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A GEOLOGICAL INVESTIGATION OF THE OFFSHORE AREA ALONG FLORIDA'S NORTHEAST COAST YEAR THREE (STATE FISCAL YEAR 2004-2005) ANNUAL REPORT SUBMITTED TO THE UNITED STATES DEPARTMENT OF THE INTERIOR MINERALS MANAGEMENT SERVICE

Contract Period July 1, 2004 through June 30, 2005
Cooperative Agreement No. 1435-0001-30757

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Florida Geological Survey
Tallahassee, Florida
December, 2005

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EXECUTIVE SUMMARY

The U.S. Minerals Management Service (MMS) and the Florida Geological Survey (FGS) have a long history of cooperative investigations of Florida's offshore marine sediment resources. These agencies are currently engaged in a multi-year study titled "A Geological Investigation of the Offshore Area Along Florida's Northeast Coast, Under MMS/FGS Cooperative Agreement No. 1435-0001-30757." This study's specific goals are:

- The identification of the location, aerial extent and volumes of potentially available restoration-quality sand resources (i.e. borrow material) lying on the seabed in federal waters which are suitable for beach nourishment along the study area shorelines of Nassau, Duval, St. Johns, Flagler and Volusia Counties and,

- The characterization of the granulometry and lithology of current beach sediments (e.g., native material).

This report discusses data and interpretations derived from specific tasks accomplished during Year Three (State Fiscal Year 2004-2005) of the above agreement. The study area includes offshore federal coastal waters and adjoining beaches lying between the southern boundary of Volusia County and the Georgia-Florida border. Offshore exploratory work was conducted in federal waters, extending from three nautical miles (5.6 kilometers) to a maximum of eighteen nautical miles (33.3 kilometers), adjacent to state submerged lands. This report provides an interim update of ongoing investigations of available restoration-quality sand resources within the study area prior to the completion of a final report. This report also references data presented in previous yearly reports.

Exploratory and sampling field work, accomplished by either the FGS, the U.S. Army Corps of Engineers (USACE) or USACE contractors, included native beach sediment sampling, as well as offshore vibracoring, seabed grab sampling, subsurface acoustic profiling, and electrical resistivity surveying. It should be understood that not all of these tasks were accomplished solely by the FGS or during Year Three. The task of vibracoring was spread over multiple years and was in part accomplished independently by the FGS, in part in coordination with the USACE, and in part accomplished independently of the FGS by the USACE's consultant Challenge Engineering Inc. (Challenge), using Alpine Ocean Surveys (Alpine) as a subcontractor. Electrical resistivity surveying was conducted solely by Dredging Exploration Mining Consultants (DEMCO), a subcontractor to Challenge.

The tasks of beach sediment sample collection and their analyses, as summarized below, were conducted by the FGS in consecutive state fiscal years. St. Johns and Flagler County beaches were sampled in Year Two (State Fiscal Year 2003-2004) and Volusia County beaches in Year Three. Whereas Flagler County results are included in this report, the results of the analyses of the beach sediment samples from St. Johns County were reported in the Year Two report (Phelps *et al.,* 2004). Volusia County results will be included in the Year Four (State Fiscal Year 2005-2006) report. While the bulk of subsurface acoustic profiler data acquired in Year Three were collected offshore of southern St. Johns County, some additional data were acquired offshore of Nassau and Duval Counties and the northern portions of St. Johns County in Year Three to supplement those data previously collected. As ship time was available, some data were acquired offshore of Flagler County in Year Three as well.

The Year Three granulometric and descriptive analyses of sediment samples, and the processing and interpretation of subsurface acoustic profiler data are summarized as follows:

- *Native Beach Sampling and Granulometry:* A total of 41 samples collected from the beaches of Flagler County were described and granulometrically analyzed. Photographs, descriptions and the results of granulometric analyses of those samples are provided in this report.

- *Seabed Grab Sampling and Granulometry:* A total of 38 samples collected offshore of northern St. Johns County were described and granulometrically analyzed. Photographs, descriptions and the results of granulometric analyses of those samples are provided in this report.

- *Offshore Vibracoring and Granulometry:* Of the vibracores variously collected offshore of Nassau and Duval Counties during the first three years of this study, ninety-one (91) were described and analyzed for the purposes of quantifying available restoration-quality sand reserves available for use in the USACE Duval County Shore Protection Program.

- *Offshore Subsurface Acoustic Profiler Data:* Roughly 272 statute miles (438 kilometers) of subsurface acoustic profile data were collected offshore of Nassau, Duval, St. Johns and Flagler Counties in Year Three, with the bulk of these data being collected offshore of southern St. Johns County. Additionally, 12.3 statute miles (19.8 kilometers) of data offshore of Crescent Beach in St. Johns County, previously collected by the U.S. Geological Survey (USGS), was obtained as well. All of these data were processed, interpreted and plotted with those data collected in the preceding two years. The subsurface acoustic profile data collected in Year Three and the smaller USGS Crescent Beach data set are provided as processed images.

- *Offshore Electrical Resistivity Data:* DEMCO, a subcontractor to Challenge, collected 57 statute miles (91.7 kilometers) of electrical resistivity data in 2004. Challenge provided a report of DEMCO's findings to the USACE (Brabers, 2004). The results of that report are discussed and, as the report is not generally available or widely known, the report is attached as an appendix.

A number of potential borrow sites offshore of Nassau, Duval and St. Johns Counties are identified and the level to which they have been, and are proposed to be investigated, is discussed. One feature, referenced as A4 in Meisburger and Field (1975), lying 8 statute miles (12.9 kilometers) east of the mouth of the St. Johns River, is examined in detail and a map of sand reserves containing a fines fraction of less than 10% is provided. Fines are defined as that material that will pass through a 4.00 phi (63 micron/0.0025 inch mesh opening) 230 sieve. Reserves of potentially available restoration-quality sand are variously calculated at less than 10% and at 5% or less fines. As specified in Chapter 62-41.007(5J) of the Florida Administrative Code, (Florida Administrative Code, 2001) the fines content of beach restoration sediments should not exceed 5% unless the fines content of the sediments on the beach to be renourished exceeds 5% and then only up to that percentage. Analysis of vibracore data obtained in Year Two and Year Three indicate that A4 contains potential reserves of up to 218.2 million cubic yards (mcy) (166.8 million cubic meters [mcm]) of available restoration-quality sand containing less than 10% fines. A smaller area within A4, identified by the USACE, was extensively cored in 2004. This area, which lies immediately adjacent to a previously dredged site on A4, is estimated, based on a content of less than 10% fines, to contain 21.7 mcy (16.6 mcm) of potentially available restoration-quality sand. Based on a content of 5% or less fines this smaller area is estimated to contain 8.0 mcy (6.1 mcm) of available restoration quality sand. A planned borrow site for the scheduled USACE's Duval County Shoreline Protection Project is located within the northern portion of that smaller area. Based on 5% or less fines, that borrow site's reserves are estimated to be 2.0 mcy (1.5 mcm) of available restoration-quality sand. The remainder of the smaller area is being permitted for near future use.

Seismic stratigraphic analysis of the subsurface acoustic profiler data indicate the presence, offshore of Duval and St. Johns Counties, of areas of anomalous dip in the subsurface which exhibit no relief on the seafloor. Similar features were also observed in those data collected in previous years. These features are believed to be related to the dissolution of underlying strata. Specific conjectured collapse features, vertically persistent to the base of the subsurface acoustic profiler data recorded, appear to be of limited areal extent and are not expressed bathymetrically.

