Dietsche, Andrew l., Quaternary Evolution of North Core Sound, North Carolina. (Under direction of Dr. David J. Mallinson and Dr. Stephen J. Culver) Department of Geological Sciences, August, 2015.

Northern Core Sound is a shallow lagoonal estuary located behind the Outer Banks barrier islands of eastern North Carolina. Thirty-two vibracores and 155 km of chirp and boomer seismic data have been used to define the geologic framework and establish the Holocene evolution of this back-barrier lagoon. Vibracores have been logged for lithology, and sampled to establish the distribution and abundance of foraminifera. The lithostratigraphy and biofacies could not be directly correlated but when related to the seismic data, apparent patterns could be recognized.

The Quaternary stratigraphic framework of North Core Sound consists of five depositional sequences, comprising transgressive, highstand, and falling stage systems tracts. Seismic reflections are prominent and are correlated to the sequence stratigraphic surfaces within Pamlico Sound defined by Mallinson et al. (2010).

The late Pleistocene paleotopographic surface dips slightly seaward and is characterized by two or three fluvial channels correlating to modern embayments. These channels are separated by a paleotopographic high that extends from Cedar Island seaward. The channels run northeast in the north and southwest in the south creating two different paleo-environments. The paleotopographic high may have contributed to differing foraminiferal assemblages found within Holocene unit.

The Holocene unit is characterized by high salinity estuarine deposits dominated by the foraminifera *Elphidium excavatum* and *Ammonia parkinsoniana*. Three very similar biofacies were defined with more abundant *Ammonia parkinsoniana* where salinities may have been slightly lower. Only a salt marsh facies was significantly

different. The biofacies may also represent the two paleo-environments illustrated in the seismic data as one is mainly found to the north of the paleotopographic high and the other to the south.

Two seismic reflections, H30 and H60, are interpreted as tidal ravinement surfaces and divide the Holocene into three parasequences. Lithologically the units are coarsening upward, which may be a result of the transgressing barrier island (Core Banks) or increased tidal energy related to inlet activity. Radiocarbon age estimates place the lower surface, H30, older than 600 cal y BP, suggesting that this erosional surface is related to the segmentation of the Outer Banks during the Medieval Warm Period or the Little Ice Age, as defined by other workers.

Quaternary Evolution of North Core Sound Sound, North Carolina

A Thesis

Presented To the Faculty of the Department of Geological Sciences

East Carolina University

In Partial Fulfillment of the Requirements for the Degree

Master of Science in Geology

by

Andrew Dietsche

August, 2015

The Quaternary Evolution of North Core Sound, North Carolina

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INTRODUCTION

The Outer Banks are a chain of barrier islands that stretch approximately 300 kilometers from the Virginia/North Carolina border to Cape Lookout (Figure 1). These islands exist in a dynamic state, continuously adjusting their geomorphology in response to processes such as storms and fluctuating sea-level changes. The protrusion of the Outer Banks into the Atlantic Ocean exposes them to intense storms such as hurricanes and nor'easters. A record of these processes occurs within the estuaries behind the barrier islands (e.g., Rosenberger, 2006; Culver et al., 2007; Hale, 2008; Pruitt et al., 2010; Mallinson et al., 2011; Grand Pre et al., 2011).

Core Sound is one of several estuaries in North Carolina separated from the Atlantic Ocean by the Outer Banks. Determining the geologic framework of this area will aid in understanding Holocene coastal dynamics and how Core Sound responded and evolved. This investigation will contribute to understanding the responses of coastal systems to past and future environmental changes in storm patterns and sea-level. North Carolina depends on the Outer Banks for economic and environmental resources; understanding the past, present, and future dynamics of this vast coastal system is important for formulating responsible management policies.

Purpose of This Study

The geology of Core Banks and the mainland adjacent to Core Sound has been studied (e.g., Moslow, 1977; Herbert, 1978; Riggs and Ames, 2007; Mallinson et al., 2010; Riggs, Ames and Mallinson, 2015), but little research has been performed on the geology of Quaternary deposits underlying Core Sound. Seismic data were collected

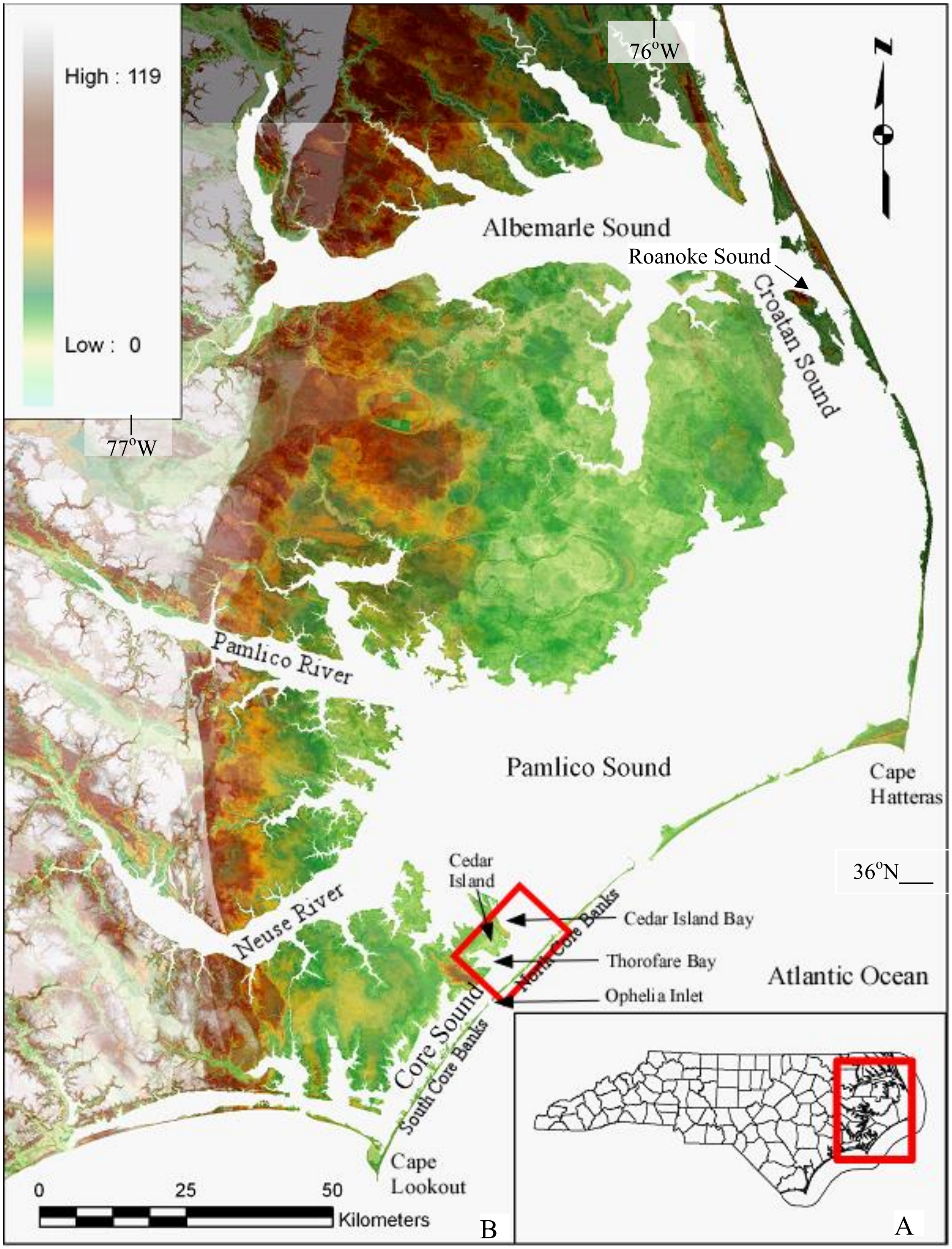


Figure 1 – A) Location of Albemarle/Pamlico Sound boxed in red.
B) Location map with LiDAR based elevations. LiDAR data are from (http://www.ncdot.org/it/gis/DataDistribution/ContourElevationData/). Boxed red area represents study area.

along transects throughout Core Sound (Mallinson et al., 2010); however no core data were acquired to ground-truth the seismic data. An analysis of the seismic data shows several depositional sequences within the Quaternary section. An in-depth study of these seismic data within Core Sound, combined with newly acquired core data, will contribute to the understanding of the Quaternary geologic history and evolution of the area in response to climate and sea-level change. Thus, the focus of this investigation is a geologic assessment of the Quaternary history and an in-depth look at Holocene environments of deposition, including an evaluation of late Holocene barrier island segmentation in this area (Culver et al., 2007; Grand Pre et al., 2011).

In this study, the dynamic coastal processes of North Carolina will be documented and further understood. Determining the sediments/stratigraphic characteristics in Core Sound will provide data to define environmental fluctuations (changes in salinity, current activity, etc.) that have occurred locally in response to climate change including sea-level, storm events, opening and closing of inlets, and changes in island geomorphology.

Objectives

The main objectives of this study are to define the geologic framework of northern Core Sound, describe its late Quaternary geologic history, and determine whether evidence exists to document any major Holocene events (such as process of formation and barrier island segmentation due to major storm impacts). This will be accomplished by conducting field and laboratory research to address five objectives.

1. **Define the Seismic Stratigraphic Framework**

   Determine the geometry of the depositional sequences which will provide an enhanced understanding of the regional stratigraphic framework.

2. **Describe the Lithostratigraphy**

   Determine the lithostratigraphic characteristics of the subsurface and determine lithofacies. Grain size, sorting, composition, sedimentary structures, contacts and fossil content will be used to establish lithofacies.

3. **Describe the Biofacies**

   Define biofacies using detailed analysis of foraminifera within cores. These data, in combination with lithofacies will help establish paleoenvironments.

4. **Determine the chronostratigraphy**

   Utilize radiocarbon age estimates, as well as chronological data from local studies to help create a chronology for the lithofacies, biofacies and paleoenvironments of deposition.

5. **Interpret Paleoenvironment of deposition**

   Reconstruct the paleoenvironmental evolution of northern Core Sound by utilizing information from previous objectives.

Study Site

Core Sound is located in Carteret County, North Carolina (Figure 1). The Sound is bordered to the northeast and southwest by Pamlico Sound and Back Sound respectively (Figure 1). Core Banks and the mainland form the eastern and western margins of Core Sound. The Sound varies from 3.25 to 4.9 kilometers wide. Several bays occur on the western margin of Core Sound (Figure 1). Water depths are greatest at bay mouths (~3 m), and shoal toward the flood-tide delta associated with Ophelia Inlet in the south (Figure 2). In recent years, three inlets have been associated with Core Sound, New Drum Inlet, New Old Drum Inlet, and Ophelia Inlet (Fisher, 1967; Mallinson et al., 2008). New Old Drum Inlet opened at the same location of Old Drum Inlet during Hurricane Dennis in 1999 (Riggs and Ames, 2007; Mallinson et al., 2008). Ophelia Inlet was opened in 2005 during Hurricane Ophelia (Mallinson et al., 2008). New Old Drum Inlet and New Drum Inlet closed in 2012 and Ophelia Inlet remain open between North and South Core Banks in August 2015. Some ephemeral inlets, which opened and closed on annual to decadal timescales, include Cedar Inlet, Sand Island Inlet, New Inlet, Whalebone Inlet, and Swash Inlet (Fisher, 1967; Riggs and Ames, 2007). The study area is northern Core Sound, defined as extending from Ophelia Inlet in the south, to the northeastern limit of Core Sound where it opens into Pamlico Sound.

Previous Work

Geologic Setting

The United States Atlantic coastline, including eastern North Carolina, is a passive margin (Riggs et al., 1995). This margin is not tectonically active and has a low-lying, gently sloping coastal region. Core Sound occurs along the southern flank of a structural low known as the Albemarle embayment (Riggs et al., 1992). This low is filled by up to 90 m of Quaternary sediment, which thickens northward and seaward (Mallinson et al., 2005; Mallinson et al., 2010). Holocene sea-level rise has produced modern transgressive barrier islands perched on top of this geologic framework (Riggs et al., 1995; Mallinson et al., 2005; Culver et al., 2008, 2011). Geomorphic features of the coastal region of North Carolina are produced by interactions between coastal processes, changing climatic patterns and the underlying geologic framework (Riggs et al., 1992; Mallinson et al., 2005, 2010). The result of these interactions produce a series of depositional environments that include the inner continental shelf, barrier islands, estuarine and riverine systems, and associated mainland (Mallinson et al., 2005, 2010). These environments, in turn, are modified by dynamic depositional and erosional processes.

Similar investigations to this study have been conducted within the Albemarle embayment in Croatan, Roanoke, and Pamlico Sounds (Figure 1) (Riggs et al., 1992; Smith, 2004; Mallinson et al., 2005; Ricardo, 2005; Culver et al., 2006; Rosenberger, 2006; Twamley, 2006; Culver et al., 2007; Foley, 2007; Smith, 2007; Grand Pre et al., 2011). Riggs et al. (1992), Mallinson et al. (2005, 2010), and Culver et al. (2006, 2008, 2011) correlated Quaternary sediment layers with sea-level fluctuations using amino acid racemization and radiocarbon age estimates (Wehmiller et al., 2010; Mallinson et al., 2010). Seismic data reveal up to 18 seismic sequences in the Quaternary sediment record, at least seven of which have been supported directly by the litho-, bio-, and aminostratigraphic subsurface analysis of core samples (Riggs et al., 1992). Mallinson et al. (2010) likewise defined the characteristics and ages of seven regionally continuous depositional sequences within the Quaternary section beneath the Pamlico Sound. The uppermost sequence comprises Holocene sediments, which were deposited above the Last Glacial Maximum unconformity, and infill the paleo-drainage systems that control some modern coastal characteristics (e.g., bathymetric variations, inlet occurrences, sediment distributions, etc.).

Major fluctuations in sea level throughout the Quaternary have created shifting centers and patterns of depositional environments and submarine/subaerial erosional processes (Riggs et al., 1992). As a result, the coastal system repeatedly reworks and destroys much of the prior deposits and creates an extremely complex sediment record (Riggs et al., 1992). A feature which occurs after a glacial episode is a ravinement surface which eliminates part of the geologic record as the result of shoreface erosion during sea-level rise (Riggs et al., 1992). The occurrence of ravinement surfaces beneath Core Sound has been confirmed through the analysis of the most recent boomer seismic data from the study area (D. Mallinson, personal communication, March, 2010). Ravinement surfaces are clearly present in the Quaternary stratigraphic column beneath Pamlico Sound just north of Core Sound (Mallinson et al., 2010).

During the lower sea level of the last glacial maximum, fluvial processes incised into the Albemarle embayment (Riggs et al., 1995; Mallinson et al., 2005, 2010; Culver et al., 2008, 2011). Because of North Core Sound proximity to the paleo-Neuse channel, it is likely that a small part of northeastern North Core Sound, near the Pamlico Sound boundary, drained into the paleo-Neuse river (Figure 2, 3).

Geology of the Holocene section of the Outer Banks region has been investigated by Ricardo (2005), Grand Pre et al. (2006), Rosenberger (2006), Twamley (2006), Culver et al. (2007), Foley (2007), Smith (2007), Hale (2008), Metger (2008), McDowell (2009) and Grand Pre et al. (2011), who defined the geologic framework and paleoenvironments

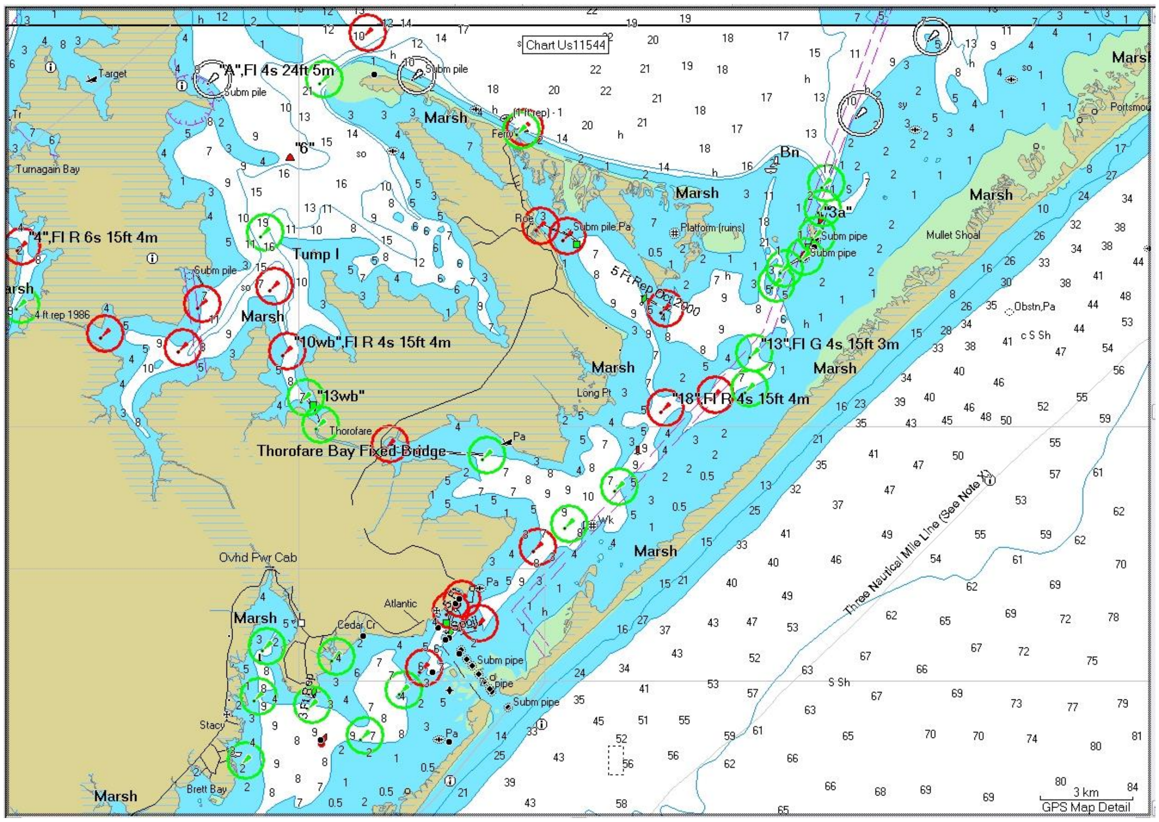


Figure 2 – Chart shows the modern bathymetry of northern Core Sound. Depths are indicated in feet below mean low water (NAVD88 datum).

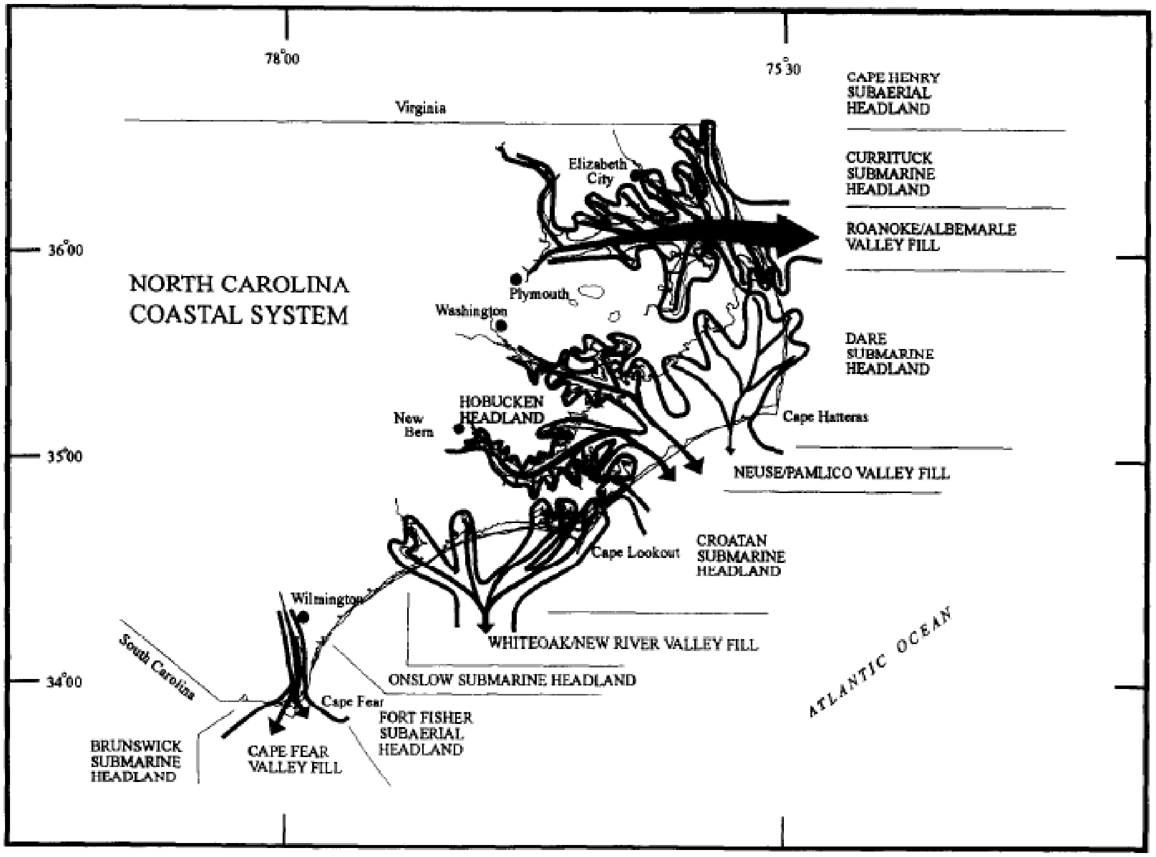


Figure 3 - Map showing major paleo-fluvial valleys and associated interfluve headland features in North Carolina (Riggs et al., 1995)

for their study areas using foraminiferal assemblages, lithofacies, geophysical and geochemical methods. Geophysical methods (seismic or ground penetrating radar) were used to locate paleofeatures (inlets, fluvial surfaces, ravinement surfaces) that provided the framework for biofacies/lithofacies analyses. Each study found normal salinity environments in Pamlico Sound that were attributed, in part, to segmentation of the barrier islands at least twice (ca. 4,000 to 3500 and ca. 1,100 to 500 cal BP, Grand Pre et al., 2011) during the Holocene. The majority of the Core Sound area was characterized by an interfluve called the Croatan Submarine Headland (Riggs et al., 1995) (Figure 3).

Moslow (1977), Herbert (1978) and Moslow and Heron (1978) conducted detailed descriptions of the underlying stratigraphy for North and South Core Banks. On North Core Banks, auger holes were drilled to depths up to 30 m (~100 ft) (Figure 4). The lowest recorded unit is a very fine to fine, green-gray, sandy-clay; this is capped by a light gray arenaceous bio-sparudite (Herbert, 1978). These two layers are part of the shallow shelf Yorktown Formation (Moslow, 1977; Herbert, 1978), dated to mid to late Pliocene (Snyder, 2001). The upper boundary produces a high amplitude seismic reflection and is easily identified (Mallinson et al., 2010).

A fine to very coarse, gray-green, highly fossiliferous clayey sand lies above the Yorktown Formation, named the Core Creek Sand (Herbert, 1978). Core Creek Sand samples have yielded radiometric "dead" age estimates of >36,320 and >35,590 years BP. The Core Creek Sand correlated to the Sandbridge Formation of Virginia which has been dated to 50,000 to 70,000 years BP (Susman and Heron, 1979), dips gently toward the northeast below Core Banks.

Above the Core Creek Sand is a lens of fine to very coarse, well-sorted sand that occurs about 50 to 60 m below New Drum Inlet. This unit, the Atlantic Sand (Herbert, 1978), pinches out below North Core Banks about 5-6 km northeast of New Drum inlet. Above the Core Creek Sand and Atlantic Sand is a dark gray-green silty-clay called the Diamond City Clay, with an age estimated estimated at 24,000 to 29,000 years BP based on radiocarbon dating (Susman and Heron, 1979). The Core Creek Sand, Atlantic Sand, and Diamond City Clay are thus late Pleistocene in age (Moslow, 1977; Herbert, 1978; Moslow and Heron, 1978; Susman and Heron, 1979). The Holocene section is represented by a single unit, the Core Banks Sand is a medium gray, silty, very fine to medium sand. The modern surface of Core Banks has fine to coarse sand that is variably sorted, with extensive relict inlet-fill scattered throughout the length of the island.

Moslow (1977) described six lithologic units under South Core Banks, from which he derived a number of general conclusions. Transgressive and regressive events characterize the Pleistocene, and the Atlantic Sand represents an ancient barrier island system. According to Moslow (1977) Core Banks originated during the Holocene as an elongate spit complex or by mainland beach detachment. The island has been migrating westward due to Holocene rising sea level. The Holocene section records the last 7,000 years and comprises three depositional environments (barrier, backbarrier, and migrating inlet) and ten sub-environments. Finally, much of the Holocene section is reworked by migrating inlets.

Herbert (1978) derived similar conclusions for North Core Banks with some exceptions. Moslow (1977) determined the Atlantic Sand to be a paleo-barrier island deposit, whereas Herbert (1978) interpreted the Atlantic Sand as paleo-inlet fill because

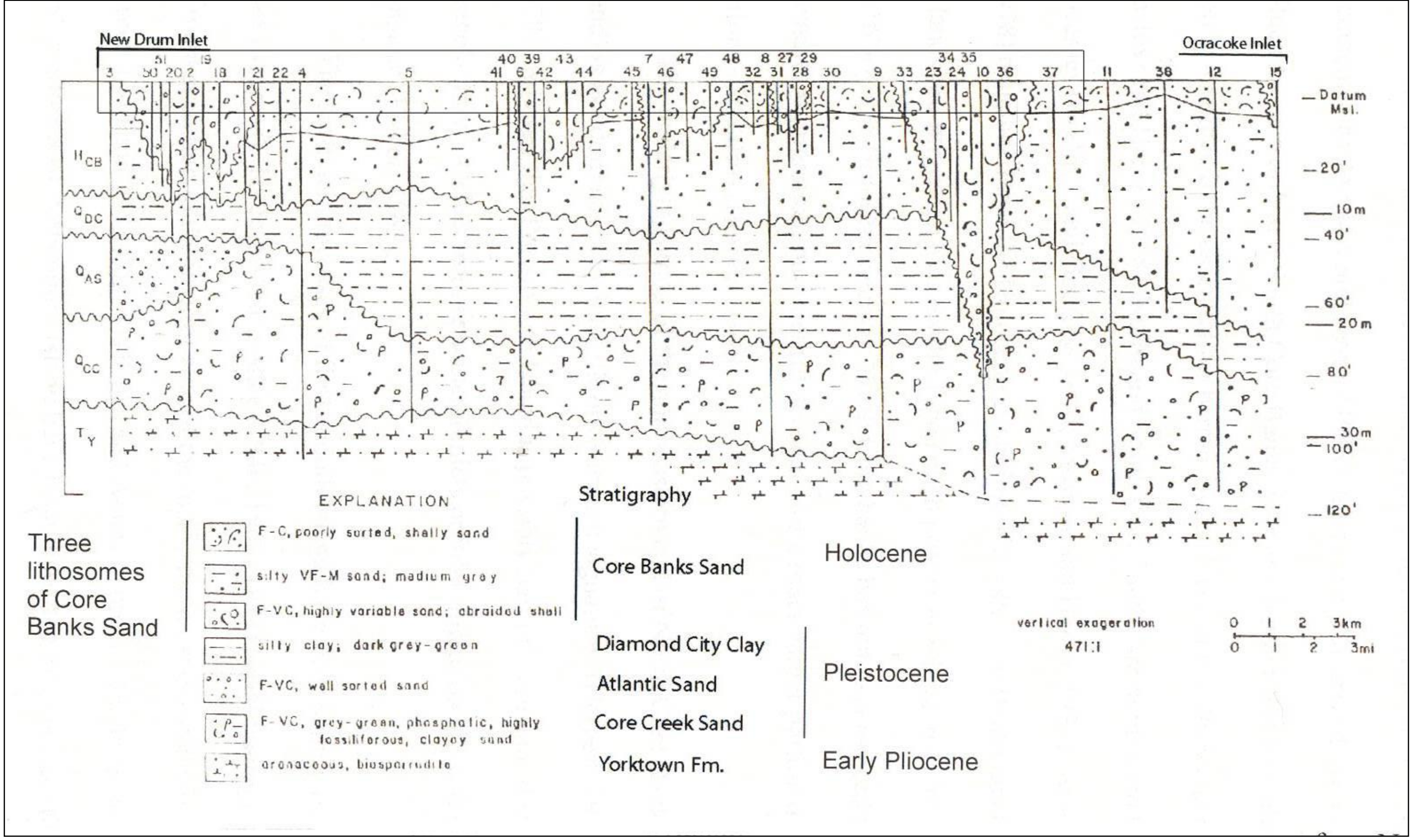


Figure 4 – Quaternary Stratigraphy of North Core Banks (modified from Herbert, 1978 and Rosenberger, 2006). Based on auger boring data collected on a transect from New Drum Inlet to Ocracoke Inlet. Area of current study is boxed

of evidence supporting an erosional surface between the Atlantic Sand and the Core Creek Sand. Herbert (1978) also indicated that 40% of the Holocene sediment was reworked by migrating inlets.

Rosenberger (2006) defined the Holocene geologic evolution of the Portsmouth Island segment of North Core Banks, immediately north of the current study area. Six paleo-environments were identified within the study area: marsh, barrier island/sand flat, inner-shelf A, inner shelf B, low energy shelf, and normal salinity inlet. The lithology and foraminiferal assemblages indicate that a low energy, normal salinity environment occurred behind a subtidal shoal from 1200 to 500 cal. yr BP, the same time as a documented segmentation of the southern Outer Banks (Portions of Ocracoke Island and North Core Banks; Culver et al., 2007; Grand Pre et al., 2011).

