STATE OF FLORIDA
DEPARTMENT OF ENVIRONMENTAL PROTECTION

FLORIDA GEOLOGICAL SURVEY
Jonathan D. Arthur, State Geologist and Director

Report of Investigation 121

THE BATHYMETRY, TOP OF ROCK, AND THICKNESS OF UNCONSOLIDATED SEDIMENTS OFFSHORE OF THE NORTHEAST AND CENTRAL EAST COAST OF FLORIDA

By
Daniel C. Phelps, Seth W. Bassett and Alan E. Baker

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REPORT OF INVESTIGATION 121

PREFACE

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The Florida Geological Survey, a Division of the Florida Department of Environmental Protection, is publishing as its Report of Investigation No. 121, The Bathymetry, Top of Rock, and Thickness of Unconsolidated Sediments Offshore of the Northeast and Central East Coast of Florida. The report presents results of geophysical surveys and sea-floor borings collected offshore of the eastern coast of Florida. Interpretation of this data, which has been collected by multiple agencies over years, allowed for development of maps of the distribution of offshore mineral sands. A better understanding of the thickness and extent of these geological resources allows for improved planning of beach nourishment efforts and other applications. State, regional, county, and local governmental agencies, as well as the public, will find this information useful in support of future coastal zone planning activities. Moreover, the maps serve as a baseline for future sediment mapping studies to better understand the migration and deposition of these sands along the coastal zone.

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ACKNOWLEDGEMENTS

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The authors appreciate our Florida Geological Survey colleagues Jonathan Arthur, Richard Green, Guy Means, and Sarah Erb for their review of the manuscript.

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THE BATHYMETRY, TOP OF ROCK, AND THICKNESS OF UNCONSOLIDATED SEDIMENTS OFFSHORE OF THE NORTHEAST AND CENTRAL EAST COAST OF FLORIDA

Daniel C. Phelps, (P.G. # 1203), Seth W. Bassett, and Alan E. Baker (P.G. # 2324)

INTRODUCTION

Beach erosion is of constant concern in Florida (Clark, 1993). Shore protection options in much of the state are limited by substantial commercial and residential development close to Florida's beaches. When faced with continual erosion and the effects of sea-level rise, asset relocation or abandonment is generally considered cost prohibitive. The periodic replacement of sand along the beach is the shore protection measure of choice. When readily available, suitable for beach restoration, sources of sand on land are unavailable, depleted, or uneconomical, offshore sand bodies are increasingly investigated and used. To further investigate this resource the Bureau of Ocean Energy Management (BOEM) of the United States Department of the Interior and the Florida Department of Environmental Protection (DEP) joined in a cooperative agreement (MC1400004). As part of that agreement, the DEP's Florida Geological Survey (FGS) analyzed widespread grids of sub-bottom profiler data and vibracores previously collected offshore of the northeast and central-east coast of Florida. These analyses were performed to delineate the interpreted top of rock and the thickness of unconsolidated sediments on the inner continental shelf, some portion of which might be suitable for beach renourishment. The unconsolidated sediment thickness was calculated by subtracting the elevation of the interpreted top of rock from the elevation of the seafloor.

Two sets of sub-bottom profiler data were examined for this study: "boomer" data and "chirp" data. The boomer data were collected over a multiyear period from 1996 to 2006 by the FGS and the US Geological Survey (USGS) and represent the primary data sets used in this study. They provided extensive areal coverage and were useful in determining the depth of both the seafloor and the top of rock. The chirp data were acquired in 2007 during a project conducted by Coastal Planning and Engineering Inc. (CPE) in coordination with URS (formerly the United Research Services) Corporation. This project surveyed state waters within the study area using a widely-spaced zig-zag grid of alternating east-west and northwest-southeast transects. That survey extended from the Georgia-Florida border in Nassau County, through Martin County, to the northern boundary of Palm Beach County. The geophysical track lines for the boomer and chirp data, as well as geological sampling locations, are shown on Figures 1 and 2.

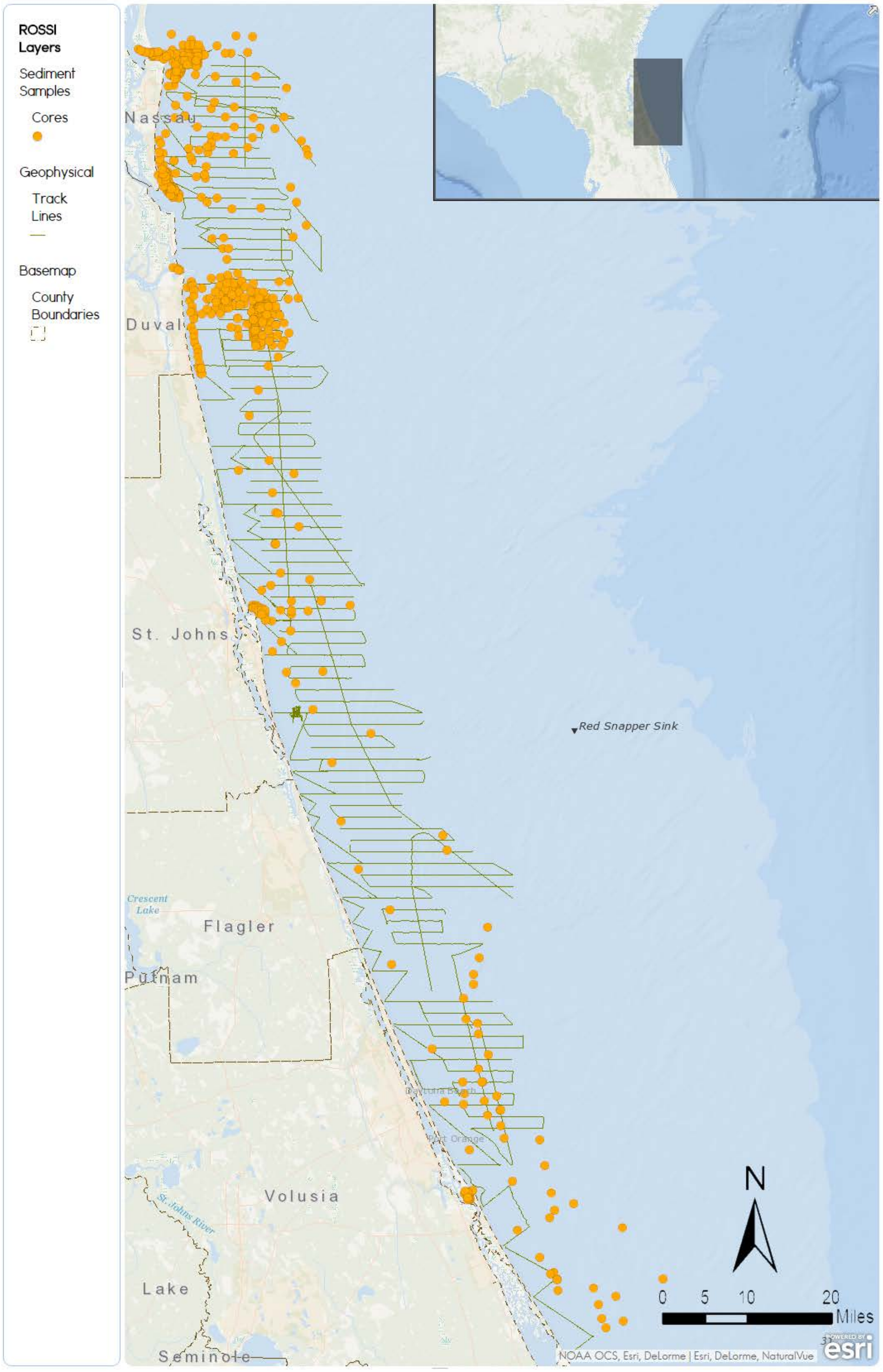


Figure 1. Nassau County to Volusia County portion of data (available through the Regional Offshore Sand Source Inventory MapViewer page [http://rossi.urs-tally.com/Map]). The zig-zag track lines along the coastline reflect "chirp" data collection. The rectilinear track lines further offshore reflect "boomer" data collection.