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INTRODUCTION

Beach erosion is a chronic problem in Florida (Clark, 1993). Within the study area, encompassing the northeastern coast of Florida, beaches comprising over 30 percent of the coastline, totaling about 44 statute miles (71 kilometers), are classified as Critically Eroding Beaches **(**Clark, 1993). Beach restoration has a long history in the state and planning for future restoration projects requires that abundant sources of restoration quality sand be available for use. As coastal development of the state proceeds at an ever increasing pace and readily available onshore sources are either unavailable or depleted, offshore sediment bodies are increasingly sought after as sources of restoration-quality sand. To address this burgeoning need, the Minerals Management Service (MMS) of the United States Department of the Interior and the Florida Geological Survey (FGS) entered into a multi-year cooperative agreement (cooperative agreement # 1435-0001-30757) to investigate the available restoration-quality sand resources offshore of the northeastern coast of Florida. This specific study was conducted in coordination and consultation with the U.S. Army Corps of Engineers (USACE) to locate and characterize both the areal extent and volume of available restoration-quality sand suitable for beach nourishment along the shorelines of Nassau, Duval, St. Johns, Flagler and Volusia counties. This was accomplished through the use of subsurface acoustic profiling, bottom grab sampling, beach sediment sampling and vibracoring. This data will be entered into the Reconnaissance Offshore Sand Search database (http://Ross.urs-tally.com) being developed by URS Corporation for the Florida Department of Environmental Protection's (FDEP), Bureau of Beaches and Coastal Systems (BBCS).

This report reviews those data acquired in the study's Years One (State Fiscal Year 2002-2003) and Two (State Fiscal Year 2003-2004) as presented in Phelps *et al.,* (2003) and Phelps *et al.,* (2004). It provides and discusses those data obtained and analyzed in Year Three (State Fiscal Year 2004-2005). Some data acquired in Year Two and analyzed in Year Three is also presented and discussed. The report presents conclusions drawn from those data analyzed in all three years and makes recommendations regarding data to be collected in future years.

PREVIOUS WORK

Meisburger and Field (1975, 1976) discussed the results of their investigations of the Florida inner continental shelf from Cape Canaveral to the Florida/Georgia border. In their studies, they collected and analyzed more than 1,153 nautical miles (2,137 kilometers) of high resolution subsurface acoustic profiles and data from 197 vibracores acquired in the late 1960's as part of the Inner Continental Shelf Sediment and Structure (ICONS) Program. Nocita *et al*., (1991) further analyzed vibracores collected for the ICONS Program and, based on low mud to high sand ratios, suggested that the region had several sites with low mud content that might be potential borrow sites for beach renourishment purposes. LaPlace (1993) analyzed in detail 20 vibracores and 248 statute miles (399 km) of subsurface acoustic profiler records collected offshore of St. Augustine for the ICONS study. As discussed in the Year Two report (Phelps *et al.,* 2004), this study suggested that the remnants of an earlier barrier island complex were locally preserved offshore of central and northern St. Johns County. These studies discussed the geomorphology and shallow sub-bottom structure of the continental shelf as well as the surficial and sub-bottom sediments in the study area. As a result of a literature review, granulometric analysis of bottom grab samples and vibracores, and seismic stratigraphic analysis, several features with a high potential for the occurrence of beach restoration-quality sand in federal waters offshore of Duval County were identified.

FIELD PROCEDURES AND LABORATORY ANALYSIS

The exploratory phase of Year Three of this program involved the use of subsurface acoustic profiling (also known as continuous seismic reflection profiling), the collection of beach samples from Volusia County and the collection of bottom sediment samples offshore of northern St. Johns County. Survey track lines for the subsurface acoustic profiling offshore of St. Johns County were laid out as a reconnaissance grid, with a north/south line spacing of one nautical mile, (1.85 kilometers) (Figure 1). Additionally, north-south trending lines were collected offshore of central and southern St. Johns and northern Flagler Counties. The reconnaissance grid spacing was a continuation of the Years One and Two grid acquired offshore of Nassau and Duval Counties and the northern portion of St. Johns County. This grid provides sufficient density to determine where additional subsurface acoustic profiling and later reconnaissance bottom sampling should be conducted in Year Four (State Fiscal Year 2005-2006). Additionally, in the areas where subsurface acoustic profiler data were collected in previous years, three connected infill lines were collected offshore of Duval County as well as two north-south trending tie lines offshore of Duval County and the northern half of St. Johns County.

As detailed in the Year Two report (Phelps *et al.,* 2004), a simple alphanumeric scheme was utilized to identify loose sediment samples. All beach samples discussed in this report are identified with a two letter designation such as FG for Flagler County. This is followed by consecutive beach location numbers, 1, 2, 3, 4 etc., and completed by a two letter designation indicating the sample's location on the beach profile. Thus, samples collected from the swash zone, berm, mid beach and back beach are designated SS, B, MB and BB, respectively. For example, a sample collected in Flagler County at sample location 1 in the swash zone would be delineated as FG-1-SS. All grab samples collected offshore with a "clam-shell" dredge sampler, are labeled with the beginning two letter geographic code referenced above, followed by a multi digit location number and the two letter designator "CG" for clamshell grab. Thus, a grab sample collected offshore of St. Johns County might be designated SJ-101-CG.

The numbering scheme utilized in these reports for the analyzed vibracores varies depending on whether they were collected in Year Two by the FGS using the survey's research vessel *R/V GeoQuest*, in Year Two by an independent contractor, Athena Technologies Inc. (Athena) with onboard oversight by FGS personnel or in Year Three by Challenge, by Alpine Ocean Surveys (Alpine) as a subcontractor, under direct contract to the USACE.

The vibracores independently collected by the FGS in Year Two are designated with a V for vibracores, followed by either DU for Duval or NA for Nassau or SJ for St. Johns to identify the adjacent county, and a unique core number. For example, the first vibracore collected offshore of Duval County would be VDU-01. Individual sediment samples obtained from the vibracore are identified as follows. The representative sediment sample collected from the top of core VDU-01 to 2 feet (0.6 meters) below the top of core would be labeled VDU-01-01. A representative sample collected from 2 feet (0.6 meters) below the top of the core to 4 feet (1.2 meters) below the top of the core would be labeled VDU-01-02. This procedure is repeated until the bottom of the core is reached. A sample collected from within the vibracore for the purposes of radiocarbon dating would be designated by its depth in the core and RC. Thus a sample collected from vibracore VDU-01 at a depth of 14.5 feet (4.4 meters) for the purpose of radiocarbon dating would be labeled VDU-01-14.5-RC. Of the vibracores and samples collected by the FGS, only VDU-01-16.8-RC and VNA-4 are discussed within this report. For a complete description of vibracores collected by the FGS in previous years please see the FGS's Year Two report to the MMS, (Phelps *et al.,* 2004).

Those cores collected by Athena in 2003, as detailed in the Year Two report (Phelps *et al.,* 2004) and the vibracores collected in 2004 by Challenge, using Alpine as a subcontractor are designated in the following manner:

- They are identified as CB, for core boring, then DU, for Duval County, followed by either 03 or 04 depending on whether they were collected in 2003 or 2004.

- These identifiers are followed by a subsequent numerical designator referring to the location number which is followed in some cores by a letter designation of A, AJ, BJ, CJ and R.

- The designator A, when it appears alone, indicates that that core is the second attempt at that location.

- The designators AJ, BJ and CJ refer to cores from locations that required jetting, which in the case of BJ and CJ indicates multiple jetting and vibracoring repetitions, to achieve sufficient penetration at a specific location.

- The designator R appearing on the "Drilling Logs" and "Gradation Curves" supplied by Wolf Technologies for the 2003 cores, represents a composite vibracore synthesized by them from the results of multiple jetting and vibracoring repetitions.

