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A GEOLOGICAL INVESTIGATION OF THE OFFSHORE FEDERAL AREA ALONG THE COASTS OF SANTA ROSA AND OKALOOSA COUNTIES OF FLORIDA (STATE FISCAL YEAR 2006-2007)

REPORT
SUBMITTED
TO
THE UNITED STATES DEPARTMENT OF THE INTERIOR
MINERALS MANAGEMENT SERVICE

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INTRODUCTION

Beach erosion is a constant concern in Florida (Clark, 1993). Between 1989 and 2006 the statewide length of beaches considered critically eroded soared from 217.6 miles (350.1 kilometers) to 385.3 miles (620.4 kilometers), an increase of 77%, due to a combination of increased development, storm erosion, and repeated expansion of the definition of "critically eroded" (Beaches and Coastal Systems, 2006). Within the Florida study area, which includes the open water coast of Santa Rosa and Okaloosa Counties extending eastward from Navarre Beach to the Walton County boundary, beaches comprising over 24 percent of the coastline, (totaling about 7 statute miles (11.3 kilometers)), are classified as Critically Eroding Beaches (Clark, 1993; Beaches and Coastal Systems, 2006). Shore protection options, in privately owned portions of the region, are limited by commercial and residential development proximal to the beach. Such conditions make the option of asset relocation or abandonment generally unpalatable. The remaining, generally undeveloped, portions are under federal control as part of a military reservation. The shore protection measure of choice in the region is the periodic placement of sand along the beach. Readily available onshore sources of suitable borrow material in the region are progressively found to be unavailable, depleted, or uneconomical. Offshore sand bodies are now increasingly sought after as sources of beach restoration-quality sand. To address this need, the Minerals Management Service (MMS) of the United States Department of the Interior and the Florida Department of Environmental Protection's (FDEP) Florida Geological Survey (FGS) entered into a cooperative agreement (Cooperative Agreement # 1435-0001-30757) to investigate the available restoration-quality sand resources in federal waters offshore of this portion of the coast of Florida. This reconnaissance level investigation has been conducted to determine if restoration quality sand resources are in fact potentially available for beach nourishment. This goal is being accomplished through the use of seismic reflection profiling, seabed sampling, and beach sediment sampling. These data will be entered into the Reconnaissance Offshore Sand Search database (ROSS) (http://Ross.urs-tally.com) being developed by URS Corporation for the FDEP, Bureau of Beaches and Coastal Systems (BBCS).

This report documents the findings of the FGS's investigations. It both provides and discusses in detail those data obtained and/or analyzed and presents conclusions drawn from those data and makes recommendations regarding data to be collected in the future.

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 of beaches adversely impacted by hurricanes and/or winter storms in future years.

This report includes photographs and granulometric analyses of samples collected by the FGS both on the beaches and offshore of Santa Rosa and Okaloosa Counties. Additionally, the seismic profiler data collected is presented. This information can be accessed using one of the following methods:

1. From the appendices listed in the table of contents above.

2. Through the "on-disk" ESRI ArcGIS project. The ArcGIS Project contains links to web pages and PDF files of vibracores, beach samples, seabed samples, and seismic lines residing on the DVD. There are three ways to view the ArcGIS Project:

a. From the ArcMap Project
   You must have ArcMap 8.x or later in order to open the ArcMap Project. If you do not have this software, please use the ArcPublisher Project (see below).

b. From the ArcPublisher Project
   You must load ArcReader in order to view the ArcPublisher Project. This free viewer can be installed with the executable file included on the DVD. Instructions are included on the ArcGIS page of the DVD. Updates and further information may be obtained from the ESRI website at http://www.esri.com.

c. From a PDF generated from the ArcMap Project. This document is zoomable and contains hyperlinks, but is otherwise static.

3. From the appropriate indices within the DVD.

4. From the appendix citations within this report text.

DEFINITIONS

"The study area" is that portion of the State of Florida consisting of the beaches of Okaloosa and Santa Rosa counties as well as the Federal waters of the inner continental shelf extending from 9.0 nautical miles (16.7 kilometers) to approximately the 100 foot bathymetric contour off those beaches. The study area is shown in Figure 1.