Foraminifera

Foraminifera can be used to reconstruct paleoenvironments (Scott et al., 2001). The abundance and specific distributions of different types of foraminifera correlate to specific coastal depositional environments (Figure 5). Studies of the North Carolina coast have used foraminifera to indicate Holocene environmental changes (e.g., Smith, 2004; Abbene et al., 2006; Vance et al., 2006; Culver et al., 2006; Twamley, 2006; Smith, 2007; Rosenberger, 2006; Culver et al., 2007; Hale, 2008; Pruitt et al., 2010; Grand Pre et al., 2011). Ricardo (2005), Rosenberger (2006), Twamley (2006), Metger (2008) Smith (2007) Hale (2008) and Grand Pre et al. (2011) defined the geologic framework for their study areas by determining foraminiferal assemblages down-core that

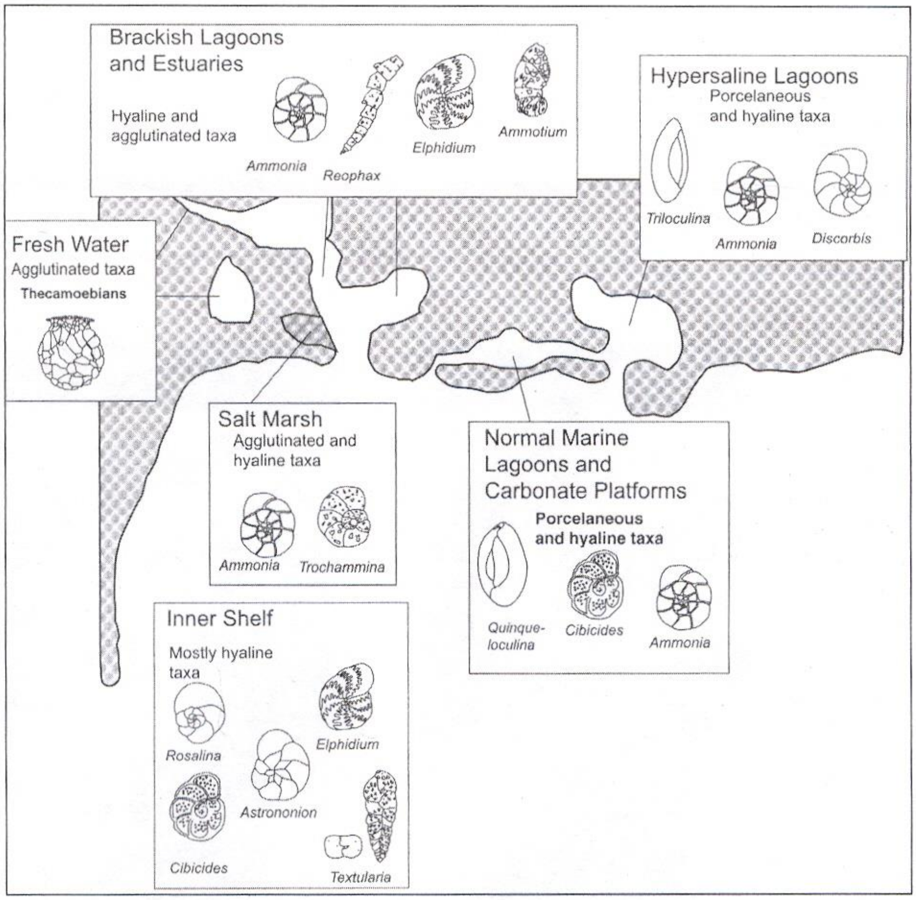
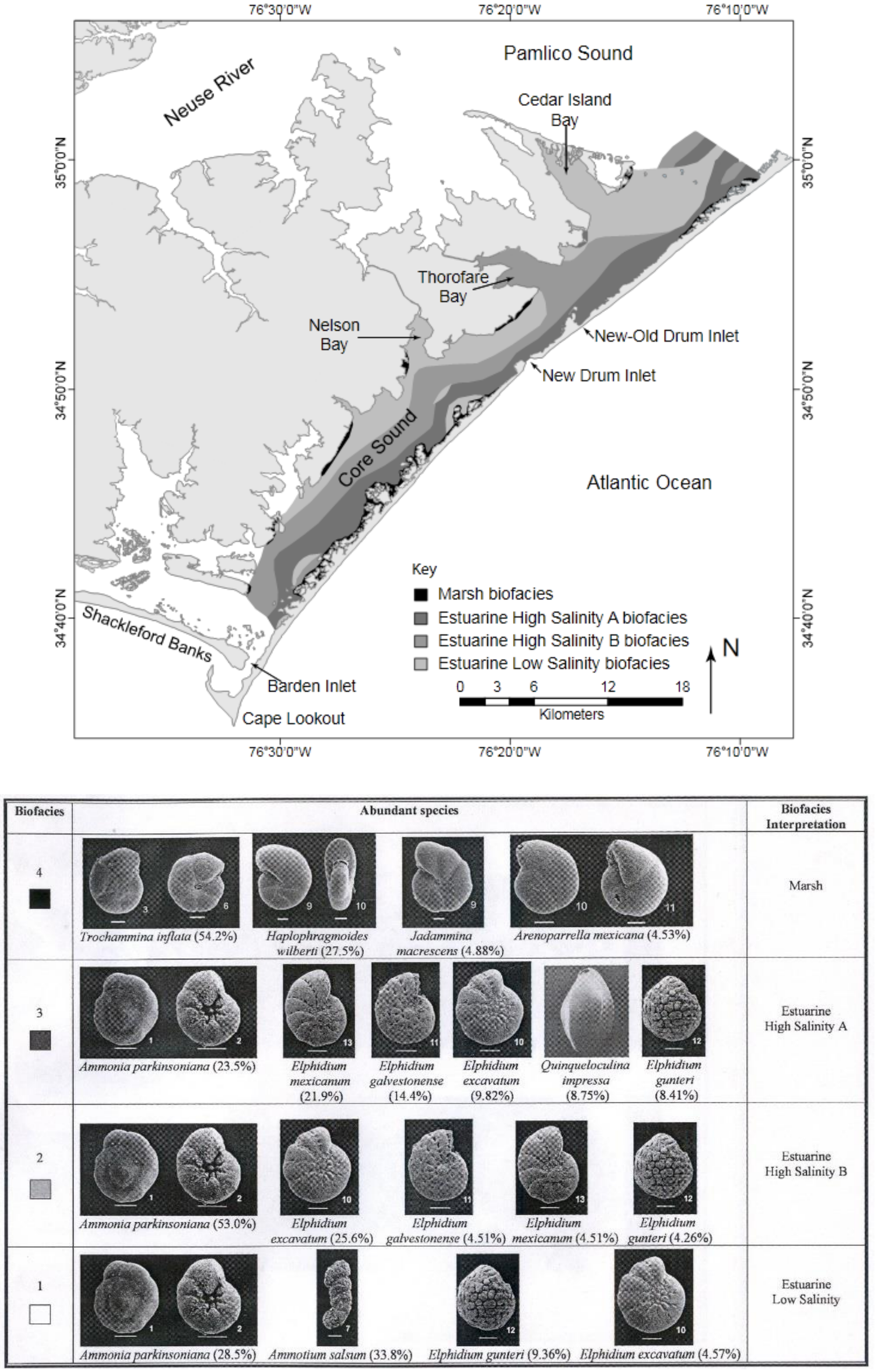


Figure 5 - Map showing typical foraminiferal assemblages associated with various marginal marine environments and adjacent marshes (Scott et al., 2001)



Biofacies	Abundant species	Biofacies Interpretation
4 ■	*Trochammina inflata* (54.2%) *Haplophragmoides wilberti* (27.5%) *Jadammina macrescens* (4.88%) *Arenoparrella mexicana* (4.53%)	Marsh
3 ■	*Ammonia parkinsoniana* (23.5%) *Elphidium mexicanum* (21.9%) *Elphidium galvestonense* (14.4%) *Elphidium excavatum* (9.82%) *Quinqueloculina impressa* (8.75%) *Elphidium gunteri* (8.41%)	Estuarine High Salinity A
2 ■	*Ammonia parkinsoniana* (53.0%) *Elphidium excavatum* (25.6%) *Elphidium galvestonense* (4.51%) *Elphidium mexicanum* (4.51%) *Elphidium gunteri* (4.26%)	Estuarine High Salinity B
1 ☐	*Ammonia parkinsoniana* (28.5%) *Ammotium salsum* (33.8%) *Elphidium gunteri* (9.36%) *Elphidium excavatum* (4.57%)	Estuarine Low Salinity

Figure 6 - A) Spatial distribution of four biofacies using total (live and dead) foraminifera (Pruitt, 2008; Pruitt et al., 2010)B) Abundant species found in four biofacies from surface samples in Core Sound (Pruitt, 2008; Pruitt et al., 2010).

could be used to determine paleo-environments. Their data suggest that a normal salinity environment was present behind the modern barrier islands during the late Holocene, and support the idea of barrier island segmentation (Culver et al., 2007; Grand Pre et al., 2011.

Modern foraminiferal distributions of Core Sound were defined by Pruitt (2008) and Pruitt et al. (2010). Four biofacies were identified: Marsh, Estuarine High Salinity A, Estuarine High Salinity B, and Estuarine Low Salinity (Figure 6). Marsh is mainly found around shorelines of the Core Banks and the mainland (Pruitt et al., 2010). Estuarine High Salinity A is found closer to Core Banks, whereas estuarine High Salinity B is mainly found along the western Sound (Pruitt et al., 2010) (Figure 6). Pruitt et al. (2010) obtained seven push cores in mainland bay sediments to determine if the paleoenvironment has recently changed. Biofacies changes were minimal in each core. This indicates little environmental change has occurred in the past few hundred years (Pruitt et al., 2010).

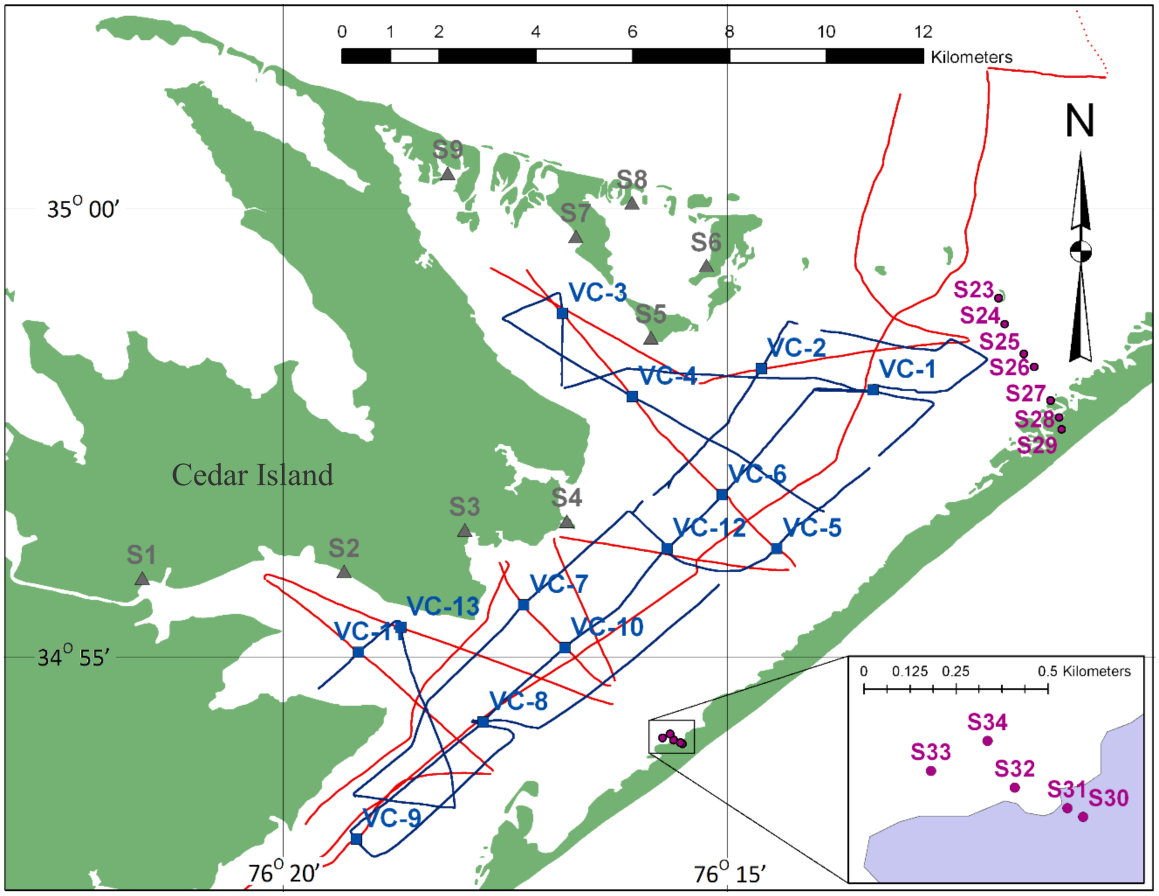


Figure 7 - Enlarged view of study area depicts the locations of seismic lines as follows: boomer data (red line), chirp data (blue line), vibracore locations on Cedar Island (grey triangles with S labels), Core Sound (blue squares wth VC labels) and Core Banks (purple circles with S labels).

METHODS

Multiple lines of evidence were used to define the Holocene geologic evolution of North Core Sound. Several geophysical and geological tools have been used to visualize, sample, and evaluate the sediment deposited below Core Sound.

Geophysical Methods

The geometry of depositional sequences was determined to enhance our understanding of the regional stratigraphic framework. Boomer seismic data were obtained using a GeoPulse and Huntec boomer seismic source and ITI hydrophone streamer. Data were recorded with Triton ISIS acquisition software (Mallinson et al., 2010). About 100 kilometers of shore-parallel and shore perpendicular data were collected in and around Core Sound (Figure 7). Fifty-five kilometers of chirp seismic data have also been collected along shore-parallel and shore-perpendicular lines in Core Sound for higher resolution imaging of the shallower sediment (Figure 7). Chirp seismic data were collected using an Edgetech 216 (2 to 16 kHz) chirp sub-bottom profiling system, Discovery software, and a Garmin differential GPS.

The boomer and chirp seismic data were analyzed using Seismic Micro-Technology, Inc., Kingdom Suite software. Medium to high amplitude horizons were digitized and several were found to be continuous throughout the study area. Horizons were gridded in two-way travel-time domain by running the travel-time value of a horizon through the gridding algorithms Flex Gridding, Nearest Neighbor or Gradient Projection. These grids interpolate time values for parts of the layer that were not directly measured by the seismic survey to produce a reflection surface. Each of these grids provided information about the orientation and topographical relief, if any, of the horizon. A 3-D model depicting a fence diagram of seismic lines was created in Kingdom Suite. The grids were added to the 3-D diagram to help interpretation. Boomer and chirp seismic analysis produced areas of interest that helped determine core locations.

Several boomer and chirp seismic transects were chosen specifically to illustrate sequence boundary and depositional sequence characteristics. These data were digitized in ACD Systems Canvas software. Boomer transects were chosen by quality of seismic reflections and coverage of study area; one transect runs down the length of Core Sound the other two are up-embayment and perpendicular to Sound length (Figure 8). Chirp transects were chosen to follow boomer data as closely as possible with the exception of an extra transect in the north (Figure 9).

Vibracore Acquisition

In 2004, eight vibracores on Core Banks and eight vibracores on Cedar Island were acquired; these terrestrial cores were used to place data from Core Sound into a broader geologic concept. An evaluation of the lithology of the study area was conducted by obtaining 13 vibracores within Core Sound in 2009. The locations for each vibracore were predetermined by the analysis of the previously acquired boomer and chirp seismic data. Core Sound vibracore transects are illustrated in Figure 7. Precise locations were recorded using a global positioning system (GPS) (Table 1).

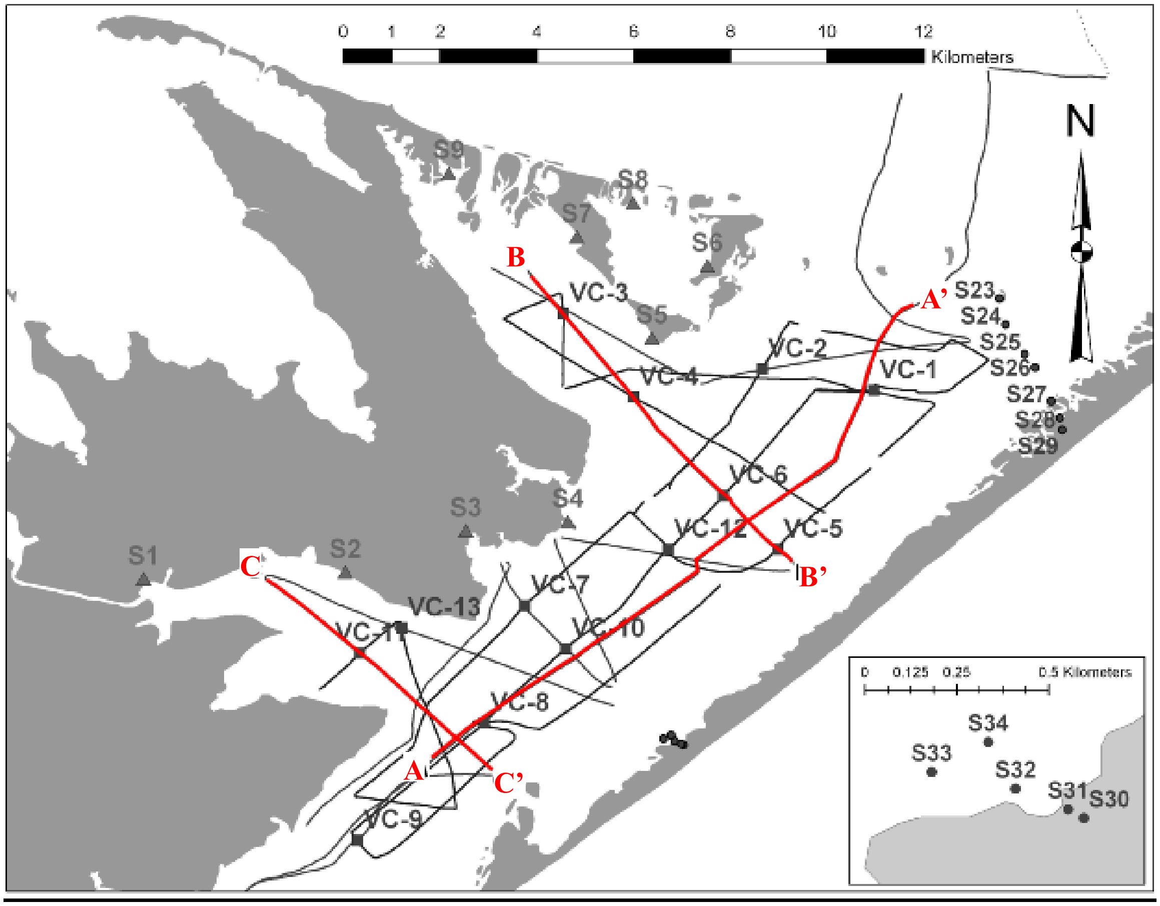


Figure 8 - Location map of boomer transects (red lines) discussed in this study. Seismic transects A-A' through C-C' presented as figures 10-12.

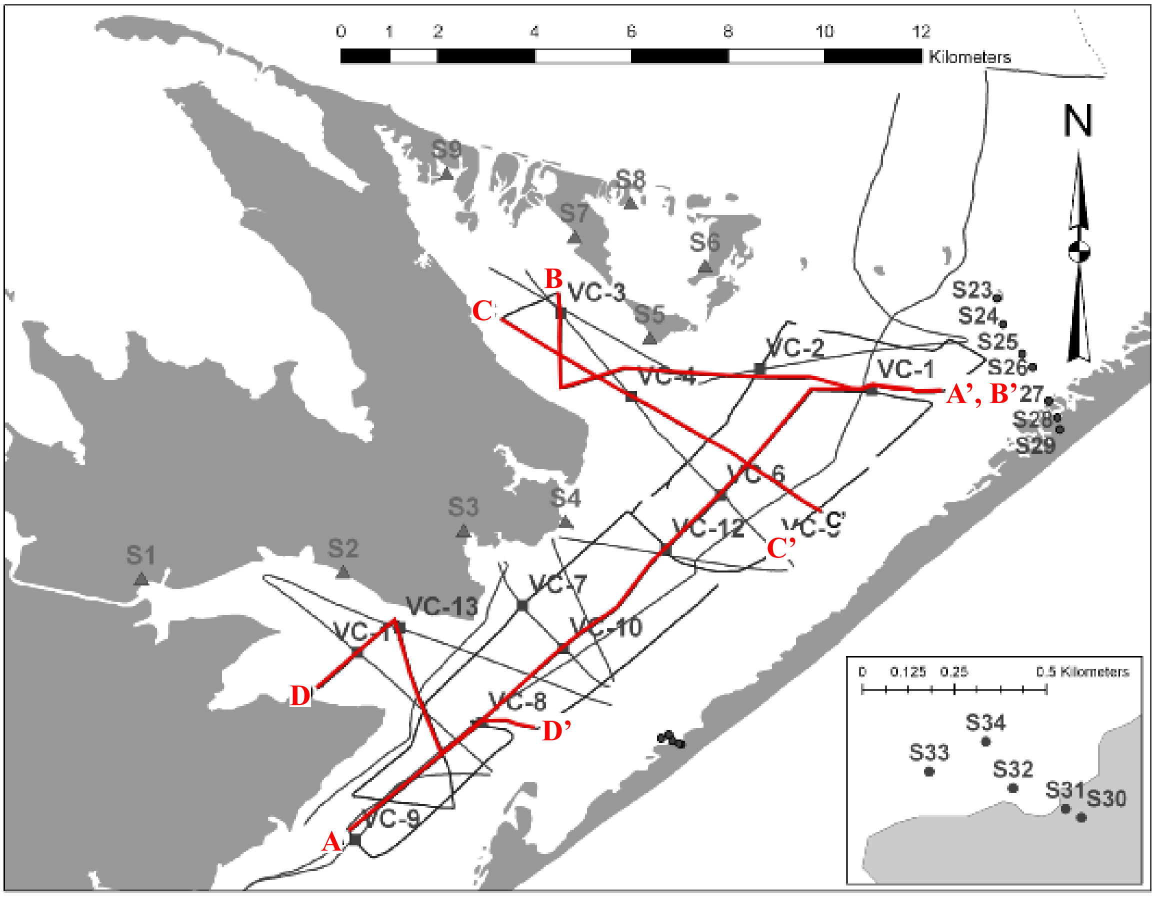


Figure 9 - Figure 8 - Location map of chirp transects (red lines) discussed in this study. Seismic transects A-A' through D-D' presented as figures 14-17.

Table 1 - Latitude and Longitude of vibracores measured in degrees and decimal minutes. Elevation, penetration and recovery of core also shown. CDR = Cedar Island, CS = Core Sound, and NCB = North Core Banks. CDR cores taken at marsh edge with estimated base sea level elevation. NCB core elevation estimated using figure 2. NR=Not Recorded.

Core Names	**Latitude North**		**Longitude West**		**Elevation (mbsl)**	**Penetration (meters)**	**Recovery (meters)**
CDR-04	Degree	Dec. minutes	Degree	Dec. minutes			
S1	34	55.846	76	21.489	0	NR	2.68
S2	34	55.921	76	19.242	0	NR	NR
S3	34	56.383	76	17.895	0	NR	NR
S4	34	56.482	76	16.757	0	NR	NR
S5	34	58.532	76	15.822	0	NR	2.11
S6	34	59.337	76	15.203	0	NR	1.15
S7	34	59.660	76	16.656	0	NR	NR
S8	35	0.037	76	16.029	0	NR	3.11
S9	35	0.368	76	18.086	0	NR	NR
CS-09	Degree	Dec.Minutes	Degree	Dec.Minutes			
VC-1	34	57.929	76	13.337	2.53	5.94	5.28
VC-2	34	58.180	76	14.593	3.23	4.64	4.64
VC-3	34	58.801	76	16.808	2.5	2.87	2.38
VC-4	34	57.870	76	16.029	2.07	2.43	1.77
VC-5	34	56.175	76	14.420	1.83	4.29	3.58
VC-6	34	56.775	76	15.028	2.32	3.64	2.43
VC-7	34	55.544	76	17.240	2.32	3.49	2.91
VC-8	34	54.237	76	17.691	3.05	3.96	3.61
VC-9	34	52.931	76	19.103	1.07	6.87	6.39
VC-10	34	55.065	76	16.783	2.35	4.28	3.88
VC-11	34	55.016	76	19.080	2.59	4.83	4.83
VC-12	34	56.175	76	15.642	2.35	4.32	3.43
VC-13	34	55.294	76	18.610	2.38	4.46	4.46
NCB-04	Degree	Dec.Minutes	Degree	Dec.Minutes			
S23	34	58.971	76	11.950	0	NR	2.63
S24	34	58.678	76	11.880	0.75	NR	2.75
S25	34	58.350	76	11.668	1	NR	3.85
S26	34	58.203	76	11.553	1	NR	NR
S27	34	57.826	76	11.370	0.75	NR	1.69
S28	34	57.637	76	11.274	0	NR	1.75
S29	34	57.506	76	11.246	0	NR	NR
S30	34	53.994	76	15.470	0	NR	2.06
S31	34	54.007	76	15.493	0	NR	NR
S32	34	54.037	76	15.570	0.5	NR	2.08
S33	34	54.062	76	15.693	0.5	NR	NR
S34	34	54.106	76	15.610	0.5	NR	2.53

Vibracores were aquired using a 3 inch diameter aluminum tube vibrated by a small motor. Each vibracore was driven as deep as possible (up to 8 m) in an attempt to acquire a complete Holocene sedimentary record. Vibracores were used to ground-truth and define lithology of reflectors imaged on processed seismic data. Lithofacies and biofacies were determined from the recovered sediment.

Lithologic Analysis

On return to the laboratory, each core was cut length-wise using a circular saw. One half was photographed and archived for future reference. The other half was sampled for lithology, foraminifera, and organic and carbonate material suitable for carbon-14 age analyses. Sediment structures, grain size, sorting, composition, color and fossils were recorded throughout each core using the methodology of Folk (1974). Core logs were created and then digitized in Rock Works 2006 (Rock Works Software Inc). The lithology was correlated to cores which had been collected previously on Core Banks (Moslow, 1977; Herbert, 1978).

Foraminiferal and Sediment Analysis

Ninty-eight Samples for foraminiferal analysis were taken down-core from differing lithofacies to aid in the definition of depositional environments (Appendix 2, 3, 4). In cases where the lithofacies was continuous or having specific characteristics (eg., very shelly layers, laminae) additional samples were taken at appropriate intervals to provide a more complete data set. Samples were dried at 60°C and weighed. After soaking in water with sodium metaphosphate $[(NaPO_3)_x{*}Na_2O]$ and sodium hydroxide

(NaOH) to disaggregate any mud and organic material, samples were wet sieved through 63 and 710 micron sieves to isolate sand and gravel fractions. These splits were dried and weighed and gravel/sand/mud ratios were calculated (Appendix A). Gravel and sand fractions were microscopically examined and described. Foraminifera in the sand fraction were concentrated using sodium polytungstate (Munsterman and Kerstholt, 1996). The float was split into fractions using a microsplitter and each split was spread evenly onto a gridded picking tray.

Foraminifera were selected randomly using a random numbers table to determine the grid squares to be picked. Two hundred foraminifera (all if less than 200) were picked for each sample. The foraminiferal taxa were identified to the species level and identifications were confirmed by comparison with type and figured specimens lodged in the Cushman Collection, Smithsonian Institution, Washington, D.C.

Rare species are not reliable indicators of foraminiferal patterns (Koch, 1987). Foraminiferal abundance data were reduced to include only those species that represented two percent or more of the assemblage in any particular sample. Any sample that only contained one specimen was also removed from the dataset. Raw data counts were converted into relative abundance data, then to transformed abundance using the equation: $2\arcsin\sqrt{p}$ (p=abundance). The transformed abundance data were used for cluster analysis.

The Using Systat 10.2 (Systat Software, Inc.) a cluster analysis (Q mode, Ward's linkage and Euclidean distances) was performed to define foraminiferal assemblages and biofacies (Mello and Buzas, 1968). Average percent abundance of each taxon was calculated for each biofacies. The average percent abundance was then compared to modern foraminifera assemblages found by Pruitt el al. (2010).

Radiocarbon Age Estimates

Carbon-14 analyses were performed on organic matter and shell remains at Beta Analytic, Inc. Preference was given to articulated bivalves which indicate minimal reworking. A pecten shell, a *Mercenaria mercenaria* shell fragment, woody material from peat, and 1000 specimens of the foraminifer *Elphidium excavatum* were analyzed. Mollusk shells and foraminiferal tests were calibrated using the marine ^{14}C calibration curve (Hughen et al., 2004) which includes a 401 year residence time adjustment. Woody material was calibrated using the standard terrestrial calibration curve (Reimer et al., 2004).

RESULTS

Geophysical Data

Boomer data (100 km within the study area) were used to image the subsurface to a depth of ca. 35 meters below sea level, using a frequency range of ca. 300 to 1000 Hz. Theoretical resolution ($\lambda/4$) obtained by this method is approximately 0.5-1 m (Sheriff, 1977). Chirp seismic uses higher frequencies (2-16 kHz) than boomer seismic resulting in shallower penetration but providing a theoretical resolution of approximately 2.0-2.5 cm. Chirp data were recovered to 20 m below sea level in the northern section of the study area and 10 m to 11 m below sea level in the southern section.

Seismic Horizons and Units

The seismic data image only a small area of inner shelf to estuarine units; however, some significant observations can be gained based on the seismic framework and boundary characteristics. Data collected in the study area showed reflections as deep as 35 m below sea level (based on an acoustic velocity of 1600 ms^{-1}; Mallinson et al., 2010). Between four and eleven horizons were depicted in any seismic profile. Horizons tended to show less topographic relief and to be more continuous in shore-normal lines. Horizons depicted in shore-parallel lines tended to show more topographic relief and sometimes merged with other horizons, or were truncated.