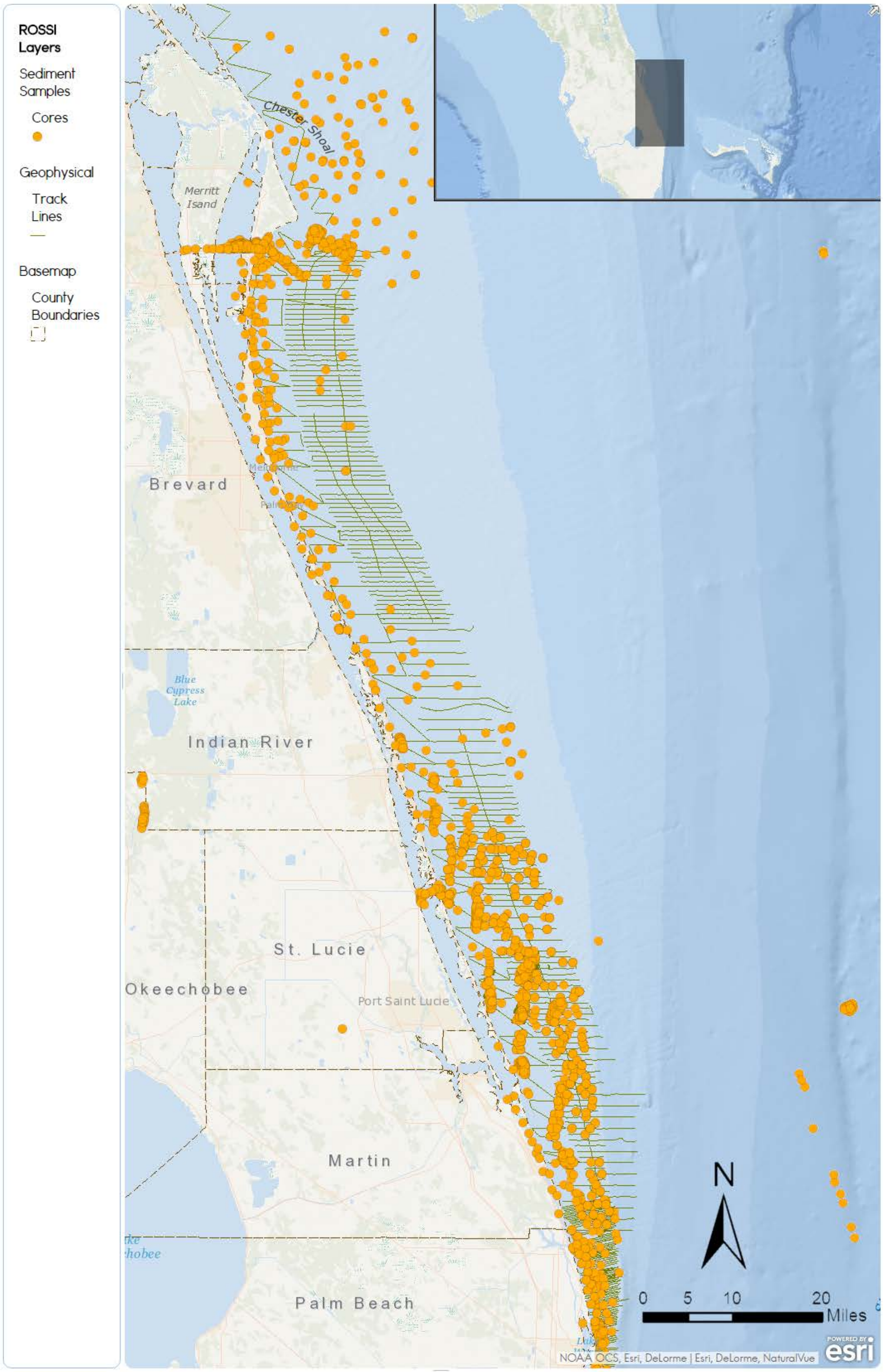


Figure 2. Brevard County to Palm Beach County portion of data (available through the Regional Offshore Sand Source Inventory MapViewer page [http://rossi.urs-tally.com/Map]). The zig-zag track lines along the coastline reflect “chirp” data collection. The rectilinear track lines further offshore reflect “boomer” data collection.

Definitions

The study area is shown in Figures 1 and 2. It consists of the State of Florida and adjacent federal waters lying over the inner continental shelf offshore of Nassau, Duval, St. Johns, Flagler, Volusia, Brevard, Indian River, St. Lucie, and Martin counties.

The instruments used to collect geophysical profiles of sub-seabed sediments, referred to in the scientific literature as sub-bottom profilers, sub-surface acoustic profilers, and continuous seismic reflection profilers, are referred to in this study as “seismic reflection profilers” or “profilers.” Two types of seismic reflection profiler data, obtained from boomer and chirp systems, were used in this investigation. The seismic reflection profiler records produced are referred to as “seismic profiles.” The map trace of an individual seismic profile, as depicted on Figures 1 and 2, is referred to as a “seismic line” or “line.” The assemblage of seismic lines, as depicted on those figures, is referred to as a “seismic grid” or “grid.” Those individual seismic lines within the seismic grid which align in a predominately east-west direction are referred to as “dip lines,” as they run parallel to the regional dip of strata. Individual seismic lines within this seismic grid, which align in a predominately north-south direction, are referred to as “strike lines.” as they run perpendicular to the regional dip of strata and/or along and parallel to the crest of linear bathymetric highs. Individual seismic lines which intersect multiple dip lines, facilitating the direct lateral correlation of reflectors, are referred to as “tie lines.”

Maps included in this document use either the North American Datum of 1983 European Petroleum Survey Group (EPSG):4269, cited as "NAD83," or the World Geodetic System of 1984 (EPSG:4326, cited as "WGS84") as the geodetic datum. The map projection used within this document is the Florida Department of Environmental Protection customized Albers Equal Area Conformal Conic projection (EPSG:3086, cited as "Albers"). Global Positioning System (GPS) instrumentation used to collect geographic global positioning fixes and/or reference points are referred to as “GPS instrumentation”, “fixes”, or “points” as applicable.

Previous Work Addressing Unconsolidated Sediment Thickness and Top of Rock

The use of geophysical methods of continental shelf sand resource investigations off the east coast of the United States of America was initiated under the US Army Corps of Engineers program of Inner Continental Shelf Sediment and Structure (ICONS) studies. The ICONS studies used seismic reflection profiler instrumentation as well as vibracoring and seafloor grab sampling. Four of those studies were conducted off the east coast of Florida: Duane and Meisberger (1969), Meisberger and Duane (1971), Field and Duane (1974), and Meisburger and Field (1975). Together, those studies were important first steps in investigating the sediments of the inner continental shelf off the east coast of Florida from the Georgia-Florida state line to Miami. They set the stage for all subsequent work in the region. Meisburger and Field (1975) established the nomenclature still used for the shoals offshore from Cape Canaveral to the Florida-Georgia border.

Meisberger and Duane (1971) presented the results of investigations of the geomorphology and sediments of the inner continental shelf from Palm Beach to Cape Kennedy (now called Cape Canaveral) Florida. They mapped what they referred to as the “blue reflector,” which was their interpreted top of rock. Only in the case of core 45A do they describe a core as having encountered rock. The rock encountered is described by them to be *"gray coarse grained coquina rock"* lying from 6 to 6.3 feet (1.8 to 1.9 meters) below the seafloor. Additionally, they describe core 34 as having encountered semi-consolidated calcarenite from 8 to 10.2 feet (2.4 to 3.1 meters) at the bottom of the core.

Field and Duane (1974) provided similar analysis for the inner continental shelf offshore of Cape Canaveral, Florida. They labeled the base of what they interpreted to be the top of consolidated sediments the "blue horizon" and considered it to be the lateral extension of the blue reflector as discussed and mapped in Meisberger and Duane (1971). They mapped the blue horizon offshore of Cape Canaveral as well as the thickness of sediments between it and the sea floor.

Meisburger and Field (1975) conducted investigations of the Florida inner continental shelf from Cape Canaveral to the Florida-Georgia border. They mapped the blue reflector in three gridded areas. They stated the following on page 36 of that document:

> *"By convention the isopach surface in ICONS studies is called the blue reflector. This does not imply that the blue reflector of this study is necessarily continuous with blue reflectors described in other ICONS studies. It is not known if continuity exists between grid areas, although core data and similarities in elevation indicate a probability."*

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 20 vibracores in detail, along with 248 statute miles (399 km) of seismic profiles collected offshore of St. Augustine for the ICONS study. Those 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.