For example, the vibracore collected by Athena designated CB-DUC03-33 is a vibracore (CB) obtained offshore of Duval County (DU) in 2003 (03) in the first attempt at location 33. Core CB-DUC03-34A on the other hand represents a second attempt at vibracoring at location 34. The vibracores designated CB-DUC03-42, CB-DUC03-42 AJ, CB-DUC03-42 BJ represent vibracores that sequentially comprise, through a process of alternating jetting and vibracoring, full penetration and recovery at location 42. The vibracore designated CB-DUC03-42R represents a synthesized composite vibracore from location 42.

Beach and Seabed Sediment Sample Collection Methodologies

Beach sample locations visited in Year One were spaced one statute mile (1.6 kilometers) apart where practicable. Sampling locations in Year Two were spaced at an approximate one statute mile (1.6 kilometers) interval along the beaches of St. Johns and Flagler Counties at every fifth beach monument survey point (BBSC, FDEP) where practicable.

The samples collected in Year Two on the beaches of Flagler County were processed and included in this report. Loose sediment samples collected on the beaches of Volusia County in Year Three will be processed and included in the Year Four report. Those samples collected in Year Three from the seabed offshore of St. Johns County are also included in this report. The following is a description of the sampling methodologies used.

Beach Sediment Sample Collection

Beach samples in Flagler and Volusia Counties were collected from December 1 to 4, 2003, and from November 15 to 17, 2004. They were collected from a total of 77 sampling locations, 20 locations in Flagler County and 57 in Volusia County, at a sample location spacing of approximately one statute mile (1.6 kilometers) (Figure 1) which included every fifth beach monument survey point (BBSC, FDEP) where practicable. Table 1 ties monument points to beach sampling locations. Photographs, descriptions and granulometric analysis of beach samples collected from Volusia County beaches in the Year Three round of beach sampling will be included in the Year Four report.

It was intended that, at each sampling location surface samples would be collected from the swash zone, the beach berm, mid-beach and back beach; however, due to the narrowness of the beach, only swash zone and back beach samples were collected at most locations. At some locations, only a swash zone sample was collected. At a few limited locations, typically where the sea beat against the sea wall, no samples were taken at all (Figure 2). GPS readings were obtained for each of the sampling points. While the elevation of the sediment surface relative to mean sea level was not recorded, these elevations did not exceed 5 feet (1.5 meters). At each sampling point within an individual sampling location, three individual replicate samples, each totaling approximately 2 ounces (56.7 grams) of sediment, were obtained for sieving analysis. Samples were collected by scooping up sediments from the surface to an approximate depth of 1 inch (25.4 millimeters) below the beach surface at each sample point using an approximately 2 ounce (56.7 gram) scoop, (Figure 3). Photographs of the beach samples collected in Year Two on the beaches of Flagler County by the FGS can be found in Appendix A.

Seabed Sediment Grab Sample Collection in Year Three

A "clam shell" dredge sampler was used for seabed grab sample retrieval in Year Three. Water depths at the sample locations were obtained using an onboard echosounder. Sample collection offshore of northern St. Johns County, Florida, was performed on April 11, 2005. Samples were recovered in Year Three using the FGS's 24 foot Carolina Skiff (Figure 4) and the smaller of the two "clam shell" dredge samplers illustrated in Figure 5. A total of 38 grab samples were obtained. Photographs of the seabed grab samples collected in Year Three by the FGS can be found in Appendix B.

Sediment Sample Processing

The sieve nest used in sample processing (Figure 6) by the FGS is delineated in Table 2. All granulometric analyses were conducted using the general guidelines of the American Society for Testing and Materials (2000a, 2000 b) and specific procedures advanced by the FGS sedimentology laboratory (Balsillie, 1995, 2002a, 2002b, Balsillie and Tanner, 1999; Balsillie, *et al.* 1999; Balsillie *et al.* 2002a; Balsillie *et al.* 2002b; Balsillie and Dabous, 2003). Each sample was initially weighed after oven drying. The sample was then wet sieved through a 230 sieve (0.63 mm or 4 phi), oven dried and reweighed with the weight loss being assigned to the fine fraction. The sample was then dry sieved with the portion of the pan fraction obtained during dry sieving also assigned to the fine fraction. This sample was then digested with a 4 M hydrochloric acid solution, rinsed, oven dried, resieved and weighed again.

Those samples exhibiting a significant percentage of fines were further analyzed. Wet sieving (4 phi) was used to separate the fine fraction and a pipetting technique was employed to determine the amounts of silt and clay present using methodology in Folk (1974) and Galehouse (1971). The significance of fines in identifying sediments for beach nourishment is discussed below.

Cumulative grain size distribution curves reflect the total grain size distribution (GSD) of each sediment sample. The weight of the fine fraction, consisting of the weight loss from wet sieving plus weight of the fraction passing through the sieve nest to the pan, was assigned to the finer than 4 phi fraction. Separate GSDs were determined for the carbonate and non-carbonate fractions of each beach and offshore sample along with the combined GSD for each sample. A link is provided in the grain size analysis column of the indices for beach, offshore grab samples, and vibracores and in appendices C, D and E respectively.

For beach samples, sample #1 of the set was processed as described above. Sample #2, subsequent to being dried, was described and photographed. These descriptions and photographs can be accessed via the index under the photograph column and in Appendix A. Sample #3 of the set was dried and, of these samples, 10% were processed like sample #1, for the purpose of granulometric analysis quality control. The results of the granulometric analyses are provided in Appendix C. Those samples not selected for processing were archived in the FGS's vibracore and sediment sample repository.

Restoration-Quality Sand Parameters

It is important to note that the thickness of available restoration-quality sand is determined in part by the percent fines content. Thus, restoration-quality sand resources are often limited vertically by the depth at which the fines content exceeds 5%, as specified in Chapter 62-41.007(5J) of Florida Administrative Code (Florida Administrative Code, 2001) unless the fines content on the beach to be renourished exceeds 5% and then only up to that percentage. Fines in this instance are defined as that material that will pass through a 4.00 phi (63 micron/0.0025 inch mesh opening) 230 sieve. With these provisos in mind, reserve estimates of restoration-quality sand have been provided at both less than 10% and at 5% or less fines.

Grain Size Distribution (GSD) Curves

GSD curves are presented in the respective indexes for beach, grab and vibracore samples. Separate GSDs were determined for the carbonate and non-carbonate fractions of each sample obtained by the FGS along with the combined GSD of the entire sample. Only combined GSDs are available from the samples obtained from the Corps of Engineers' vibracores. Digital photographs were taken of all beach and grab samples collected by the FGS. These images can be accessed via the index for beach and grab samples under the photograph page column or by recourse to Appendices A and B respectively.

Sediment Processing Quality Control

As a quality control check, a replicate sample was processed separately for eight of the beach samples and the granulometric results compared statistically with those obtained from the first samples to test similarity of the grain size distributions. Using the Mann-Whitney Test to compare the distribution medians and Levene's Test to compare the variances, at a 95% confidence there is no significant difference found between the distributions of the first and replicate samples. Graphical comparisons of initial and replicate samples can be seen in Appendix F.

Subsurface Acoustic Profiling

Subsurface acoustic profiling is a technique used to delineate and define sub-bottom structures and bedding surfaces in sediments underlying the seabed. Subsurface acoustic profiling involves the measurement of the two-way travel time of acoustic waves transmitted from sea surface and reflected back to the sea surface from the interfaces between contrasting geological layers within the sediments. Reflection of the transmitted energy will only occur when there is a contrast in the acoustic impedance (the product of the seismic velocity and density) between these layers. Continuous reflections are created by generating repetitive pulses of high energy sound underwater and recording the pulses returned as reflections from the seabed and sub-seabed sedimentary and structural features.

