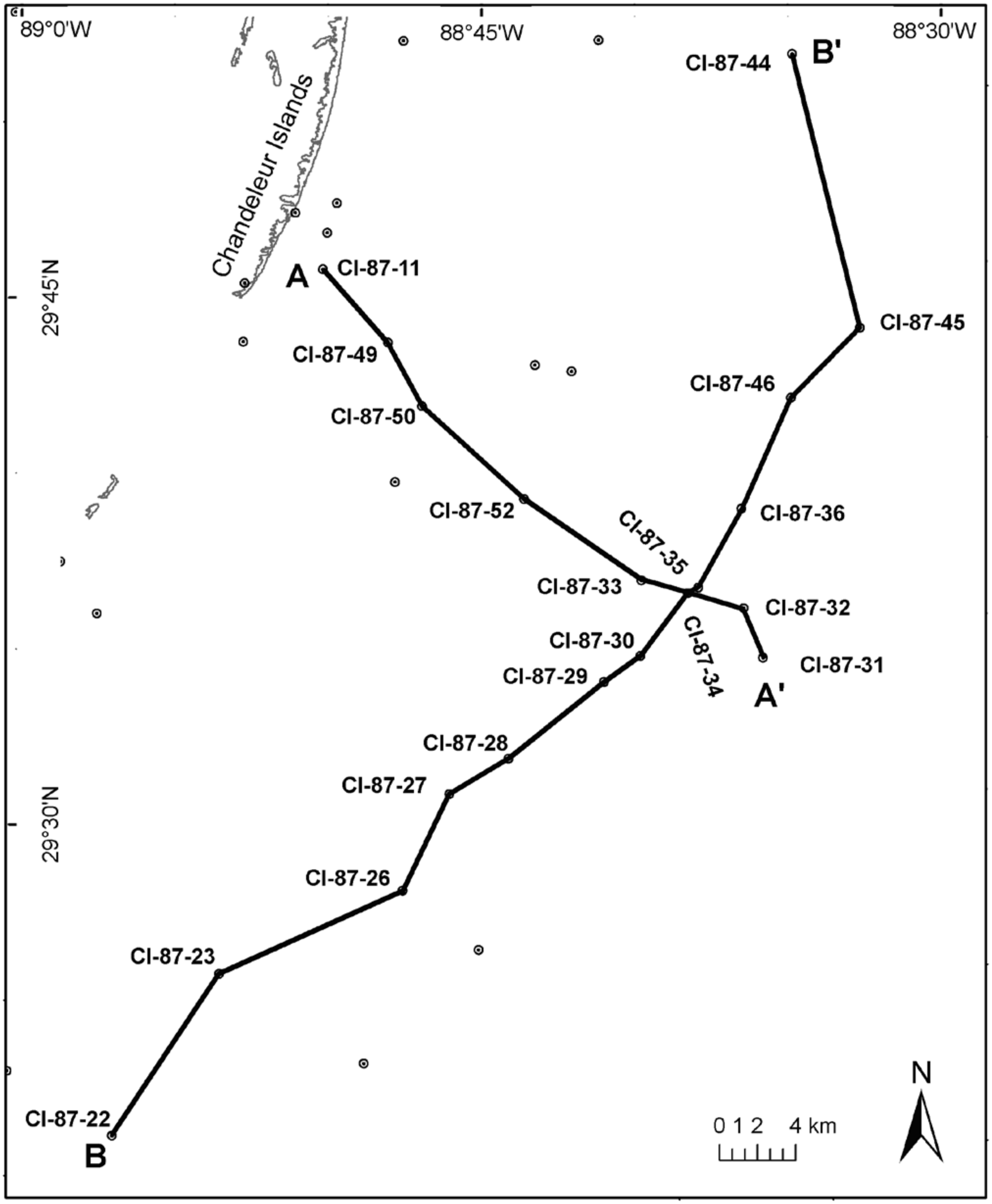

Figure 8. Base map showing the locations of stratigraphic cross sections throughout the St. Bernard Shoals, La. These cross sections were developed by using the 1987 core data and also aligned with 1987 seismic-reflection profiles.