Four reflections had characteristics of subaerial surfaces, marked by fluvial channels (cut-and-fill facies; Catuneanu et al., 2009), truncation of underlying reflections, and topographic relief. These reflections are medium to high amplitude and regionally continuous. These erosional surfaces are interpreted as sequence boundaries

(Van Wagoner et al., 1992; Catuneanu, 2006); their associated reflections are explained in detail in following sections.

The sequence boundaries defined below bound five seismic units. Because of the demonstrated unconformable contacts between these units, they can be defined as depositional sequences (genetically-related strata bounded by unconformities or their correlative conformities; Van Wagoner et al., 1992). The depositional sequences and their attributes are defined below, in stratigraphic succession from oldest to youngest (Table 2).

Sequence Boundary 1 (SB1)

This high amplitude reflection is the acoustic basement throughout the study area (i.e., no reflections are seen below it). It is generally 28 to 35 m below sea level. Digitization and gridding of this reflection reveal that it dips gently east to the southeast; the gradient of the dip was 0.88 m/km (Figures 10, 11, 12). A channel, depicted in this layer at the northeastern boundary of the study area is shore-parallel at first and then turns north (Figure 10).

Core Sound Depositional Sequence 2 (CSDS-2)

CSDS-2 is bounded by SB1 and SB3 throughout most of the study area. This sequence is divided into two components (CSDS-2a and CSDS-2b) by a regressive surface of marine erosion (RSME) (Catuneanu et al., 2009). This seismic unit ranges from 8 m to 16 m in thickness, and occurs from 10 to 35 m below present sea-level. CSDS-2a is the lower unit and is characterized by sub-horizontal parallel reflections present above the basal

Table 2 - Core Sound reflection and Core Sound depositional sequence (CSDS) ages and attributes; Pleistocene ages based on correlation to Mallinson et al. 2010. MSWI=Modern sed/water interface; LGM=Last glacial maximum; MIS=Marine Isotope Stage; TST=Transgressive systems tract; HST=Highstand systems tract; FSST=Falling stage systems tract; TMRS=transgresive marine ravinement surface; BSFR=Basel surface of forced regression; RSME=Regressive surface of marine erosion; SU=subaerial unconformity. Reflection abbreviations are as follows: H=Holocene and SB=Sequence Boundary.

Reflection	**CSDS**	**Mallinson et al. 2011 Correlation**	**Age**	**Characteristics**	**Interpretation**
H100		Q100	Holocene		MSWI
	6c	SSU VI	Holocene	Thin unit, cores indicate sand and mud type facies	Holocene estuarine
H60			Holocene	Terminates at MSWI	Tidal ravinement surface
	6b	SSU VI	Holocene	Thin unit, sand and mud facies sand and mud type facies	Holocene estuarine
H30			Holocene	Terminates at MSWI	Tidal ravinement surface
	6a	SSU VI	Holocene	Discontinuous seismic facies in channels	Holocene Estuarine and fluvial fill
SB6		Q99	Pleistocene	Fluvial incision	LGM subaerial unconformity
	5	SSU V	Pleistocene MIS 5	Dipping parasequences	HST
SB5		Q50	Pleistocene	Slight southwest dip, low relief	TMRS (MIS 6/5 sea level rise?)
	4	SSU IV	Pleistocene	Dipping parasequences	HST
SB4		Q30	Early Pleistocene	High amplitude continuous; incised valleys	SU
	3		Early Pleistocene	Multiple parasequences	multiple parasequences, HST
SB3			Early Pleistocene	Medium amplitude continuous	TMRS
	2b			Southeastern dipping clinoforms	FSST
			Early Pleistocene	Medium amplitude few channels	BSFR or RSME
	2a			Horizontal parasequences	HST
SB1		Q0	Plio/Pleist Boundary	High amplitude continuous	SU

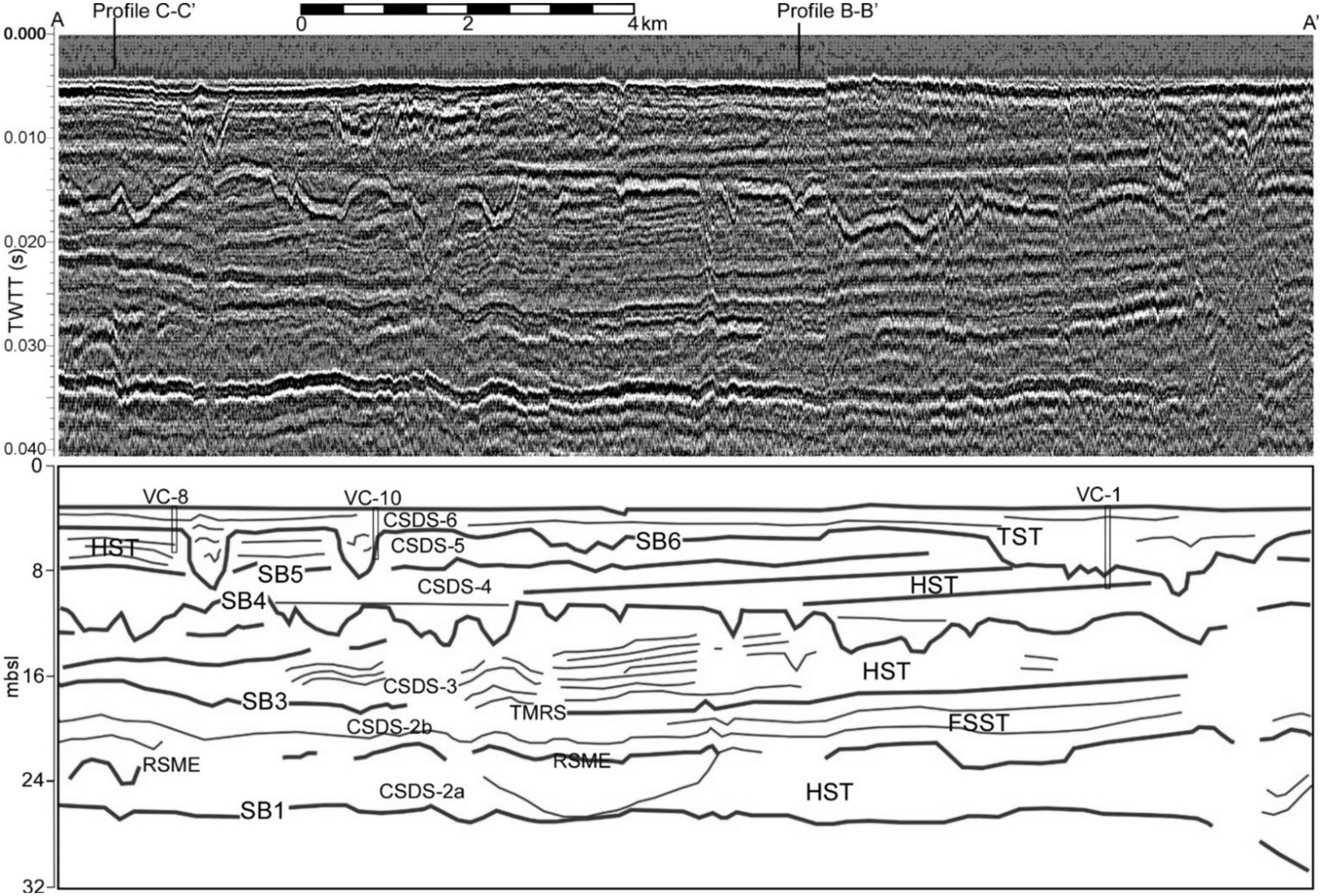


Figure 10: Raw boomer seismic data of transect A-A' with interpretation of sequence boundaries and depositional sequences below. Vertical axis of raw data in two way travel time (TWTT) and of interpretation in meters below sea level (mbsl). Refer to figure 8 for location. Refer to table 2 for abbreviations.

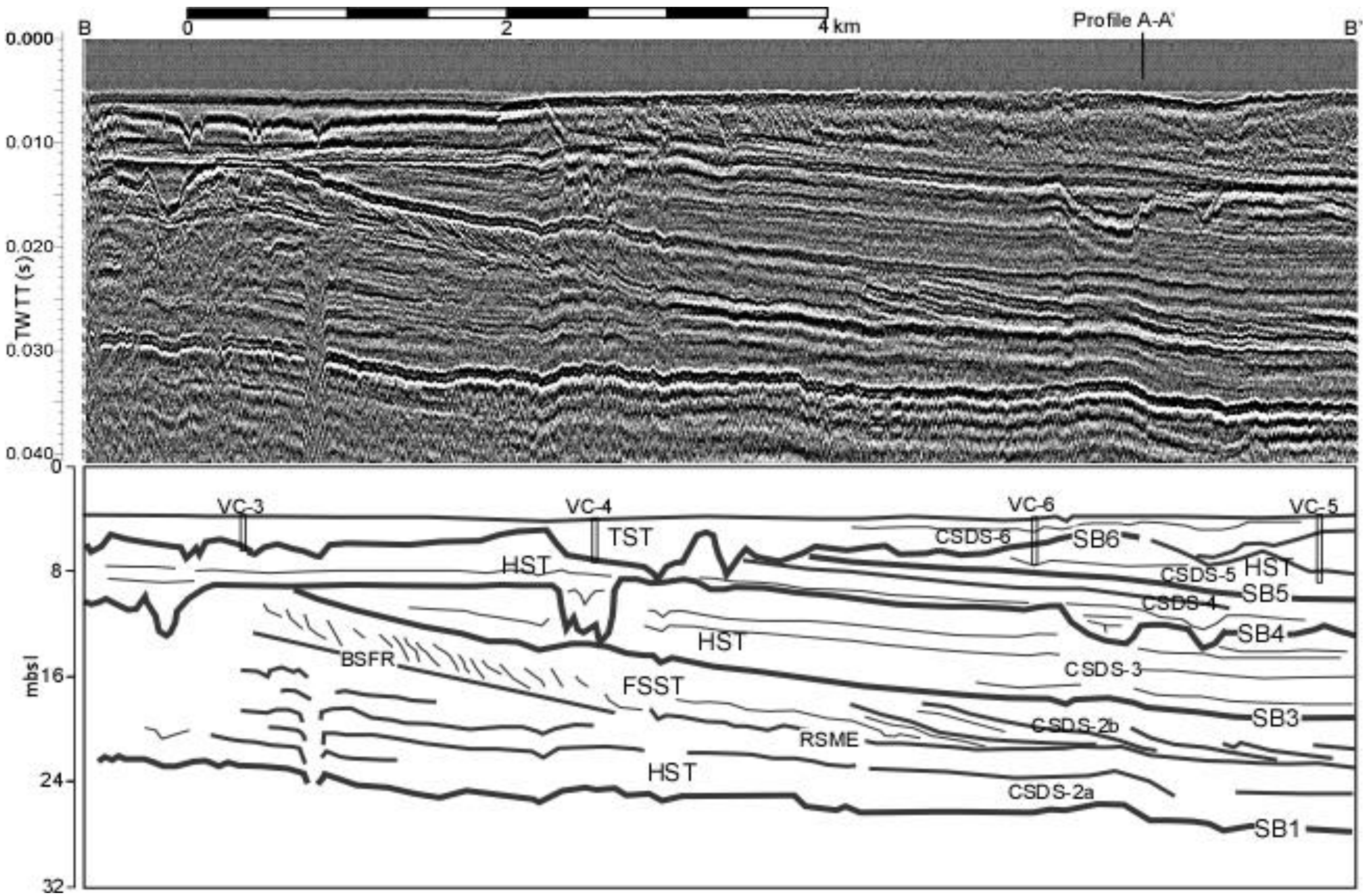


Figure 11: Raw boomer seismic data of transect B-B' with interpretation of sequence boundaries and depositional sequences below. Vertical axis of raw data in two way travel time (TWTT) and of interpretation in meters below sea level (mbsl). Refer to figure 8 for location. Refer to table 2 for abbreviations.

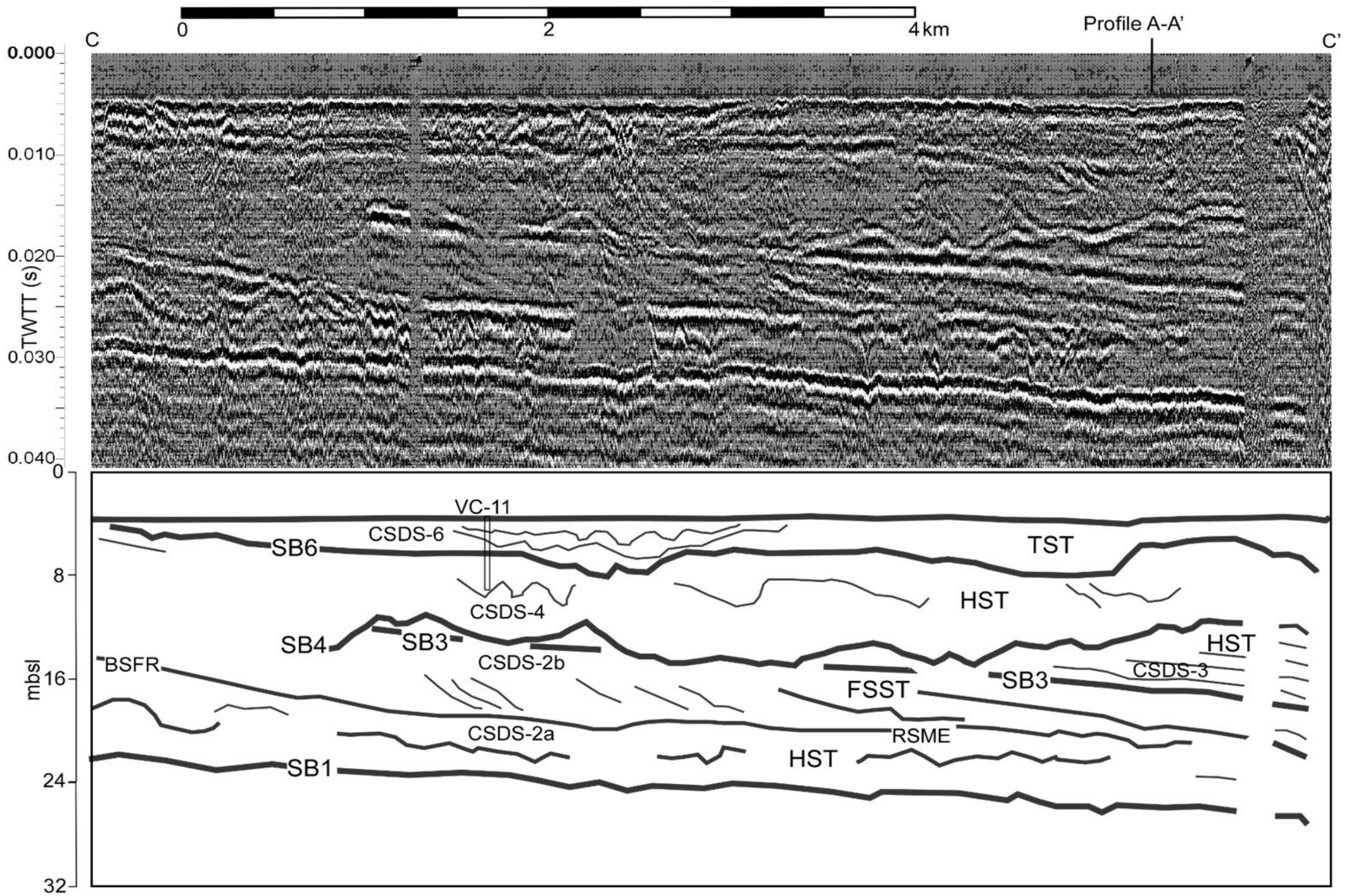


Figure 12: Raw boomer seismic data of transect C-C' with interpretation of sequence boundaries and depositional sequences below. Vertical axis of raw data in two way travel time (TWTT) and of interpretation in meters below sea level (mbsl). Refer to figure 8 for location. Refer to table 2 for abbreviations.

sequence boundary (SB1) (Figures 10, 11). The RSME truncates the horizontal bedding of CSDS-2a (Figure 10) and is the basal surface of the downlapping clinoforms of CSDS-2b. This reflection is immediately followed, above 16 m below present sea level, by numerous downlapping clinoforms leading to the sharp reflection being interpreted as a basal surface of forced regression (BSFR) (Figure 10, 11). At a depth below 16 m below present sea level the sharp reflection is interpreted as a regressive surface of marine erosion based on the model defined in Catuneanu et al., 2009. The upper unit in this area returned with a range of acoustic amplitude, producing well defined bedding. Characteristic seismic facies include three units interpreted as regressive deposits (Catuneanu et al., 2009). These deposits are classified as large oblique clinoforms; surfaces are laterally continuous in the shore-parallel direction and form a shore-perpendicular lenticular unit (Figure 10).

Sequence Boundary 3 (SB3)

This medium amplitude reflection is sub-parallel to SB1 and is 10 to 18 m below present sea level. It dips gently southeast and terminates against SB5 (Figure 10, 11). This layer is interpreted as a transgressive marine ravinement surface (TMRS). No evidence of an associated erosional surface which indicates complete truncation of previous depositional sequence.

Core Sound Depositional Sequence 3 (CSDS-3)

This sequence, bounded by SB3 and SB4, ranges from 0 m to 4 m in thickness, and occurs from 10 m to 18 m below present sea level. Reflections within this unit returned with a range of acoustic amplitudes, leaving the units appearance well defined. Characteristic seismic facies include six parasequences interpreted as transgressive to highstand deposits because of their onlapping relationship with SB3.

Sequence Boundary 4 (SB4)

This high amplitude reflection occurs from 8 m below sea level to 14 m below sea level (Figure 10). This reflection is prominent and is continuous throughout the study area. A topographic high occurs under northern Cedar Island and Cedar Island Bay, and a topographic low under Pamlico Sound and the inner shelf (Figure 11). The geomorphology of this reflection mimics SB1 and SB3 by having an east to southeast dip. Channels ranging from 5 to 13 m deep and 60 to 300 m wide are prevalent under Thorofare Bay and in the southern part of the study area under Core Sound (Figures 10, 12). A transgressive marine ravinement surface (TMRS) can be found across channel-fills. Seismic facies found in channels include clinoforms that toplap to the TRS and horizontal deposits that terminate on SB4.

Core Sound Depositional Sequence 4(CSDS-4)

This sequence is bounded by SB4 and SB5 in northern Core Sound and is bounded by SB4 and SB6 in the mid and southern areas. CSDS-4 is 2 to 6 meters in thickness and occurs from 7 m to 14 m below present sea level. Characteristic seismic facies include channel-fill and flooding surfaces.

Sequence Boundary 5(SB5)

This medium amplitude reflection is semi-continuous and occurs 7 m to 10 m below present sea level (Figure 10). It dips gently east to southeast and is less continuous in the southwest of the study area. It terminates against SB6 in the northeast. Five channels are prominent in the southern part of the study area and correlate with modern embayments. A transgressive marine ravinement surface (TMRS) can be depicted across channels in this layer (Figure 14).

Core Sound Depositional Sequence 5 (CSDS-5)

CSDS-5 is bounded by SB5 and SB6, ranges from 0 m to 3 m in thickness and occurs from 4 m to 7 m below present sea level. This unit thickness made imaging with boomer seismic difficult due to the low resolution near the surface. Reflections that did return within this unit had high amplitude variation, leaving it darker in appearance then other depositional sequences. Characteristic seismic facies include several parasequences (Figures 10, 11).

Sequence Boundary 6 (SB6)

This medium to high amplitude reflection occurs between 4 m to 11 m below sea level. Channels ranging from 1 to 5 m deep, 100 to 500 m wide and at a depth up to 11 meters below sea level, are found throughout Core Sound and under modern embayments (Figures 10, 11, 13-17). This reflection was intermittently resolved by the boomer

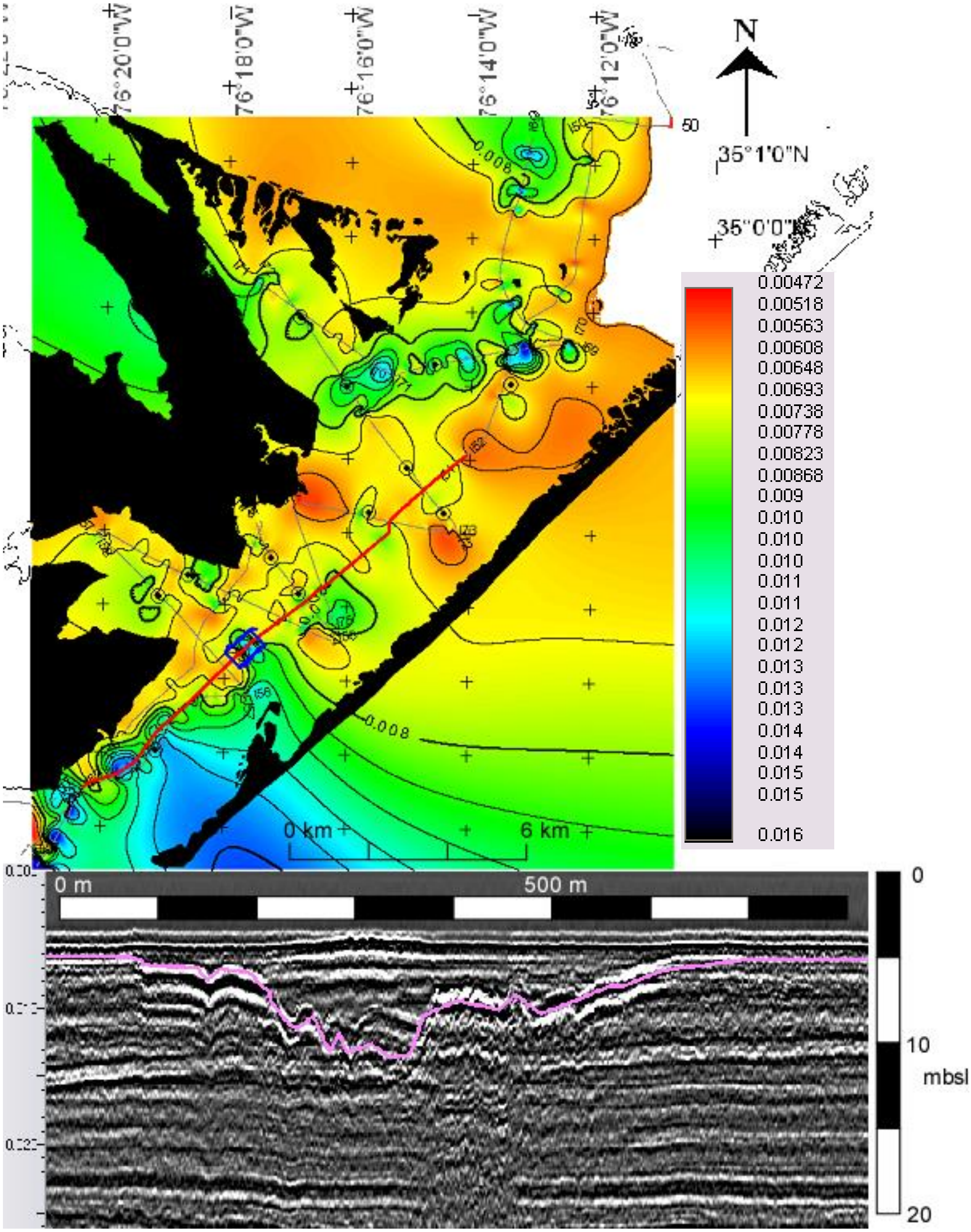


Figure 13: (Top panel: Grid of SB6 from boomer seismic with contours (CI=0.002 seconds). Blue box indicates location of processed seismic line shown in the bottom panel. Bottom panel; Processed seismic line (pink line indicates SB6). Vertical scale are in meters below mean sea level (mbsl) based on a conversion of two-way travel time to depth using an acoustic velocity of 1600 m/s. Left scale is two-way travel time (twtt) in seconds (s).

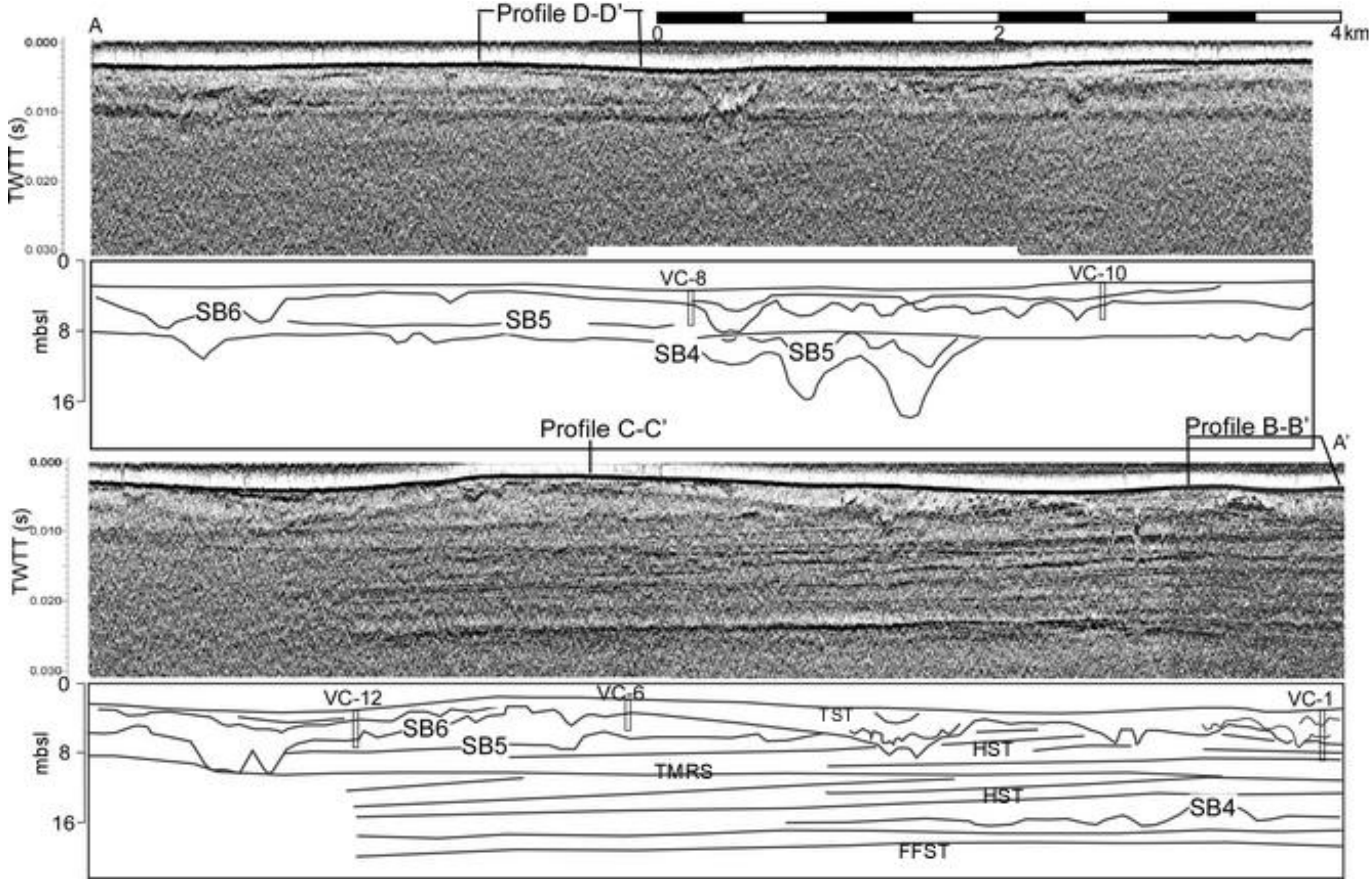


Figure 14 - Raw chirp seismic data of transect A-A' with interpretation of sequence boundaries and depositional sequences below. Vertical axis of raw data in two way travel time (TWTT) and of interpretation in meters below sea level (mbsl). Refer to figure 9 for location. Refer to table 2 for abbreviations.

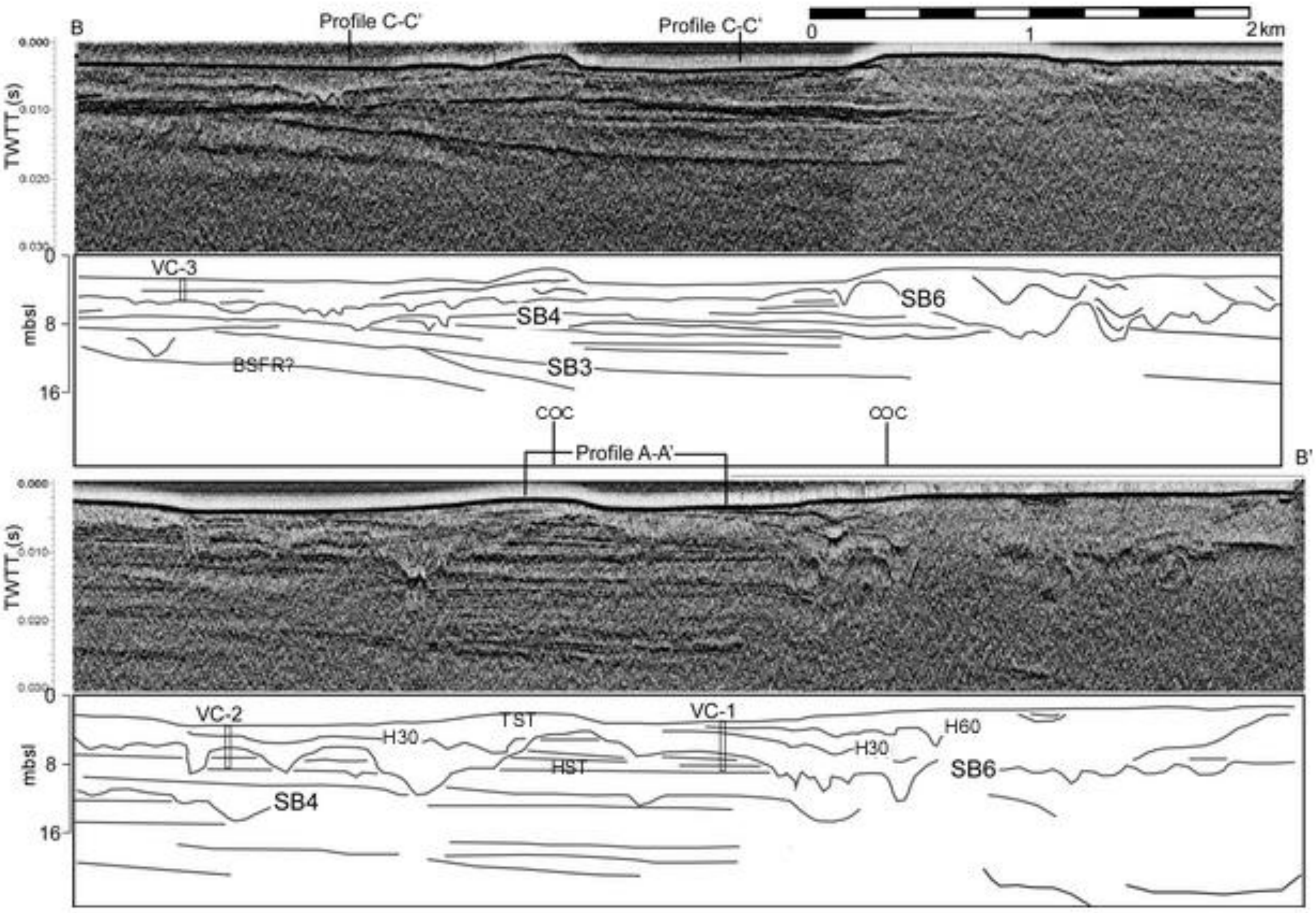


Figure 15 - Raw chirp seismic data of transect B-B' with interpretation of sequence boundaries and depositional sequences below. Vertical axis of raw data in two way travel time (TWTT) and of interpretation in meters below sea level (mbsl). Refer to figure 9 for location. Refer to table 2 for abbreviations.