Subsurface acoustic profiler surveys carried out in Years One, Two and Three offshore of Nassau, Duval, St. Johns and Flagler Counties, were conducted by towing sound pulse generating and receiving instruments behind a survey vessel traversing predetermined survey track lines at a set vessel speed. The sound pulse generator was initiated at a fixed rapid rate and the returning signals were received by a geophone array. The reflections were recorded digitally and these data signals were amplified, fed to a chart recorder, and graphically plotted in two-way signal travel time as an analog paper record. The sonic velocity utilized in plotting the subsurface acoustic profiler analog data was 4,921.2 feet per second (ft/sec) (1,500.00 meters per second [m/s]), i.e. the average velocity of sound in sea water. Horizontal control is achieved by the use of frequent navigational fixes.

The digital data set recorded typically comprises three files for each line; a navigational file (.nav), a geophysical response file (.tra) and a data acquisition parameters file (.par). The geophysical response file for each line was subsequently processed in-house at the FGS to produce a graphics (.jpg) file.

Subsurface Acoustic Profiler Data Collection

Including 12.3 statute miles (19.8 kilometers) of data previously collected by the U.S. Geological Survey (USGS), approximately 272 statute miles (438 kilometers) of subsurface acoustic profile data were acquired in Year Three, with the bulk of these data being acquired offshore of southern St. Johns County. The data collection program consisted of 18 east-west (dip) lines which vary in length from 6 to 12 statute miles (9.7 to 19.3 kilometers) totaling approximately 180 statute miles (290 kilometers) lying offshore of southern St. Johns County, five north-south (strike) lines totaling approximately 65 statute miles (105 kilometers), lying offshore of Nassau, St. Johns and Flagler Counties and three interconnected infill lines totaling approximately 27 statute miles (43.4 kilometers) lying offshore of Duval County. These infill data were collected in Duval County to compliment data previously collected in Years One and Two. The strike lines connect consecutively-acquired east-west lines and as such are commonly referred to as tie lines. Locations for the east-west lines were chosen to provide an approximate one nautical mile (1.9 kilometers), on minutes of latitude, north-south separation between east-west lines. Figure 1 displays the location of all subsurface acoustic profiler data collected to date.

It was noted by Freedenberg et al. (2002), in their studies to the south, that the highest quality sand accumulations were associated with bathymetric highs. The length of dip lines and the placement of the tie line offshore of southern St. Johns and Flagler Counties were therefore determined by distance from the shore, the eastward extent of bathymetric highs, and, in the case of tie lines, the strike of the crest of those highs as determined from the available bathymetric charts.

The subsurface acoustic profiles recorded for this study were collected aboard the FGS vessel R/V GeoQuest, (Figure 7). Signal energy for the survey conducted in Year Three was provided either by a Applied Acoustic Engineering boomer sled or a C-Products C-LVB (low voltage boomer) boomer sled towed approximately 30 feet (9.1 meters) behind the survey vessel. These instruments are shown on Figures 8 and 9 respectively. For the Applied Acoustic Engineering sled an Innovative Transducers, Inc. streamer cable was deployed for signal detection. Figures 10 and 11 show respectively how such a sled and streamer are physically deployed while Figure 12 provides a diagram of how the entire system was deployed. The sled-mounted Applied Acoustic Engineering boomer signal source was towed at an approximate speed over the seabed of 4 knots, fired at a shooting interval of 500 milliseconds with record lengths of 100 and 120 milliseconds. A boomer generates its signal via the use of a rapidly moving electromagnetically controlled plate that imparts a pulse into the water column. For the Year Three survey, the boomer was configured so that most of the source energy had a frequency of 4 kHz. Signal energy for the Year Three survey was also provided by a C-Products C-LVB boomer sled. Figure 9 shows the unit on the vessel's back deck and Figure 13 shows the unit as deployed. A Benthos multi-element mesh array streamer cable was used for signal detection (Figure 14). The equipment towing diagram, shown in Figure 12, was essentially the same except that the C-LVB and the Benthos streamer cable were substituted for the Applied Acoustic Engineering boomer sled and ITI streamer cable, respectively. The sled-mounted C-LVB 100 joule boomer signal source was towed at an approximate speed over the seabed of 4 knots, while firing at a shooting interval of 500 milliseconds with a record length of 100 milliseconds. For this portion of the survey, the boomer was configured so that the peak of the source energy imparted had a dominant frequency of 3 kHz. Field data were sampled and converted to a digital format. All field records were retained on CD disks in Year One and DVD disks in Years Two and Three for long term storage and are available for general distribution.

Limitations imposed by equipment, safety, and personnel availability initially constrained the time window for subsurface acoustic profiler data acquisition in Year Three. These data could only be acquired during day-light hours and over a 2 week period in a time of the year not particularly notable for good sea conditions in the study area. The data quality of the subsurface acoustic profiles obtained during the marine geophysical survey in Year Three was impacted by occasional marginal/adverse sea conditions and the second boomer sled's higher sensitivity to "choppy" sea conditions.

As was noted above an additional 12.3 statute miles (19.8 kilometers) of subsurface acoustic profiler data, previously acquired by the USGS in 2001, were also obtained. These data encompass a feature know as "Crescent Beach Spring", lying approximately 2 .5 statute miles (4 kilometers) offshore of the southern half of St. Johns County. An Applied Acoustic Engineering boomer sled and ITI streamer cable were used in their acquisition. These data were processed and are of good quality. They have been included in this report and can be accessed via the inset map on Figure 1. Subsurface acoustic profiler line 04B15, in Appendix G, ties this data set into the subsurface acoustic profiler data acquired by the FGS in Year Three.

Computer Processing of Subsurface Acoustic Profiler Data

Processing of the subsurface acoustic profiler data collected or acquired in Year Three was accomplished using the SonarWeb Pro software package developed by Chesapeake Technologies Inc. Individual subsurface acoustic profiler lines were processed such that the graphics files created produce images with west to the left on all east/west trending lines and north to the left on all north/south trending lines. This orientation facilitates ease of comparison of individual lines and is in keeping with standard practices and conventions generally used in seismic data processing. As was the case for the plotted analog data, the sonic velocity utilized in data processing was 4921.2 ft/sec (1500.00 m/s), i.e. the average velocity of sound in sea water. While this is in keeping with standard practice in the processing of subsurface acoustic profiler analog records, the actual sonic velocity in the near seafloor sediments investigated, due to their higher density relative to sea water, progressively increases with depth and probably averages nearer to 5,905.44 ft/sec (1,800.00 m/s). This assumption is based on sonic velocities reported in Meisberger and Field, (1975). They divided the sequence they investigated into three velocity layers. The uppermost layer, lying from 0 to 90 feet (0 to 27.5 meters) below mean sea level (MSL), was estimated to exhibit a sonic velocity approximating that of sea water. The second layer, extending downward from 90 feet (27.5 meters) below MSL, to its base ranging from 200 to 900 feet (61 to 274 meters) below MSL, was estimated to exhibit sonic velocities ranging from 5,169 to 6,300 ft/sec (1,576 to 1,920 m/s). The third layer extending downward from its base ranging from 200 to 900 feet (61 to 274 meters) below MSL to below the base of our recorded data was estimated to exhibit sonic velocities ranging from 7,218 to 9,514 ft/sec (2,200 to 2,900 m/s). The top of this third layer probably lies near or below the base of our recorded data. Lacking sonic velocity data for the water column, collected at the time the digital data was acquired, and a detailed sonic velocity profile for the subsurface sediments being investigated as well as recourse to sophisticated computer software capable of modeling such velocity gradients and utilizing the resultant output as a processing parameter; 4,921.2 ft/sec (1,500.00 m/s) was deemed an acceptable compromise value. Within the consulting industry, this velocity is typically used as the default value in the processing of such profiler data. The resulting subsurface acoustical profiler sections are thus roughly comparable to geologic cross sections. Depths to the seabed are considered to be the most accurate with depths to specific horizons displayed on individual subsurface acoustic profiler sections marginally, albeit progressively, displayed deeper than their actual depth below the seabed. The depth scales provided on individual subsurface acoustic profiles are thus considered to be the best approximations achievable given the available data and computer software. All digital data collected has been retained so that more sophisticated processing might be applied in the future. The depth markers provided on the subsurface acoustic profiler sections are therefore approximations. All of the subsurface acoustic profile data collected in Year Three and the smaller Crescent Beach subsurface acoustic profile data set can be accessed in Appendix G.