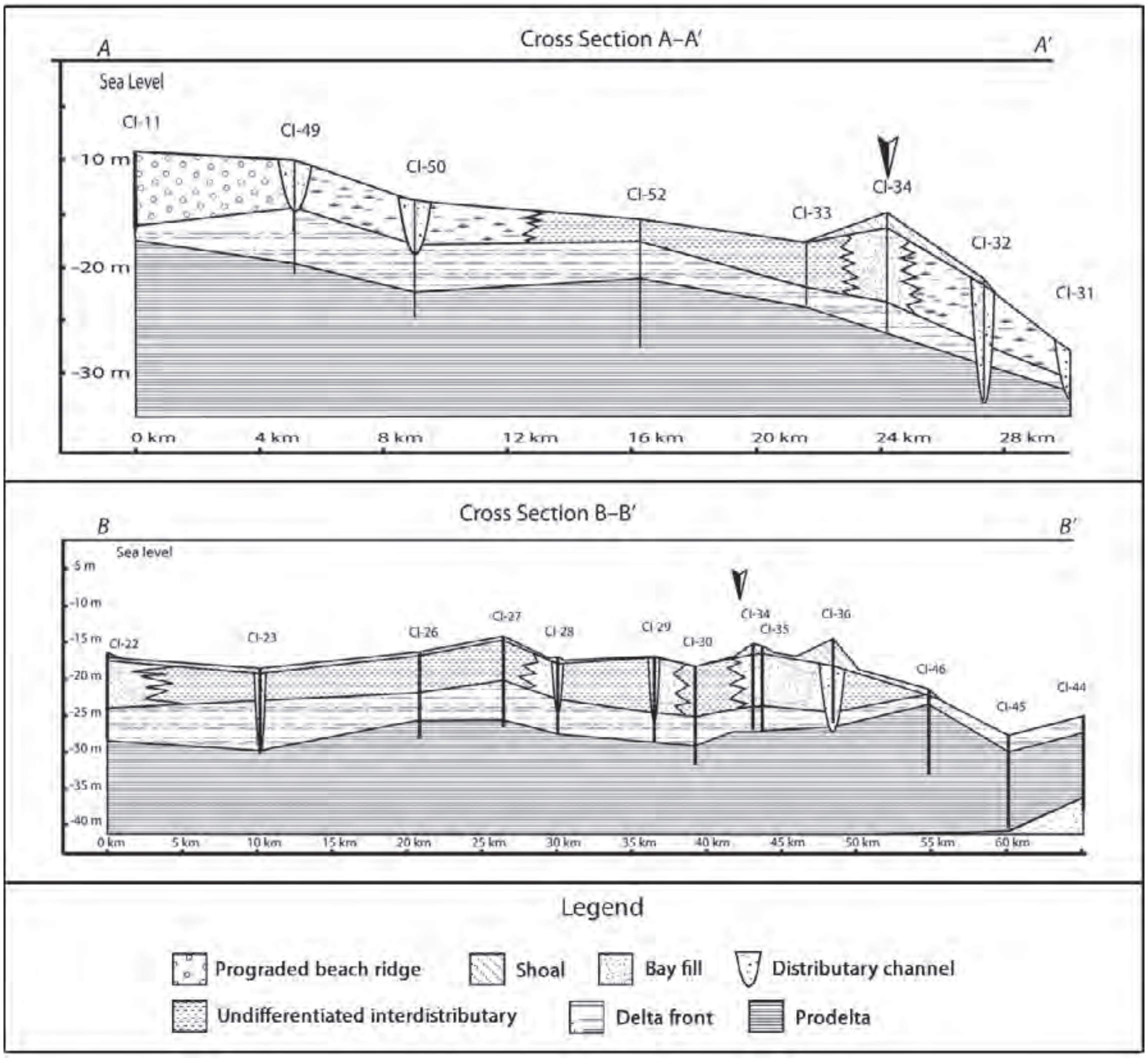

Figure 9. Stratigraphic cross sections of the St. Bernard Shoals, La., showing the shallow subsurface stratigraphy and overall cross-sectional framework and morphology of the shoals. Note the wide variability of interpreted depositional environments in the subsurface and the close relation between distributary facies and shoals. Locations of cross sections are shown in figure 8.

Textural Character and Volume of the Shoals

Grain-size analyses were initially conducted on sediments from the CI-87 vibracores in 1988 and 1989. A more complete analysis was performed by Pope and others (1993), which provided a comprehensive dataset describing grain size, sorting, and mineral composition of the shoal sediments.

The 2008 sea floor grab sample sediment analyses indicated that the shoal sand is fine to very fine in size (2–2.5 phi), moderate yellowish brown in color, and well sorted (fig. 10). As is typical of Mississippi River sediment, the sand of the St. Bernard Shoals is feldspathic or arkosic (25 percent), oligoclase dominant, and is garnet rich with very little staurolite or kyanite (Hsu, 1960; Pope and others, 1993). Earlier studies performed by Ludwick (1964), Frazier (1974), and Kindinger and others (1982) described similar characteristics for the sediment of the eastern Louisiana shelf and the St. Bernard Shoals. The sand present in the underlying distributary channel and bay fill deposits have color and grain size similar to that of the shoals, which suggests that transgression of the underlying, older distributary channels provided the sediment that ultimately formed the shoals. For more details of mineralogy, the reader is referred to Pope and others (1993).