"Critically eroded" refers to shoreline where erosion and recession of the beach or dune system is threatening or has destroyed upland development, recreational interests, wildlife habitat, or important cultural resources as well as to stable or minimally eroding shoreline whose inclusion is necessary to the design integrity of adjacent beach management projects or for continuity of coastal system management (Beaches and Coastal Systems, 2006).

"Beach samples" are grab samples of beach sediments.

"Beach sampling locations" are the individual sites selected for the collection of multiple beach samples. The beach sampling locations utilized are shown on Figure 1. Photographs of individual beach samples can be found in Appendix A.

"Seabed samples" are grab samples of surficial seabed sediments. The locations of these seabed samples are shown on Figure 1. Photographs of individual seabed samples can be found in Appendix B.

"Granulometric analysis" is sediment analysis conducted to characterize a beach, seabed or vibracore sample's grain size distribution. This analysis is graphically displayed on grain size determination (GSD) curves. GSD curves created from beach and seabed samples can be found in Appendix A and Appendix B respectively.

"Fines" are those sediments which will pass through a 4.00 phi, 0.0025 inch (63 micron) mesh opening, # 230 sieve.

"Seismic reflection profiler" is the instrument used to collect geophysical profiles of sub-seabed sediments, variously referred to in the scientific literature as a sub-bottom profiler, a sub-surface acoustic profiler, or a continuous seismic reflection profiler. The returning reflections off the seabed and stratigraphic horizons within the sub-seabed sediments are received on hydrophones as pressure pulses. The system utilized by the FGS for this survey produced impulses, known as "chirps", in two bands of frequencies. It thus produced simultaneously both high frequency, 8 to 23 kHz, and low frequency, 2 to 7 kHz seismic profiles.

"Seismic profiling" is the data collection process variously referred to in scientific literature as continuous seismic reflection profiling, subsurface acoustic profiling, and sub-bottom profiling.

"Seismic profiles" are seismic reflection profiler records produced through seismic profiling, either in digital or analog format. An example of a pair of such seismic profiles is illustrated as Figure 2. The seismic profiles produced can be found in Appendix C. The map trace of an individual seismic profile, as depicted on Figure 1, is called a **"seismic line"**. The assemblage of seismic lines, as depicted on Figure 1 is referred to as a **"seismic grid"**. Reflections from suspected manmade objects lying on or just below the seabed are described as **"targets"**. An example of such a target is illustrated on Figure 3.

GEODETICS AND UNIT CONVERSIONS

Maps included in this document use either the North American Datum of 1983 (NAD83), or the World Geodetic System of 1984 (WGS84), as the datum. Projection for maps within this document is a Florida Department of Environmental Protection customized Albers Equal Area Conformal Conic (Albers). Global Positioning System (GPS) instrumentation was used to collect all geographic position information.

All "unit conversion factors", English to the International System of Units, i.e. Le Système International d'Unités, (SI) and SI to English, used in this report can be found listed on Table 1. These conversion factors were obtained from Eshbach and Souders (1975). Within the body of this report, when recourse to quantification of distance, weight or volume is required, quantifications are first expressed in English units followed, enclosed in brackets, by their expression in SI units.

EGLIN AIR FORCE BASE AND ITS OVER-WATER RANGE

In 1933, an airport was established near the City of Valparaiso, Florida. In 1935, this airport became the Valparaiso Bombing and Gunnery Base and on August 4, 1937, the base was redesignated Eglin Field. Eglin Field was an important armaments testing facility for the prewar Army Air Corps, and after 1941, the Army Air Force during World War II. It still provides this service for the U.S. Air Force, as Eglin Air Force Base (AFB) today (Globalsecurity.org, 2006a; USAF, 2006).