Freedenburg et al. (1995a, 1995b, 1997, 1999, 2000, and 2002) and Phelps et al. (2003, 2004, 2005, and 2007) discuss grab sampling as well as boomer data and vibracore data collected offshore of the central east coast and northeast coast of Florida respectively. These projects were conducted under cooperative agreements with the U.S. Department of the Interior's Minerals Management Service (MMS) (now the BOEM) and the boomer data collected were the primary data sets used in the mapping efforts north and south of Cape Canaveral, Florida.

Phelps and Baker (2012) analyzed all available chirp sub-bottom profiler data offshore of St. Lucie County and adjacent areas offshore of Indian River County to the north, and Martin County to the south. Those chirp data were collected during survey cruises in 2006, 2007, and 2011 by various consultants using EdgeTech 512i sub-bottom profiler systems. In contrast to the boomer data primarily used in this study which covers a large geographic area, the two main chirp data sets used by Phelps and Baker (2012) covered three relatively small areas with a tight grid of east-west trending dip lines crossed by north-south trending tie lines. Phelps and Baker (2012) used what they interpreted to be the blue reflector/blue horizon of the ICONS studies as the top of rock for unconsolidated sediment thickness mapping. In specific seismic profiles, they found that their interpreted top of rock reflector underlay the base of shoals' inclined bedding planes.

Geophysical and Geological Data

As discussed above, this report uses two types of sub-bottom profiler data to delineate sand bodies: chirp data and boomer data. The signal sources of these profiler systems generate repetitive impulses. The returning reflections off the seabed and stratigraphic horizons within the sub-seabed sediments are received on hydrophones as acoustic pulses. Chirp systems produce a frequency-modulated acoustic pulse or chirp. Boomer systems generate a tight bell-shaped curve of frequencies. These two systems produce distinctly different seismic profiles. Chirp systems, as used in the study area, typically only produced usable data down to 50 feet (15.25 meters) into the subsurface in ideal conditions. Boomer systems, as used in the study area, typically produced usable data down to 150 feet (45.7 meters) into the subsurface. Boomer data were collected using instruments towed on the sea surface. Chirp data were collected using a submerged towfish without the depth of the towfish below the sea surface being recorded. Since those chirp data could not be corrected for the depth of the towfish, they could not be used in mapping either bathymetry (water depths) or the elevation of the top of rock. However, because the calculation of unconsolidated sediment thickness is independent of the chirp towfish's depth, both data types can be used to map the thickness of unconsolidated sediments above the top of rock.

The boomer data surveys, with one exception, were collected during multiple cruises by the Florida Geological Survey (FGS) in cooperation with the United States Geological Survey (USGS). The earliest of those geophysical surveys were conducted in 1996. Collection of those data continued, generally on an annual basis, until 2005. Those surveys were part of multi-year studies funded by the Mineral Management Service (MMS) that ultimately included surveying federal waters out to approximately 18 nautical miles (33.3 kilometers) off the northeast and central east coast of Florida. The data south of Cape Canaveral were collected during the period 1996 to 2000, and are discussed in Freedenberg et al. (2002). The youngest boomer data used in this study were collected north of the Cape from 2002 to 2006. Those data are discussed in detail in Phelps et al. (2003, 2004, 2005, and 2007).

The collection of boomer data off the central east coast of Florida is discussed in Freedenburg et al. (1995a, 1995b, 1997, 1999, 2000, and 2002), and the collection of boomer data off the northeast coast of Florida is discussed in Phelps et al. (2003, 2004, 2005, and 2007). Each of these surveys were primarily comprised of widely spaced grids of dip lines at approximately one nautical mile (1.85 kilometer) spacing north of Cape Canaveral, and either one or 0.5 nautical mile (either 1.85 kilometer or 0.93 kilometer) spacing south of Cape Canaveral. The exceptions to this were data collected in one small tightly gridded survey offshore of northern St. Johns County, and those collected in a limited area offshore of northern Volusia County. The data collected offshore of northern St. Johns County were collected by the USGS in waters spanning the boundary between state and federal waters over a feature known as Crescent Beach Spring. Those data are discussed in Kindinger et al. (2000). In the case of the limited area offshore of northern Volusia County, only strike lines were collected. There is a rather large gap in the boomer data grid between southern Volusia County and just south of Cape Canaveral in southern Brevard County.

The boomer data collection program generally consisted of east-west dip lines and north-south strike lines. Some strike lines cross and thus tie multiple dip lines, while others extend from adjacent dip lines' end and start points. Not all dip lines are crossed by strike lines.

The chirp data were collected in 2007 within state waters using a widely-spaced zig-zag grid of alternating east-west and northwest-southeast lines. Geographically, the chirp survey dataset extends from the Georgia-Florida border in northern Nassau County, south to Martin County. Unfortunately, the chirp lines intersect the boomer data lines in very few locations.

Processing of the seismic reflection profiler data was accomplished using the SonarWiz5 software package developed by Chesapeake Technology Inc. The sonic velocity used in data processing was 4921.2 ft/sec (1500.00 m/s), i.e. the average velocity of sound in sea water. This velocity is typically used as the standard default value in the processing of such data. The resulting seismic profiles produced are comparable to geologic cross sections.

The format the boomer data were collected in is obsolete and not recognized by SonarWiz5. The dataset had to be converted into .sgy format. This conversion was not entirely without data degradation, nor could it be successfully accomplished in all cases. In most cases, the converted files produced data that could be processed into seismic profiles which could be interpreted.

The geological data consisted of vibracores and a few jet cores collected to a maximum depth below the seafloor of 20 feet (6.1 meters) as well as surficial seafloor samples. Those data were collected either as part of reconnaissance surveys or as tightly spaced grids of vibracores over specific features of interest. Very few vibracores reached the top of rock.

Geophysical and Geological Data Analysis and Interpretation

Acoustic contrasts, which generate reflections, are the result of the variations in the physical and acoustic properties inherent in the lithologic differences in layers above and below a reflecting surface. Even if a distinct reflector is generated locally, that reflector may cease to be continuous if a gradual lateral facies change occurs. The analyses presented in this study tie vibracores to specific seismic profiles and thus, wherever possible, establish direct lithologic control for the base of unconsolidated sediment and the top of rock. An example of this is shown in Figure 3. Seismic line SL-24, which was collected offshore of St. Lucie County, is intersected by vibracore VB-SLC12-120. The core boring log of VB-SLC12-120, Figure 4, shows only 0.3 feet (0.09 meter) of sandstone was penetrated. The depth of penetration of the core on the seismic section in Figure 3 is exaggerated for the purposes of illustration. Because the core has been projected in from slightly off the seismic line and collected at a different date than the seismic data, there is a difference between the top of the core shown on the seismic line and the seabed.

The first blue line on the seismic section delineates the seafloor, the second, lower, blue line delineates the top of rock. The thickness of unconsolidated sediments between the top of rock and the seafloor is shown by blue hatching. Seismic line SL-24, on Figure 3, exhibits strong reflectance characteristics due to the substantive acoustic contrast between the top of rock and both seawater and overlying unconsolidated sediments. Such surfaces typically exhibit persistent strong responses in their first and even second multiples. Seafloor multiples derive from reflections from the seafloor and the sea surface traveling back and forth within the water column. Second multiples, as seen in the example below, are the result of the strong reflectance that consolidated sediments exhibit even after the sonic impulse attenuates.