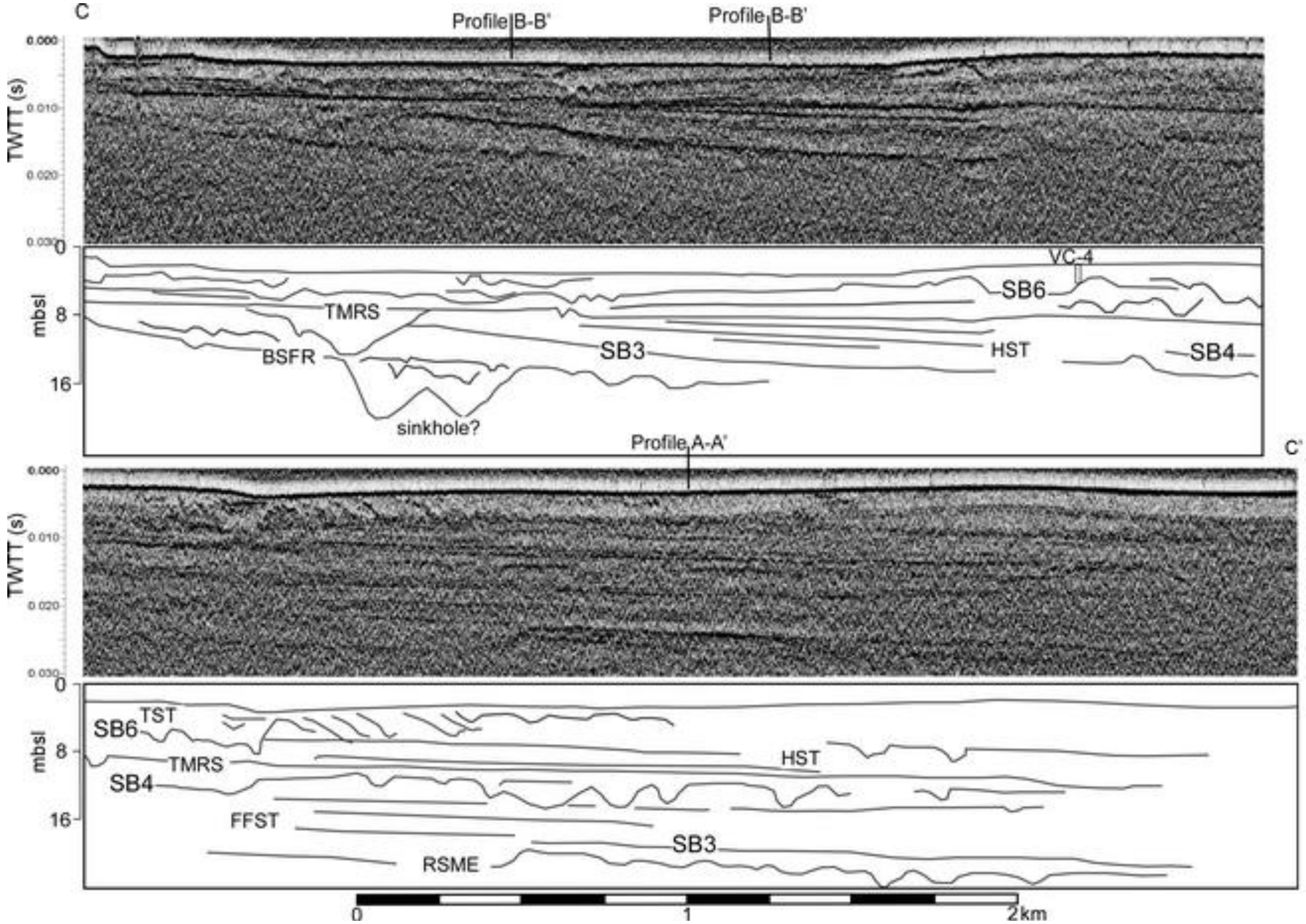


Figure 16 - Raw chirp seismic data of transect C-C' with interpretation of sequence boundaries and depositional sequences below. Vertical axis of raw data in two way travel time (TWTT) and of interpretation in meters below sea level (mbsl). Refer to figure 9 for location. Refer to table 2 for abbreviations.

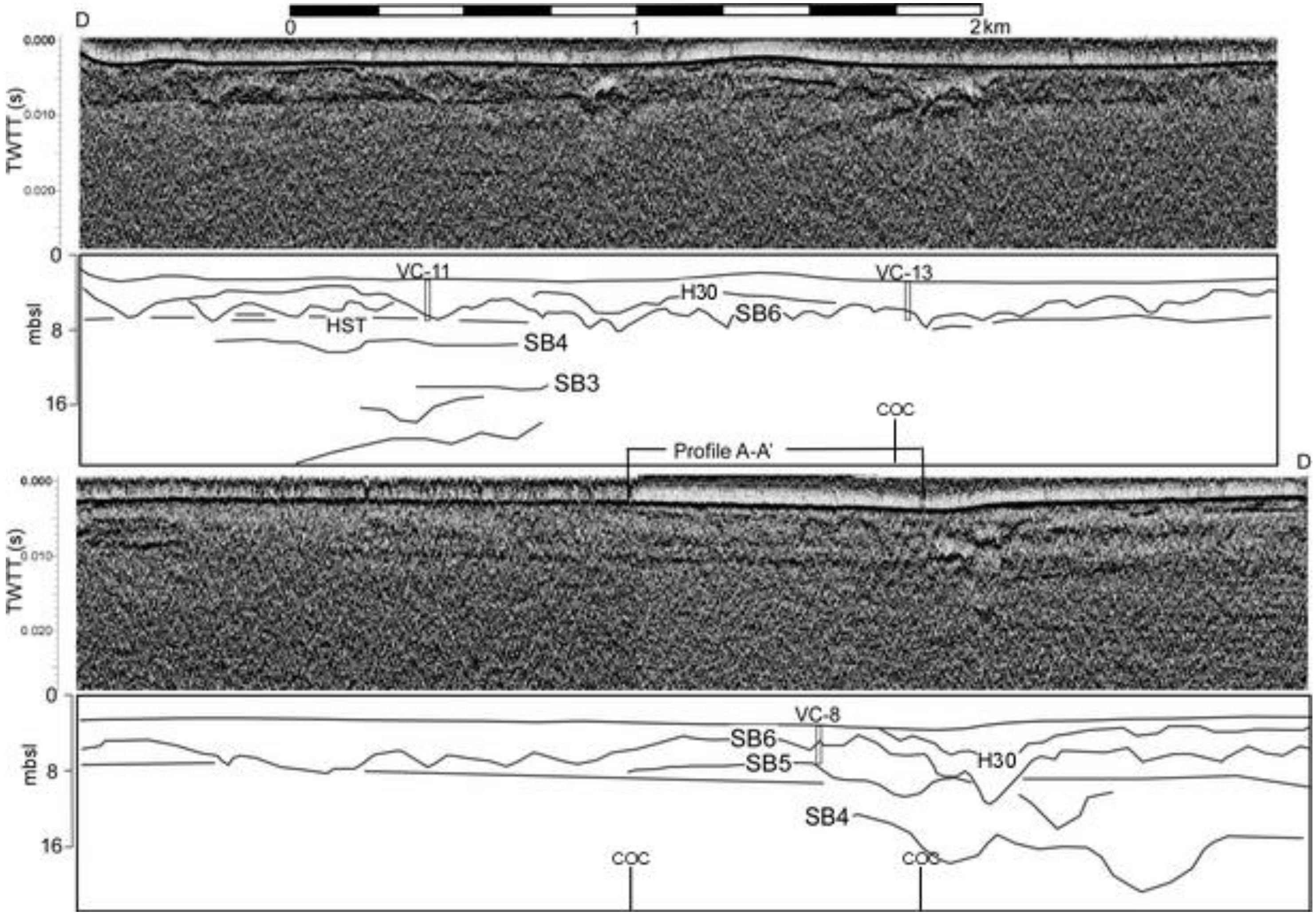


Figure 17- Raw chirp seismic data of transect D-D' with interpretation of sequence boundaries and depositional sequences below. Vertical axis of raw data in two way travel time (TWTT) and of interpretation in meters below sea level (mbsl). Refer to figure 9 for location. Refer to table 2 for abbreviations.

seismic data due to the thin nature of the overlying unit. Only in deeper channels was the horizon well defined.

In the chirp seismic data this reflection varied in amplitude and was intermittently resolved. The digitized chirp horizon was combined with the boomer reflection data to produce a grid of the horizon (Figure 13). The resulting grid shallows toward Cedar Island, suggesting a paleo-topographic high in this area (Figure 13). Paleo-topographic lows in the form of channels occur under Core Sound and associated embayments.
A paleo-topographic high continues under Core Sound from the eastern edge of Cedar Island to Core Banks. This high acts as a divide between the channels in the northern and southern parts of the study area.

The channel under Cedar Island Bay trends northeast into Core Sound. Based on the trend, it likely merged with the larger Neuse River paleo-valley farther east, though the seismic data do not cover this area. The channel under Thorofare Bay runs seaward, and combines with a channel running southwest originating from the topographic divide. The combined channel continues southwest but it is unclear if it turns seaward at the southern end of the study area or continues southwest.

SB6 occurs less than 1 m below the sediment/water interface (3 m below sea level) near Cedar Island and as deep as 11 m below sea level in channels closer to Core Banks.

Core Sound Depositional Sequence 6 (CSDS-6)

This sequence, bounded by SB6 and H100 (the modern sediment/water interface), ranges from 1 m to 10 m in thickness and occurs from 1 m to 11 m below present sea level. Reflections within this unit are characterized by less acoustic variation than CSDS-4 and CSDS-5, leaving it lighter (occasionally transparent) in appearance. Many of the reflections within this unit are non-continuous and represent channel-fill of SB6. CSDS-6 includes two discontinuous reflections, H30 and H60 (Figure 15). Both of these reflections generally parallel SB6 and interact with the modern sediment/water interface at several locations. They define wide channels that run parallel to each other. Narrower channels about 100 m wide are found in H30 and H60. Three parasequences within

CSDS-6 (CSDS-6a-c) are defined by these reflections. CSDS-6a, bounded by SB6 and H30 (Figure 15), ranges from 1 m to 5 m in thickness. Characteristic seismic facies correlated to lithofacies recovered in cores are interpreted as fluvial-fill overlain by estuarine deposits within valleys. CSDS-6b, bounded by H30 and H60 (Figure 15), ranges from 0 m to 3 m in thickness and pinches out at these modern sediment/water interface. The characteristic seismic facies is primarily estuarine deposits. CSDS-6c, bounded by H60 and H100 (Figure 15), ranges from 0 m to 3 m in thickness and pinches out at the modern sediment/water interface at several locations. The seismic facies is interpreted to represent primarily estuarine deposits.

Lithofacies Description

Eleven lithofacies were identified from 13 vibracores from Core Sound, nine vibracores from Cedar Island and 10 vibracores from Core Banks. Table 3 summarizes the lithofacies descriptions.

Table 3 - Sedimentological characteristics of 11 lithofacies identified in cores.

LITHOFACIES NAME	DESCRIPTION	SEDIMENTARY FEATURES	GRAVEL (%)	SAND (%)	MUD (%)	ORGANICS (%)	SHELL FRAG. (%)
Sand (S)	Moderately-well sorted Subangular-subrounded Very fine-medium grain size	Minor heavy mineral laminations, rare woody debris	<1	>95	1-4	<1	<10
Muddy Sand (mS)	Moderately-well sorted Subangular-subrounded Very fine-fine grain size	Bioturbated, some mud burrows	<1	50-95	10-45	<1	<10
Shelly Sand (shS)	Poorly-well sorted Subangular-subrounded Very fine-medium grain size	Massive, some shell lag deposits, occasional gravel-sized shells	<1	50-85	1-4	<1	10-45
Interbedded Sand and Mud (iSM)	Moderately sorted Subangular-subrounded Very fine-medium grain size and mud in laminae	Sharp contacts between layers	<1	25-75	25-75	<1	<1
Shelly Mud (shM)	Mud with articulated shell and shell fragments	Massive, some shell lag deposits, occasional gravel-sized shells	<1	<1-5	55-90	<1	10-45
Sandy Mud (sM)	Mud with moderately sorted fine sands	Bioturbated	<1	10-45	50-90	<1	<10
Mud (M)	Massive mud	Few sand laminations	<1	1-4	>95	<1	<10
Clay (Cl)	Dense clay	Some mud burrows	<1	<1-5	>99	<1-15	<1
Sandy Clay (sCl)	Clay with moderately sorted fine-medium sands	Some mud laminations	<1	25-40	60-75	<1	<1
Interbedded Clay and Sand (iClS)	Clay and sand in laminae	Sharp contacts between layers	<1	25-40	60-75	<1	<1
Peat (P)	Fibric and	Root fragments, loose organic material	<1	10-40	5-20	60-90	<1
	Sapric	Decomposed organics	<1	1-10	1-10	85-100	<1

A. Sand (S)

The sand lithofacies is light gray to yellowish brown, moderately to well sorted, subangular to subrounded, very fine to medium grained sand. Sand is mainly composed of quartz (> 95 %), with 1 to 4 % mud, and less than 1% heavy minerals, organics and shell fragments. High percentages of heavy minerals occur in occasional laminations.

B. Muddy Sand (mS)

The muddy sand lithofacies is grayish-brown to brown, moderately to well sorted, subangular to subrounded, very fine to fine-grained sand. Sand is mainly composed of quartz (50 to 95 %), with 5 to 45 % mud, and less than 1% heavy minerals, organics and shell fragments. Sand and mud occurs in laminations in this lithofacies.

C. Shelly Sand (shS)

The shelly sand lithofacies is light gray to yellowish-brown, poorly to well sorted, subangular to subrounded, very fine to medium-grained sand. Sand is mainly composed of quartz (50 to 85 %), with 10 to 45 % shell fragments, and less than 1% heavy minerals, organics and mud.

D. Interbedded Sand and Mud (iSM)

The shelly, muddy sand lithofacies is grayish-brown to yellowish-brown, moderately to well sorted, subangular to subrounded, very fine to fine-grained sand. Sand is mainly composed of quartz (50 to 95 %), with 5 to 45 % mud, 10 to 30 % shell fragments, and less than 1% heavy minerals and organics. Sand and mud can also occur as laminae. Occasional articulated bivalve and oyster shells occur within this lithofacies.

E. Shelly Mud (shM)

The shelly mud lithofacies is light brown to dark brown, 55 to 90 % mud, 10 to 45% shell or shell fragments.

F. Sandy Mud (sM)

The sandy mud lithofacies is light brown to medium brown, moderately, sorted, subangular to subrounded, very fine to medium sand. Mud composes 50 to 90 % of this facies, with 10 to 45 % sand, and less than 1% heavy minerals, organics and shell fragments. Sand and mud occur as laminations in this lithofacies.

G. Mud (M)

The mud lithofacies, is medium brown to dark brown, 95 to 100% massive mud, and <1-5% sand.

H. Cohesive Mud (cM)

The cohesive mud facies is dark gray to blue gray. Soft mud burrows are common in this lithofacies. Cohesive mud is very compact and composes >95% of this facies, with <1-5% sand.

I. Interbedded Cohesive Mud and Sand (icMS)

The interbedded cohesive mud and sand lithofacies is dominantly cohesive mud with occasional interbeds and laminae of fine-grained quartz sand. Contacts between layers are abrupt and sand layers range from 5 mm to 2 cm in thickness.

J. Peat

The peat lithofacies is composed of 85 to 100% organic material and <15% sand and mud. Organic material is mainly a light brown color and consists of roots, twigs and grasses mainly occurred at the current land surface. Buried peat was mainly a black decomposed material with small organic fragments.

Biofacies

One hundred sediment samples were taken from 13 vibracores within Core Sound, six of eight cores on Cedar Island and five of eight Cores on Core Banks. Samples were taken from cores aligned in three transects, one shore-normal and two shore-perpendicular (Figure 6). Fifty-one of the one hundred sediment samples contained foraminifera. Foraminiferal abundance data from these samples were subjected to cluster analysis in order to define biofacies (Figure 18; Table 4).

Biofacies A

Biofacies A occurs in 17 samples and is composed of 18 species. It is dominated by *Elphidium excavatum* (81%); *Ammonia parkinsoniana* (6.4%), *Haynesina germanica* (4.5%), *Elphidium gunteri* (1.3%) and *Elphidium mexicanum* (1.3%) are the next four

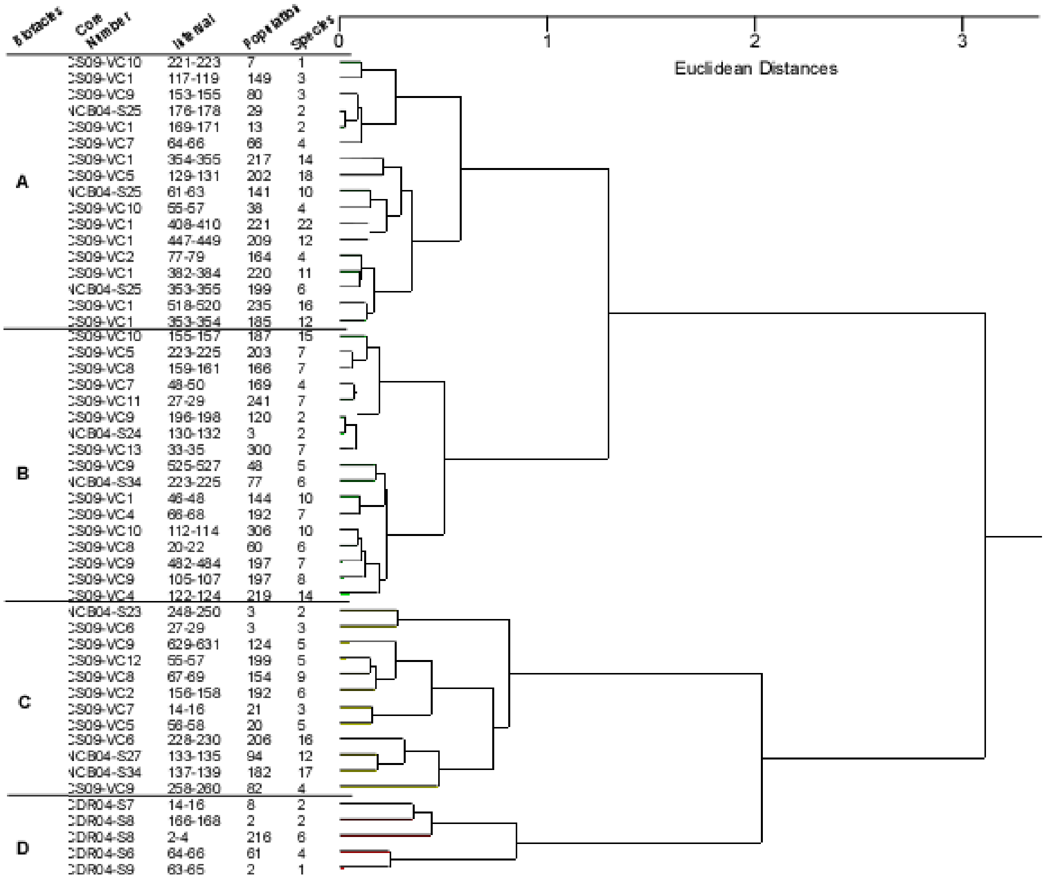


Figure 18 - Dendrogram from cluster analysis (Ward's Linkage, Euclidean distances) with sample and foraminiferal data, as well as biofacies.

Table 4 - Average species abundance (%) calculated for each biofacies. The five most abundant taxa for each biofacies are indicated by bold type.

Taxon	Biofacies A	Biofacies B	Biofacies C	Biofacies D
Ammonia parkinsoniana	**6.4**	**29.7**	**33.1**	
Arenoparrella mexicana				**0.7**
Buliminella elegantissima	0.5			
Cibicides fletcheri	0.3		0.1	
Cibicides lobatulus	0.2	0.3	0.9	
Elphidium excavatum	**80.8**	**60.9**	**22.9**	
Elphidium galvestonense	0.3	1.0	**17.6**	
Elphidium gunteri	**1.3**	**1.5**	**6.2**	
Elphidium mexicanum	**1.3**	**1.9**	3.9	
Elphidium poeyanum	0.4	0.2	0.5	
Elphidium sp.	0.1	0.2		
Elphidium transluscens	0.1	0.3	0.1	
Eponides repandus		0.1	0.5	
Gavilinopsis praegeri	0.8	0.1		
Hanzawaia strattoni	0.4	0.5	2.1	
Haplophragmoides wilberti				**46.7**
Haynesina germanica	**4.5**	**1.9**	**8.3**	
Miliammina petila				**1.3**
Nonionella atlantica	0.3	0.1	0.4	
Nonionella auricula			0.4	
Quinqueloculina lamarckiana			0.5	
Quinqueloculina seminula	0.3	0.1	2.0	
Rosalina floridana	0.4	0.1		
Tipotrocha comprimata				**9.4**
Trochammina inflata	0.1			**33.1**
Number of species	**18**	**16**	**17**	**5**

most abundant taxa (Table 4). The 17 samples characterized by Biofacies A occurred in seven vibracores at varying depths from 2.5 to 7.6 mbsl. Biofacies A was found throughout Core Sound, excluding mainland embayments, but was more prevalent in cores in the northeast portion of the study area. It was found in the muddy sand (mS), interbedded mud and sand (iMs), sandy mud (sM), and mud (M) lithofacies. Biofacies A is interpreted as representing a high salinity estuary environment. Metger (2009) found a biofacies, Biofacies E, with very similar species abundance and interpreted it to represent a normal marine salinity environment (Table 5). The species abundance in Biofacies A foraminiferal assemblage suggests high salinity above 25 psu (Abbene et al., 2006; Foley, 2007; Grand Pre et al., 2011).

Biofacies B

Biofacies B occurs in 17 samples and is composed of 16 species. It is dominated by *Elphidium excavatum* (61%) and *Ammonia parkinsoniana* (30%) with less abundant taxa *Haynesina germanica* (1.9%), *Elphidium mexicanum* (1.9%) and *Elphidium gunteri* (1.5%) (Table 4). The 17 samples characterized by Biofacies B occurred in ten vibracores throughout Core Sound at varying depths from 2.0 to 6.3 mbsl. This biofacies was found mostly in the muddy sand (mS), shelly sand (shS), and sand (S) lithofacies; a few samples characterized by this biofacies occurred in sandy mud (sM) and mud (M) lithofacies. Biofacies B is representative of a high salinity estuary environment. The percentages of *Elphidium excavatum* and *Ammonia parkinsoniana* matched most closely with Metger's (2009) Biofacies B, but Biofacies B of this study has less abundant

Quinqueloculina. The lack of any agglutinated taxa within this biofacies indicates salinities of ~20-25 psu (Abbene et al., 2006; Foley, 2007; Metger, 2009). Core VC9 is characterized almost exclusively by Biofacies B. VC9 consists of flood tide delta deposits associated with Drum and Ophelia inlets.

Biofacies C

Biofacies C occurs in 12 samples and is composed of 16 species. It is dominated by *Ammonia parkinsoniana* (33.1%), *Elphidium excavatum* (22.9%), *Elphidium galvestonense* (17.6%) with *Haynesina germanica* (8.3%) and *Elphidium gunteri* (6.2%) also as moderately abundant taxa (Table 4). The 12 samples characterised by this biofacies occurred in seven vibracores throughout Core Sound at varying depths from 2.3 to 7.3 mbsl. This biofacies was found in the muddy sand (mS), interbedded sand and mud (iSM), sandy mud (sM), and mud (M) lithofacies. Based upon the abundance of *Ammonia parkinsoniana*, *Elphidium* species and *Quinqueloculina* species, Biofacies C is representative of a high salinity foraminiferal assemblage similar to Biofacies 2 of Pruitt et al. (2010) in central Core Sound, interpreted as Estuarine High Salinity B (Table 5).

Biofacies D

Biofacies D occurs in five samples and contains only five species. It is dominated by *Haplophragmoides wilberti* (46.7%), *Trochamina inflata* (33.1%), *Tiphotrocha comprimata* (9.4%) with *Miliammina petila* (1.3%), *Arenoparrella mexicana* (0.7%) in low abundance (Table 4). The five samples were found in four Cedar Island vibracores at

Biofacies defined in this study							
Biofacies A		Biofacies B		Biofacies C		Biofacies D	
Elphidium excavatum	**80.8%**	*Elphidium excavatum*	**60.9%**	*Ammonia parkinsoniana*	**33.1%**	*Haplophragmoides wilberti*	**46.7%**
Ammonia parkinsoniana	**6.4%**	*Ammonia parkinsoniana*	**29.7%**	*Elphidium excavatum*	**22.9%**	*Trochammina inflata*	**33.1%**
Haynesina germanica	**4.5%**	*Elphidium mexicanum*	**1.9%**	*Elphidium galvestonense*	**17.6%**	*Tipotrocha comprimata*	**9.4%**
Elphidium gunteri	**1.3%**	*Haynesina germanica*	**1.9%**	*Haynesina germanica*	**8.3%**	*Miliammina petila*	**1.3%**
Elphidium mexicanum	**1.3%**	*Elphidium gunteri*	**1.5%**	*Elphidium gunteri*	**6.2%**	*Arenoparrella mexicana*	**0.7%**
Metger, 2009 (Biofacies E) **High Brackish Estuary** **~25 psu**		**Metger, 2009 (Biofacies B)** **High Brackish Estuary** **~20-25 psu**		**Pruitt et al., 2010 (Biofacies 2)** **Estuarine-High Salinity B** **?~20-25 psu?**		**Pruitt et al., 2010 (Biofacies 4)** **Marsh** **~6-15 psu**	
Elphidium excavatum	**88.3%**	*Elphidium excavatum*	**48.1%**	*Ammonia parkinsoniana*	**53.0%**	*Trochammina inflata*	**54.2%**
Ammonia parkinsoniana	**9.4%**	*Ammonia parkinsoniana*	**22.2%**	*Elphidium excavatum*	**26.0%**	*Haplophragmoides wilberti*	**27.5%**
Grand Pre et al., 2011 **High Brackish Estuary** **~25 psu**		*Quinqueloculina seminula*	**14.2%**	*Elphidium galvestonense*	**4.5%**	*Jadammina macrescens*	**4.9%**
Elphidium excavatum	**82.0%**	*Quinqueloculina jugosa*	**5.7%**	*Elphidium mexicanum*	**4.5%**	*Arenoparrella mexicana*	**4.5%**
Ammonia parkinsoniana	**18.0%**	*Hanzawaia strattoni*	**1.7%**	*Elphidium gunteri*	**4.3%**		

Figure 5 – Modern Source (Foley, 2007; Metger, 2009 and Pruitt et al., 2010) with biofacies comparable to those of the present study. Taxa are listed with percent abundance. Salinity values are listed for the modern biofacies.

varying depths from 0 to 1.7 mbsl. This biofacies occurs in the peat (P) lithofacies. This foraminiferal assemblage and sediment type is representative of a back-barrier salt marsh environment (Grossman and Benson, 1967; Smith, 2004; Culver et al., 2005; Culver and Horton, 2005; Ricardo, 2006; Rosenberger, 2007; Pruitt et al., 2010) (Table 5).