Offshore Seabed Sediment Grab Sample Analysis

Based on geophysical data interpretation, seabed sediment grab sample sites for Year Three were chosen to emphasize those areas with indicated potential for restoration-quality sand accumulation. Grain size distribution and percent carbonate content were determined for all seabed grab samples collected in Year Three. The procedures described above for beach samples were followed, with the exception that the seabed sediment grab samples obtained were split using a sample splitter to obtain a suitable sample volume for sediment processing. Granulometric analysis results can be found in Appendix D. Additional seabed grab sample locations, indicative of restoration-quality sand accumulations based on analysis of bathymetric and subsurface acoustic profiler data, will be investigated further during Year Four.

OVERVIEW OF WORK

Years One and Two

The following is a history of accomplishments in Years One and Two:

- A bibliography identifying previous work in the study area, as well as more general publications germane to the study was compiled.
- Over 420 statute miles (675.8 kilometers) of subsurface acoustic profiler data were collected offshore of Nassau, Duval and northern St. Johns Counties and interpreted to determine locations thought to be favorable for the occurrance of restoration-quality sand.
- A beach sampling program was initiated to establish a baseline characterization of native beach sands in Nassau, Duval, St. Johns and Flagler Counties. This included 97 beach locations in those counties from which 233 points were sampled.
- A total of 18 offshore seabed grab samples were collected.
- Three push cores were collected on the ebb tidal delta of the Nassau River.
- A preliminary seismic stratigraphic analysis of the subsurface acoustic profiler data collected was completed.
- A total of 52 vibracores were collected offshore of Nassau and Duval Counties with 11 vibracores collected by the FGS and 41 collected by the FGS's subcontractor Athena.
- An additional 3 vibracores were collected by Athena in the mouth of the St. Johns River.
- Descriptions were made and grain size distributions determined for beach and offshore seabed sediment grab samples, push cores and vibracores.
- A radiocarbon date at 16.8 feet (5.1 meters) below the seabed was obtained from one of the vibracores collected by the FGS.
- The computer processing of all subsurface acoustic profiler data collected in Years One and Two was completed.

Year Three

This report documents the findings of the Year Three investigation. The Year Three study area includes federal waters extending from three to approximately ten nautical miles (from 4.8 to 16.1 kilometers) offshore of Nassau, Duval and St. Johns Counties as well as the northern half of Flagler County (Figure 1). Information derived from this study will assist the MMS in making decisions concerning the future use of the available restoration-quality sand deposits delineated. Additionally, identifying and inventorying suitable offshore restoration-quality sand resources will serve to expedite sand replenishment on beaches adversely impacted by hurricanes and/or winter storms in future years.

This report includes photographs and granulometric analyses of samples collected both on the beaches of Flagler County and offshore of St. Johns County. It also includes subsurface acoustic profiler data collected offshore of Nassau, Duval, St. Johns, and Flagler Counties. This information can be accessed using one of four methods:

1. From the "on-disk" ArcMap project. Please note that the previous Arcview 3.x Project (Year Two report (Phelps *et al.,* 2004)) was converted into ArcMap 8.3 and accessing it requires ArcMap 8.x or higher.

2. From the web-based map. Please note that accessing this web project requires downloading and installing the free Scalable Vector Graphics (SVG) viewer on your machine. This viewer can be obtained from Abode at the following URL address:

   http://www.adobe.com/svg/viewer/install/main.html.

3. From the sample or subsurface acoustic profile indices as appropriate.

4. From the pertinent appendices within this report text.

INTERPRETATIONS

In regards to the shoals offshore it is important to note that, in previous studies on the central east Florida coast (Freedenberg *et al.*, 2002), the FGS determined that the highest quality sand accumulations were associated with bathymetric highs. Seismic stratigraphic analysis of the subsurface acoustic profiles was the predominant tool used to examine such features in the study area. As shown on Figure 1, analyses of the subsurface acoustic profiles obtained in Years One, Two and Three have identified several near seabed features of interest. As previously discussed in the Years One and Two reports (Phelps *et al.*, 2003, 2004), these features offshore of Nassau and Duval Counties were interpreted to be a complex of channels and disturbed sediments that comprise the remains of channels and ebb tidal delta/estuarine complexes associated with the ancestral St. Johns, Nassau and St. Mary's Rivers. This interpretation was considered to be consistent with Meisburger and Field's (1975) findings which showed that while portions of the "channel" they identified were sand-rich, other portions contained a significant admixture of finer grained material unsuitable for beach restoration use. The data suggests that a mantle of reworked sediments of variable thickness is superimposed on these features; therefore, a program of vibracoring, conducted in coordination with the USACE, was initiated to define locations where this mantel was sufficiently thin or absent. This mantle is present offshore of Duval County as the shoal, lying seaward of the Duval/Nassau County boundary region, originally identified in Meisburger and Field (1975) as A4. Because this shoal was determined to contain sufficient suitable sand-rich sediments for beach replenishment projects in the past, it was selected to be one of this study's vibracoring targets.

The FGS further analyzed the subsurface acoustic profiler data available in southern Duval County immediately adjacent to the east and west of the previously used sand borrow area associated with the shoal previously identified as A4. The following interpretation is based on Meisburger and Field (1975) (Figures 15, 16 and 17), Scott (1988), Odum *et al*. (1997), Kindinger *et al.* (2000) and Davis *et al*. (2001). The subsurface acoustic profile section shown as Figure 18 was interpreted to show the base of Recent marine sediments. That horizon is depicted in green with the seabed delineated as the red horizon above it. The sequence delineated corresponds to Unit A of Meisberger and Field (1975). Between the green horizon and the blue horizon, based on Meisberger and Field (1975) as well as analysis of subsurface acoustic profiles to the south (Kindinger *et al.*, 2000) and well log analysis to the west (Davis *et al*., 2001), are Pliocene and Pleistocene undifferentiated sands, clays, and shell. The top this sequence is age dated in FGS's vibracore VDU-01. Contained within this sequence, as seen in the vibracores, are occasional laterally discontinuous thin beds of highly weathered limestone and sandstone. Examples of this can be seen in the various vibracores displayed on Figures 19 and 20. This sequence corresponds to Unit B of Meisberger and Field (1975). The blue horizon, an erosional unconformity in this subsurface acoustic profile section, is believed to be at or near the top of the Hawthorn Group based on analysis of subsurface acoustic profiles to the south (Kindinger *et al.*, 2000) and well log analysis to the west (Davis *et al*., 2001). The black horizon shown on this section is interpreted to be a reflector within the Hawthorn Group. The lowest red horizon delineated on this section is interpreted to be at or above the top of the Ocala Limestone based on well log analysis to the west (Davis *et al*., 2001). Note that the white reflector shown on this section is the first water bottom multiple and as such is purely an artifact of data collection. The locations of the cores forming cross section A - A', shown as Figure 19, are annotated on this section as well. From Figures 18, 19 and 20, individual core drilling logs and granulometric data can be accessed by placing the cursor on the individual core descriptors and clicking on them.