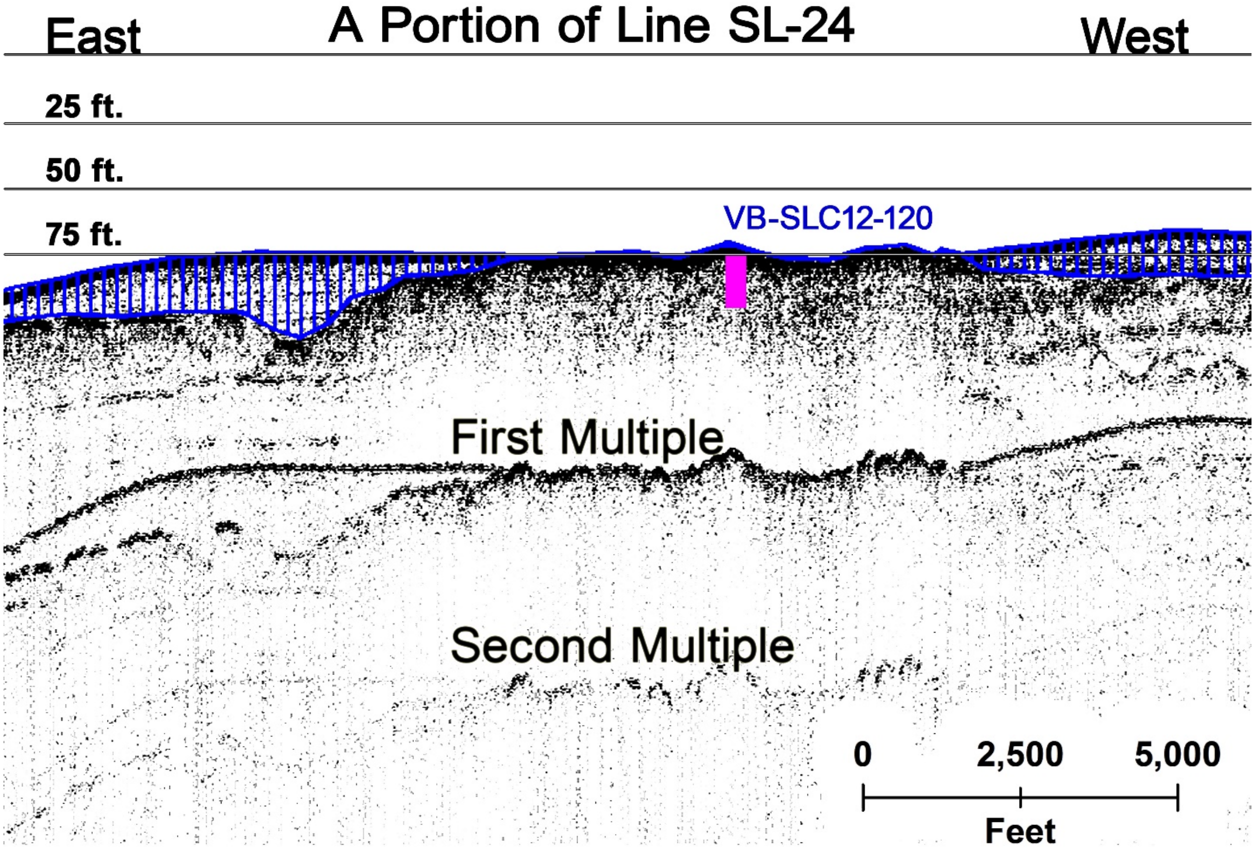
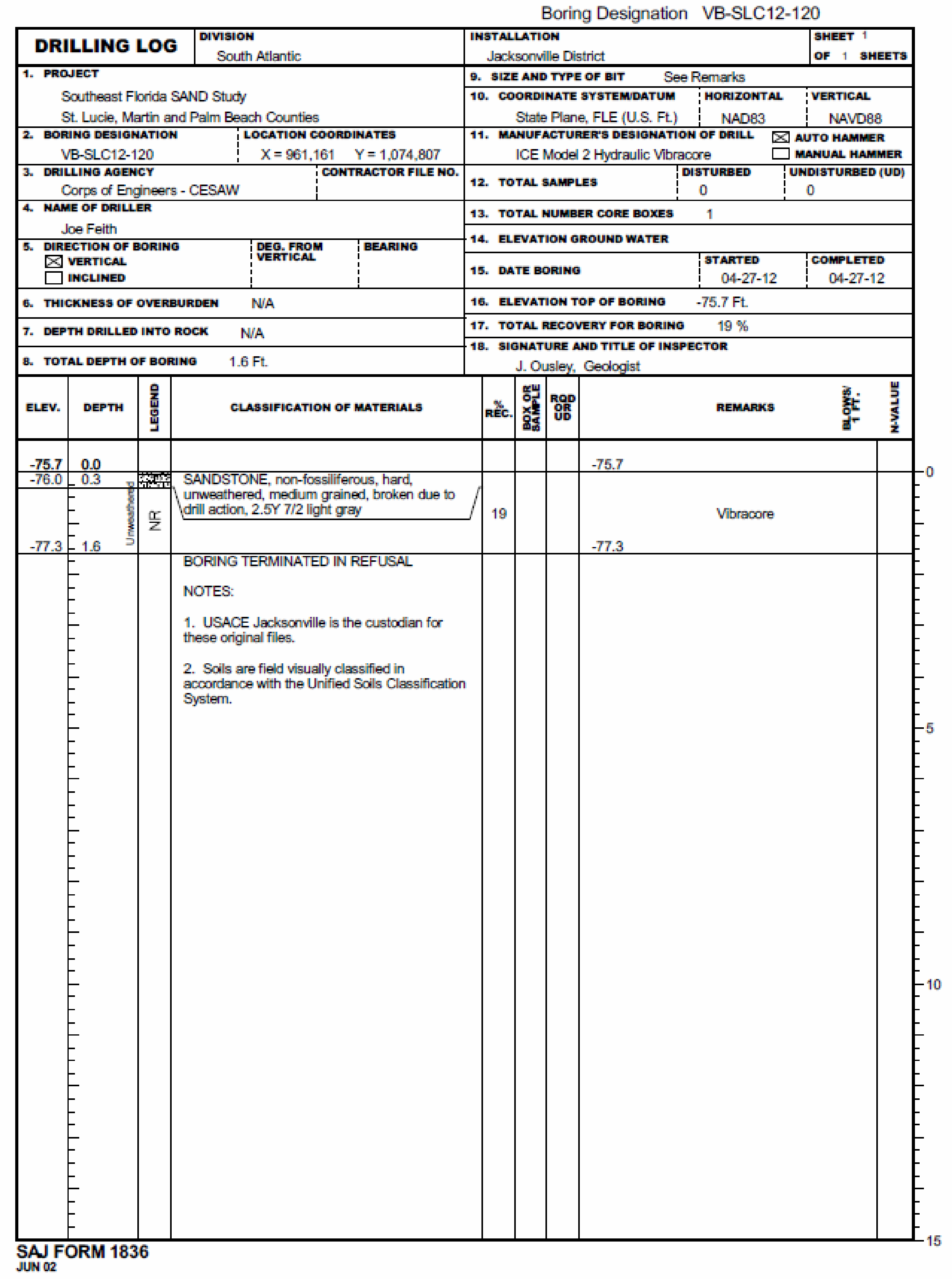


Figure 3. Seismic line SL-24 and vibracore VB-SLC12-120. The uppermost blue line delineates the seafloor, the lowermost blue line delineates the top of rock, and the thickness of unconsolidated sediments lying between those blue lines is illustrated by the vertical blue "hatch" lines.



Boring Designation VB-SLC12-120

DRILLING LOG

DIVISION: South Atlantic

INSTALLATION: Jacksonville District

SHEET 1 OF 1 SHEETS

1. PROJECT: Southeast Florida SAND Study
St. Lucie, Martin and Palm Beach Counties

2. BORING DESIGNATION: VB-SLC12-120

LOCATION COORDINATES: X = 961,161 Y = 1,074,807

3. DRILLING AGENCY: Corps of Engineers - CESAW

CONTRACTOR FILE NO.:

4. NAME OF DRILLER: Joe Feith

5. DIRECTION OF BORING: ☒ VERTICAL ☐ INCLINED

DEG. FROM VERTICAL:

BEARING:

6. THICKNESS OF OVERBURDEN: N/A

7. DEPTH DRILLED INTO ROCK: N/A

8. TOTAL DEPTH OF BORING: 1.6 Ft.

9. SIZE AND TYPE OF BIT: See Remarks

10. COORDINATE SYSTEM/DATUM: State Plane, FLE (U.S. Ft.)

HORIZONTAL: NAD83

VERTICAL: NAVD88

11. MANUFACTURER'S DESIGNATION OF DRILL: ICE Model 2 Hydraulic Vibracore

☒ AUTO HAMMER

☐ MANUAL HAMMER

12. TOTAL SAMPLES: DISTURBED 0 UNDISTURBED (UD) 0

13. TOTAL NUMBER CORE BOXES: 1

14. ELEVATION GROUND WATER:

15. DATE BORING: STARTED 04-27-12 COMPLETED 04-27-12

16. ELEVATION TOP OF BORING: -75.7 Ft.

17. TOTAL RECOVERY FOR BORING: 19 %

18. SIGNATURE AND TITLE OF INSPECTOR: J. Ousley, Geologist

ELEV.	DEPTH	LEGEND	CLASSIFICATION OF MATERIALS	% REC.	BOX OR SAMPLE	RQD OR UD	REMARKS	BLOWS/ 1 FT.	N-VALUE
-75.7	0.0						-75.7		
-76.0	0.3		SANDSTONE, non-fossiliferous, hard, unweathered, medium grained, broken due to drill action, 2.5Y 7/2 light gray	19			Vibracore		
		Unweathered NR							
-77.3	1.6						-77.3		
			BORING TERMINATED IN REFUSAL NOTES: 1. USACE Jacksonville is the custodian for these original files. 2. Soils are field visually classified in accordance with the Unified Soils Classification System.						