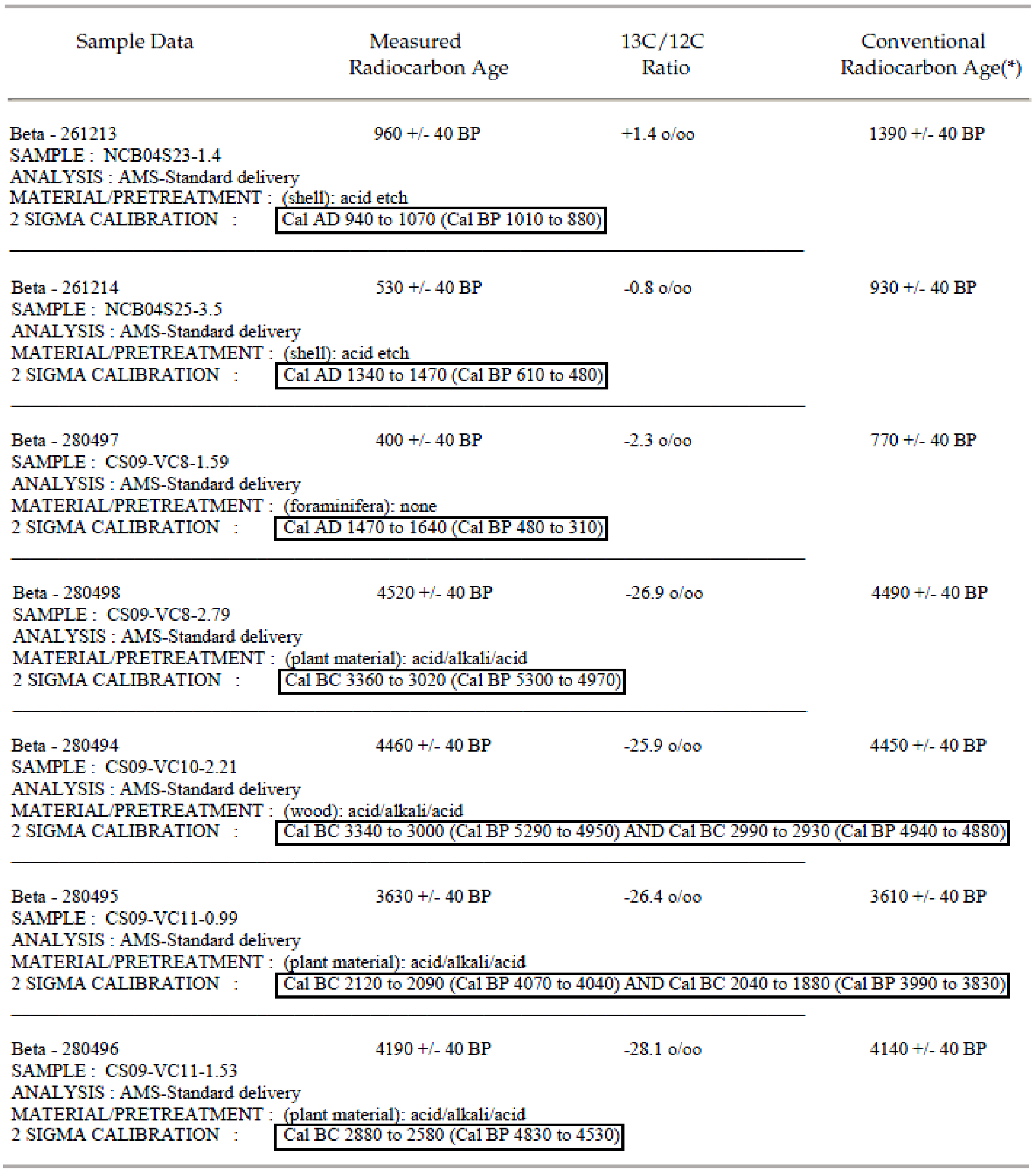
Age Data

Chronologic data were obtained from seven AMS ^{14}C age estimates. Two age estimates were obtained from a pecten shell and an articulated *Mercenaria* bivalve found in two cores; four age estimates, obtained from plant material, recovered from buried organics found in three cores and one sample consists of 100 foraminifera tests (*Elphidium excavatum*) sampled from CS09-VC8. Table 6 summarizes the age estimates.

Two age estimates obtained from a pecten shell and an articulated *Mercenaria mercenaria* were collected from cores NCB04-S23 and NCB04-S25 in a small shore perpendicular transect (Figure 6). The fragment of the shell found in NCB04-S23 was collected at a depth of 1.4 mbsl and has a 2σ age of 880 to 1010 cal y BP (Table 6). The fragment of the shell found in NCB04-S25 was collected at a depth of 4.6 mbsl and has a 2σ age of 480 to 610 cal y BP (Table 6).

Four age estimates were obtained from buried organics in the Thorofare Bay area. Two plant material samples in CS09-VC11 at 3.58 and 4.12 mbsl were dated. Their 2σ age estimates are 3830 to 3990 and 4040 to 4070 cal y BP and 4530 to 4830 cal y BP respectively; a wood sample dated from CS09-VC10 at 4.56 mbsl yielded a 2σ age of

Table 6 - Results of radiocarbon dating Carbon-14 from prepared samples (Beta Analytic Inc.).



Sample Data	Measured Radiocarbon Age	13C/12C Ratio	Conventional Radiocarbon Age(*)
Beta - 261213 SAMPLE : NCB04S23-1.4 ANALYSIS : AMS-Standard delivery MATERIAL/PRETREATMENT : (shell): acid etch 2 SIGMA CALIBRATION : Cal AD 940 to 1070 (Cal BP 1010 to 880)	960 +/- 40 BP	+1.4 o/oo	1390 +/- 40 BP
Beta - 261214 SAMPLE : NCB04S25-3.5 ANALYSIS : AMS-Standard delivery MATERIAL/PRETREATMENT : (shell): acid etch 2 SIGMA CALIBRATION : Cal AD 1340 to 1470 (Cal BP 610 to 480)	530 +/- 40 BP	-0.8 o/oo	930 +/- 40 BP
Beta - 280497 SAMPLE : CS09-VC8-1.59 ANALYSIS : AMS-Standard delivery MATERIAL/PRETREATMENT : (foraminifera): none 2 SIGMA CALIBRATION : Cal AD 1470 to 1640 (Cal BP 480 to 310)	400 +/- 40 BP	-2.3 o/oo	770 +/- 40 BP
Beta - 280498 SAMPLE : CS09-VC8-2.79 ANALYSIS : AMS-Standard delivery MATERIAL/PRETREATMENT : (plant material): acid/alkali/acid 2 SIGMA CALIBRATION : Cal BC 3360 to 3020 (Cal BP 5300 to 4970)	4520 +/- 40 BP	-26.9 o/oo	4490 +/- 40 BP
Beta - 280494 SAMPLE : CS09-VC10-2.21 ANALYSIS : AMS-Standard delivery MATERIAL/PRETREATMENT : (wood): acid/alkali/acid 2 SIGMA CALIBRATION : Cal BC 3340 to 3000 (Cal BP 5290 to 4950) AND Cal BC 2990 to 2930 (Cal BP 4940 to 4880)	4460 +/- 40 BP	-25.9 o/oo	4450 +/- 40 BP
Beta - 280495 SAMPLE : CS09-VC11-0.99 ANALYSIS : AMS-Standard delivery MATERIAL/PRETREATMENT : (plant material): acid/alkali/acid 2 SIGMA CALIBRATION : Cal BC 2120 to 2090 (Cal BP 4070 to 4040) AND Cal BC 2040 to 1880 (Cal BP 3990 to 3830)	3630 +/- 40 BP	-26.4 o/oo	3610 +/- 40 BP
Beta - 280496 SAMPLE : CS09-VC11-1.53 ANALYSIS : AMS-Standard delivery MATERIAL/PRETREATMENT : (plant material): acid/alkali/acid 2 SIGMA CALIBRATION : Cal BC 2880 to 2580 (Cal BP 4830 to 4530)	4190 +/- 40 BP	-28.1 o/oo	4140 +/- 40 BP

4880 to 5290 cal BP and a plant material sample at 5.84 mbsl in CS09-VC8 yielded an age estimate of 4970 to 5300 cal y BP. A foraminifera sample of only *Elphidium excavatum* (1000 count) 4.64 mbsl from core CS09-VC8 was determined to have an age estimate of 310 to 480 cal y BP.

The peats were sampled at the top of each lithofacies and CS09-VC11 was also sampled at the base of the peat. The peats lacked foraminifera, have sharp contacts with surrounding sediment and are very clean (lack large organics) and have little or no sand/mud. The age estimates in core CS09-VC11 were determined to be 4530 to 4830 years B.P. at the base of the peat and 3830 to 4070years B.P. at the top.

Horton et al. (2009) utilized radiocarbon age estimates from published and unpublished records to create a comprehensive sea-level curve. Fifty-four index points that were related to an appropriate tide level and 33 limiting dates were used to create a North Carolina relative sea level curve. This curve was then corrected for glacial-isostatic adjustment using the ICE-5G(VM2) model. The 54 index points were used as a base for comparison of radiocarbon dates in this study area and surrounding studies (Figure 19).

Core Correlation

Vibracores were correlated based on the seismic, lithofacies, biofacies, and age data. Vibracores in Core Sound were acquired along shore-parallel and shore-perpendicular transects (Figure 20). The seismic, lithofacies and biofacies were correlated between each core. Five transects were created using the above method (Figures 21-26).

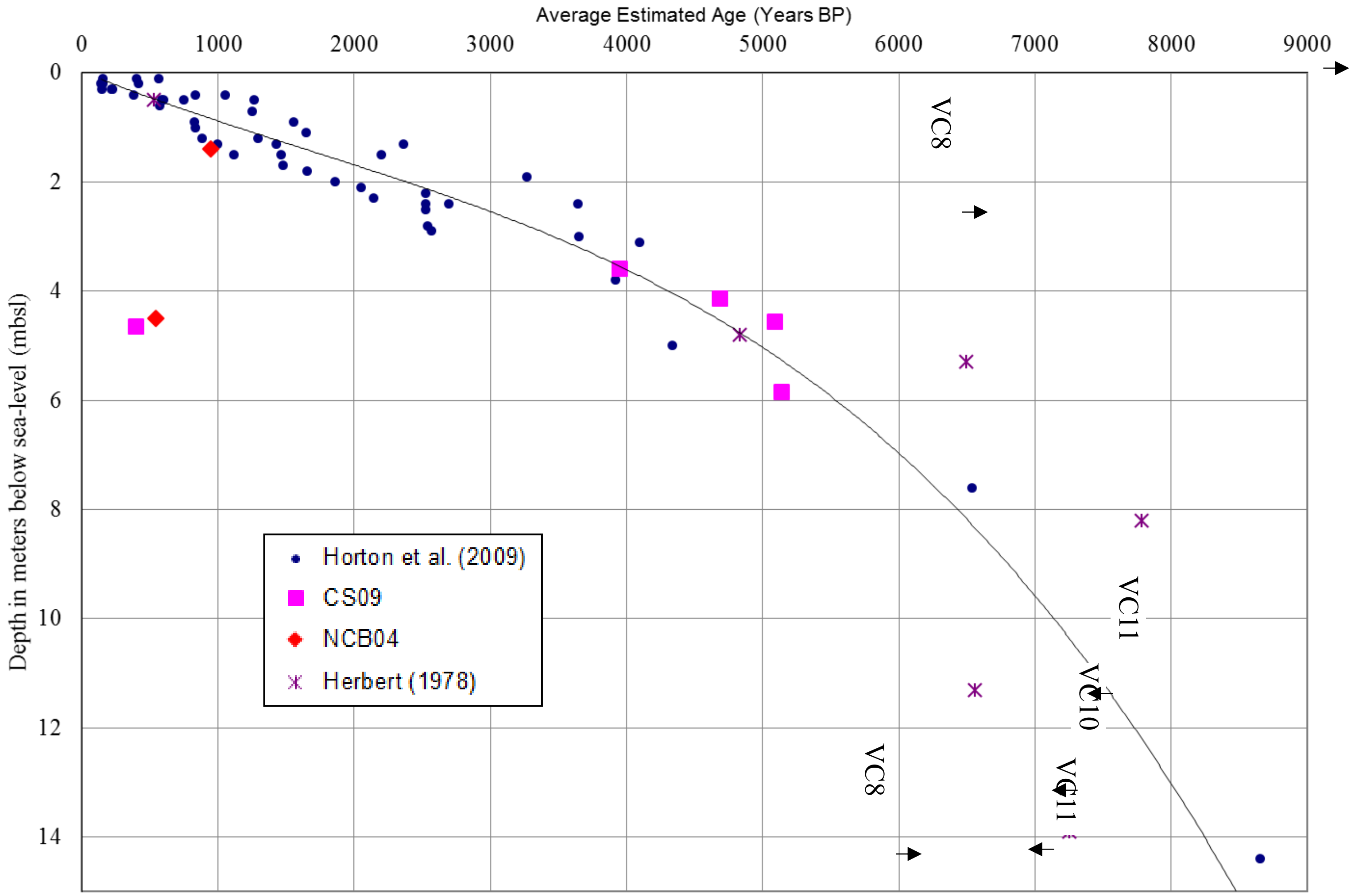


Figure 19 - Graph of radiocarbon dates compared to recent sea-level data (Horton et al., 2009). Blue circles represent Horton et al. (2009) data, red diamonds are NCB04 data, pink squares are CS09 data, and purple asterisks are Herbert (1978) data.

Seismic reflections were correlated with abrupt lithofacies boundaries using a seismic velocity (Vp) of 1600 m/s for sediment. Seismic reflections H0 and H30 have been correlated throughout all core transects (Figures 21, 22, 23, 24, 25, 26). Seismic reflection H60 was only correlated in transect A-A' and B-B' because it pinched out a modern sediment water interface and was not found in more southern transects (Figures 21, 22, 23).

The lithofacies constrained by seismic reflections H0 and H30 tend to consist of mud to sandy mud. Lithofacies constrained by seismic reflections H30 and H60 tend to be interbedded sand and mud, to sand. The lithofacies constrained by seismic reflections H60 to H100 tend to be muddy sand to sand.

The seismic and lithofacies did not correlate well with the biofacies. Biofacies A is more prevalent in the northeast region and biofacies B occurs mainly in the southwest region of the study area (Figure 21, 22, 23, 24, 25, 26). Biofacies C occurs mainly in the center of study area, up embayments and at the base of some seismic reflections (Figure 21, 22, 23).

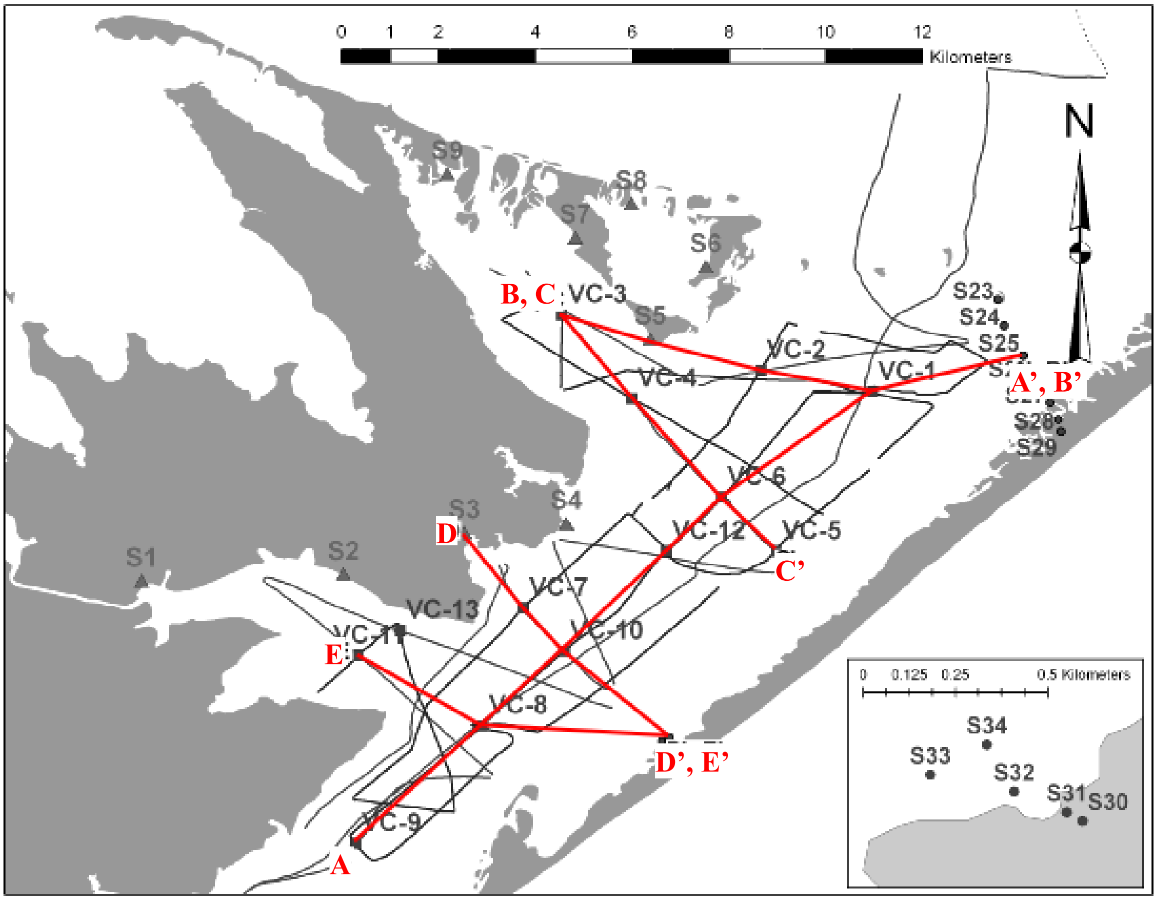


Figure 20 - Location map of cross sections A-A' through E-E'

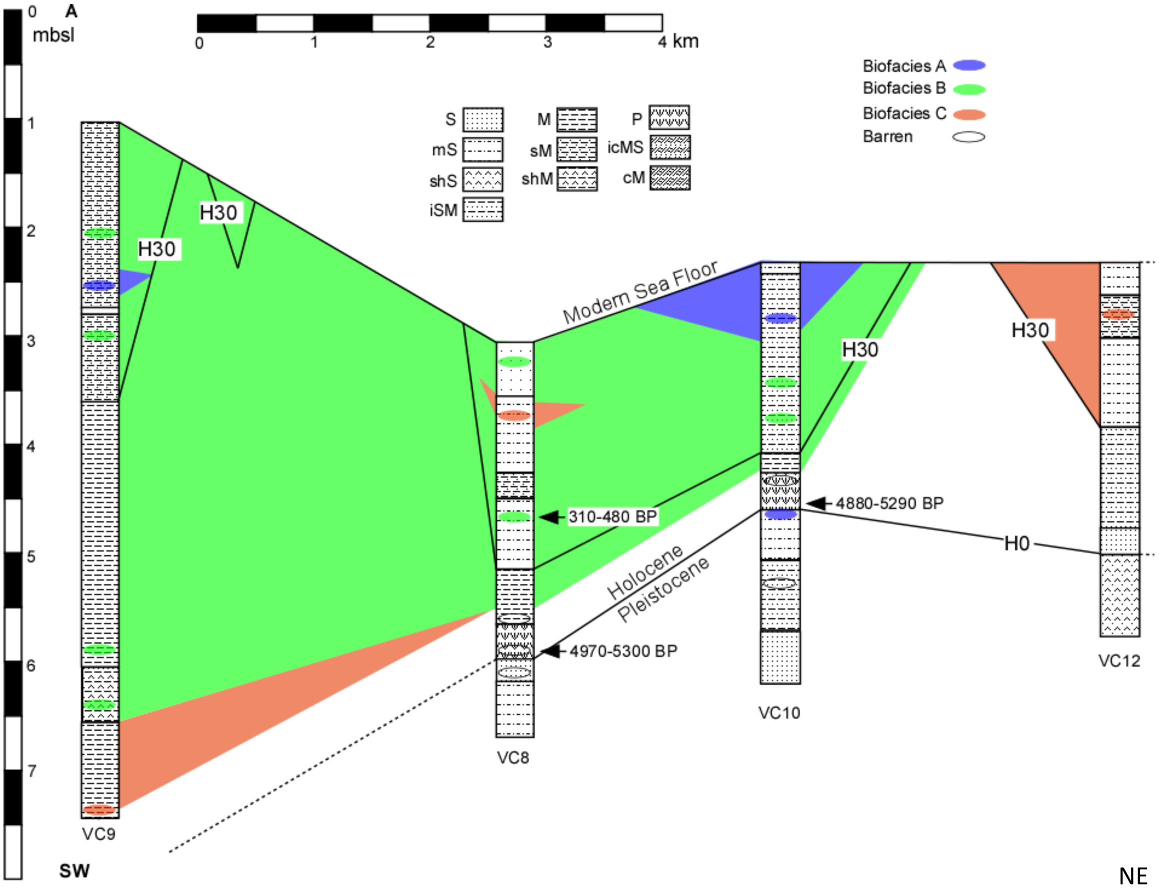


Figure 21 – Southwest part of cross-section A-A’ in North Core Sound showing lithofacies and biofacies. Lines of correlation are the seismic reflections. Colors are biofacies correlations. Note the prevalence of Biofacies B.

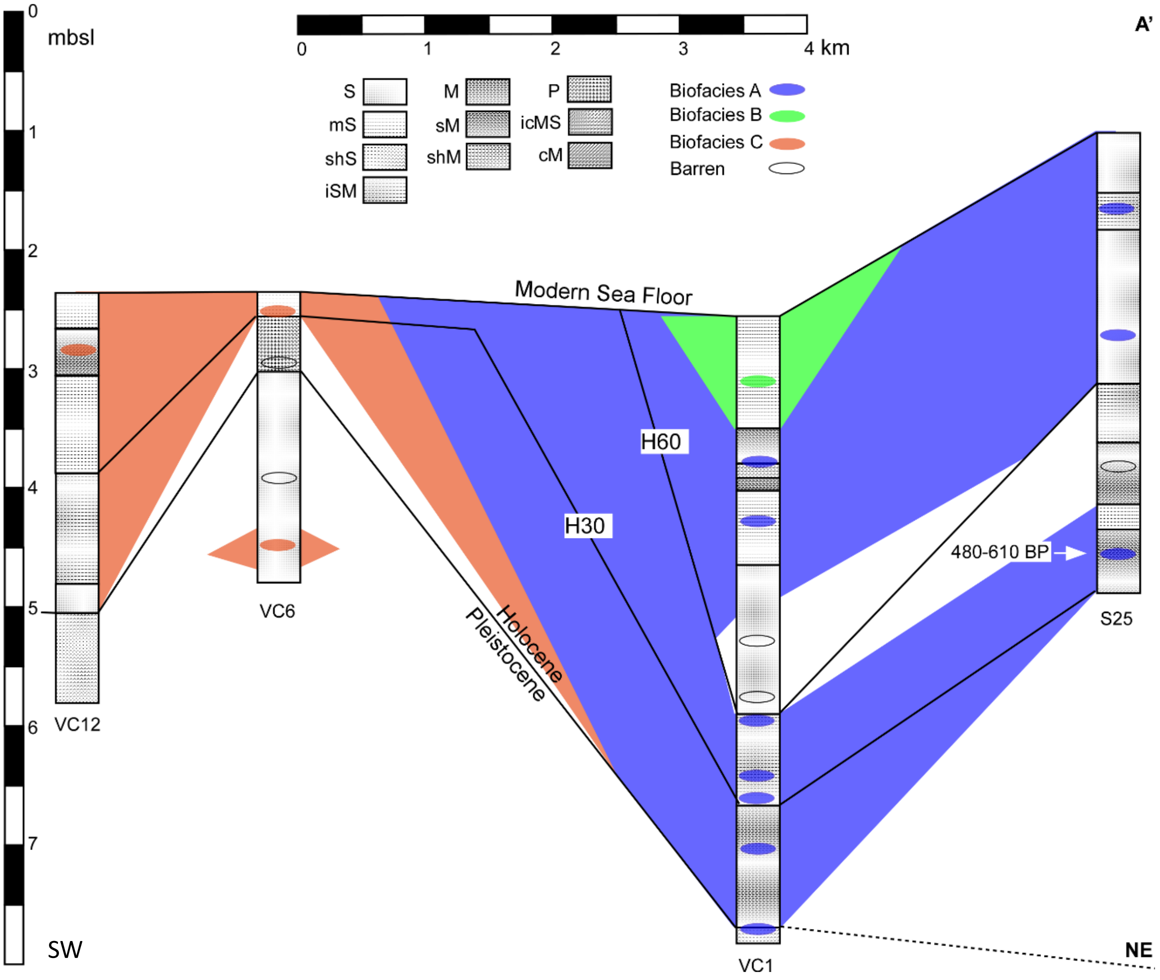


Figure 22 - Northeast part of cross-section A-A' in North Core Sound showing lithofacies and biofacies. Lines of correlation are the seismic reflections. Colors are biofacies correlations. Note the prevalence of biofacies A to the northeast, and Biofacies C above the Pleistocene high (VC6).

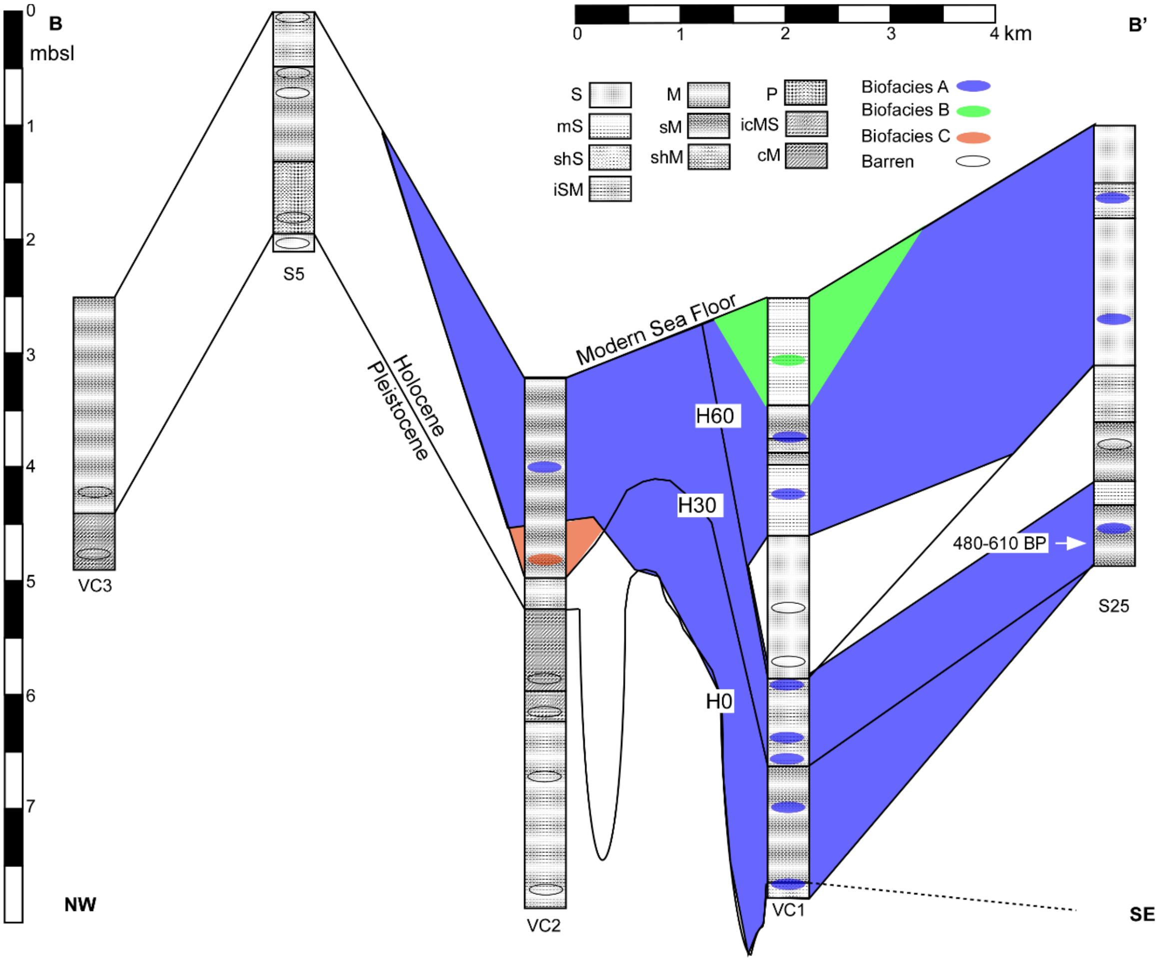


Figure 23 - Cross-section B-B' in North Core Sound showing lithofacies and biofacies. Lines of correlation are the seismic reflections. Colors are biofacies correlations.

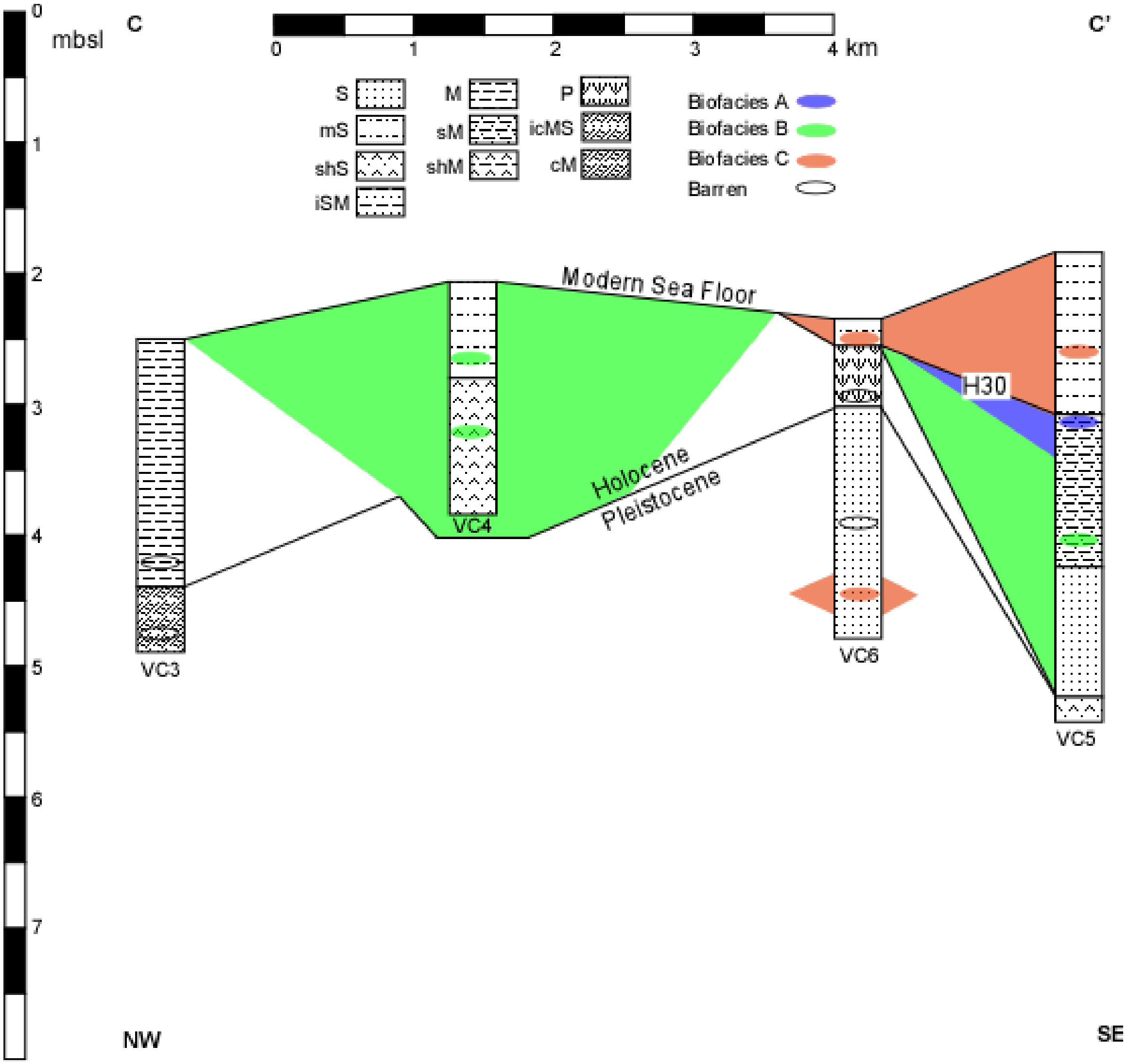


Figure 24 - Cross-section C-C' in North Core Sound showing lithofacies and biofacies. Lines of correlation are the seismic reflections. Colors are biofacies correlations.