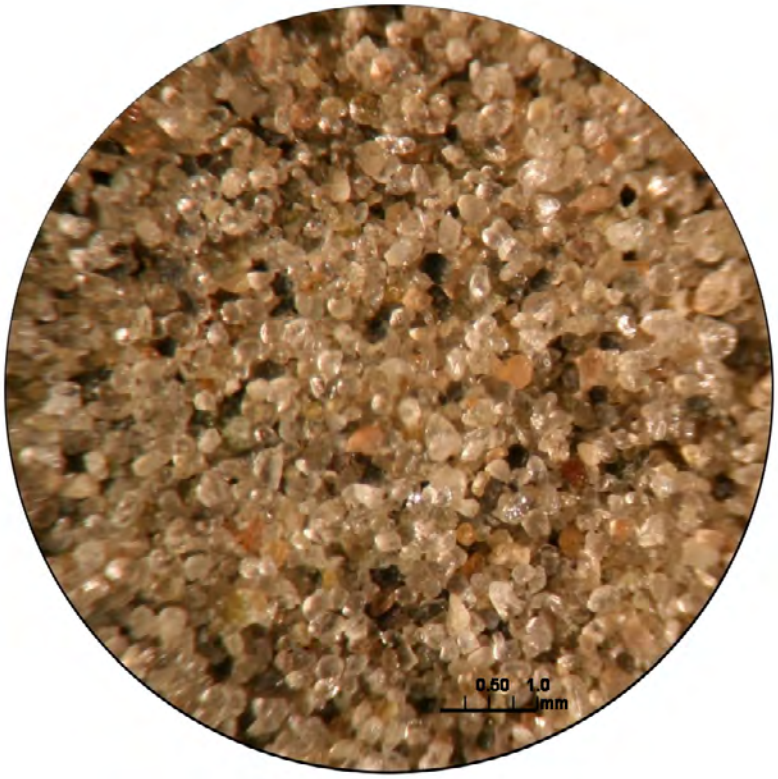

Figure 10. Magnified image of the sediment obtained from the 2008 sea floor grab sample from the top of shoal 14. The image shows that grain size ranges between 0.125 and 0.25 mm and that the grains are well rounded.

Volume of Shoals

Pope and others (1993) also calculated the volume of the individual shoals and the entire shoal platform (fig. 11). Total volume of sediment was estimated by Pope and others (1993) to be approximately 200 × 10^6 m^3 within the 61 discrete sand bodies. The southern shoal field, which is the larger of the two, contains 192 × 10^6 m^3 of sand (92 percent of the total volume). The southern shoal field also contains the five largest individual shoals. Individual shoals range in volume from 75.6 × 10^6 m^3 to 0.14 × 10^6 m^3. In order of decreasing volume the largest shoals are shoal 49, shoal 45, shoal 35, shoal 1, and shoal 14. These five shoals contain 65 percent of the entire volume of the St. Bernard Shoals, or 135 × 10^6 m^3 of sandy sediment (figs. 7 and 12).

Current Process Affecting Modern Day Shoal Evolution

The research conducted in the late 1980s clearly established the presence of the shoals and their general morphology, composition, and volumes. Numerous tropical cyclones have since then crossed over the shoals, which despite their depth (about 15–25 m) are subject to the marine processes generated by large tropical cyclones. Because no work had been done on the shoals since the 1980s, a primary question of this assessment was whether after 20 years the shoals were still present or had been substantially modified.

The SBS-08 CHIRP and side scan datasets conclusively showed that the St. Bernard Shoals had not undergone any large-scale migrations (greater than 100 m) since the CI-87 Louisiana Geological Survey data collection in 1987. The 2008 seismic and side scan data do, however, indicate a sea floor morphology that is highly suggestive of localized deposition and current reworking, as indicated by numerous erosional features.