SAJ FORM 1836
JUN 02

Figure 4. Drilling log for vibracore VB-SLC12-120. (Source: USACE Southeast Florida Sand Study; St. Lucie, Martin and Palm Beach counties.)

There were problems inherent in the analysis of the geophysical data. Within the boomer datasets, many of the dip lines were not crossed by tie lines. When that occurred, the mapping horizon could only be identified and “tied” by matching the seismic character of the seismic profiles of adjacent dip lines. There were also various areas within the boomer data grids where either data could not be successfully processed or were not collected.

Because of the nature of the zig-zag grid, none of the chirp lines cross other lines within the chirp data set. Thus, individual lines could not be directly tied to each other. As with the boomer data sets, the mapping horizon could only be identified and tied by matching the seismic character of the seismic profiles of adjacent lines. On rare occasions, chirp lines crossed boomer lines. Because of the substantive time separation between when boomer and chirp data were collected, the towing of the chirp towfish at unknown depths, and the differences in the two geophysical systems, tying one data type to the other was not always reliable enough to produce satisfactory results.

The reconnaissance sand source inventory (ROSSI) database shows a substantive number of cores within the study area. These cores are not evenly distributed. Additionally, a number cores exist for which very little information, other than their location, is available. Very few of the vibracores collected within the study area reached the top of rock. Only a fraction of the vibracores collected intersect seismic lines or lay within 500 feet (152.4 meters) of seismic lines. Of those that did intersect seismic lines, seafloor bathymetric change occurring between the dates of their collection and the date of the collection of boomer data often resulted in mismatches between the top of cores and the seabed shown on seismic profiles. Tying chirp lines to individual vibracores was further complicated by the fact that true seabed depths could not be derived from chirp data.

Identification of the top of rock was accomplished by: 1) correlating seismic profiles to intersecting vibracores, 2) analyzing variations in seismic reflection intensity, and 3) seismic stratigraphic analysis. From the digitized surfaces of the seabed and the top of rock, the thickness of unconsolidated sediments in the study area was estimated seismic profile by seismic profile.

The interpreted top of rock was delineated by digitizing the surface of the first coherent, laterally contiguous, parallel, and flat-lying reflector seen in the seismic profiles. Wherever possible, that reflector was directly tied to the top of rock seen in vibracores. In many seismic profiles the reflector was interpreted to be truncating underlying stratigraphy. In specific seismic profiles which crossed shoals, the reflector was occasionally seen to directly underlie inclined bedding planes at the base of those shoals. Continuity of the reflector was consistently established, wherever possible, by tying it on east-west trending seismic profiles to north-south trending seismic profiles and/or the seismic profiles of the 2007 chirp survey. Where the reflector could not be directly tied, ties were made on adjacent seismic profiles based on seismic character.

To create the sediment thickness maps above the interpreted top of rock layer, both the seabed and the top of rock surface were digitized using SonarWiz5 software. The data points for each boomer or chirp return, along with the interpreted values, were then exported from SonarWiz5 as a set of XYZ comma separated value (CSV) files. A PostgreSQL 9.3 database was created to house the entire dataset. A custom Python 2.7 script was created to translate and QA/QC the CSV files into a unified database table. The result was a PostgreSQL database containing 904,883 individual observations (rows) imported from 767 individual CSV files.

These database rows were then exported to an Environmental Systems Research Institute ESRI® ArcGIS® ArcMap™ (ESRI) ArcGIS 10.3 geodatabase and projected into the DEP custom Albers projection. To inspect the data visually for errors, the XYZ values for each individual sonar return were used to create a Triangular Irregular Network (TIN) surface. TINs are a form of vector-based digital geographic data that run very quickly on large datasets, and are constructed by the simple triangulation of a set of 3-dimensional points.

After the combined boomer and chirp datasets were inspected for errors, the Empirical Baysian Kriging function in ArcGIS 10.3 Geostatistical Analyst was used to generate the top of rock and seabed surfaces for this report. These surfaces were then contoured using the contouring tool within ArcGIS 10.3.

Mapping North of Cape Canaveral

The boomer seismic grid used in this mapping was comprised of widely spaced grids of east-west dip lines, at approximately one nautical mile (1.85 kilometer) spacing, jointed by strike lines and crossed by tie lines. The maps, shown in Figures 5, 6, and 7, provide a generalized overview of the bathymetry, the interpreted top of rock, and unconsolidated sediment thickness north of Cape Canaveral. The bathymetry and unconsolidated sediment thicknesses are indicative of conditions that existed at the time data were collected.

As shown in Figure 5, the seafloor, referenced to mean sea level, slopes both southward and eastward. This trend is locally interrupted by shoals, most noticeably those lying offshore of northern St. Johns and southern Flagler counties. Figure 6 shows that the top of rock, referenced to mean sea level, generally deepens both southward and eastward. Figure 7 reveals that the thickness of unconsolidated sediments also increases both southward and eastward.