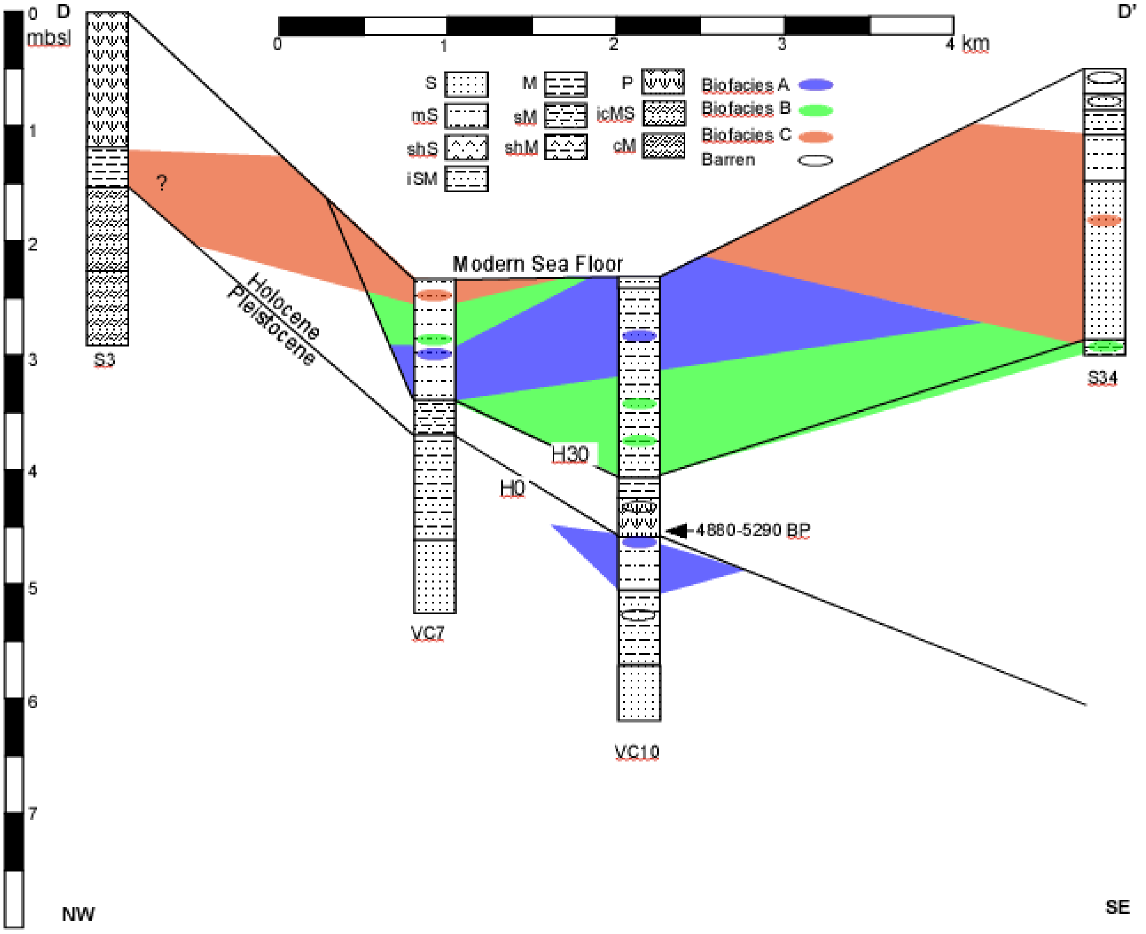


Figure 25 - Cross-section D-D' in North Core Sound showing lithofacies and biofacies. Lines of correlation are the seismic reflections. Colors are biofacies correlations.

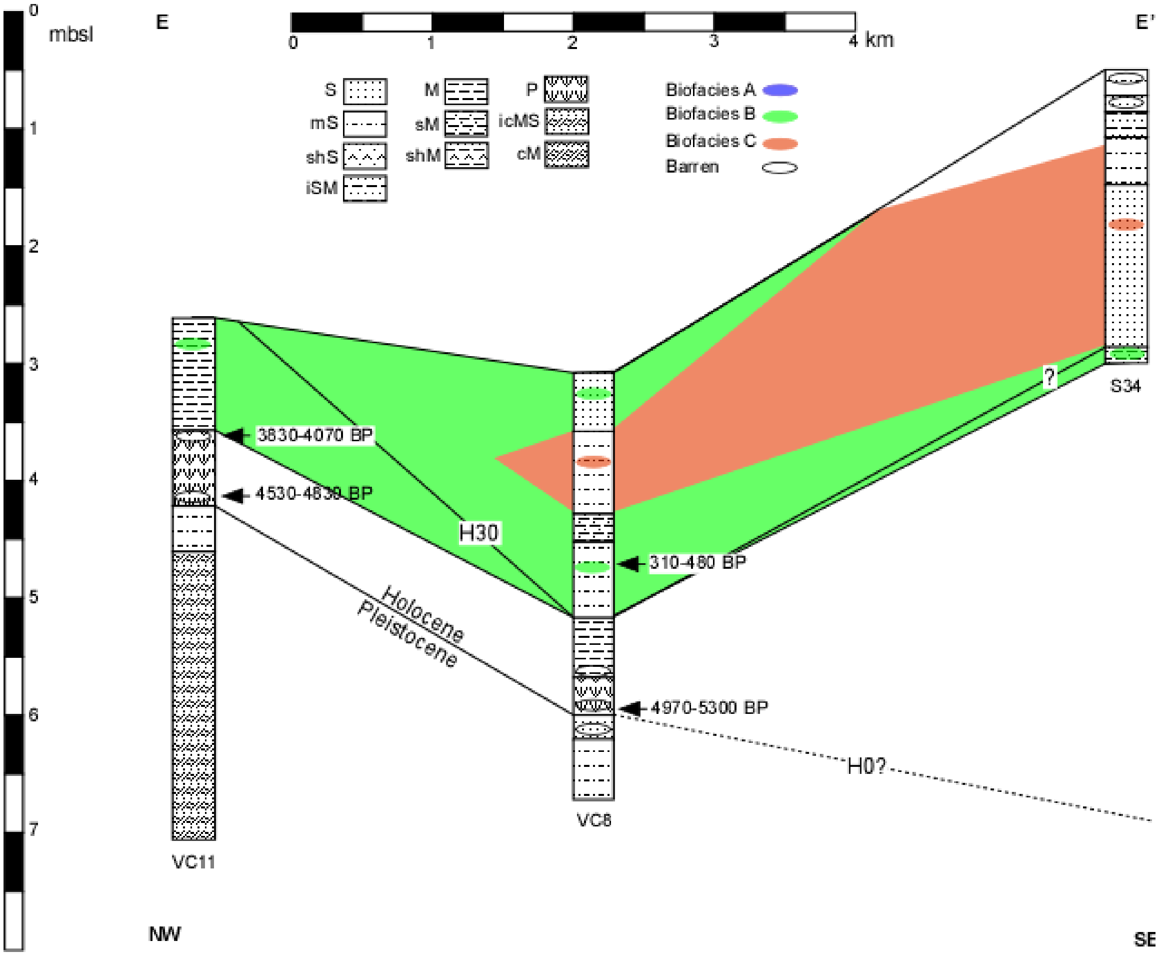


Figure 26 - Cross-section E-E' in North Core Sound showing lithofacies and biofacies. Lines of correlation are the seismic reflections. Colors are biofacies correlations.

DISCUSSION

Pleistocene Sequence Stratigraphic Evolution

Sequence Boundary 1 is the oldest reflection seen in the seismic data of this study. Sequence Boundary 1 is recognized and designated Q0 beneath the Pamlico Sound and Core Sound by Mallinson et al. (2010). Based upon correlation to a drill core (MLD2) on Cedar Island, this horizon likely represents the Pliocene-Pleistocene boundary (Mallinson et al., 2010). The lithological correlation from MLD2 suggests that SB1 is the result of a strong acoustic impedance contrast at the top of a bioclastic limestone which accounts for the high amplitude reflection.

The earliest most continuous Pleistocene unit, CSDS-2, started by filling a paleotopographic low created by SB1 (Figure 10). CSDS-2 was recognized by Mallinson et al. (2010), as Seismic Stratigraphic Unit I (SSU I). The deposited sediment built the shelf vertically and eastward (Mallinson et al., 2010). Foraminiferal assemblages and sediment analysis indicated that sediment fill was deposited in mid to outer shelf environments (Mallinson et al., 2010). The thickest section of CSDS-2 occurs in northeast Core Sound. The thickest section of SSU I occurs in northwestern Pamlico Sound. Sediments associated with SSU I were recovered in cores MLD01 and MLD05 (Mallinson et al., 2010), and are very fine to coarse grained sands and muddy sands.

Sequence Boundary 3 appears to truncate underlying reflections (Figure 10) indicating erosion during a forced regression and defining this as primarily a regressive surface of marine erosion (RSME). Sequence Boundary 3 is recognized as a medium to high amplitude reflection, occurring as a RSME that is sub-parallel to SB1. This definition resembles a horizon designated as Q10 by Mallinson et al. (2010). Q10 dips gradually eastward from a depth of 50 mbsl in western Pamlico Sound, to 80 mbsl in eastern Pamlico Sound (Mallinson et al., 2010). SB3 follows a similar trend as Q10, deepening from 19 m in the west to 25 m in the northeast. The maximum depth of SB3 (25 mbsl) occurs in northeastern Core Sound and is west of the Q10 eastern limit of 50 mbsl. Q10 was not defined in eastern Pamlico Sound. Mallinson et al. (2010) defined this boundary as an unconformity that had minimal subaerial exposure. Sea level began to fall creating a forced regression and a RSME. Sediment started to build seaward over the ravinement surface depositing CSDS-3.

CSDS-3 has characteristics that are similar to seismic units recognized by Mallinson et al. (2010), specifically Seismic Stratigraphic Unit II (SSU II) and Seismic Stratigraphic Unit III (SSU III) (Mallinson et al., 2010). The CSDS-3 unit is bounded by reflections SB3 and SB4. Three to four horizons, interpreted as seaward dipping clinoforms, dominate the upper 5-8 meters of this unit (Figure 10). Clinoforms dip east to southeast. Mallinson et al. (2010) described a moderate to high amplitude reflection labeled Q20 that was depicted dividing the two units. Oblique to sigmoidal clinoforms composed of sand and gravel occur within SSU III and prograde east to northeast. SSU II consists of a quartzose sandy mud overlain by interbedded sandy muds and muddy sands. These sediments were recovered from MLD01 and MLD05 (Mallinson et al., 2010).

SB4 truncates CSDS-3 and exibits many small channels indicating that this surface, based on the model of Catuneanu et al. (2009), is a subaerial unconformity (Figure 10, 11, 12; Table 2). SB4 marks the basal sequence boundary for CSDS-4.

CSDS-4 is bounded by SB4 and SB5 under Core Sound. Under northeast Core Sound and into Pamlico Sound the unit is bounded by reflections SB4 and SB6 as SB5 is truncated by SB6 close to the northern limit of Core Sound (Figure 10). The lower portion of CSDS-4 contains fluvial channel fill. The channel fill is overlain by stratigraphic surfaces that are characteristic of a transgressive ravinement surface and maximum flooding surface (Catuneanu et al., 2009). The maximum flooding stage is indicated by downlapping reflections associated with the overlying high stand systems tract. CSDS-4 was sampled by VC-11. The HST consists of interbedded mud and sands (Figure 12 and 25). This unit can be correlated to Seismic Stratigraphic Unit IV (SSU IV) defined by Mallinson et al. (2010). SSU IV is bounded by reflections Q30 and Q50 with thin (<5 m) horizontally-bedded sequences with fluvial channel fill (Mallinson et al., 2010).

Based on the Catuneanu et al. (2009) model the upper boundary of CSDS-4 (SB5) is highly characteristic of a subaerial unconformity, SB5. SB5 also has an associated transgressive ravinement surface found mainly across channels. CSDS-5 includes fluvial fill within SB-5 channels. A series of parallel beds dipping to the south may represent shoreface deposits that occurred during a mid-Plestocene highstand (Figure 10). CSDS-5 is relatively thin, at most 3 m, as a result of erosion by SB6 during the subsequent sea-level fall. Mallinson et al. (2010) defined a horizon with the same characteristics as SB5 but in Pamlico Sound it is designated as Q30, a subaerial unconformity with a closely associated, sometimes coplanar, transgressive ravinement surface defined as Q30b. Clinoforms are found within channel-fill. SB5 is truncated by SB6 in northeast Core Sound making CSDS-5 pinch out between CSDS-4 and CSDS-6. CSDS-5 can be related to the Seismic Stratigraphic Unit V (SSU V) recognized by Mallinson et al. (2010). SSU V is bounded by reflections Q50 and Q99 which have been correlated to SB5 and SB6.

SB6 is a subaerial unconformity with incised channels which truncates the upper section of CSDS-5 and defines the lower boundary of CSDS-6. This unconformity was penetrated and recovered in VC- 1-3, 5- 8, 10-12. Based on radiocarbon ages from overlying sediment, SB6 likely formed during the last glacial maximum lowstand. CSDS-6 is composed of horizontal bedding and represents the Holocene section.

The modern geomorphology of Core Sound correlates to the paleo-topography defined by the SB6 reflection. Embayments occur in paleo-channel locations and land occurs on paleo-highs (Figure 14). A paleo-channel runs down the middle of Cedar Island Bay and turns northeast toward Pamlico Sound (Figure 13). It can be inferred that this channel connects with the Neuse/Tar fluvial paleo-valley. Another channel is found under Thorofare Bay which turns southwest down Core Sound. Further data would have to be collected to determine if this channel continues southwest down Core Sound or turns southeast. If the channel did turn southeast it may have been a precursor for the historical Drum Inlet.

SB1 through SB7 all show a similar characteristic of a topographic high under all or part of Cedar Island. This suggests that modern Cedar Island morphology is related to Pleistocene and late Pliocene topography.

Holocene Geologic Evolution

Sequence Boundary 6 is a medium to high amplitude reflection immediately below the modern sediment water interface; this reflection is correlated to Q99 of Mallinson et al. (2010), which represents the LGM unconformity (Figure 2). Sediment overlying this boundary corresponds to CSDS-6, and is mostly Holocene in age

(Mallinson et al., 2005; Mallinson et al., 2008; Mallinson et al., 2010; Culver et al., 2007) indicating that this reflection is a close approximation of the Holocene-Pleistocene boundary, except at the base of fluvial valleys where late Pleistocene fluvial deposits are preserved.

North Core Sound was inundated from two directions. A paleo-topographic high divided the area with its axis running southeast from present-day Cedar Island (Figure 27). Paleo-channels are found under modern-day embayments (Figure 27). A paleo-channel ran the length of current Cedar Island Bay bending northeast and may have connected with the paleo-Neuse channel (Figure 27). A less prominent channel is found under Thorofare Bay and bends south to southwest (Figure 13, 16, 17, 27). These channels would have been initially inundated when sea level began to rise from the last glacial maximum.

During the inundation of Core Sound the paleo-topographic high created a high salinity shallow estuarine environment ideal for Biofacies C (Figure 21, 22). Biofacies C was also found near the base of CSDS-6a unit indicating these shallow environments were present as inundation occurred (Figure 21, 22, 23, 24). Smaller paleo-channels, and later inlets, in the south allowed for Biofacies B high salinity estuarine foraminiferal assemblages to flourish (Figure 21, 24, 26). The larger paleo-channels and inlets such as Ocracoke Inlet and Whalebone Inlet also created high salinity environments (Biofacies A) in the north (Figure 22, 23). The absence of low salinity estuarine biofacies (characterized by the agglutinated taxon *Ammotium salsum*; Pruitt et al., 2010) indicates that north Core Sound stayed connected to marine waters throughout the Holocene. The distance from a fresh water source contributed to the continuous high salinity throughout the Holocene unit.

As the main lagoon of Core Sound formed, marsh peat was deposited at the base of CSDS-6 in some areas of the Sound (Figure 21, 22, 23, 24, 26). Based on the lack of foraminifera and sharp contacts with surrounding sediment, these peats may be detrital (Table 6; Figure 19), limiting their potential as sea-level indicators. However, the peats contain little or no sand or mud, and the age estimates in CS09-VC11 are in stratigraphic order (4830-4530 cal y BP at the base, and 4070 to 3830 cal y BP at the top). Furthermore, radiocarbon ages of the peats, indicate they were deposited near sea level when plotted on the relative sea-level curve (Horton et al., 2009) (Figure 19). A basal salt marsh peat at approximately 8 m under Core Banks was dated to ca. 7800 cal y BP, indicating inundation occurred at this time (Herbert, 1978). Similarly Pamlico Sound initial flooding started 9000 cal y BP and Hatteras Flats Interstream divide was almost completely flooded by 7000 cal y BP (Culver et al., 2007; Metger et al., 2008; Grand Pre et al., 2011) and Bogue Sound was present later than 6000 cal y BP (Timmons et al., 2010; Lazar et al., in press) . Radiocarbon ages calculated from the peats at the base of the Holocene section indicate North Core Sound was flooded by 5300 cal y BP (Table 6, Figure 25 and 26) and high salinity estuarine environments occurred in embayments by 3830 cal y BP (Table 6; Figure 21, 25, 26). Interstream divides between the channels may have provided a buffer from high energy open ocean wave action and allowed peats to be preserved and muds to be the dominant sediment (Figure 13). With the exception of channel-fill, much of the initial deposits in this study area were sandy mud to mud of CSDS-6a (Figures 21-26).

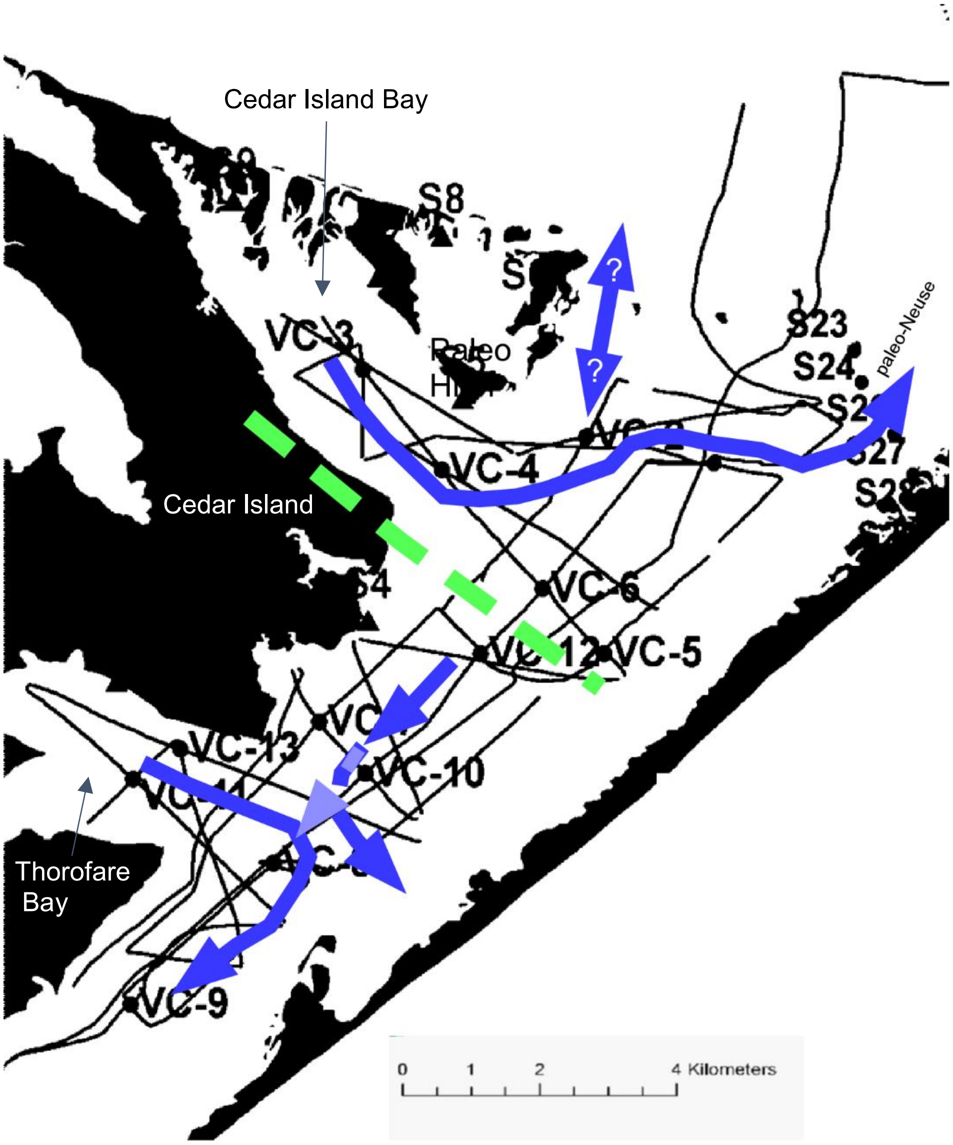


Figure 27 – Map depicts the orientation of paleo-channels (placement based on grid in figure 13). Light green dashed line lies on axis of paleo-topographic high. Light blue arrow depicts alternate direction channel may have flowed. More data needed to determine direction of most northern channel which connects to channel directly south. Modern surface and seismic transects in black for reference.

The CSDS-6a unit composing of mainly muddy facies may indicate a low energy environment. This low energy environment could be a result of the narrow nature of Core Sound (limited fetch) and its continuous protection by Core Banks from high energy conditions. A similar unit is found under Bogue Sound and determined to be low energy, high salinity estuarine deposit (Lazar et al., in publication). This unit estimated to be deposited earlier then 6000 cal y BP and is overlain by a floodtide delta unit. The boundary between these two units are dated to about 1,100 cal y BP and are related to the higher hurricane activity that correlated to the medieval warm period (Timmons et al., 2010; Lazar et al., in publication). Peek et al., (2013) had a similar boundary at the base of a flood tide delta unit also dated to about 1,100 cal y BP. It is possible these boundaries relate to the H30 boundary in this study.

Buried back-barrier marsh, dating to 530 cal y BP, is found under Core Banks (Herbert, 1978). This correlates to increased tidal action in northern Core Sound creating a tidal ravinement surface (H30) estimated to have occurred earlier than 600 cal y BP (Figure 15, 17, 21, 22, 26). This surface can be found intermittently throughout northern Core Sound (Figures 14-17). If H30 was created much earlier than 600 y BP the tidal ravinement surface could be a product of the wider inlets created during the Medieval Warm period barrier island segmentation that occurred near the region of Ocracoke Island and North Core Banks around 1100 y BP (Culver et al., 2007; Metger et al., 2008; Grand Pre et al., 2011). The radiocarbon age estimates in CSDS-6b, just above H30, ranging from 310-610 cal y BP, suggest this surface originated more recently. The creation of the H30 surface and coarser sediments found in CSDS-6b might be related to the larger number of inlets associated with the onset of the Little Ice Age that occurred roughly 550 to 50 cal y BP (Cronin et al., 2003; Mallinson et al., 2011).

The greater tidal influence brought in more sand creating interbedded sand and mud (iSM) layers (tidalites) and muddy sand deposits associated with CSDS-6b (Figures 21- 26, 28). Another ravinement surface (H60) is found exclusively in the north of the study area (Figures 15, 28). It is not clear whether H60 represents wave or tidal ravinement. Sand is the main sediment associated with deposits above H60 (Figure 28). CSDS-6c (constrained at its base by H60) is relatively thin and pinches out at the modern sediment-water interface. This unit is influenced by wave energy from Pamlico Sound, and also tidal currents related to Ocracoke Inlet. The predominance of the slightly higher salinity Biofacies A and the extra ravinement surface (H60) suggests that the northern portion of the study area has been influenced by a more open system (greater tidal exchange and wave energy) than the south throughout its development.

A lithological trend of coarsening-upward sediment was identified throughout the Holocene section (Figure 28). Sediments that were deposited between H0 and H30 are mainly muddy in nature indicating less energy during deposition. Interbedded sand and mud or a sandy mud to muddy sand facies are present between seismic reflections H30 and H60. This indicates a change in the system to a higher energy environment. Interbedded deposits may indicate tidal deposition. Sediment above H60 to the modern sediment water interface are mainly sandy in nature. A coarsening-upward trend is possibly related to the increased proximity to sand source from the transgressing barrier island in response to sea-level rise.

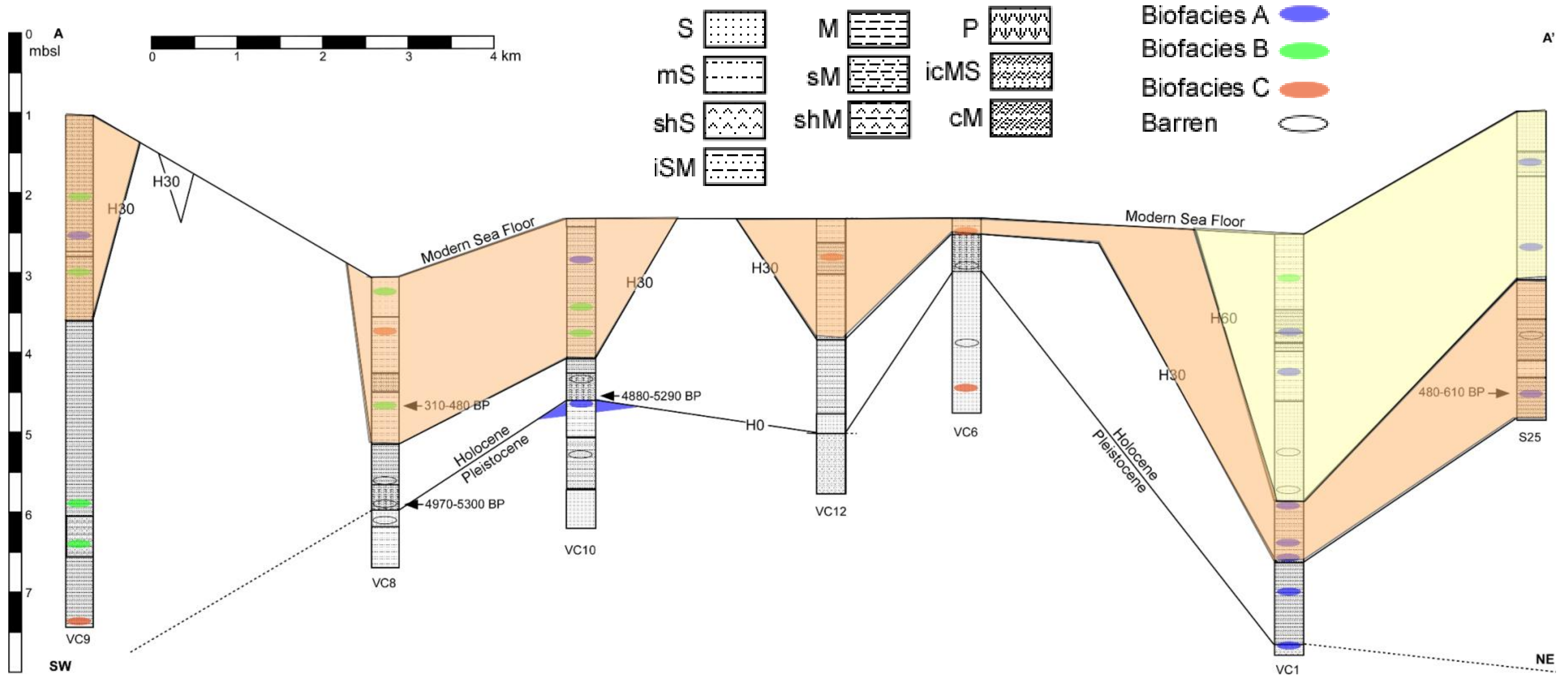


Figure 28 – Seismic/Lithology cross section A-A'. Refer to figure 20 for location. Section in white between P/H boundary and H30 mainly muddy facies. Section in light orange determined as sandy mud, muddy sand or interbedded sand and mud, and section in yellow mainly sand facies.