The Eglin AFB over water range provides 86,500 square miles (223,938 square kilometers) of over-water airspace that is jointly used for a variety of test and evaluation activities and training exercises. The over-water range contains a number of test areas that are used for long-range, all altitude, air-to-air and air-to-surface activities including drone target engagements, electronic combat, as well as long-range (or anti-ship) air-to-surface and surface-to-surface evaluations. Many of these activities involve gunnery and weapons releases (both live and inert) which have inevitably deposited metallic debris (including unexploded ordnance) on the seabed for decades (Globalsecurity.org, 2006b; USAF, 2002). The study area falls entirely inside the over-water range designated Warning Area W-151A on nautical and aviation charts. W-151A is described in the Environmental Assessment for the Eglin range (Appendix E) as “the area of highest gunnery activity” for air-to-surface live-fire explosive ammunition training (USAF, 2002).

PREVIOUS WORK

To the north of the study area, Clark and Schmidt (1982) investigated the shallow (well depth =< 1000 feet [305 meters]) stratigraphy of Okaloosa County and vicinity based on water well cuttings and geophysical well logs.

From 1986 to 1988, researchers from the University of South Florida investigated the Neogene to Recent stratigraphy and depositional regimes of the northwest Florida inner continental shelf, aboard the *R/V Suncoaster*. A diagonal gridwork of 200 miles (320 kilometers) of seismic tracklines extending from just off the shoreline to the 100 foot (30 meter) bathymetric contour was shot covering the area from the Alabama border to St. Joseph Bay. Side scan sonar, bathymetry, and 681 underway bottom samples were accumulated as well (Locker and Doyle, 1992; Locker *et al*., 1999). Much of this material was provided to URS Corporation and is available from their ROSS database.

Subsequent to that study, McBride and Byrnes, (1996a, 1996b), McBride (1997), and McBride *et al* (1999) investigated the late-Pleistocene and Holocene geology of the northeastern Gulf of Mexico shelf offshore Alabama and northwest Florida using vibracores, radiocarbon dating, foraminiferal and macrofauna assemblages, and bathymetry data. The morphologic and stratigraphic signatures of the last rise of eustatic sea level along this passive continental margin were examined. The major shelf features noted included shore-oblique sand ridges, mid-shelf linear shoals, and shelf-edge deltas. Surficial shelf sediments progress in a westerly direction from a medium to a fine sand. McBride (1997), identified six lithofacies and two erosional surfaces throughout the shelf to the 20 foot (6 meter) depth obtained from vibracores. The lowest facies reached (Facies 1), which is a nonfossiliferous yellow-burnt-orange clay-sand mixture, terminates upward at an apparent subaerial erosional surface probably produced after sea-level fall. Facies 2, 3, and 4 represent estuarine deposits dominated by clay and silt while Facies 5 and 6 are marine and dominated by sand. The linear shoals identified in these studies were determined not to be in-situ or degraded barriers but are reworked marine shoals as marine species dominate the foraminiferal and molluscan assemblages, and these deposits lie above shoreface ravinement (McBride, 1997).

URS Corporation delivered the final report for their reconnaissance level Florida Panhandle sand search to the FDEP Bureau of Beaches and Coastal Systems in 2004 (Niedoroda *et.al.*, 2004). Their report is a synthesis of various material in the ROSS database and it identifies several potential borrow areas based on bathymetry. One of these, feature W-5, is crossed by Seismic Line 06C06B (Figure 4) included in the current report.

In 2005, vibracoring was performed on feature W-5 by the Walton County Sand Source Investigation, and the data, including core logs and core photographs was placed in the ROSS database (URS, 2007). Copies of the logs and photographs for cores WN-1, WN-4, WN-6 and WN-10 (from URS, 2007), used in seismic interpretation, are provided in Figure 4.

FIELD PROCEDURES AND LABORATORY ANALYSIS

The exploratory phase of this program involved both the collection of seismic profile data offshore and the collection and analysis of beach and seabed samples. Seismic lines for the seismic profiling program conducted were laid out as a reconnaissance seismic grid, with an approximate spacing of two nautical miles, (3.7 kilometers) (Figure 1) between lines. The seismic grid lies in federal waters from 9 nautical miles (16.7 km) to approximately the 100 foot (30 meter) bathymetric contour offshore. The seismic data collected provides sufficient grid density to determine where additional supplementary seismic profiling and later reconnaissance seabed sampling might be conducted in future years.