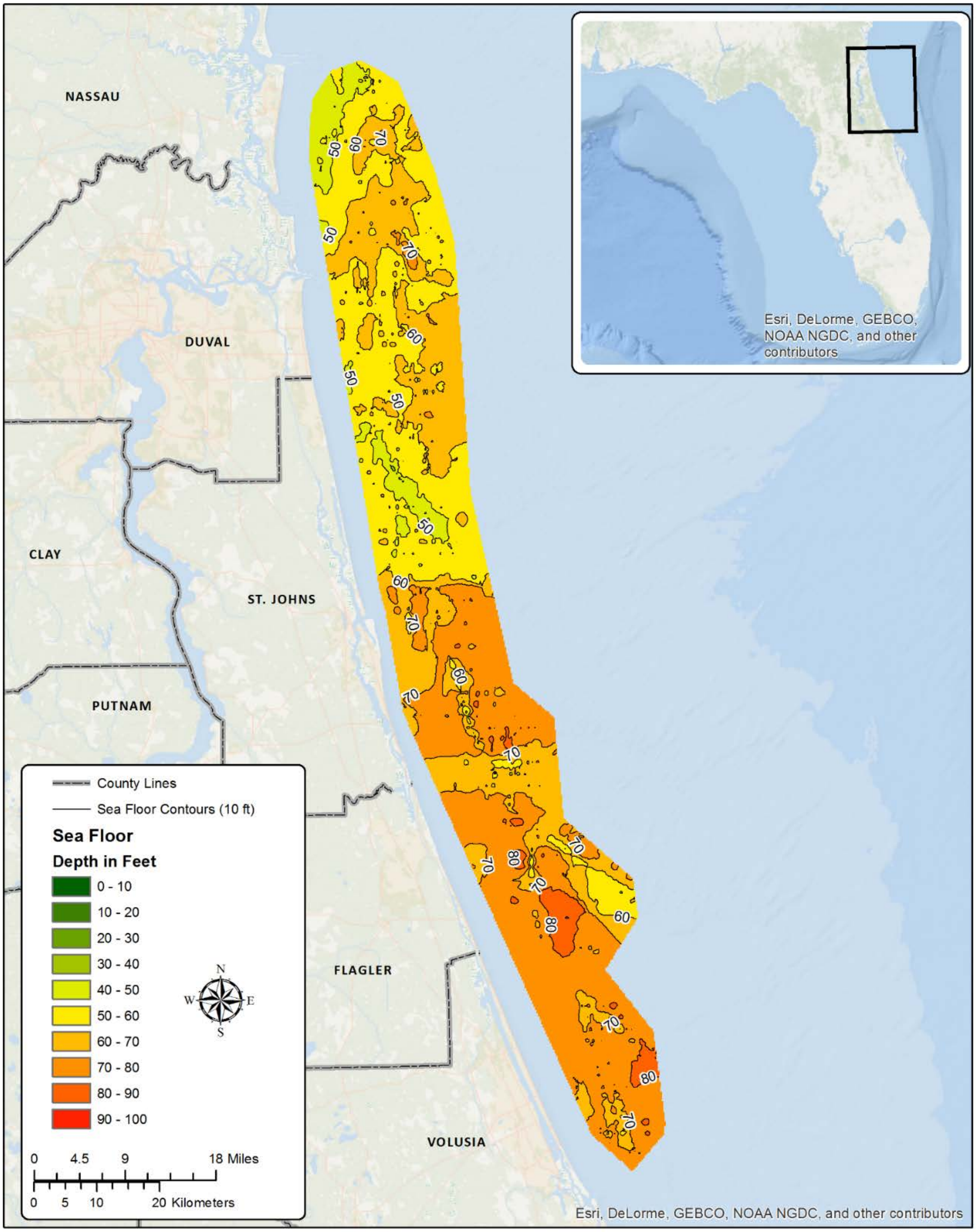


Figure 5. Bathymetric map of the seafloor north of Cape Canaveral based on boomer data collected from 2002 to 2006.

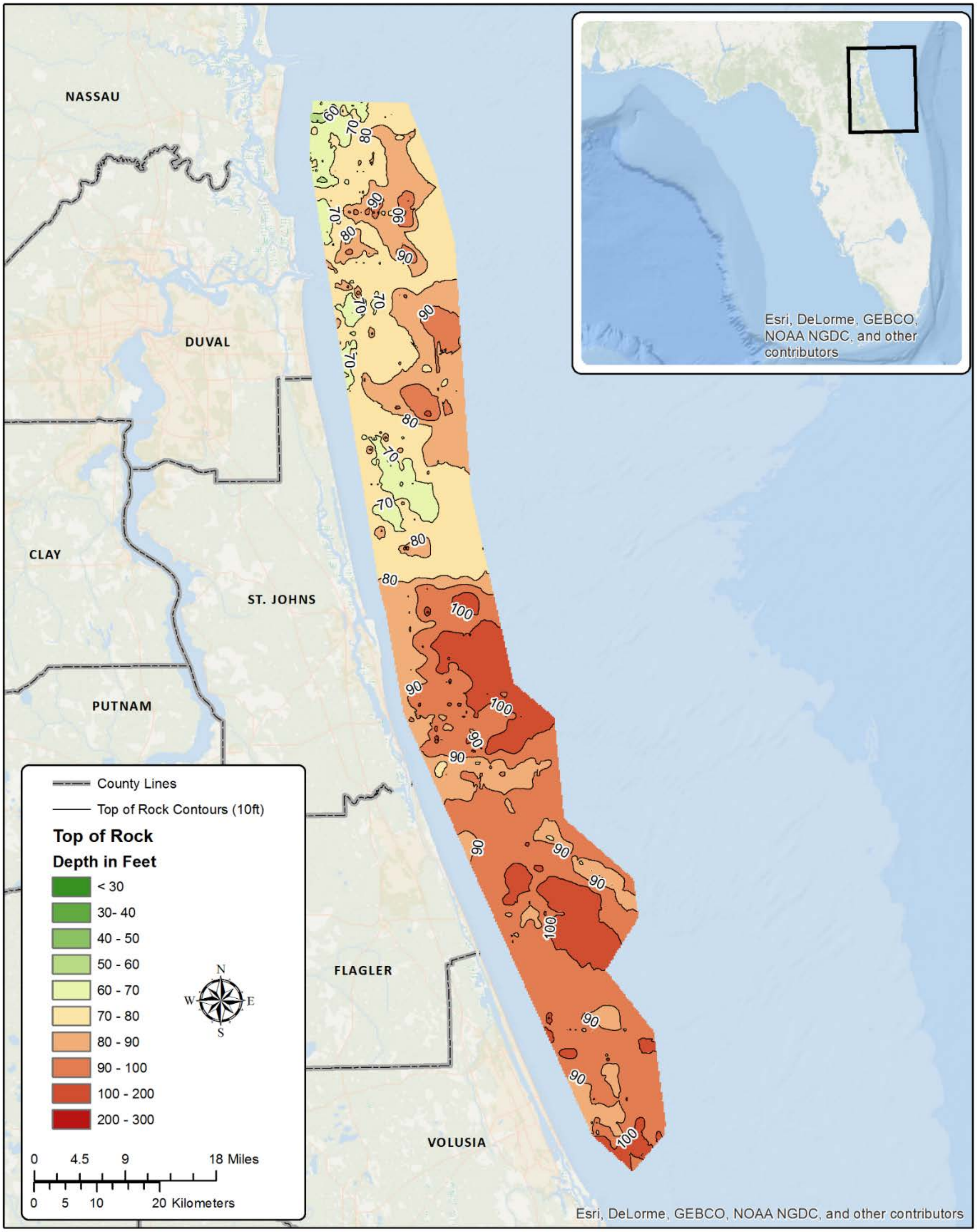


Figure 6. Interpreted top of rock north of Cape Canaveral.

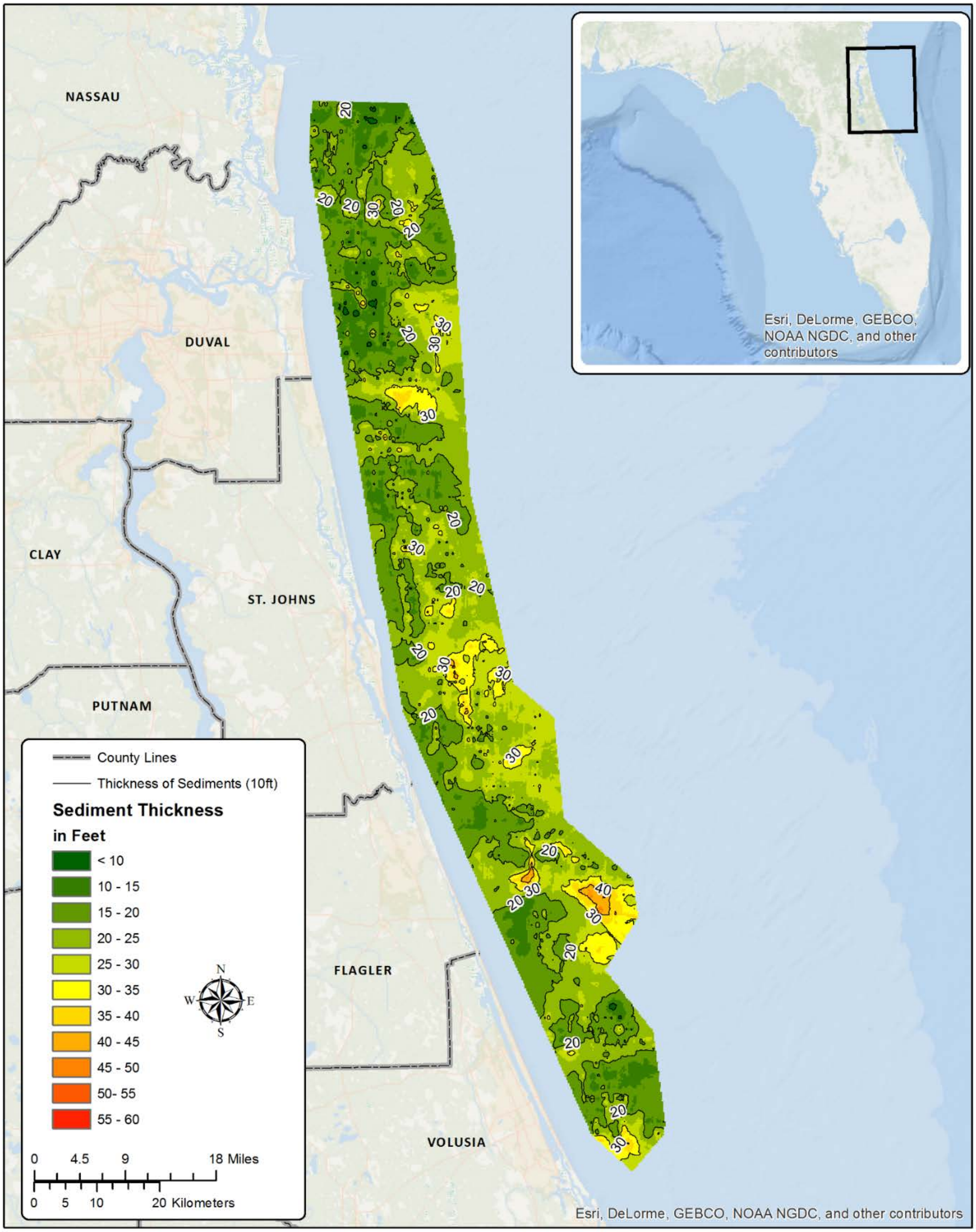


Figure 7. Unconsolidated sediment thickness north of Cape Canaveral based on boomer and chirp data, collected from 2002 to 2006, and 2007, respectively.