SUMMARY

1) This study reconstructed the Pleistocene and Holocene evolution of North Core Sound using sedimentological, micropaleontolological, geophysical and geochronologic data.
2) Boomer seismic reflections were depicted up to 26 mbsl and four were correlated with Mallinson et al. (2010) reflections.
3) Chirp seismic reflections up to 25 mbsl were obtained throughout North Core Sound.
4) Thirteen vibracores were collected in Core Sound. In addition, nine previously acquired vibracores from Cedar Island and 11 previously acquired viabracores from back-barrier Core Banks were utilized.
5) Ten lithofacies and four biofacies were mapped throughout the study area.
6) Five cross-sections were constructed from core transects across Core Sound, using a combination of biofacies, geophysics and geochronoloogy. Seismic data correlated well and radiocarbon dates indicated a change from mainly muddy deposits to more sandy deposits about 600 cal y BP. The distribution of biofacies was influenced by antecedent topography.
7) North Core Sound was inundated after 7780 cal y BP from two directions, northeast and southwest. A paleo-high extended from Cedar Island creating a drainage divide between the mouth of modern Cedar Island Bay and Thorofare Bay. Inundation of the drainage divide occurred no later than 4880 cal y BP

8) Micropaleontological, geophysical and geochronologic data indicate that high salinity conditions occurred throughout northern Core Sound during the Holocene.

9) The future of this study area is dependent on numerous factors. The number of inlets has been greater in the historical past, but the area is prone to high energy storms that could create more inlets in the future. Understanding the past evolution is the key to predicting the future changes. Anthropogenic factors can play a role on how this region changes in the future.

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APPENDIX A

Percent weights of gravel, sand and mud in core samples. Weights highlighted are measured in grams

CORE	CDR04 S 1													
SAMPLE	INTERVAL (cm)	Dry Weight + Boat (g)	Boat	Total Cale-Dry Weight (Pre-sieve) (g)	Post Sieve >710 um + Boat (g)	Boat	Gravel > 710 um	Total Post Sieve 63-710 um + Boat (g)	Sand 63-710 um (g)	Total Post-Sieve Weight Gravel + Sand (g)	Mud < 63 um (g)	%G	%S	%M
F1	2.43-2.45	33.13	2.87	30.26	2.91	2.89	0.02	7.18	4.31	4.33	25.93	0.07%	14.24%	85.69%

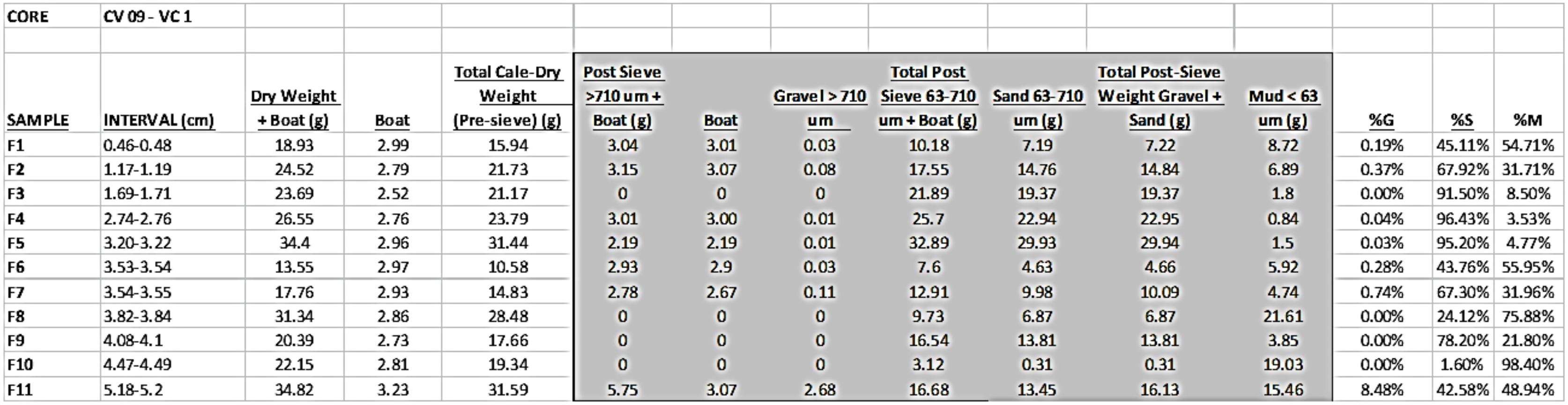
CORE	CDR04 S 5													
SAMPLE	INTERVAL (cm)	Dry Weight + Boat (g)	Boat	Total Cale-Dry Weight (Pre-sieve) (g)	Post Sieve >710 um + Boat (g)	Boat	Gravel > 710 um	Total Post Sieve 63-710 um + Boat (g)	Sand 63-710 um (g)	Total Post-Sieve Weight Gravel + Sand (g)	Mud < 63 um (g)	%G	%S	%M
F1	0.07-0.09	29.47	2.87	26.6	2.66	2.54	0.12	28.81	25.94	26.06	0.54	0.45%	97.52%	2.03%
F2	0.53-0.55	24.53	2.89	21.64	2.63	2.54	0.09	19.86	16.97	17.06	4.58	0.42%	78.42%	21.16%
F3	0.70-0.72	23.9	2.93	20.97	0	0	0	22.76	19.83	19.83	1.14	0.00%	94.56%	5.44%
F4	1.87-1.89	20.96	2.98	17.98	0	0	0	20.07	17.09	17.09	0.89	0.00%	95.05%	4.95%
F5	2.06-2.08	28.8	2.99	25.81	3.03	2.83	0.2	27.67	24.68	24.88	0.93	0.77%	95.62%	3.60%

CORE	CDR04 S 6													
SAMPLE	INTERVAL (cm)	Dry Weight + Boat (g)	Boat	Total Cale-Dry Weight (Pre-sieve) (g)	Post Sieve >710 um + Boat (g)	Boat	Gravel > 710 um	Total Post Sieve 63-710 um + Boat (g)	Sand 63-710 um (g)	Total Post-Sieve Weight Gravel + Sand (g)	Mud < 63 um (g)	%G	%S	%M
F1	0.64-0.66	15.16	3.05	17.68	2.79	2.78	0.01	4.39	1.34	1.35	16.33	0.06%	7.58%	92.36%
F2	1.32-1.34	25.74	3.03	22.71	2.67	2.51	0.16	22.21	19.18	19.34	3.37	0.70%	84.46%	14.84%
F3	2.07-2.09	26.03	3.06	22.97	3.11	2.92	0.19	23.08	20.02	20.21	2.76	0.83%	87.16%	12.02%

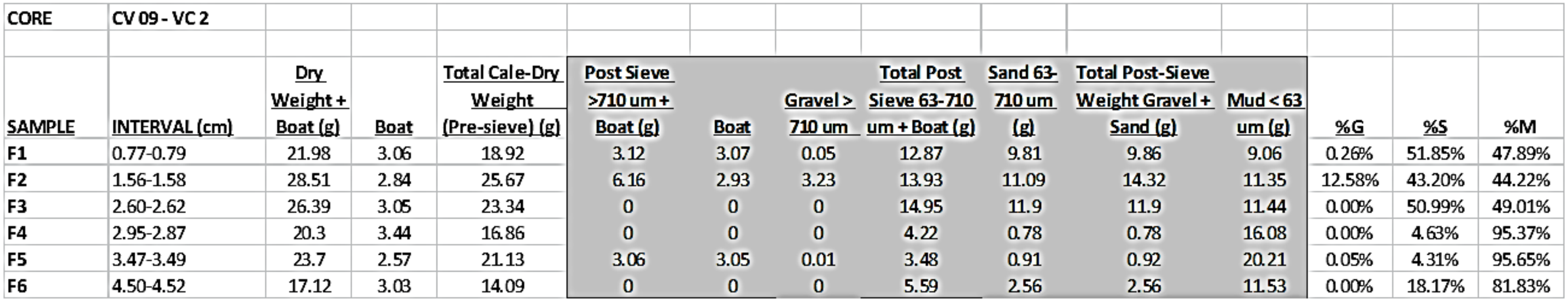
CORE	CDR04 S 7													
SAMPLE	INTERVAL (cm)	Dry Weight + Boat (g)	Boat	Total Cale-Dry Weight (Pre-sieve) (g)	Post Sieve >710 um + Boat (g)	Boat	Gravel > 710 um	Total Post Sieve 63-710 um + Boat (g)	Sand 63-710 um (g)	Total Post-Sieve Weight Gravel + Sand (g)	Mud < 63 um (g)	%G	%S	%M
F1	0.14-0.16	6.73	3.14	3.59	2.61	2.56	0.05	2.96	-0.18	-0.13	3.72	1.39%	-5.01%	103.62%
F2	0.48-0.50	21.07	3.13	17.94	2.78	2.67	0.11	19.88	16.75	16.86	1.08	0.61%	93.37%	6.02%
F3	0.64-0.66	20.89	3.13	17.76	2.87	2.74	0.13	17.6	14.47	14.6	3.16	0.73%	81.48%	17.79%

CORE	CDR04 S8													
SAMPLE	INTERVAL (cm)	Dry Weight + Boat (g)	Boat	Total Cale-Dry Weight (Pre-sieve) (g)	Post Sieve >710 um + Boat (g)	Boat	Gravel > 710 um	Total Post Sieve 63-710 um + Boat (g)	Sand 63-710 um (g)	Total Post-Sieve Weight Gravel + Sand (g)	Mud < 63 um (g)	%G	%S	%M
F1	0.02-0.04	12.25	2.65	9.6	2.8	2.79	0.01	4.99	2.34	2.35	7.25	0.10%	24.38%	75.52%
F2	0.75-0.77	15.57	2.67	12.9	0	0	0	6.69	4.02	4.02	8.88	0.00%	31.16%	68.84%
F3	1.67-1.69	19.88	2.71	17.17	2.93	2.69	0.24	8.41	5.7	5.94	11.23	1.40%	33.20%	65.40%
F4	2.85-2.87	17.29	2.76	14.53	0	0	0	8.52	5.76	5.76	8.77	0.00%	39.64%	60.36%
F5	3.33-3.35	35.96	2.85	33.11	3.01	2.64	0.37	34.2	31.35	31.72	1.39	1.12%	94.68%	4.20%

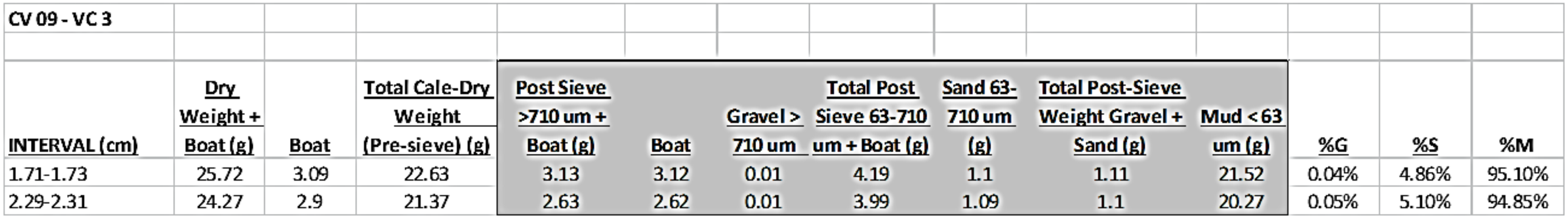
CORE	CDR04 S 9													
SAMPLE	INTERVAL (cm)	Dry Weight + Boat (g)	Boat	Total Cale-Dry Weight (Pre-sieve) (g)	Post Sieve >710 um + Boat (g)	Boat	Gravel > 710 um	Total Post Sieve 63-710 um + Boat (g)	Sand 63-710 um (g)	Total Post-Sieve Weight Gravel + Sand (g)	Mud < 63 um (g)	%G	%S	%M
F1	0.63-0.65	16.86	2.79	14.07	3.07	2.65	0.42	11.95	9.16	9.58	4.49	2.99%	65.10%	31.91%
F2	1.00-1.03	26.3	2.85	23.45	2.73	2.61	0.12	25.05	22.2	22.32	1.13	0.51%	94.67%	4.82%



CORE	CV 09 - VC 1													
SAMPLE	INTERVAL (cm)	Dry Weight + Boat (g)	Boat	Total Cale-Dry Weight (Pre-sieve) (g)	Post Sieve >710 um + Boat (g)	Boat	Gravel > 710 um	Total Post Sieve 63-710 um + Boat (g)	Sand 63-710 um (g)	Total Post-Sieve Weight Gravel + Sand (g)	Mud < 63 um (g)	%G	%S	%M
F1	0.46-0.48	18.93	2.99	15.94	3.04	3.01	0.03	10.18	7.19	7.22	8.72	0.19%	45.11%	54.71%
F2	1.17-1.19	24.52	2.79	21.73	3.15	3.07	0.08	17.55	14.76	14.84	6.89	0.37%	67.92%	31.71%
F3	1.69-1.71	23.69	2.52	21.17	0	0	0	21.89	19.37	19.37	1.8	0.00%	91.50%	8.50%
F4	2.74-2.76	26.55	2.76	23.79	3.01	3.00	0.01	25.7	22.94	22.95	0.84	0.04%	96.43%	3.53%
F5	3.20-3.22	34.4	2.96	31.44	2.19	2.19	0.01	32.89	29.93	29.94	1.5	0.03%	95.20%	4.77%
F6	3.53-3.54	13.55	2.97	10.58	2.93	2.9	0.03	7.6	4.63	4.66	5.92	0.28%	43.76%	55.95%
F7	3.54-3.55	17.76	2.93	14.83	2.78	2.67	0.11	12.91	9.98	10.09	4.74	0.74%	67.30%	31.96%
F8	3.82-3.84	31.34	2.86	28.48	0	0	0	9.73	6.87	6.87	21.61	0.00%	24.12%	75.88%
F9	4.08-4.1	20.39	2.73	17.66	0	0	0	16.54	13.81	13.81	3.85	0.00%	78.20%	21.80%
F10	4.47-4.49	22.15	2.81	19.34	0	0	0	3.12	0.31	0.31	19.03	0.00%	1.60%	98.40%
F11	5.18-5.2	34.82	3.23	31.59	5.75	3.07	2.68	16.68	13.45	16.13	15.46	8.48%	42.58%	48.94%



CORE	CV 09 - VC 2													
SAMPLE	INTERVAL (cm)	Dry Weight + Boat (g)	Boat	Total Cale-Dry Weight (Pre-sieve) (g)	Post Sieve >710 um + Boat (g)	Boat	Gravel > 710 um	Total Post Sieve 63-710 um + Boat (g)	Sand 63-710 um (g)	Total Post-Sieve Weight Gravel + Sand (g)	Mud < 63 um (g)	%G	%S	%M
F1	0.77-0.79	21.98	3.06	18.92	3.12	3.07	0.05	12.87	9.81	9.86	9.06	0.26%	51.85%	47.89%
F2	1.56-1.58	28.51	2.84	25.67	6.16	2.93	3.23	13.93	11.09	14.32	11.35	12.58%	43.20%	44.22%
F3	2.60-2.62	26.39	3.05	23.34	0	0	0	14.95	11.9	11.9	11.44	0.00%	50.99%	49.01%
F4	2.95-2.87	20.3	3.44	16.86	0	0	0	4.22	0.78	0.78	16.08	0.00%	4.63%	95.37%
F5	3.47-3.49	23.7	2.57	21.13	3.06	3.05	0.01	3.48	0.91	0.92	20.21	0.05%	4.31%	95.65%
F6	4.50-4.52	17.12	3.03	14.09	0	0	0	5.59	2.56	2.56	11.53	0.00%	18.17%	81.83%



CV 09 - VC 3												
INTERVAL (cm)	Dry Weight + Boat (g)	Boat	Total Cale-Dry Weight (Pre-sieve) (g)	Post Sieve >710 um + Boat (g)	Boat	Gravel > 710 um	Total Post Sieve 63-710 um + Boat (g)	Sand 63-710 um (g)	Total Post-Sieve Weight Gravel + Sand (g)	Mud < 63 um (g)	%G	%S	%M
1.71-1.73	25.72	3.09	22.63	3.13	3.12	0.01	4.19	1.1	1.11	21.52	0.04%	4.86%	95.10%
2.29-2.31	24.27	2.9	21.37	2.63	2.62	0.01	3.99	1.09	1.1	20.27	0.05%	5.10%	94.85%

CORE	CV 09 - VC 4												
SAMPLE	INTERVAL (cm)	Dry Weight + Boat (g)	Boat	Total Cale-Dry Weight (Pre-sieve) (g)	Post Sieve >710 um + Boat (g)	Boat	Gravel > 710 um	Total Post Sieve 63-710 um + Boat (g)	Sand 63-710 um (g)	Total Post-Sieve Weight Gravel + Sand (g)	Mud < 63 um (g)	%G	%S	%M
F1	0.20-0.22	22.08	2.48	19.6	3.19	2.48	0.71	18.34	15.86	16.57	3.03	3.62%	80.92%	15.46%
F2	0.66-0.68	24.4	2.96	21.44	4.21	2.79	1.42	20.6	17.64	19.06	2.38	6.62%	82.28%	11.10%
F3	1.22-1.24	37.66	2.84	34.82	20.95	2.73	18.22	18.86	16.02	34.24	0.58	52.33%	46.01%	1.67%

CORE	CV 09 - VC 5												
SAMPLE	INTERVAL (cm)	Dry Weight + Boat (g)	Boat	Total Cale-Dry Weight (Pre-sieve) (g)	Post Sieve >710 um + Boat (g)	Boat	Gravel > 710 um	Total Post Sieve 63-710 um + Boat (g)	Sand 63-710 um (g)	Total Post-Sieve Weight Gravel + Sand (g)	Mud < 63 um (g)	%G	%S	%M
F1	0.56-0.58	26.94	2.85	24.09	3.06	2.79	0.27	25.56	22.71	22.98	1.11	1.12%	94.27%	4.61%
F2	1.29-1.31	24.67	2.77	21.9	2.8	2.79	0.01	16.42	13.65	13.66	8.24	0.05%	62.33%	37.63%
F3	2.23-2.25	22.93	3.2	19.73	3.15	2.69	0.46	18.96	15.76	16.22	3.51	2.33%	79.88%	17.79%

CORE	CV 09 - VC 6												
SAMPLE	INTERVAL (cm)	Dry Weight + Boat (g)	Boat	Total Cale-Dry Weight (Pre-sieve) (g)	Post Sieve >710 um + Boat (g)	Boat	Gravel > 710 um	Total Post Sieve 63-710 um + Boat (g)	Sand 63-710 um (g)	Total Post-Sieve Weight Gravel + Sand (g)	Mud < 63 um (g)	%G	%S	%M
F1	0.27-0.29	24.3	3.14	21.16	2.94	2.65	0.29	16.86	13.72	14.01	7.15	1.37%	64.84%	33.79%
F2	0.59-0.61	36.08	3.13	32.95	0	0	0	21.9	18.77	18.77	14.18	0.00%	56.97%	43.03%
F3	1.53-1.55	39.15	2.95	36.2	0	0	0	38.46	35.51	35.51	0.69	0.00%	98.09%	1.91%
F4	2.28-2.30	32.94	2.93	30.01	6.18	2.82	3.36	29.14	26.21	29.57	0.44	11.20%	87.34%	1.47%

CORE	CV 09 - VC 7												
SAMPLE	INTERVAL (cm)	Dry Weight + Boat (g)	Boat	Total Cale-Dry Weight (Pre-sieve) (g)	Post Sieve >710 um + Boat (g)	Boat	Gravel > 710 um	Total Post Sieve 63-710 um + Boat (g)	Sand 63-710 um (g)	Total Post-Sieve Weight Gravel + Sand (g)	Mud < 63 um (g)	%G	%S	%M
F1	0.14-0.16	33.88	2.6	31.28	2.71	2.57	0.14	32.07	29.47	29.61	1.67	0.45%	94.21%	5.34%
F2	0.48-0.50	25.17	2.65	22.52	0	0	0	15.56	12.91	12.91	9.61	0.00%	57.33%	42.67%
F3	0.64-0.66	24.31	2.68	21.63	2.51	2.43	0.08	18.29	15.61	15.69	5.94	0.37%	72.17%	27.46%

CORE	CV 09 - VC 8												
SAMPLE	INTERVAL (cm)	Dry Weight + Boat (g)	Boat	Total Cale-Dry Weight (Pre-sieve) (g)	Post Sieve >710 um + Boat (g)	Boat	Gravel > 710 um	Total Post Sieve 63-710 um + Boat (g)	Sand 63-710 um (g)	Total Post-Sieve Weight Gravel + Sand (g)	Mud < 63 um (g)	%G	%S	%M
F1	0.20-0.22	28	2.54	25.46	0	0	0	27.55	25.01	25.01	0.45	0.00%	98.23%	1.77%
F2	0.67-0.69	21.9	2.66	19.24	3.04	3.02	0.02	16.33	13.67	13.69	5.55	0.10%	71.05%	28.85%
F3	1.59-1.61	23.17	3.06	20.11	3.3	3.08	0.22	9.08	6.02	6.24	13.87	1.09%	29.94%	68.97%
F4	2.53-2.55	24.52	2.83	21.69	2.68	2.67	0.01	4.85	2.02	2.03	19.66	0.05%	9.31%	90.64%
F5	2.79-2.81	10.72	2.89	7.83	2.84	2.73	0.11	9.22	6.33	6.44	1.39	1.40%	80.84%	17.75%
F6	3.09-3.11	24.34	2.92	21.42	2.92	2.78	0.14	21.79	18.87	19.01	2.41	0.65%	88.10%	11.25%
F7	3.55-3.57	21.86	3.00	18.86	3.08	3	0.08	19.81	16.81	16.89	1.97	0.42%	89.13%	10.45%

CORE	CV 09 - VC 9													
SAMPLE	INTERVAL (cm)	Dry Weight + Boat (g)	Boat	Total Cale-Dry Weight (Pre-sieve) (g)	Post Sieve >710 um + Boat (g)	Boat	Gravel > 710 um	Total Post Sieve 63-710 um + Boat (g)	Sand 63-710 um (g)	Total Post-Sieve Weight Gravel + Sand (g)	Mud < 63 um (g)	%G	%S	%M
F1	1.05-1.07	31.19	2.75	28.44	5.02	2.85	2.17	26.58	23.83	26	2.44	7.63%	83.79%	8.58%
F2	1.53-1.55	29.2	3.06	26.14	3.57	2.56	1.01	17.14	14.08	15.09	11.05	3.86%	53.86%	42.27%
F3	1.96-1.98	34.79	2.9	31.89	8.84	2.73	6.11	27.48	24.58	30.69	1.2	19.16%	77.08%	3.76%
F4	2.58-2.60	27.69	2.58	25.11	2.67	2.62	0.05	9.29	6.71	6.76	18.35	0.20%	26.72%	73.08%
F5	3.56-3.58	16.33	2.8	13.53	2.84	2.81	0.03	4.87	2.07	2.1	11.43	0.22%	15.30%	84.48%
F6	4.82-4.84	30.01	2.49	27.52	2.82	2.71	0.11	26.32	23.83	23.94	3.58	0.40%	86.59%	13.01%
F7	5.25-5.27	30.98	2.63	28.35	3.1	2.62	0.48	21.23	18.6	19.08	9.27	1.69%	65.61%	32.70%
F8	6.29-6.31	20.5	2.73	17.77	2.84	2.65	0.19	4.23	1.5	1.69	16.08	1.07%	8.44%	90.49%

CORE	CV 09 - VC 10													
SAMPLE	INTERVAL (cm)	Dry Weight + Boat (g)	Boat	Total Cale-Dry Weight (Pre-sieve) (g)	Post Sieve >710 um + Boat (g)	Boat	Gravel > 710 um	Total Post Sieve 63-710 um + Boat (g)	Sand 63-710 um (g)	Total Post-Sieve Weight Gravel + Sand (g)	Mud < 63 um (g)	%G	%S	%M
F1	0.55-0.57	27.51	3.24	24.27	2.84	2.83	0.01	23.65	20.41	20.42	3.85	0.04%	84.10%	15.86%
F2	1.12-1.14	32.5	3.13	29.37	2.94	2.78	0.16	25.37	22.24	22.4	6.97	0.54%	75.72%	23.73%
F3	1.55-1.57	25.65	2.96	22.69	0	0	0	5.65	2.69	2.69	20	0.00%	11.86%	88.14%
F4	2.06-2.08	12.23	2.99	9.24	0	0.00	0	3.46	0.47	0.47	8.77	0.00%	5.09%	94.91%
F5	2.21-2.23	16.37	3.04	13.33	7.87	2.93	4.94	5.18	2.14	7.08	6.25	37.06%	16.05%	46.89%
F6	2.93-2.95	27.77	2.89	24.88	0	0	0	21.35	18.46	18.46	6.42	0.00%	74.20%	25.80%

CORE	CV 09 - VC 11													
SAMPLE	INTERVAL (cm)	Dry Weight + Boat (g)	Boat	Total Cale-Dry Weight (Pre-sieve) (g)	Post Sieve >710 um + Boat (g)	Boat	Gravel > 710 um	Total Post Sieve 63-710 um + Boat (g)	Sand 63-710 um (g)	Total Post-Sieve Weight Gravel + Sand (g)	Mud < 63 um (g)	%G	%S	%M
F1	0.27-0.29	17.49	3.32	14.17	2.83	2.77	0.06	4.91	1.59	1.65	12.52	0.42%	11.22%	88.36%
F2	0.88-0.90	25.18	3.33	21.85	2.87	2.77	0.1	3.88	0.55	0.65	21.2	0.46%	2.52%	97.03%
F3	0.99-1.01	9.98	3.29	6.69	2.78	2.75	0.03	3.75	0.46	0.49	6.2	0.45%	6.88%	92.68%
F4	1.53-1.55	13.49	3.25	10.24	2.79	2.72	0.07	8.31	5.06	5.13	5.11	0.68%	49.41%	49.90%

CORE	CV 09 - VC 12													
SAMPLE	INTERVAL (cm)	Dry Weight + Boat (g)	Boat	Total Cale-Dry Weight (Pre-sieve) (g)	Post Sieve >710 um + Boat (g)	Boat	Gravel > 710 um	Total Post Sieve 63-710 um + Boat (g)	Sand 63-710 um (g)	Total Post-Sieve Weight Gravel + Sand (g)	Mud < 63 um (g)	%G	%S	%M
F1	0.55-0.57	22.46	2.45	20.01	2.56	2.55	0.01	17	14.55	14.56	5.45	0.05%	72.71%	27.24%

CORE	CV 09 - VC 13													
SAMPLE	INTERVAL (cm)	Dry Weight + Boat (g)	Boat	Total Cale-Dry Weight (Pre-sieve) (g)	Post Sieve >710 um + Boat (g)	Boat	Gravel > 710 um	Total Post Sieve 63-710 um + Boat (g)	Sand 63-710 um (g)	Total Post-Sieve Weight Gravel + Sand (g)	Mud < 63 um (g)	%G	%S	%M
F1	0.33-0.35	16.33	2.55	13.78	2.81	2.43	0.38	7.79	5.24	5.62	8.16	2.76%	38.03%	59.22%
F2	0.73-0.75	21.64	2.78	18.86	2.49	2.47	0.02	4.93	2.15	2.17	16.69	0.11%	11.40%	88.49%
F3	0.83-0.85	26.72	2.65	24.07	2.76	2.58	0.18	26.19	23.54	23.72	0.35	0.75%	97.80%	1.45%

CORE	NCB04 S 23												
SAMPLE	INTERVAL (cm)	Dry Weight +Boat (g)	Boat	Total Cale-Dry Weight (Pre-sieve) (g)	Post Sieve >710 um + Boat (g)	Boat	Gravel > 710 um	Total Post Sieve 63-710 um + Boat (g)	Sand 63-710 um (g)	Total Post-Sieve Weight Gravel + Sand (g)	Mud < 63 um (g)	%G	%S	%M
F1	0.73-0.75	17.93	2.96	14.97	0	0	0	13.46	10.5	10.5	4.47	0.00%	70.14%	29.86%
F2	1.44-1.46	28.01	3.06	24.95	3.06	3.05	0.01	22.75	19.69	19.7	5.25	0.04%	78.92%	21.04%
F3	1.69-1.72	19.88	3.00	16.88	0	0	0	3.98	0.98	0.98	15.9	0.00%	5.81%	94.19%
F4	2.48-2.50	40.76	2.88	37.88	2.61	2.57	0.04	39.44	36.56	36.6	1.28	0.11%	96.52%	3.38%

CORE	NCB04 S 24													
SAMPLE	INTERVAL (cm)	Dry Weight + Boat (g)	Boat	Total Cale-Dry Weight (Pre-sieve) (g)	Post Sieve >710 um + Boat (g)	Boat	Gravel > 710 um	Total Post Sieve 63-710 um + Boat (g)	Sand 63-710 um (g)	Total Post-Sieve Weight Gravel + Sand (g)	Mud < 63 um (g)	%G	%S	%M
F1	0.80-0.83	29.18	3.19	25.99	3.05	2.97	0.08	26.95	23.98	24.06	1.93	0.31%	92.27%	7.43%
F2	1.30-1.33	38.3	3.15	35.15	2.88	2.6	0.28	37.43	34.83	35.11	0.04	0.80%	99.09%	0.11%
F3	1.85-1.87	27.87	3.18	24.69	0	0	0	21.9	18.72	18.72	5.97	0.00%	75.82%	24.18%
F4	2.60-2.62	29.93	3.15	26.78	2.61	2.59	0.02	24.4	23.75	23.77	3.01	0.07%	88.69%	11.24%

CORE	NCB04 S 25													
SAMPLE	INTERVAL (cm)	Dry Weight + Boat (g)	Boat	Total Cale-Dry Weight (Pre-sieve) (g)	Post Sieve >710 um + Boat (g)	Boat	Gravel > 710 um	Total Post Sieve 63-710 um + Boat (g)	Sand 63-710 um (g)	Total Post-Sieve Weight Gravel + Sand (g)	Mud < 63 um (g)	%G	%S	%M
F1	0.61-0.63	23.64	3.43	20.21	0	0	0	20.07	16.64	16.64	3.57	0.00%	82.34%	17.66%
F2	1.76-1.78	37.94	3.13	34.81	0	0	0	37.13	34	34	0.81	0.00%	97.67%	2.33%
F3	2.81-2.83	29.26	3.14	26.12	0	0	0	19.08	15.94	15.94	10.18	0.00%	61.03%	38.97%
F4	3.53-3.55	21.14	3.2	17.94	2.84	2.82	0.02	15.16	11.96	11.98	5.96	0.11%	66.67%	33.22%

CORE	NCB04 S 27													
SAMPLE	INTERVAL (cm)	Dry Weight + Boat (g)	Boat	Total Cale-Dry Weight (Pre-sieve) (g)	Post Sieve >710 um + Boat (g)	Boat	Gravel > 710 um	Total Post Sieve 63-710 um + Boat (g)	Sand 63-710 um (g)	Total Post-Sieve Weight Gravel + Sand (g)	Mud < 63 um (g)	%G	%S	%M
F1	0.19-0.21	11.76	3.08	8.68	2.75	2.72	0.03	5.75	2.67	2.7	5.98	0.35%	30.76%	68.89%
F2	1.33-1.35	41.27	2.69	38.58	5.18	2.62	2.56	38.18	35.49	38.05	0.53	6.64%	91.99%	1.37%

CORE	NCB04 S 34													
SAMPLE	INTERVAL (cm)	Dry Weight + Boat (g)	Boat	Total Cale-Dry Weight (Pre-sieve) (g)	Post Sieve >710 um + Boat (g)	Boat	Gravel > 710 um	Total Post Sieve 63-710 um + Boat (g)	Sand 63-710 um (g)	Total Post-Sieve Weight Gravel + Sand (g)	Mud < 63 um (g)	%G	%S	%M
F1	0.09-0.11	35.78	3.15	32.63	2.84	2.48	0.36	34.29	31.14	31.5	1.13	1.10%	95.43%	3.46%
F2	0.51-0.53	28.16	3.18	24.98	2.91	2.64	0.27	22.04	18.86	19.13	5.85	1.08%	75.50%	23.42%
F3	1.37-1.39	34.66	3.1	31.56	3.06	2.73	0.33	33.78	30.68	31.01	0.55	1.05%	97.21%	1.74%
F4	2.43-2.45	24.95	3.23	21.72	2.96	2.59	0.37	20.01	16.78	17.15	4.57	1.70%	77.26%	21.04%

APPENDIX B

Raw census data foraminifera includes the total number of specimens of each species in down-core samples.