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 SA for Santa Rosa County. This is followed by consecutive beach location numbers, 01, 02, 03, 04 etc., and completed by a two letter designation indicating the sample's placement on the beach profile. More specifically, samples collected from the swash zone, beach berm, mid-beach and dune are designated S, B, M and D, respectively. For example, a sample collected in Santa Rosa County at sample location 1 in the swash zone would be delineated as SR-01-S. All samples collected offshore with a "clam-shell" dredge sampler, are labeled with the beginning two letter geographic codes referenced above, followed by a multi-digit sample number and the two letter designator "CG" for clamshell grab. Thus, a seabed sample collected offshore of Santa Rosa County might be designated SR-101-CG.

Beach Sample Collection

The beach sample locations visited were spaced at an approximate one statute mile (1.6 kilometers) interval and at every fifth beach monument survey point (BBSC, FDEP) where practicable. These sample locations are shown on Figure 1. Table 2 ties beach monument survey points to beach sampling locations. A total of 85 beach samples, from 33 sampling locations, were collected in Santa Rosa and Okaloosa Counties, from the western border of Walton County to the eastern border of Escambia County. Analyses of the beach samples collected is included in this report.

While it was intended that at each sampling location beach samples would be collected from the swash zone, the beach berm, mid-beach and dune, due to the narrowness of the beach, only swash, berm and mid-beach samples were collected at some locations. At other locations, where the beach was extremely narrow, only swash and mid-beach samples were collected. 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 7-10 ounces (200-300 grams) of sediment, were obtained for granulometric analysis. Samples were collected by scooping 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 10 ounce (300 gram) scoop. Photographs of the beach samples collected can be found in Appendix A.

Seabed Sample Collection

Based on geophysical data interpretation, seabed sample sites 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 samples. Granulometric analysis results can be found in Appendix B. Additional seabed sample locations, indicative of restoration-quality sand accumulations based on analysis of bathymetric and seismic reflection profiler data, may be investigated further during future years.

Sample collection offshore was performed on November 14, 2006. Samples were recovered using the FGS's 24 foot Carolina Skiff (Figure 5) and the "clam shell" dredge sampler illustrated in Figure 6 and Figure 7. Water depths at the sample locations were obtained using an onboard echosounder. A total of 12 seabed samples were obtained - 1 seabed sample from offshore of Santa Rosa County, 10 seabed samples from offshore of Okaloosa County, and 1 seabed sample from offshore of Walton County. Photographs of the seabed samples collected by the FGS can be found in Appendix B.

Sediment Sample Processing

The sieve nest used in sample processing (Figure 8) by the FGS is described in Table 3. All granulometric analyses were conducted using the general guidelines of the American Society for Testing and Materials (ASTM) (2000a, 2000b) 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). Samples were oven dried and then split to obtain between 50 and 75 grams of sample material for processing. The selected sample split was initially weighed, 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 split was then dry sieved with the portion of the pan fraction obtained during dry sieving also assigned to the fine fraction. If the fraction of carbonate contained within the sample split was deemed to be significant the sample split was then digested with a 4 M hydrochloric acid solution, rinsed, oven dried, resieved and weighed again.

No samples exhibited a sufficiently significant percentage of fines to support further characterization using the methodology of Folk (1974) and Galehouse (1971) employed in the previous studies in this series. 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. Where the carbonate fraction was deemed significant, separate GSDs were determined for the carbonate and non-carbonate fractions of such beach and offshore samples along with the combined GSD for those samples. A link is provided in the grain size analysis column of the indices for beach and seabed samples (Appendix A and Appendix B 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, five samples were processed like sample #1, for the purpose of granulometric analysis quality control. The results of the granulometric analyses are provided in Appendix A, beach samples, and Appendix B, seabed samples. Those samples not selected for processing were archived in the FGS's sediment sample repository. For seabed samples, the procedures described above for beach samples were followed.

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 on the beach to be renourished exceeds 5% and then only up to that percentage.

Grain Size Distribution (GSD) Curves

GSD curves are presented in the respective indexes for beach, seabed and vibracore samples. When the carbonate fraction was deemed significant, separate GSDs were made for the carbonate and non-carbonate fractions of such samples along with a combined GSD of the entire sample.