Deeper in the geological section offshore of Nassau, Duval and St. Johns Counties are areas of anomalous dip as well as clearly identifiable buried depressions in the seafloor sediments. All of these features are interpreted to be the result of karst processes (Popenoe *et al.,* 1984). Analysis of data associated with these features by the FGS strongly suggests that they are of dissolution collapse origin. Such features are particularly well shown on subsurface acoustic profile lines 04B15 and 04B17 in Appendix G. These features are vertically persistent to the base of the subsurface acoustic profiler data recorded and, in the two examples cited, their fill appears to be erosionally truncated at the base of the Holocene. Subsurface acoustic profile line 04B24 (in Appendix G) while of lower quality, reveals a similar collapse feature as well. These features are also seen on the Crescent Beach Spring subsurface acoustic profiler data set previously collected by the USGS in 2001. The USGS data set is included in this report and can be accessed via Figure 1 and Appendix G. Subsurface acoustic profile line 04B15, in Appendix G, ties into that data set on its western end . Subsurface acoustic profile line 04B15, in Appendix G, shows multiple crossings of the bathymetric depression that forms the Crescent Beach Spring's vent. This feature lies approximately 2.5 statute miles (4 kilometers) offshore and the spring is reported to flow from the Ocala Limestone, Kindinger *et al.* (2000). Its vent is estimated to be approximately 300 to 500 feet (91.4 to 152.4 meters) in diameter. The upper portion of the vent lies in approximately 59 feet (18 meters) of water depth and its base extends to over 115 feet (35.1 meters) below sea level (Kindinger *et al.* 2000).

Offshore Nassau County Sites

Meisburger and Field (1975) noted several features of interest in the study area offshore of Nassau County. Two of these features, identified by them respectively as a "low linear shoal" (A1 on Figure 15), and as a "low linear ridge atop a bank shoal" (A2 on Figure 15), lie approximately 11 and 13 statute miles (17.7 and 20.9 kilometers) offshore, respectively. Subsurface acoustic profiler data and vibracores were collected in Year Two and subsurface acoustic profiler data were collected in Year Three to further investigate these features.

As reported in the Year Two report (Phelps *et al.,* 2004), the FGS vibracoring program attempted a two fold investigation of the sediments offshore of Nassau and Duval Counties. The first of those two objectives was to investigate the potential for available restoration-quality sand in channel deposits contemporaneous with those identified as area A5 on Figure 15. The second objective was to investigate the shoals noted as worthy of further investigation in Meisburger and Field (1975). The shoal identified as area A2 was vibracored by them and subsurface acoustic profiler data was acquired and analyzed as part of our investigation. Meisburger and Field (1975) report that their vibracore 76 found "…clean quartz sand with a median diameter range of 0.330 to 0.268 millimeters..." Their vibracore 76 was only 3 feet (0.9 meters) long. The FGS's vibracore VNA-4, south of vibracore 76 but on the shoal's axial trend, is 6 feet long (1.8 meters) and has restoration-quality sand throughout its entire length. Diver reconnaissance in the immediate vicinity of vibracore VNA-4, conducted at the time that vibracore was collected, suggests that this accumulation of restoration-quality sand is laterally extensive.

Additional vibracoring to investigate features A1 and A2 has recently been accomplished with the collection of three vibracores. Estimates of available restoration-quality sand reserves associated with these features will be included in the Year Four report.

Offshore Duval County Sites

The earliest known vibracoring investigation in the area was conducted, between August 1966 and February 1967, for the Inner Continental Sediment and Structure (ICONS) study (Meisburger and Field, 1975). Meisburger and Field (1975) identified a number of areas offshore of Nassau and Duval Counties that, based on the vibracoring and subsurface acoustic profiler data, were of particular interest. They postulated the existence of over 5.0 million cubic yards (mcy) (3.8 million cubic meters [mcm]) of restoration-quality sand in a channel deposit 3 to 4 statute miles (4.8 to 6.4 kilometers) east of the mouth of the St. Johns River (see area A5 located on Figure 15).

As reported in the Year Two report (Phelps *et al*., 2004) and in Phelps and Holem (in press), the shoal identified as area A4, as noted on Figure 15, was selected for investigation because it had previously been dredged as a source of sediments for beach replenishment. See Figure 1 for an outline of the previously dredged area. In 2003, with onboard oversight provided by the FGS, 44 vibracores were collected offshore of southern Duval County by Athena for the USACE. These cores were processed by Wolf Technologies, Inc. (Wolf). This vibracoring program was intended to more fully investigate area A4 (Phelps *et al*., 2004). The FGS's initial analysis of the Athena vibracore data suggests that significant reserves of restoration-quality sand remain offshore of the southern half of Duval County, both east and southwest of the area previously dredged. Based on data collected in Year Two, the FGS estimated that there were potential reserves of approximately 198.5 mcy (151.8 mcm) of restoration-quality sand offshore of southern Duval County in the vicinity of area A4.

As previously reported in our Year Two report, in addition to the vibracores obtained in conjunction with the USACE, the FGS independently obtained eleven vibracores offshore of Duval and Nassau Counties north of area A4 (Phelps *et al*., 2004). When organic material of a "woody" nature was observed in these vibracores, samples were obtained for radiocarbon age dating to permit an estimate of average sediment accumulation rates. One of these samples, processed by Beta Analytic, Inc. yielded the following results:

Beta #	FGS Sample #	Measured Radiocarbon Age	Conventional Radiocarbon Age
188958	VDU-01-16.8-RC	14,160 +/- 60 YBP	14,140 +/- 60 YBP

This would indicate sample growth and deposition near the end of the Pleistocene. Calculated sedimentation rates from sample VDU-01-16.8-RC to the seabed would be 0.0145 inches per year +\- 0.00006 inches (0.3683 mm per year +\- .00152 mm). Considering the effect of natural compaction, compaction inherent in the vibracoring method and the effect of any recent erosion of the seabed, this figure would probably be more representative of the rate of deposition of the clay sequence above the sample zone in which the organic material was found (i.e. that of the Holocene) rather than that of the sand itself. It is believed that this figure would set an approximate lower limit on the average local Holocene sedimentation rate (Phelps *et al*., 2004).

The identification of several features with a high potential for the occurrence of beach restoration-quality sand in federal waters offshore of southern Duval County in area A4 prompted an extensive joint FGS and USACE vibracoring program in Year Three to define offshore restoration-quality sand sources meeting both immediate and near term needs for beach-quality sand (Phelps *et al*., 2005). The investigation includes the collection, by Challenge using Alpine as a subcontractor for core collection and Southern Earth Sciences for core processing, of an additional 50 vibracores and 57 statute miles (91.7 kilometers) of electrical resistivity data immediately adjacent to the east and south of the sand borrow area. Using these data, the USACE's consultant, Challenge, through their subcontractor Dredging Exploration Mining Consultants (DEMCO), estimated an average available restoration-quality sand thickness of 9.5 feet (2.9 meters) and a volume of 22.9 mcy (17.5 mcm) of possible reserves of restoration-quality sand lying in the immediate vicinity both east and south of the previously dredged area, Appendix H (Brabers, 2004). These investigations were more narrowly focused within the area vibracored in Year Two. This additional vibracore data set suggests that localized occurrences of beds of cobble-sized shell, not encountered in the vibracores previously collected, may adversely impact sediment usability in some areas.