Mapping South of Cape Canaveral

The boomer seismic grid used in this mapping is comprised of widely spaced grids of east-west dip lines, at approximately one or 0.5 nautical mile (1.85 or 0.93 kilometer) spacing, jointed by strike lines and crossed by tie lines. The maps, shown in Figures 8, 9, and 10, provide a generalized overview of the bathymetry, the interpreted top of rock, and unconsolidated sediment thickness south of Cape Canaveral. The bathymetry and unconsolidated sediment thicknesses are indicative of conditions that existed at the time data were collected, which was more than 17 years ago.

As shown in Figure 8, the seafloor, referenced to mean sea level, slopes gently to the southeast offshore of the southern half of Brevard County. Distal to the coast, starting in the southern half of Indian River County, and progressing southward its slope becomes progressively steeper toward the south. The steepening trend becomes more and more proximal to the coast southward off St. Lucie and Martin counties until the edge of the study area is reached at Martin County’s southern boundary.

As shown in Figure 9, the top of rock, referenced to mean sea level, dips gently to the north northeast across the southern half of Brevard, Indian River, and St. Lucie counties. Distal to the coast, it becomes progressively steeper starting near the St. Lucie-Martin County border and progressing southward. From that point, the direction of dip shifts to the southeast and finally to the east. As with the bathymetric contours, the steepening trend becomes progressively more proximal to the coast southward until the edge of the study area is reached at Martin County’s southern boundary.

Figure 10 shows an initial generalized eastward thickening of unconsolidated sediment offshore of southern Brevard County. Unconsolidated sediments thicken from less than 10 feet (3 meters) to greater than 70 feet (21 meters). This trend continues through northern Indian River County where unconsolidated sediments thicken eastward from less than 10 feet (3 meters) to greater than 30 feet (9.1 meters). Offshore of southern Indian River and progressing southward through St. Lucie and Martin counties, unconsolidated sediments thicken eastward and then thin as the shelf progressively narrows southward.

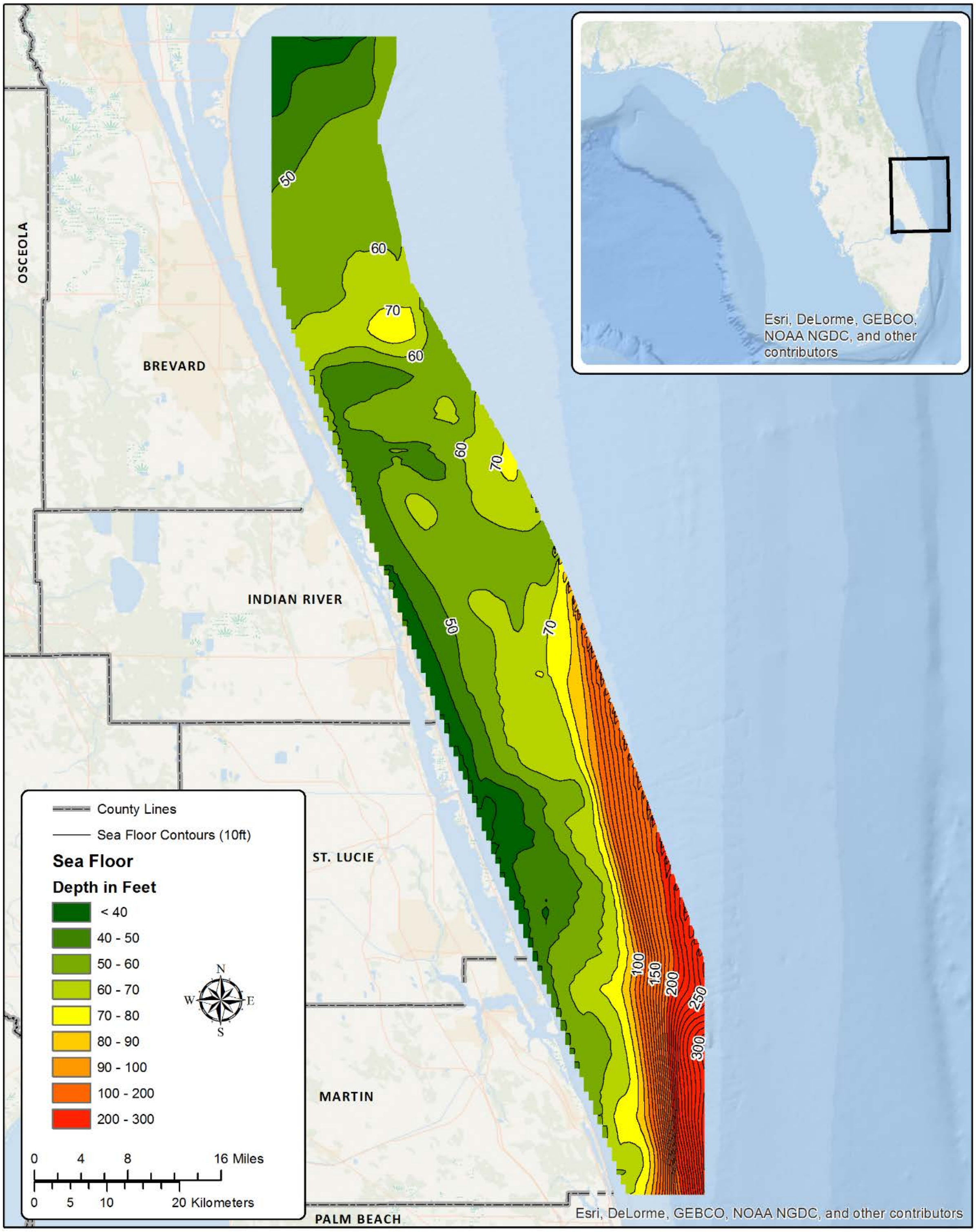


Figure 8. Bathymetric map of the seafloor south of Cape Canaveral based on boomer data collected from 1996 to 2000.