Seismic Reflection Profiling

The seismic reflection profiling was conducted by towing a sound pulse generating and receiving instrument behind a survey vessel traversing predetermined survey track lines at a set vessel speed of between 4.5 and 5 knots. The sound pulse generator was initiated at a fixed rapid rate. The reflections were recorded digitally. Horizontal control is achieved by simultaneously recording a GPS fix for each pulse. The digital data set recorded comprises a geophysical response file (.seg), which also contains the GPS data.

Seismic Reflection Profiler Data Collection

Approximately 133 nautical miles (246.2 kilometers) of seismic profiles were acquired. Figure 1 displays the location of the seismic profiles collected to date.

The seismic profiles recorded for this study were collected aboard the FGS vessel R/V GeoSearch, (Figure 9). The instrument utilized to collect these data was a Benthos Chirp II system. This system emits low frequency pulses from 2 to 7 kHz and high frequency pulses from 8 to 23 kHz at a rate of 240 pulses per minute. All field records were retained on DVD disks for long term storage and are available for general distribution.

Limitations imposed by equipment, safety, and personnel availability constrained the time window for seismic profile acquisition. These data could only be acquired during day-light hours. The data quality of the seismic profiles obtained during the marine geophysical survey was impacted by occasional marginal/adverse sea conditions.

Computer Processing of Seismic Profile Data

The geophysical response file for each line was subsequently processed in-house, at the FGS, to produce a graphics (.jpg) file and a navigational file (nav.). Processing of the seismic reflection profiler data collected was accomplished using the Sonar Web Pro software package developed by Chesapeake Technologies Inc. Individual seismic profile lines were processed such that the graphics files created produce images with southwest to the left on all northeast/southwest trending lines, northwest to the left on all southeast/northwest trending lines and north to the left on all north/south trending lines. This orientation facilitates the comparison of individual lines and is in keeping with standard practices and conventions generally used in seismic data processing.

The sonic velocity utilized in processing the seismic profile 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. Within the geophysical consulting industry, this velocity is typically used as the default value in the processing of such data. Given the unavailability of sonic velocity data specific to the waters and sediments actually surveyed, 4,921.2 ft/sec (1,500.00 m/s) was thus deemed an acceptable compromise value for sonic velocity. While this is in keeping with standard practice in the processing of seismic reflection profiler records, the actual sonic velocity in the near seafloor sediments investigated, due to their higher density relative to sea water, progressively increases with depth. The resulting seismic profiles are thus roughly comparable to geologic cross sections. All digital data collected has been retained so that more sophisticated processing might be applied in the future. All of the seismic profile data collected can be accessed in Appendix C.

OVERVIEW OF WORK

Beach sediment samples were collected in Santa Rosa and Okaloosa Counties. Seabed samples were collected offshore of Santa Rosa, Okaloosa, and Walton Counties. These sediment samples were brought to the FGS laboratory for sample description and granulometric analysis. 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 can be found in Appendix A and Appendix B respectively. Granulometric analyses of these samples can also be found in Appendix A and Appendix B respectively.

The following is a summary of work accomplished:

- Approximately 133 nautical miles (246.2 kilometers) of seismic reflection profile data were collected offshore of Santa Rosa, Okaloosa, and Walton Counties.
- From offshore Santa Rosa, Okaloosa, and Walton Counties, a total of 12 seabed samples were collected, described and analyzed and their grain size distributions were analyzed.
- A total of 85 samples from 33 beach sampling locations in Santa Rosa and Okaloosa Counties were described and their grain size distributions analyzed.
- The computer processing of all seismic profile data collected was completed.
- A preliminary seismic stratigraphic analysis of the seismic profile data collected was completed.
- A table of 55 seafloor acoustic targets, Table 4, suspected to be man made objects lying on the seabed was complied.