Shoal Tops

In general the side scan images in conjunction with the seismic data revealed expansive flats that form large areas across the upper surface of each shoal. Grain-size analysis of the grab samples on these areas indicated the presence of sediment that approaches 100 percent sand. Mean grain size of grab samples from the top of shoal 14 was 2.8 phi with a mean phi sorting value of 0.4 (figs. 7 and 13), representing well-sorted, fine-grained sand. Sediment color was moderate yellowish brown. Moreover, in many shoal top areas the side scan imagery revealed numerous large-scale fields (greater than 100 m^2) of sand waves. Although a thorough analysis of these sand waves has not yet been completed, the vast majority appear to have wavelengths of several meters and amplitudes of as much as 2 m locally. Because no previous side scan images exist for the shoals, it is not possible to gage from the 2008 data whether these features represent very recent features or have been a component of the shoal system since their origin.

Shoal Margins

In general the shoals are bounded by highly erosional features, and many of the shoal boundaries are represented by steep surfaces. These sharp boundaries along the shoals create a generally fragmented pattern for the shoals. Adjacent to the primary sand-rich shoals are numerous signs of scours, slumps, and slides. Evidence for the erosional features of the shoal system is most easily understood by looking at individual sea floor features that are herein referred to as

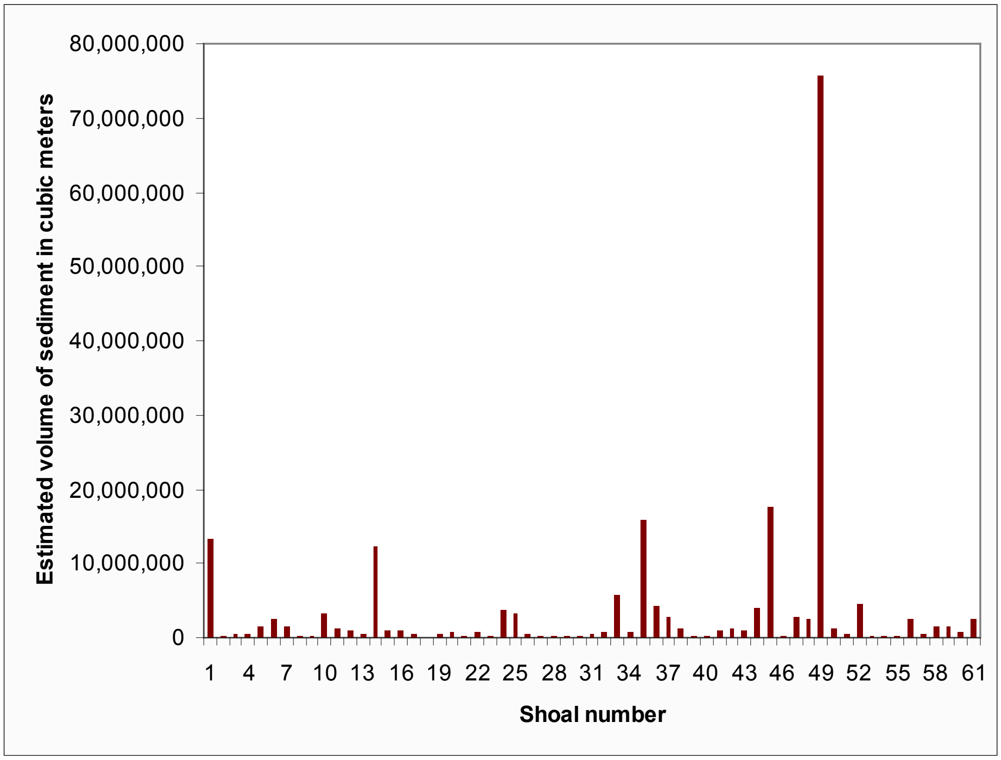

Figure 11. Graph depicting the estimated volume of individual shoals within the St. Bernard Shoals, La., based upon calculations from Pope and others (1993). The largest shoals are shoal 49, shoal 45, shoal 35, shoal 1, and shoal 14. Together they contain a total of 135×10^6 m^3 of sandy sediment.