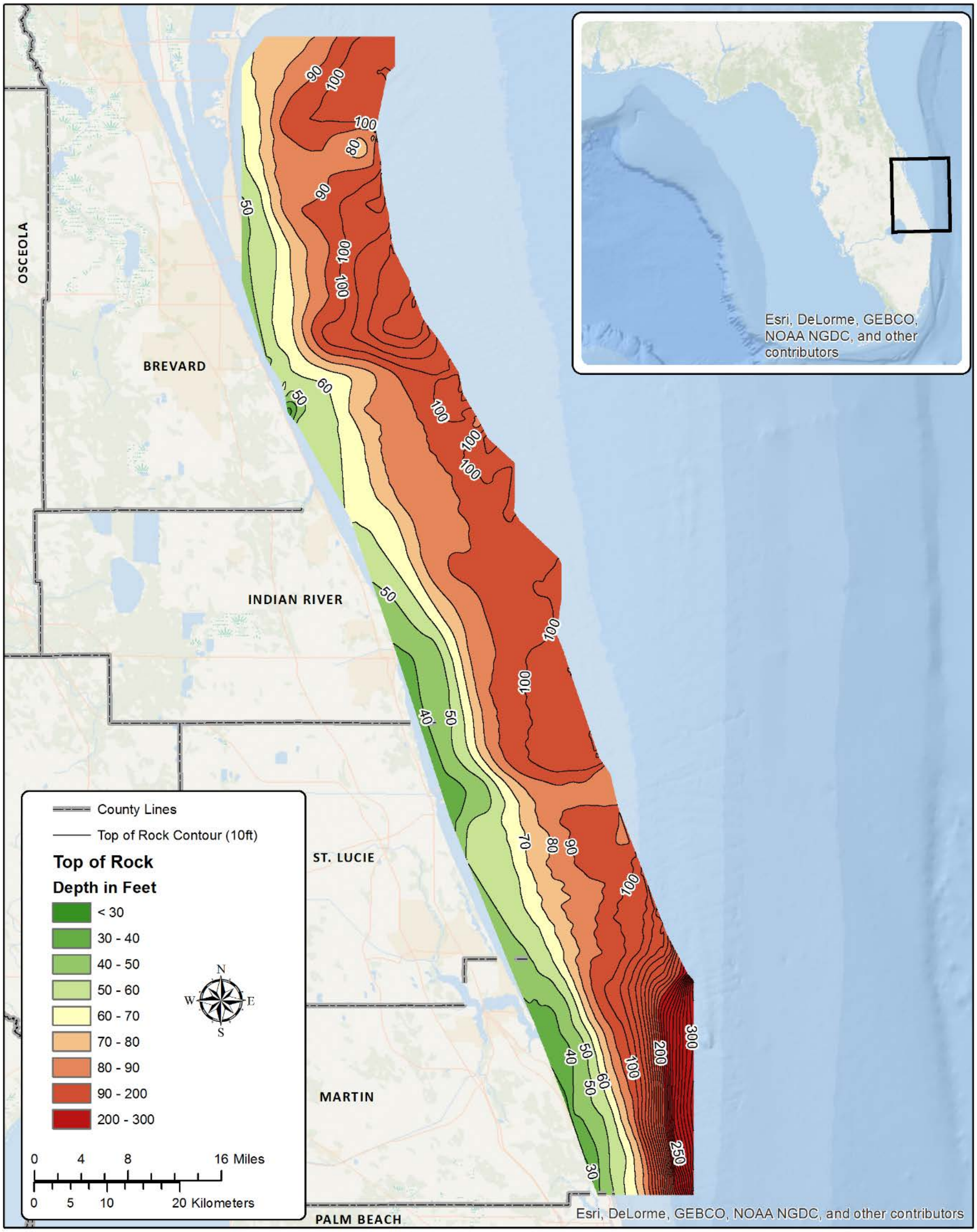


Figure 9. Interpreted top of rock south of Cape Canaveral.

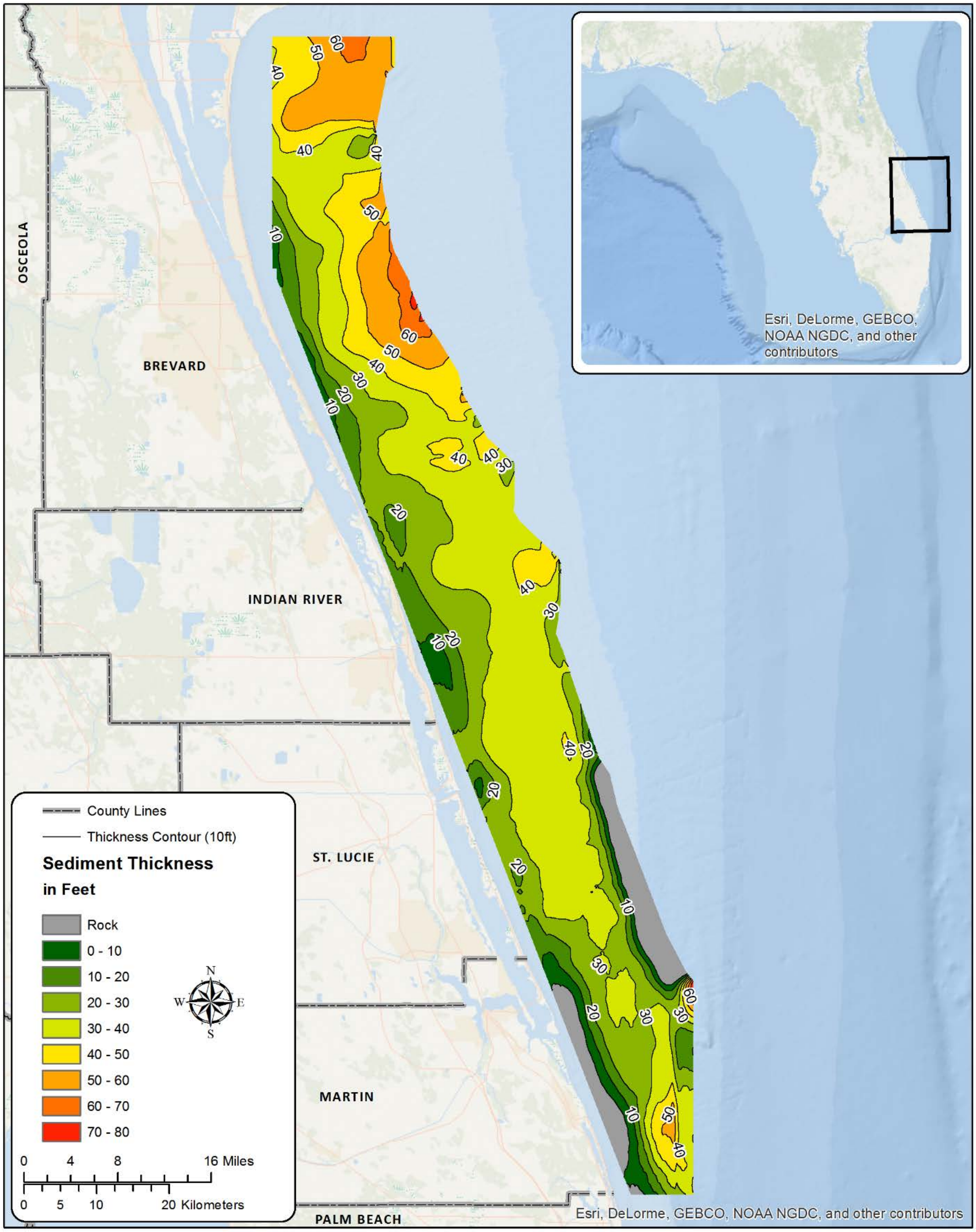


Figure 10. Unconsolidated sediment thickness south of Cape Canaveral based on boomer and chirp data, collected from 1996 to 2000, and 2007, respectively.

Discussion

The analyses presented in this study tied both the seafloor and the top of rock, seen in vibracores, to reflectors seen in specific seismic profiles. Those reflectors were then tied across the geophysical data grid. Correlation of reflectors to vibracores established, wherever possible, direct lithologic control for the base of unconsolidated sediments, and thus the top of rock. Digitization of both reflectors, the seafloor, and the interpreted top of rock allowed calculation of the thickness of unconsolidated sediments. Very few vibracores in the study area penetrate consolidated sediments, so great care was taken to consistently digitize the reflector which directly correlated to the top of rock penetrated by vibracores. In many seismic profiles, that reflector is seen to be truncating underlying consolidated strata. In seismic profiles that cross shoals, the interpreted top of rock reflector was often seen to directly underlie inclined bedding planes at the base of shoals.

The maps created in this study were based primarily upon boomer data, all of which were collected between 10 and 21 years ago. Those boomer data, as processed sections, as well as the chirp data, as processed sections, and the vibracore data utilized can be found at http://rossi.urs-tally.com/. Considering the relatively coarse geographic density of the geophysical data grids and the dated nature of those data, the bathymetric, the top of rock, and the sediment thickness maps produced in this study provide only a broad outline of trends on Florida's northeast and central inner continental shelf. Tighter grids using chirp technology would allow more precise detail for future mapping efforts. Data used in this study did not include data collected under the BOEM's 2016 Broad Area Agreement (BAA). Once those data collected are analyzed, further light will be shed upon the bathymetry, unconsolidated sediment thicknesses, and the top of rock in the study area.

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