DATA ANALYSIS

Table 4 lists targets seen on the seismic profiles that are suspected to be reflections from man made objects of significant size lying on or just below the seafloor. Figure 3 shows a representative example of such targets. As can be seen on Figure 1 there appears, based on the limited sampling obtained from the seismic reflection profiler records, to be an uneven, i.e. non-random, distribution of a significant portion of these targets within the study area. Most, if not all, of these targets are believed to be debris deposited on the seabed during military training missions. Such debris includes ordnance and shrapnel deposits from bombs, missiles and drones. The most recent drones utilized include converted jet fighter aircraft. A significant, albeit unquantifiable, portion of this material is thought to be live munitions. It is possible that expended depleted uranium rounds may be present in the study area as well.

Seismic Line 06C06B (Figure 4) was shot outside the study area specifically to transect feature W-5, a proposed borrow area identified from bathymetric indications by URS (Niedoroda *et.al.*, 2004). In 2005 vibracores were taken in the area by Alpine Ocean Seismic Survey, Incorporated as part of the Walton County Sand Search managed by Taylor Engineering, Incorporated. Data on these cores, including photographs were provided to URS and entered into the ROSS database (URS, 2007). Four of these cores, WN-1, WN-4, WN-6, and WN-10 were taken within 0.54 nautical mile (1 kilometer) of Seismic Line 06C06B (Figure 4) in a line roughly parallel to it, and photographs and core logs of them were downloaded from ROSS for interpretive use. The locations of these cores, of the W-5 feature, and of the seismic line are shown in Figure 1. These cores are the closest to the study area which can be referenced to a seismic line.

Figure 4 shows the vibracores to accurate vertical scale in the approximate horizontal positions they occupy with respect to the seismic line together with photographs and core logs of each vibracore. With reference to this figure (at a zoom of 200%), the northernmost core, WN-1, contains about 3.1 feet (0.94 meters) of a light colored sand with visible shells and shell fragments, but no visible structure. From 3.1 to 7.2 feet (0.94 to 2.20 meters) the sand becomes an increasingly dark gray with signs of bioturbation and silt increasing with depth. At 7.2 feet (2.2

meters) to 10 feet (3 meters) a highly bioturbated sandy silt occurs. From 10 feet (3 meters) to about 15 feet (4.5 meters) dark clay dominates with some sand present in burrow fill. From 15 feet (4.5 meters) to 17 feet (5.2 meters) orange oxidized clay is mingled with the dark clay, until, from 17 feet (5.2 meters) to the bottom of the core at 18.5 feet (5.6 meters) the clay is an orange shade indicating subaerial weathering. Referring to the seismic line at the approximate vibracore location, the facies changes noted above appear to be represented by a series of different reflectors, especially the sand-clay transition. These apparent facies changes are better displayed in Figure 4 approximately 550 feet (170 meters) to the south of WN-1.

Vibracore WN-4, shown approximately 0.75 nautical miles (1.5 kilometers) south of WN-1, penetrates the seabed as deeply as WN-1. It shows light colored sand to a depth of 10 feet (3 meters). The last foot (0.3 meters) of the sand layer contains burrows with infill the core log identifies as clay. Below this level, a dark gray-brown clay visibly dominates, bearing silt and large shells from 11 to 14 feet (3.3 to 4.2 meters), highly burrowed with signs of small amounts of oxidized material mixed with the darker matrix from 14 to 18.5 feet (4.2 to 5.6 meters) , with oxidized clay appearing to dominate the very bottom of the core at 18.8 feet (5.7 meters). The seismic line shows reflectors at the sand-clay transition, as well as at the limit of penetration.

Vibracore WN-6, approximately 1,300 feet (397 meters) south of WN-4, predominantly consists of light colored, somewhat shelly sand to a depth of 12 feet (3.6 meters), where a layer of dark organics abruptly occurs. From this depth to the bottom of the core at 19.5 feet (5.9 meters) a mixture of silt, clay, sand, and occasional organics exists showing signs of turbation. Vibracore WN-10, approximately 1000 feet (305 meters) south of WN-6 shows two basic facies, with increasingly silty shelly sand down to about 10 feet (3 meters), with bioturbation and clay becoming apparent below that, and shells and sand persisting to the base of the core at 19.5 feet (5.9 meters). The seismic line shows two reflectors indicated within the penetration depth of these two cores, with a third reflector slightly below the level reached.