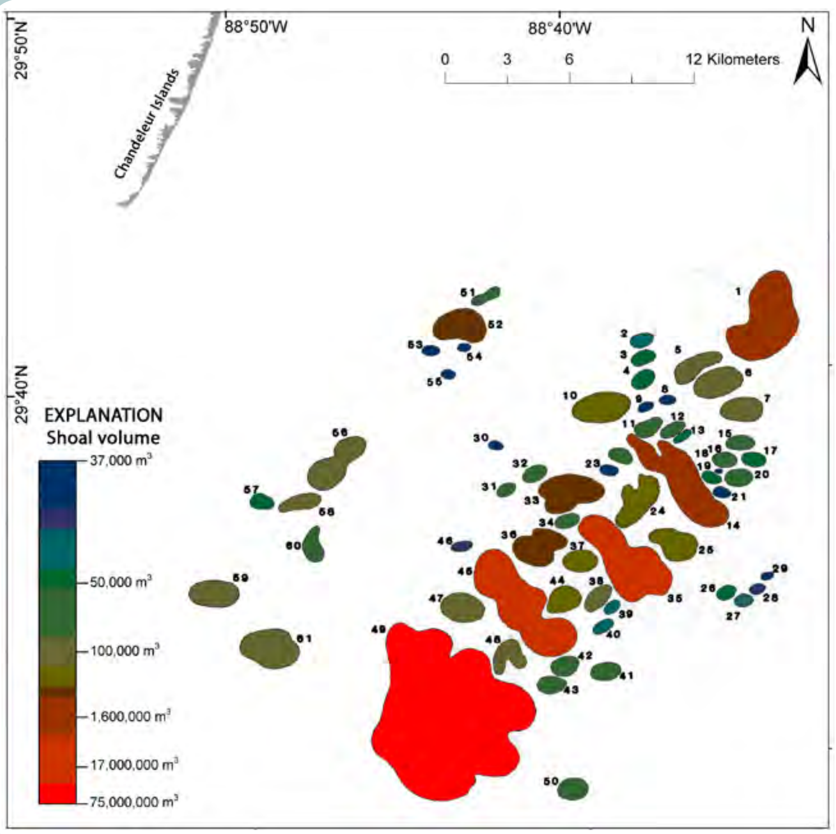

Figure 12. Map of the St. Bernard Shoals, La., depicting the volumes estimated to exist within the individual shoals. Note the spatial variance in the volumes of the shoals.