Figures 19 and 20 depict vibracore-based cross sections and are labeled A - A', and B - B' respectively on Figure 21. From both Figure 19 and Figure 20 individual core logs and granulometric data can be accessed by placing the cursor on the individual core descriptors and clicking on them. From Figure 21, the earlier described Figures 18, 19 and 20 can be accessed by placing the cursor on and clicking on "nd43" (which is the descriptor for subsurface acoustic profile line 43, Figure 18), the "A" for cross section A to A' (Figure 19) and the "B" for cross section B to B' (Figure 20). Cross section A - A' (Figure 19) runs west to east and lies to the south of the area previously dredged. Cross section B - B' (Figure 20) runs from north to south and lies east of the area previously dredged. The vibracores depicted on these cross sections were collected in Years Two and Three. Data from these cores can be accessed via either Appendix E, or Figures 18, 19, 20 or 21. Depths to the base of postulated reserves of restoration-quality sand containing less that 10% fines are shown on these cross sections.

Although a substantial number of cores collected in Years Two (Athena) and Three (Alpine) in area A4 contained available restoration-quality sand to the limit of penetration (20 feet [6.1 meters]), a number of these cores consisted of restoration-quality sand underlain either by clay or limestone. Grain-size distributions for all samples collected were thus examined with the goal of adjusting prospective restoration-quality sand reserves to include sediments containing a fines content of less than 10%. In calculating reserves of available restoration-quality sands, an effort was made by the FGS to include in those calculations only those sequences which were described, sampled and analyzed granulometrically rather than basing available restoration-quality sand reserve calculations on core descriptions alone. This is an important distinction to make because the cores, as described, typically exhibit sands to greater depths than were analyzed, albeit often with an admixture of clay and/or silt as a minor component. Thus, our available restoration-quality sand reserve calculations are based primarily on the granulometric analysis of specific sedimentary units within the cores and secondarily on lithologic descriptions. Lithologic descriptions were used only to establish the base of analyzed sedimentary units. To delineate potentially available restoration-quality sands, a sediment thickness contour interval of 5 feet (1.5 meters) was chosen. Five feet (1.5 meters) of sand thickness was selected as the minimum acceptable sand thickness for the purposes of available restoration-quality sand reserve calculations. Based on these limits 218.2 mcy (166.8 mcm) of potentially available restoration-quality sand was estimated in the area cored in Years Two and Three. Figure 21 is a thickness map of these possible reserves. Within the smaller area outlined in blue on Figure 21, extensively cored in Year Three and lying immediately adjacent to the previously dredged area, are an estimated 21.7 mcy (16.6 mcm) of probable restoration-quality sand. Based on a grid of more closely spaced vibracores, confidence in the reserve estimates within this smaller area is the stronger of the two reserve calculations. The borrow area for the planned USACE Duval County Shore Protection Project is located within the upper section of the area outlined in blue from approximately vibracore CG-DU04-13, northward (Figure 21). This area contains an estimated 2.0 mcy (1.5 mcm) of available restoration-quality sand containing 5% or less fines. The remainder of the blue outlined area on Figure 21 is being permitted for near-future use and contains approximately 6.0 mcy (4.6 mcm) of available restoration-quality sand containing 5% or less fines.

Further vibracoring of feature A4 has been recently completed and eleven additional vibracores have been collected. A re-estimate of available restoration-quality sand reserves associated with this feature will be included in the Year Four report.

Vibracoring to investigate the feature lying offshore of northern Duval County identified as A3 by Meisburger and Field (1975) as well as a geomorphologically similar feature lying immediately to the south of it has been recently accomplished and three vibracores were collected. Feature A3 is shown on Figure 15. Estimates of available restoration-quality sand reserves associated with these features will be included in the Year Four report.

Offshore St. Johns County Sites

Meisburger and Field (1975) also noted two features of primary interest in the study area offshore of St. Johns County north of St. Augustine. The first, "…a large irregular shoal centered 5 to 6 [statute] miles [8.0 to 9.7 kilometers] offshore between Jacksonville Beach and St. Augustine is judged to be the best available restoration-quality sand prospect in the northern part of the study area." This feature is shown as A6 on Figure 16. They describe it as "…of very low relief and nearly flat topped…". Based on the geophysical data available to them, the investigators opined that it "…may have formed by accretion, possibly during the latter part of the last transgression." They report that "…the few cores from the highest part of the shoal recovered up to 10 feet [3.0 meters] of clean uniform quartz sand of medium and coarse size." They further state that "Two small ridge-like features surmounting the shoal and its highest central feature are considered the best prospects. If this shoal was formed entirely by accretion, the total volume of sand within the shoal would be approximately 178 mcy (136.1 mcm)."

The second area of interest identified by them was smaller and further south. This feature is shown as A7 on Figure 16. They state that it is "…the only prospective site within the St. Augustine grid." Two of their cores in the area penetrated "…a clean medium quartz sand layer 4 to 6 feet (1.2 to 1.8 meters) thick." They were of the opinion that the ridge line feature they observed is "…the most likely locale for a suitable borrow area." They estimated the volume of available restoration-quality sand in the ridge to be 7.4 mcy (5.7 mcm).

FGS plans to collect from features A6 and A7 a total of ten vibracores in Year Four. Upon collection and analysis of those vibracores, the FGS will re-estimate the volumes of available restoration-quality sand these features may contain.

Offshore Flagler County Sites

Meisburger and Field (1975) noted three features of primary interest in the study area south of St. Augustine and north of Ponce De Leon Inlet. The most northern of these features, identified as A8 on Figure 17, lies approximately 10 to 12 statute miles (16.1 to 19.3 kilometers) offshore of Flagler Beach, Flagler County. It is a linear shoal lying sub-parallel to the present coastline with approximately the same orientation and distance from the coast as feature A2 and several similar features lying offshore of Nassau and northern Duval County. This feature lies on the margin of the subsurface acoustic profiler data collected in Year Three and was transversed along its axis by a single northwest/southeast subsurface acoustic profile line. Meisburger and Field (1975), based on their vibracore 140, describe this feature as consisting of clean sand and state it is "…over 10 feet (3.0 meters) thick with mean diameters ranging from 0.287 to 0.308 millimeters [0.0113 to 0.0121 inches]… was recovered by core 140 in the center of this linear shoal. Prospects for locating suitable borrow material in this ridge are judged to be very good. If the entire ridge is of suitable material the estimated reserve is 39 mcy (29.8 mcm)."

Despite the fact that the feature lies approximately 15 statute miles (24.1 kilometers) offshore this shoal would appear to have a strong potential as a restoration-quality sand borrow site for Flagler County beach restoration.

SUMMARY

Years One and Two

As a result of the seismic stratigraphic analysis conducted, several features were identified as having a high potential for the occurrence of available restoration-quality sand in federal waters offshore of Duval County. The results of this analysis was discussed with representatives of the U.S. Army Corps of Engineers, Jacksonville District Office, and a copy of the preliminary work map delineating those features was provided to them. From those data, they selected a number of locations in the study area of particular interest for vibracoring in Year Two. The results of the tasks completed in Years One and Two of this investigation are detailed in Phelps *et al.*, (2003) and Phelps *et al.*, (2004), respectively.

Year Three

Beach-sediment grab samples were collected at the outset of the field season. Seabed-sediment grab samples were collected offshore of northern St. Johns County. Results of the offshore sample analyses will be used to aid in the selection of vibracoring locations for Year Four. These sediment samples were brought to the FGS laboratory for sample description and granulometric analysis. Data from the vibracores collected in 2003 and 2004 by the USACE's consultants and utilized in this report can be found in Appendix E. As was performed on Years One and Two samples, granulometric analyses were conducted using the general guidelines of the American Society for Testing and Materials (2000a, 2000b) and specific procedures followed by the FGS sedimentology laboratory (Balsillie, 1995, 2002a, 2002b, Balsillie and Tanner, 1999; Balsillie, *et al.* 1999; Balsillie *et al.* 2002a; Balsillie *et al.* 2002b; Balsillie and Dabous, 2003). It is intended that all sample descriptions and granulometric data will be entered into the Reconnaissance Offshore Sand Search database (http://Ross.urs-tally.com) being developed by URS Corporation for the

FDEP's BBCS. Photographs of the beach and sea bed sediment samples collected in Year Three can be found in Appendices A and B respectively. Granulometric analyses of these samples can be found in Appendices C and D respectively.