Figure 2 is Seismic Line 06C05, a typical seismic profile within the study area. Analysis of the section of seismic profile shown in Figure 11, which is a detail from Figure 2, suggests the presence of a submarine spring located at approximately 30^{o} 12.1057' N latitude 086^{o} 45.3519' W longitude. This hypothesis is prompted by observed diffraction of the seismic waves within the water column immediately above a seafloor depression with seismic evidence of possible fissures radiating beneath it adjacent to an interpreted outcrop of hard bottom. This diffraction would be produced by the outflow of waters of a different density than seawater emerging from a break in an aquatard.

Based on the work of McBride (1997) and Clark and Schmidt (1982), as well as the evidence from the vibracores and the seismic profile discussed above, the reflector cropping out proximal to the possible submarine spring is interpreted to be clay. The material overlying it is interpreted to be Pleistocene to Recent quartz sands. As can be seen in Figure 2, based on its reflectance signature, this conjectured surface crops out as hard bottom on the seabed. Insufficient data coverage is currently available to either map these outcrops or to confirm the hypothesis that the hard bottom noted represents a prior erosional surface. It will be noted that the outcrop indicated is unique on this seismic line. At all the other declivities portrayed on this line, the reflector occurs at an apparently uniform depth below the surface approximating 10 feet (3 meters), and is not exposed on the seabed. This appears to be the usual pattern across the study area, with outcrops being rare.

Sea bed samples were obtained from surficial sediments across the study area. Granulometric analyses of these samples are provided in Appendix B. To summarize, these samples are all very similar, being yellow-gray sands with around 1.6 % fines (none over 2.21%) and reasonably uniform granulometries. A comparison of a representative sample of these sediments with a representative sample obtained from a beach in Okaloosa County is shown as Figure 10. Assuming this material is indeed acceptable for use in beach restoration, significant thicknesses of roughly ten feet (3 meters) of these sediments are revealed in various individual seismic profiles. Insufficient data is currently available to estimate reserves of restoration-quality sand or to map the areal extent of these occurrences.

CONCLUSIONS

An area with the potential for the occurrence of available beach-restoration quality sand in federal waters offshore of Santa Rosa and Okaloosa Counties has been identified. This sand is present as a mantle of reworked sediments approximately 10 feet (three meters) thick overlying a reflector found throughout the area which is interpreted to be a layer containing silt and clay. While the sand mantle appears generally uniform throughout the study area, occasional thinning of the sand and outcrops of the clay beneath can be observed on the seismic lines collected.

It is known that operations at Eglin Air Force base, from approximately 1935, to the present, have placed an unquantified amount of metallic debris, some of which is of significant size, on or within the seabed in the offshore portions of the study area. Individual occurrences of pieces of metallic debris of significant size, when intersected by the seismic grid, were noted on the seismic profiles. The distribution of the bulk of those occurrences appears to be substantially non-random. An unknown amount of that debris is expected to be in the form of live ordnance and munitions. Such live debris may range from cannon rounds to missile warheads and air dropped munitions.

A feature has been identified that appears to be indicative of a submarine spring. There is insufficient data currently available to confirm this hypothesis.

RECOMMENDATIONS

The FGS recommends that further surveys of the study area be made to delineate areas of potential for the occurrence of beach-restoration quality sand with the intent of both qualifying and quantifying such reserves of beach-restoration quality sediments that might be present. It is further recommended that the potential submarine spring location identified be investigated.

Future tasks should include:

- side scan sonar and magnetometer surveys as well as diver reconnaissance of prospective borrow sites to quantify the degree to which the presence of metallic debris may hinder dredging operations,

- side scan sonar to identify clay/hard bottom areas and the areal extent of sand deposits,

- surficial bottom sediment sampling through the use of mechanical grab sampling, diver reconnaissance and

- vibracoring to accurately ground truth the interpretations based on the seismic data.

It is also suggested that diver reconnaissance of the suspected submarine spring be accomplished and, if a spring is confirmed, an estimate of flow volumes be obtained.

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