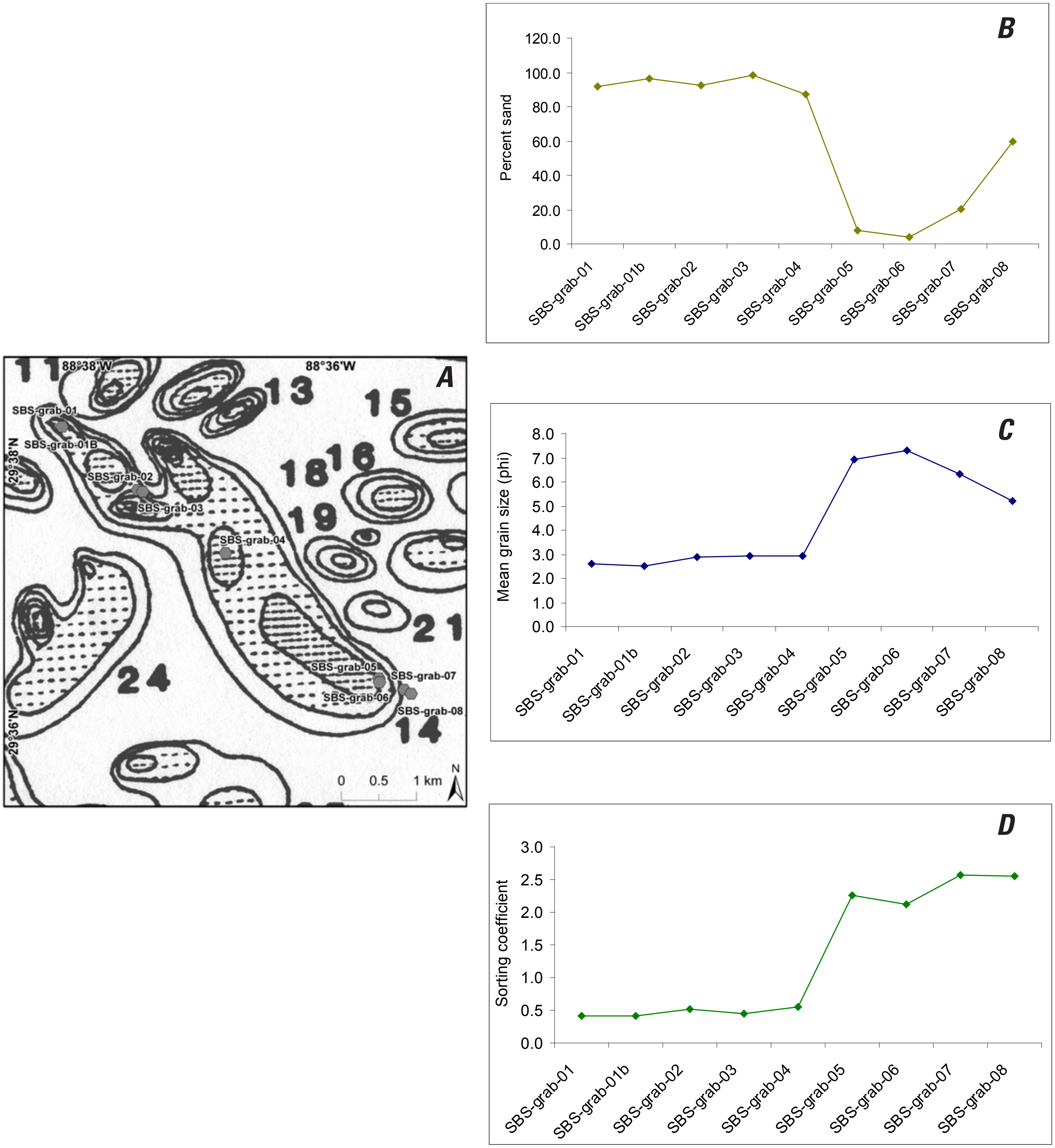

Figure 13. Distribution map and grain-size analysis results of grab samples acquired across shoal 14 in the St. Bernard Shoals, La. (location shown in fig. 7). *A*, Distribution map. *B*, Percent sand. *C*, Mean grain size. *D*, Sorting coefficient. The overall coarsest and most well sorted sediments are located along the northwestern end of the shoal and generally centered around the maximum areas of thickness for this individual body.

"pedestals" (fig. 14). Pedestals are features that are elevated 1–3 m above the adjacent sea floor. In side scan images they appear as highly reflective features, and in the CHIRP seismic data they appear to have nearly vertical sides. These sea floor features are always separated from a nearby shoal by a low in the sea floor. On the basis of sea floor morphology it appears that the shoals are subjected to reworking and erosion by strong bottom currents. Overly steep margins along many of the shoals and the pedestals suggest that reworking may have taken place in the relatively recent past because the sea floor shows little indication of recovery toward less steep profiles. In chapter I, marine currents within the area of the shoals that may be driving current alteration of the shoals are discussed.

Suitability as Borrow Material for the Chandeleur Islands

Ideally, borrow material used for a beach/shoreline restoration and renourishment project is texturally equivalent to the native shoreline sediment. Hydrodynamic conditions along a shoreline influence the textural character, and placement of the appropriate material is fundamental to establishing a stable shoreline. Any borrowed material that is finer grained than the native sediment can generally be expected to be winnowed by marine processes. Thus, the volume of sediment added as fill to a shoreline and the longevity of a sediment-fill restoration project will ultimately be reduced if the borrow material does not closely match the native sediment. Fill ratios provide an estimate of the amount of borrow material required to produce a volume of sediment with the specific native grain-size characteristics.

Sediment analyses performed for this study and in several other studies (Hsu, 1960; Frazier and others, 1975; Mazullo and Bates, 1985; Penland and others, 1989; Pope and others, 1993) show that the St. Bernard Shoals consist of as much as 97 percent sand and that the sand has a rounded to well-rounded texture with a mean grain size ranging from 2.6 to 3.2 phi and sorting of 0.27–0.66. The mean grain size of the St. Bernard Shoals sediment is similar to that of other beach sands and shoal deposits in the Mississippi River Delta. Sediments at Grand Isle, La., range in mean grain size from 2.7 to 2.8 phi (Hsu, 1960), and those at the Chandeleur Islands range between 2.1 and 3.0 phi with a sorting coefficient between 0.40 and 0.25 (Ellis and Stone, 2006). The sediment in Ship Shoal, La. (for location see fig. 1), can vary between 2.7 and 2.9 phi and has sorting coefficients that range between 0.35 and 0.46 (Penland and others, 1988).

The cut and fill ratios for the use of Ship Shoal and the St. Bernard Shoals on the Chandeleur Islands were compared by using the fill factor developed by Hobson (1977) (fig. 15). This method, developed to quantify the amount of borrow material for beach nourishment projects, is accomplished by comparing the sorting coefficient ratio of borrow material (b) to native