The following is a summary of work accomplished in Year Three:

- Over 272 statute miles (438 kilometers) of sub-bottom profiler data were collected offshore of Nassau, Duval and St. Johns Counties as well as the northern portions of Flagler County, with the bulk of these data being collected offshore of southern St. Johns County.

- The FGS's beach sampling program, designed to establish a baseline characterization of native beach sands on the northeastern beaches of Florida, was continued across Flagler County and through Volusia County, including sampling of 148 points from 57 beach sampling locations.

- From offshore northern St. Johns County, a total of 38 offshore seabed grab samples were collected, described and their grain size distributions analyzed.

- A total of 41 samples from 20 beach sampling sites in Flagler County were described and grain size distributions analyzed.

- The granulometric results from a total of 91 vibracores collected in Year Two by Athena and in Year Three by Challenge, using Alpine, from the seafloor offshore of southern Duval County were analyzed and a detailed analysis of the potential available restoration-quality sand resources prepared.

- The computer processing of all subsurface acoustic profiler data collected or acquired in Year Three was completed.

- A preliminary seismic stratigraphic analysis of the subsurface acoustic profiler data collected offshore of southern St. Johns and northern Flagler Counties was completed.

Additional offshore seabed grab sample and vibracoring locations, based on the subsurface acoustic profiler data, are currently being chosen. These samples and vibracores will be collected during the Year Four field season. Work in future years will further investigate submerged lands beneath federal waters offshore of Nassau, Duval, St. Johns, Flagler and Volusia Counties and possibly the northern half of Brevard County.

CONCLUSIONS

Several features with a high potential for the occurrence of available beach-restoration quality sand in federal waters offshore of Duval County have been identified by the FGS. These findings have been discussed with representatives of the USACE Jacksonville District Office. From these features, the FGS and the USACE have identified the feature, identified as A4 located offshore of southern Duval County, to be of particular interest preparatory to the initiation of the USACE's Duval County Shore Protection Project projected to commence in 2005. Based on a criteria of less than 10% fines content, analysis of vibracore data by the FGS suggests possible total offshore reserves of available restoration-quality sand proximal to a previously dredged site, as illustrated on Figure 21, are 218.2 mcy (166.8 mcm). Using the same assumption, probable available restoration-quality sand reserves, as outlined in blue on Figure 21 and lying immediately adjacent to the site previously dredged, are estimated to be 21.7 mcy (16.6 mcm). The current overall possible reserve volume of 218.2 mcy (166.8 mcm) for the area vibracored in 2003 and 2004 on feature A4 is in general agreement with the volume of 198.5 mcy (151.8 mcm) of possible available restoration-quality sand reserves previously calculated by the FGS and discussed in the Year Two report (Phelps *et al*., 2004). The 21.7 mcy (16.6 mcm) volume of probable available restoration-quality sand reserves is in general agreement with the 22.9 mcy (17.5 mcm) volume of probable available restoration-quality sand reserves independently calculated by DEMCO (Brabers, 2004; Appendix H). The borrow area for the USACE Duval County Shore Protection Project is located within the upper section of the area outlined in blue on Figure 21 from approximately vibracore CG-DU04-13, northward. Assuming a sediment content of 5% or less fines, the USACE estimates that this area contains a potential 2.0 mcy (1.5 mcm) of available restoration-quality sand (Phelps and Holem, 2005). The remainder of the blue outlined area contains approximately 6.0 mcy (4.6 mcm) of available restoration-quality sand meeting the 5% or less fines criteria (Phelps and Holem, 2005).

RECOMMENDATIONS

The FGS, in the Year Two vibracoring program, investigated a shoal, identified as A2, offshore of Nassau County in Meisburger and Field (1975). Vibracoring and diver reconnaissance suggest that an accumulation of available restoration-quality sand may be laterally extensive on this feature. Further vibracoring to investigate this shoal and two geomorphologically similar features lying immediately to the south in northern Duval County has been recently accomplished with six vibracores collected. Estimates of available restoration-quality sand reserves associated with these features will be included in the Year Four report.

Further vibracoring of the feature offshore of Duval County identified as A4 has been recently completed and eleven additional vibracores have been collected. A re-estimate of available restoration-quality sand reserves associated with this feature will be included in the Year Four report.

The FGS plans to collect, offshore of northern St. Johns County, ten vibracores in Year Four from features identified as A6 and A7 in Meisburger and Field (1975). Upon collection and analysis of those vibracores, the FGS will re-estimate the volumes of available restoration-quality sand features A6 and A7 may contain.

Year Four tasks should include the collection and analysis of bottom samples as well as the analysis of subsurface acoustic profiler data already collected offshore of northern Volusia County and of extensive vibracoring data recently collected offshore of Volusia County by Coastal Technology Incorporated. It is further recommended that a program of beach sampling to characterize the existing beach sediments be conducted on the beaches in the northern half of Brevard County in Year Four for the purposes of comparison of those un-renourished beaches with renourished beaches further north. Additionally, it is recommended that the FGS continue discussions with the USACE during their dredging-area selection process to complement the USACE's preparations for the Duval County Shore Protection Project projected to occur in 2005 and coordinate with them regarding additional proposed projects to occur in the vicinity of St. Augustine and Flagler Beach in St. Johns and Flagler Counties, respectively.

It is recommended that the FGS ultimately integrate the data collected on the Florida northeastern inner continental shelf with the data previously collected in the FGS's Florida central eastern inner continental shelf study reported in Freedenberg *et al.,* (2002). This would be accomplished in part by tying the subsurface acoustic profiler grid to be collected in future years of this study with the grid previously collected offshore of southern Brevard County in previous studies on the central Florida east coast (Freedenberg *et al.*, 2002).

The research recommendations outlined above will facilitate the further investigation of the beach and near shore coastal areas of:

- Volusia County to evaluate and quantify offshore available restoration-quality sand resources for the purpose of beach restoration in the immediate future.

- Nassau, northern Duval, St. Johns and Flagler Counties to evaluate potential offshore available restoration-quality sand resources for anticipated future need.

- Northern Brevard County beaches to evaluate potential offshore available restoration-quality sand resources for anticipated future need and to characterize the sediments on those un-renourished beaches.

The accomplishment of these goals would also facilitate a more detailed investigation and understanding of the geomorphology, shallow structure, and sediments of the Florida northeastern and central inner continental shelf.

ACKNOWLEDGEMENTS

The authors are indebted to the St. Petersburg, Florida office of the United States Geological Survey for assistance in the acquisition and processing of the subsurface acoustic profile data. Dana Wiese and Shawn Dadismen, in particular, provided invaluable assistance in these areas. Special thanks are extended to Paula Polson and David Anderson for their efforts in the preparation of the web and graphics portions of this report and to Frank Rupert, Dr. Tom Scott, Dr. Richard Copeland, Harley Means, Jacqueline Lloyd, Paulette Bond and Dr. Walter Schmidt for their efforts in the review and editing of the various drafts of this report. Finally, we would like to thank Julian (Wade) Stringer, our boat captain, for getting us out the inlets, on station, and back again safely and efficiently.

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