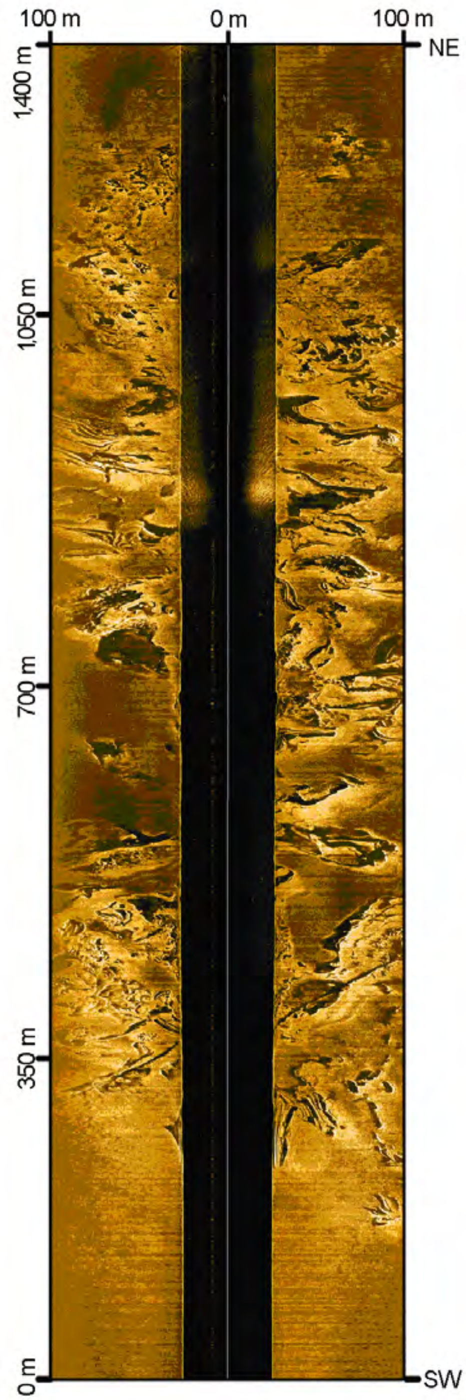

Figure 14. 2008 side scan image of the sea floor across shoal 27 and shoal 28 in the distal southeastern study area of the St. Bernard Shoals, La. The shoals are represented in the image at the ends of the transect where the sea floor appears relatively flat and featureless. Note the folded, tapestry-like appearance of the sea floor in the intervening low, which on the basis of CHIRP data appears to be the site of an intense scour.

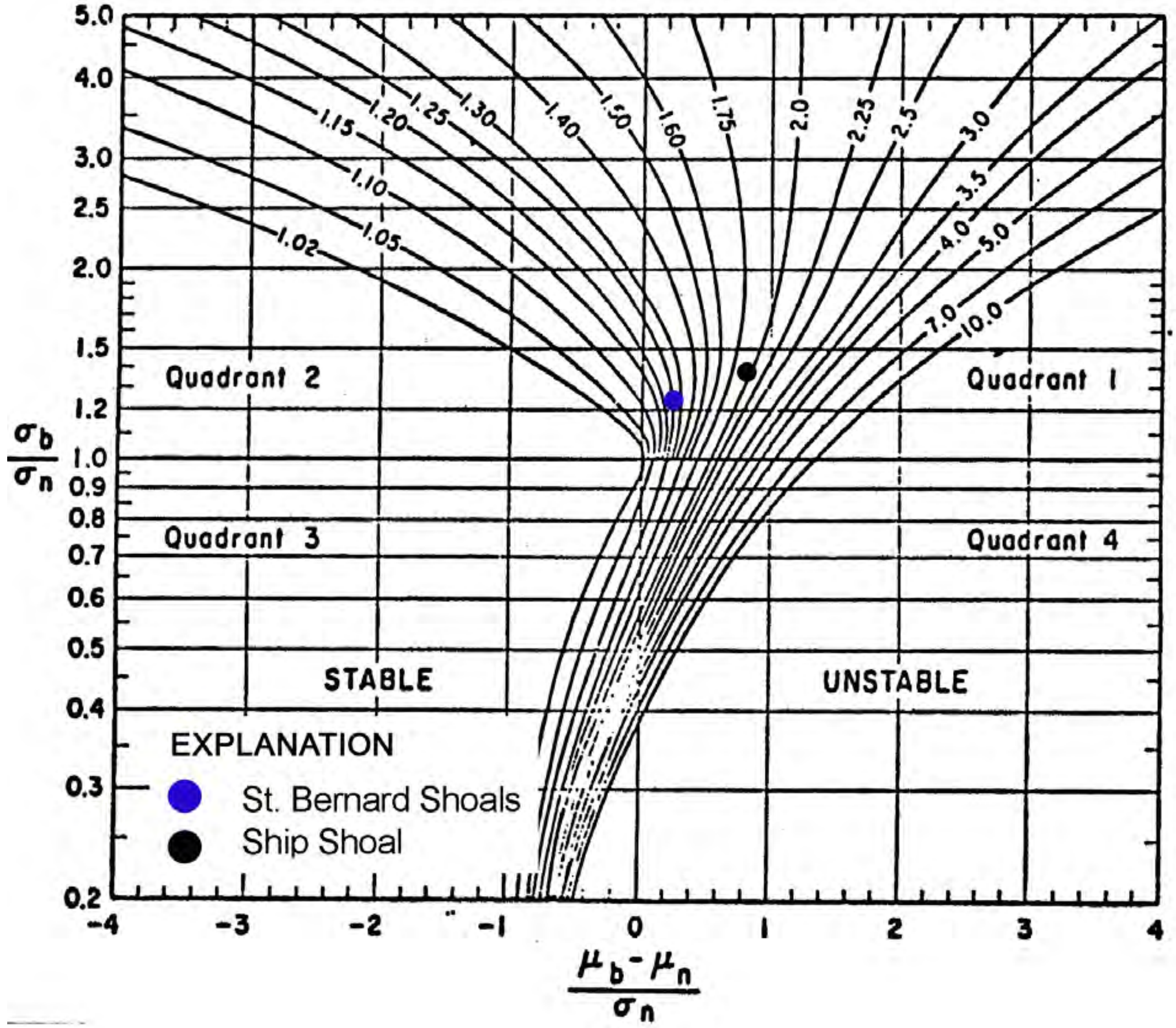

Figure 15. Graph showing the cut and fill ratios for sediment of the St. Bernard Shoals and Ship Shoal, La., if used to replace the native sediment of the modern Chandeleur Islands system. On the basis of this information it is suggested that the St. Bernard Shoals could provide a suitable and hydrodynamically stable sediment source for shoreline renourishment projects of the Chandeleur Islands because of the similarity of sediments (method and graph derived from Hobson, 1977).

material (n) versus the difference between borrow and native mean grain size scaled by the native sorting coefficient (Hobson, 1977). The sediment textures of the Chandeleur Islands reported by Ellis and Stone (2006) were used as the values for the native materials. The more alike two sediment sources are, the closer to the center of the graph they will be (fig. 15). On the basis of the available grain-size data, it seems that the sediment of the St. Bernard Shoals would be ideally suited for use as renourishment sediment of the Chandeleurs.

Hydrodynamic Impacts

The removal and relocation of sediment by dredging alter the sea floor topography and consequently the bathymetric profile of the dredged area. A consequence of sediment dredging is an increase in the water depth at the dredged area. The direction and magnitude of currents and sediment transport cells are in part controlled by sea floor topography; thus, currents, sediment transport cells, and wave climate offshore of the Chandeleur Islands could be altered by dredging of the recommended borrow sites. Quantitatively assessing these potential alterations is paramount because perturbations of these conditions could adversely impact the surrounding coastline and islands; however, the potential effects of dredging in the area have not yet been quantitatively studied, and it is unreasonable at this time to attempt to predict the exact effect that dredging of recommended sites would have on the eastern Louisiana continental shelf. It is common practice to use numerical models to assess the impact of dredging on currents, sediment budgets, and wave climates.

Concluding Remarks

High-resolution seismic-reflection profiles, side scan sonar, vibracores, and grain-size analysis have been used to clearly define the sedimentary framework and characteristics of the St. Bernard Shoals. These data indicate that the shoals are derived from sediment that was deposited by depositional systems similar to those that contributed to the formation of the Chandeleur Islands. Consequently the sediment that contributed to the generation of the shoals is similar to the sediment that contributed to the Chandeleur Islands. For this reason the shoals have a sedimentary texture that is quite similar to that of the Chandeleur Islands, making them an ideal borrow material for renourishment of the Chandeleur Island system.

Depending upon the location and extent of proposed dredging and the nature of the targeted borrow, additional sediment sampling may be required to fully define the character of the proposed dredged sites because of the lateral and vertical variability of the deposits addressed in this study. In addition, a magnetometer survey across the areas of proposed borrow material excavation would further refine the areas where dredging can be safely, efficiently, and economically completed by locating existing pipe and cable lines. Finally, quantitative modeling should be performed to assess the probable impact of dredging plans on offshore currents, sediment-transport cells, and wave climates in conjunction with environmental testing of the proposed dredge material. The results of these studies could be used to assess the potential for adverse effects on the surrounding wetlands and shorelines caused by dredging and to establish finalized plans for the renourishment of Chandeleur Islands.

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Appendix G–1. SBS-08 Seism (See Index Page To Access Data)

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