	CS09												
Core	VC1	VC1	VC1	VC1	VC1	VC1	VC1	VC1	VC1	VC2	VC2	VC4	VC4
Midpoint	47	118	170	353.5	354.5	383	409	448	519	78	157	21	67
Species													
Acervulina inhaerens													
Ammonia parkinsoniana	34	4	1	6	31	2	10	2	11	9	110	1	61
Ammonia tepida													
Ammotium salsum	2												
Amphistegina sp.													
Arenoparrella mexicana													
Bolivina sp.													
Bolivina lowmani					2	3	3	1					
Bolivina striatula													
Buccella inusitata					3		1						
Bulimina elongata													
Buliminella sp.													
Buliminella elegantissima				1	2	2	2	8					
Cassidulina sp. B							1						
Cassidulina minuta								1	1				
Cibicides sp.						2	1						
Cibicides fletcheri					9								
Cibicides lobatulus				1	1				3				
Cornuspira planorbis							2						
Elphidium sp.							1	1	1				
Elphidium discoidale													
Elphidium excavatum	83	144	12	126	132	183	166	187	178	129	36		94
Elphidium galvestonense	5									1	3		9
Elphidium gunteri	3			6			1		2		2		5
Elphidium mexicanum	3			2	1		8		2				
Elphidium poeyanum				1			1				9		
Elphidium transluscens									1				
Elphidium subarcticum													
Epistominella sp.					1								
Eponides repandus													
Fursenkoina sp.													
Fissurina sp.													
Gavelinopsis praegeri					20	2	3	3	2				
Haplophragmoides sp.													1
Haplophragmoides manilaensis													
Haplophragmoides wilberti													
Hanzawaia strattoni	1			1		1	2		1				
Haynesina germanica	11	1		36	4	22		1	22	25	32		20

	CS09												
Core	VC1	VC1	VC1	VC1	VC1	VC1	VC1	VC1	VC1	VC2	VC2	VC4	VC4
Midpoint	47	118	170	353.5	354.5	383	409	448	519	78	157	21	67
Species													
Jadammina macrescens													
Miliammina fusca													
Miliammina petila													
Miliolinella subrotunda							4						
Neoconorbina terquemi													
Nonionella sp.					1								
Nonionella atlantica				2	3				1				
Nonionella auricula	1												
Nonionella opima													
Planulina sp.													
Eponides repandus													
Quinqueloculina sp.													
Quinqueloculina auberiana													
Quinqueloculina bosciana						1	2	1					
Quinqueloculina dimidiata							2		2				
Quinqueloculina frigida													
Quinqueloculina jugosa							2		1				
Quinqueloculina lamarckiana													
Quinqueloculina seminula						1	4	1	6				
Rosalina sp.													
Rosalina floridana				1	7		3	2					
Siphonaptera sp.									1				
Siphotrochammina Lobata													
Siphotrocha sp.													
Spiroloculina atlantica							1						
Textularia earlandi	1					1							
Tipotrocha comprimata													
Trifarina sp.													
Trifarina angulosa				2									
Trochammina sp.													
Trochammina inflata													1
Uvigerina auberina/peregrina													
Valvulineria sp.													
Planktonics							1						
Total	144	149	13	185	217	220	221	209	235	164	192	1	191

	CS09												
Core	VC4	VC5	VC5	VC5	VC6	VC6	VC7	VC7	VC7	VC8	VC8	VC8	VC9
Midpoint	123	57	130	224	28	229	15	49	65	21	68	160	106
Species													
Acervulina inhaerens						1							
Ammonia parkinsoniana	70	5	26	44	1	29	9	44	8	16	76	35	75
Ammonia tepida													2
Ammotium salsum													
Amphistegina sp.	1												
Arenoparrella mexicana													
Bolivina sp.													
Bolivina lowmani			1										
Bolivina striatula													
Buccella inusitata	2					2							
Bulimina elongata													
Buliminella sp.			1										
Buliminella elegantissima			3										
Cassidulina sp. B													
Cassidulina minuta	1												
Cibicides sp.													
Cibicides fletcheri			2			1							
Cibicides lobatulus	7		1	1		7					1		
Cornuspira planorbis													
Elphidium sp.	1												
Elphidium discoidale													
Elphidium excavatum	107	6	111	154		76	7	122	56	36	39	124	96
Elphidium galvestonense		7			1		5	1	1		11		
Elphidium gunteri	6		4	1		9			1	2	3	1	13
Elphidium mexicanum	5	1	9	1		4				4	6	1	5
Elphidium poeyanum			6	1		1						3	
Elphidium transluscens			3			1					1	1	2
Elphidium subarcticum													
Epistominella sp.													
Eponides repandus													
Fursenkoina sp.													
Fissurina sp.												1	
Gavelinopsis praegeri	2												
Haplophragmoides sp.								1					
Haplophragmoides manilaensis													
Haplophragmoides wilberti													
Hanzawaia strattoni	13		7	1		21				1	1		
Haynesina germanica			18		1					1	16		3

	CS09												
Core	VC4	VC5	VC5	VC5	VC6	VC6	VC7	VC7	VC7	VC8	VC8	VC8	VC9
Midpoint	123	57	130	224	28	229	15	49	65	21	68	160	106
Species													
Jadammina macrescens													
Miliammina fusca													
Miliammina petila													
Miliolinella subrotunda													
Neoconorbina terquemi	1												
Nonionella sp.													
Nonionella atlantica			4			8							
Nonionella auricula		1	1										
Nonionella opima													
Planulina sp.	1												
Eponides repandus						9							
Quinqueloculina sp.													1
Quinqueloculina auberiana													
Quinqueloculina bosciana													
Quinqueloculina dimidiata													
Quinqueloculina frigida						1							
Quinqueloculina jugosa						1							
Quinqueloculina lamarckiana													
Quinqueloculina seminula			1			35							
Rosalina sp.			1										
Rosalina floridana	2		3										
Siphonaptera sp.													
Siphotrochammina Lobata													
Siphotrocha sp.													
Spiroloculina atlantica													
Textularia earlandi													
Tipotrocha comprimata													
Trifarina sp.													
Trifarina angulosa													
Trochammina sp.													
Trochammina inflata													
Uvigerina auberina/peregrina													
Valvulineria sp.													
Planktonics													
Total	219	20	202	203	3	206	21	168	66	60	154	166	197

	CS09												
Core	VC9	VC9	VC9	VC9	VC9	VC9	VC10	VC10	VC10	VC10	VC11	VC12	VC13
Midpoint	154	197	259	483	526	630	56	113	156	222	28	56	34
Species													
Acervulina inhaerens													
Ammonia parkinsoniana	9	45	7	56	24	111	2	85	34		70	123	102
Ammonia tepida													
Ammotium salsum											1		
Amphistegina sp.													
Arenoparrella mexicana													
Bolivina sp.									2				
Bolivina lowmani													
Bolivina striatula									1				
Buccella inusitata								1	2		1		
Bulimina elongata									1				
Buliminella sp.													
Buliminella elegantissima								1					
Cassidulina sp. B													
Cassidulina minuta													
Cibicides sp.													
Cibicides fletcheri													
Cibicides lobatulus						1			3				
Cornuspira planorbis													
Elphidium sp.					1			2					1
Elphidium discoidale													
Elphidium excavatum	69	75	21	114	21	9	30	184	128	7	165	47	190
Elphidium galvestonense			7		1							14	3
Elphidium gunteri			47	9		1	4	4			1	13	2
Elphidium mexicanum				3	1		2	12	1				
Elphidium poeyanum	2							3					1
Elphidium transluscens											1		
Elphidium subarcticum													
Epistominella sp.									2				
Eponides repandus									4				
Fursenkoina sp.									2				
Fissurina sp.													
Gavelinopsis praegeri													
Haplophragmoides sp.													
Haplophragmoides manilaensis													
Haplophragmoides wilberti													
Hanzawaia strattoni				1									
Haynesina germanica				9		2		12			2	2	

	CS09												
Core	VC9	VC9	VC9	VC9	VC9	VC9	VC10	VC10	VC10	VC10	VC11	VC12	VC13
Midpoint	154	197	259	483	526	630	56	113	156	222	28	56	34
Species													
Jadammina macrescens													
Miliammina fusca													
Miliammina petila													
Miliolinella subrotunda													
Neoconorbina terquemi													
Nonionella sp.													
Nonionella atlantica									2				
Nonionella auricula													
Nonionella opima									2				
Planulina sp.													
Eponides repandus													
Quinqueloculina sp.													
Quinqueloculina auberiana													
Quinqueloculina bosciana													
Quinqueloculina dimidiata													
Quinqueloculina frigida													
Quinqueloculina jugosa													
Quinqueloculina lamarckiana													
Quinqueloculina seminula				5									
Rosalina sp.													
Rosalina floridana													
Siphonaptera sp.													
Siphotrochammina Lobata													
Siphotrocha sp.													
Spiroloculina atlantica													
Textularia earlandi													
Tipotrocha comprimata													
Trifarina sp.													
Trifarina angulosa													
Trochammina sp.													1
Trochammina inflata													
Uvigerina auberina/peregrina									2				
Valvulineria sp.									1				
Planktonics								2					
Total	80	120	82	197	48	124	38	306	187	7	241	199	300

	CDR04					NCB04								
Core	S6	S7	S8	S8	S9	S23	S24	S25	S25	S25	S27	S34	S34	S34
Midpoint	65	15	3	167	64	249	131	62	177	354	134	10	138	244
Species														
Acervulina inhaerens														
Ammonia parkinsoniana							1	15	3	5	6		16	19
Ammonia tepida														
Ammotium salsum														
Amphistegina sp.														
Arenoparrella mexicana	2													
Bolivina sp.														
Bolivina lowmani														
Bolivina striatula														
Buccella inusitata														
Bulimina elongata														
Buliminella sp.														
Buliminella elegantissima														
Cassidulina sp. B														
Cassidulina minuta														
Cibicides sp.														
Cibicides fletcheri													1	
Cibicides lobatulus										1	4		2	
Cornuspira planorbis														
Elphidium sp.								1						
Elphidium discoidale											1			
Elphidium excavatum							2	101	26	175	37		63	44
Elphidium galvestonense						2		4			14		24	4
Elphidium gunteri								3		3			4	
Elphidium mexicanum								8			9		49	7
Elphidium poeyanum													1	
Elphidium transluscens													1	2
Elphidium subarcticum													1	
Epistominella sp.														
Eponides repandus											1			
Fursenkoina sp.														
Fissurina sp.														
Gavelinopsis praegeri														
Haplophragmoides sp.			1					1						
Haplophragmoides manilaensis										1				
Haplophragmoides wilberti	50		3	1	2									
Hanzawaia strattoni								1			8		10	
Haynesina germanica						1		5		14	2		3	1

	CDR04					NCB04								
Core	S6	S7	S8	S8	S9	S23	S24	S25	S25	S25	S27	S34	S34	S34
Midpoint	65	15	3	167	64	249	131	62	177	354	134	10	138	244
Species														
Jadammina macrescens			55											
Miliammina fusca			13											
Miliammina petila	4													
Miliolinella subrotunda														
Neoconorbina terquemi														
Nonionella sp.														
Nonionella atlantica													1	
Nonionella auricula														
Nonionella opima														
Planulina sp.														
Eponides repandus														
Quinqueloculina sp.														
Quinqueloculina auberiana													1	
Quinqueloculina bosciana														
Quinqueloculina dimidiata														
Quinqueloculina frigida														
Quinqueloculina jugosa														
Quinqueloculina lamarckiana											6			
Quinqueloculina seminula											5		3	
Rosalina sp.														
Rosalina floridana													1	
Siphonaptera sp.														
Siphotrochammina Lobata		1												
Siphotrocha sp.														
Spiroloculina atlantica														
Textularia earlandi														
Tipotrocha comprimata			101											
Trifarina sp.											1			
Trifarina angulosa														
Trochammina sp.														
Trochammina inflata	5	7	43	1				2				1		
Uvigerina auberina/peregrina														
Valvulineria sp.														
Planktonics													1	
Total	61	8	216	2	2	3	3	141	29	199	94	1	182	77

APPENDIX C

Abundance of foraminifera in each sample expressed as percent.

	CS09											
Core	VC1	VC1	VC1	VC1	VC1	VC1	VC1	VC1	VC1	VC2	VC2	VC4
Midpoint	47	118	170	353.5	354.5	383	409	448	519	78	157	21
Species												
Acervulina inhaerens												
Ammonia tepida												
Ammonia parkinsoniana	23.6	2.7	7.7	3.2	14.3	0.9	4.5	1.0	4.7	5.5	57.3	100.0
Ammotium salsum	1.4											
Amphistegina sp.												
Arenoparrella mexicana												
Bolivina sp.												
Bolivina lowmani					0.9	1.4	1.4	0.5				
Bolivina striatula												
Buccella inusitata					1.4		0.5					
Bulimina elongata												
Buliminella sp.												
Buliminella elegantissima				0.5	0.9	0.9	0.9	3.8				
Cassidulina sp. B							0.5					
Cassidulina minuta								0.5	0.4			
Cibicides sp.						0.9	0.5					
Cibicides fletcheri					4.1							
Cibicides lobatulus				0.5	0.5				1.3			
Cornuspira planorbis							0.9					
Elphidium sp.							0.5	0.5	0.4			
Elphidium discoidale												
Elphidium excavatum	57.6	96.6	92.3	68.1	60.8	83.2	75.1	89.5	75.7	78.7	18.8	
Elphidium galvestonense	3.5									0.6	1.6	
Elphidium gunteri	2.1			3.2			0.5		0.9		1.0	
Elphidium mexicanum	2.1			1.1	0.5		3.6		0.9			
Elphidium poeyanum				0.5			0.5				4.7	
Elphidium transluscens									0.4			
Elphidium subarcticum												
Epistominella sp.					0.5							
Eponides repandus					0.0							
Fursenkoina sp.												
Fissurina sp.												
Gavelinopsis praegeri					9.2	0.9	1.4	1.4	0.9			
Haplophragmoides sp.												
Haplophragmoides manilaensis												
Haplophragmoides wilberti												
Haynesina germanica	7.6	0.7		19.5	1.8	10.0		0.5	9.4	15.2	16.7	
Hanzawaia strattoni	0.7			0.5		0.5	0.9		0.4			

	CS09											
Core	VC1	VC1	VC1	VC1	VC1	VC1	VC1	VC1	VC1	VC2	VC2	VC4
Midpoint	47	118	170	353.5	354.5	383	409	448	519	78	157	21
Species												
Haynesina germanica	7.6	0.7		19.5	1.8	10.0		0.5	9.4	15.2	16.7	
Jadammina macrescens												
Miliammina fusca												
Miliammina petila												
Miliolinella subrotunda							1.8					
Neoconorbina terquemi												
Nonionella sp.					0.5							
Nonionella atlantica				1.1	1.4				0.4			
Nonionella auricula	0.7											
Nonionella opima												
Planulina sp.												
Quinqueloculina sp.												
Quinqueloculina auberiana						0.5	0.9	0.5				
Quinqueloculina bosciana							0.9		0.9			
Quinqueloculina dimidiata												
Quinqueloculina frigida							0.9		0.4			
Quinqueloculina jugosa												
Quinqueloculina lamarckiana						0.5	1.8	0.5	2.6			
Quinqueloculina seminula												
Rosalina sp.				0.5	3.2		1.4	1.0				
Rosalina floridana									0.4			
Siphonaptera sp.												
Siphotrochammina Lobata												
Siphotrochammina sp.							0.5					
Spiroloculina atlantica	0.7					0.5						
Textularia earlandi												
Tipotrocha comprimata												
Trifarina sp.				1.1								
Trifarina angulosa												
Trochammina sp.												
Trochammina inflata												
Uvigerina auberina/peregrina												
Valvulineria sp.							0.5					
Total percent	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
Total	144	149	13	185	217	220	221	209	235	164	192	1

	CS09											
Core	VC4	VC4	VC5	VC5	VC5	VC6	VC6	VC7	VC7	VC7	VC8	VC8
Midpoint	67	123	57	130	224	28	229	15	49	65	21	68
Species												
Acervulina inhaerens							0.5					
Ammonia parkinsoniana	31.9	32.0	25.0	12.9	21.7	33.3	14.1	42.9	26.2	12.1	26.7	49.4
Ammonia tepida												
Ammotium salsum												
Amphistegina sp.		0.5										
Arenoparrella mexicana												
Bolivina sp.												
Bolivina lowmani				0.5								
Bolivina striatula												
Buccella inusitata		0.9					1.0					
Bulimina elongata												
Buliminella sp.				0.5								
Buliminella elegantissima				1.5								
Cassidulina sp. B												
Cassidulina minuta		0.5										
Cibicides sp.												
Cibicides fletcheri				1.0			0.5					
Cibicides lobatulus		3.2		0.5	0.5		3.4					0.6
Cornuspira planorbis												
Elphidium sp.		0.5										
Elphidium discoidale												
Elphidium excavatum	49.2	48.9	30.0	55.0	75.9		36.9	33.3	72.6	84.8	60.0	25.3
Elphidium galvestonense	4.7		35.0			33.3		23.8	0.6	1.5		7.1
Elphidium gunteri	2.6	2.7		2.0	0.5		4.4			1.5	3.3	1.9
Elphidium mexicanum		2.3	5.0	4.5	0.5		1.9				6.7	3.9
Elphidium poeyanum				3.0	0.5		0.5					
Elphidium transluscens				1.5			0.5					0.6
Elphidium subarcticum												
Epistominella sp.												
Eponides repandus							4.4					
Fursenkoina sp.												
Fissurina sp.												
Gavelinopsis praegeri		0.9										
Haplophragmoides sp.	0.5								0.6			
Haplophragmoides manilaensis												
Haplophragmoides wilberti												
Hanzawaia strattoni		5.9		3.5	0.5		10.2				1.7	0.6

	CS09											
Core	VC4	VC4	VC5	VC5	VC5	VC6	VC6	VC7	VC7	VC7	VC8	VC8
Midpoint	67	123	57	130	224	28	229	15	49	65	21	68
Species												
Haynesina germanica	10.5			8.9		33.3					1.7	10.4
Jadammina macrescens												
Miliammina fusca												
Miliammina petila												
Miliolinella subrotunda												
Neoconorbina terquemi		0.5										
Nonionella sp.												
Nonionella atlantica				2.0			3.9					
Nonionella auricula			5.0	0.5								
Nonionella opima												
Planulina sp.		0.5										
Quinqueloculina sp.												
Quinqueloculina auberiana												
Quinqueloculina bosciana												
Quinqueloculina dimidiata							0.5					
Quinqueloculina frigida							0.5					
Quinqueloculina jugosa												
Quinqueloculina lamarckiana				0.5			17.0					
Quinqueloculina seminula				0.5								
Rosalina sp.		0.9		1.5								
Rosalina floridana												
Siphonaptera sp.												
Siphotrochammina Lobata												
Siphotrochammina sp.												
Spiroloculina atlantica												
Textularia earlandi												
Tipotrocha comprimata												
Trifarina sp.												
Trifarina angulosa												
Trochammina sp.	0.5											
Trochammina inflata												
Uvigerina auberina/peregrina												
Valvulineria sp.												
Total percent	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
Total	191	219	20	202	203	3	206	21	168	66	60	154

	CS09											
Core	VC8	VC9	VC9	VC9	VC9	VC9	VC9	VC9	VC10	VC10	VC10	VC10
Midpoint	160	106	154	197	259	483	526	630	56	113	156	222
Species												
Acervulina inhaerens												
Ammonia parkinsoniana	21.1	38.1	11.3	37.5	8.5	28.4	50.0	89.5	5.3	27.8	18.2	
Ammonia tepida		1.0										
Ammotium salsum												
Amphistegina sp.												
Arenoparrella mexicana												
Bolivina sp.											1.1	
Bolivina lowmani												
Bolivina striatula											0.5	
Buccella inusitata										0.3	1.1	
Bulimina elongata											0.5	
Buliminella sp.												
Buliminella elegantissima										0.3		
Cassidulina sp. B												
Cassidulina minuta												
Cibicides sp.												
Cibicides fletcheri												
Cibicides lobatulus								0.8			1.6	
Cornuspira planorbis												
Elphidium sp.							2.1			0.7		
Elphidium discoidale												
Elphidium excavatum	74.7	48.7	86.3	62.5	25.6	57.9	43.8	7.3	78.9	60.1	68.4	100.0
Elphidium galvestonense					8.5		2.1					
Elphidium gunteri	0.6	6.6			57.3	4.6		0.8	10.5	1.3		
Elphidium mexicanum	0.6	2.5				1.5	2.1		5.3	3.9	0.5	
Elphidium poeyanum	1.8		2.5							1.0		
Elphidium transluscens	0.6	1.0										
Elphidium subarcticum												
Epistominella sp.											1.1	
Eponides repandus		0.5									2.1	
Fursenkoina sp.											1.1	
Fissurina sp.	0.6											
Gavelinopsis praegeri												
Haplophragmoides sp.												
Haplophragmoides manilaensis												
Haplophragmoides wilberti												
Hanzawaia strattoni						0.5						

	CS09											
Core	VC8	VC9	VC9	VC9	VC9	VC9	VC9	VC9	VC10	VC10	VC10	VC10
Midpoint	160	106	154	197	259	483	526	630	56	113	156	222
Species												
Haynesina germanica		1.5				4.6		1.6		3.9		
Jadammina macrescens												
Miliammina fusca												
Miliammina petila												
Miliolinella subrotunda												
Neoconorbina terquemi												
Nonionella sp.												
Nonionella atlantica											1.1	
Nonionella auricula												
Nonionella opima											1.1	
Planulina sp.												
Quinqueloculina sp.												
Quinqueloculina auberiana												
Quinqueloculina bosciana												
Quinqueloculina dimidiata												
Quinqueloculina frigida												
Quinqueloculina jugosa												
Quinqueloculina lamarckiana						2.5						
Quinqueloculina seminula												
Rosalina sp.												
Rosalina floridana												
Siphonaptera sp.												
Siphotrochammina Lobata												
Siphotrochammina sp.												
Spiroloculina atlantica												
Textularia earlandi												
Tipotrocha comprimata												
Trifarina sp.												
Trifarina angulosa												
Trochammina sp.												
Trochammina inflata											1.1	
Uvigerina auberina/peregrina											0.5	
Valvulineria sp.										0.7		
Total percent	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
Total	166	197	80	120	82	197	48	124	38	306	187	7

	CS09			CDR04				
Core	VC11	VC12	VC13	S6	S7	S8	S8	S9
Midpoint	28	56	34	65	15	3	167	64
Species								
Acervulina inhaerens								
Ammonia parkinsoniana	29.0	61.8	34.0					
Ammonia tepida								
Ammotium salsum	0.4							
Amphistegina sp.								
Arenoparrella mexicana				3.3				
Bolivina sp.								
Bolivina lowmani								
Bolivina striatula								
Buccella inusitata	0.4							
Bulimina elongata								
Buliminella sp.								
Buliminella elegantissima								
Cassidulina sp. B								
Cassidulina minuta								
Cibicides sp.								
Cibicides fletcheri								
Cibicides lobatulus								
Cornuspira planorbis								
Elphidium sp.			0.3					
Elphidium discoidale								
Elphidium excavatum	68.5	23.6	63.3					
Elphidium galvestonense		7.0	1.0					
Elphidium gunteri	0.4	6.5	0.7					
Elphidium mexicanum								
Elphidium poeyanum			0.3					
Elphidium transluscens	0.4							
Elphidium subarcticum								
Epistominella sp.								
Eponides repandus								
Fursenkoina sp.								
Fissurina sp.								
Gavelinopsis praegeri								
Haplophragmoides sp.						0.5		
Haplophragmoides manilaensis								
Haplophragmoides wilberti				82.0		1.4	50.0	100.0
Hanzawaia strattoni								

	CS09			CDR04				
Core	VC11	VC12	VC13	S6	S7	S8	S8	S9
Midpoint	28	56	34	65	15	3	167	64
Species								
Haynesina germanica	0.8	1.0						
Jadammina macrescens						25.5		
Miliammina fusca						6.0		
Miliammina petila				6.6				
Miliolinella subrotunda								
Neoconorbina terquemi								
Nonionella sp.								
Nonionella atlantica								
Nonionella auricula								
Nonionella opima								
Planulina sp.								
Quinqueloculina sp.								
Quinqueloculina auberiana								
Quinqueloculina bosciana								
Quinqueloculina dimidiata								
Quinqueloculina frigida								
Quinqueloculina jugosa								
Quinqueloculina lamarckiana								
Quinqueloculina seminula								
Rosalina sp.								
Rosalina floridana								
Siphonaptera sp.					12.5			
Siphotrochammina Lobata								
Siphotrochammina sp.								
Spiroloculina atlantica								
Textularia earlandi						46.8		
Tipotrocha comprimata								
Trifarina sp.								
Trifarina angulosa			0.3					
Trochammina sp.				8.2	87.5	19.9	50.0	
Trochammina inflata								
Uvigerina auberina/peregrina								
Valvulineria sp.								
Total percent	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
Total	241	199	300	61	8	216	2	2

	NCB04								
Core	S23	S24	S25	S25	S25	S27	S34	S34	S34
Midpoint	249	131	62	177	354	134	10	138	244
Species									
Acervulina inhaerens									
Ammonia parkinsoniana		33.3	10.6	10.3	2.5	6.4		8.8	24.7
Ammonia tepida									
Ammotium salsum									
Amphistegina sp.									
Arenoparrella mexicana									
Bolivina sp.									
Bolivina lowmani									
Bolivina striatula									
Buccella inusitata									
Bulimina elongata									
Buliminella sp.									
Buliminella elegantissima									
Cassidulina sp. B									
Cassidulina minuta									
Cibicides sp.									
Cibicides fletcheri								0.5	
Cibicides lobatulus					0.5	4.3		1.1	
Cornuspira planorbis									
Elphidium sp.			0.7						
Elphidium discoidale						1.1			
Elphidium excavatum		66.7	71.6	89.7	87.9	39.4		34.6	57.1
Elphidium galvestonense	66.7		2.8			14.9		13.2	5.2
Elphidium gunteri			2.1		1.5			2.2	
Elphidium mexicanum			5.7			9.6		26.9	9.1
Elphidium poeyanum								0.5	
Elphidium transluscens								0.5	2.6
Elphidium subarcticum								0.5	
Epistominella sp.									
Eponides repandus						1.1			
Fursenkoina sp.									
Fissurina sp.									
Gavelinopsis praegeri									
Haplophragmoides sp.			0.7						
Haplophragmoides manilaensis					0.5				
Haplophragmoides wilberti									
Hanzawaia strattoni			0.7			8.5		5.5	

	NCB04								
Core	S23	S24	S25	S25	S25	S27	S34	S34	S34
Midpoint	249	131	62	177	354	134	10	138	244
Species									
Haynesina germanica	33.3		3.5		7.0	2.1		1.6	1.3
Jadammina macrescens									
Miliammina fusca									
Miliammina petila									
Miliolinella subrotunda									
Neoconorbina terquemi									
Nonionella sp.									
Nonionella atlantica								0.5	
Nonionella auricula									
Nonionella opima									
Planulina sp.									
Quinqueloculina sp.								0.5	
Quinqueloculina auberiana									
Quinqueloculina bosciana									
Quinqueloculina dimidiata									
Quinqueloculina frigida									
Quinqueloculina jugosa						6.4			
Quinqueloculina lamarckiana						5.3		1.6	
Quinqueloculina seminula									
Rosalina sp.								0.5	
Rosalina floridana									
Siphonaptera sp.									
Siphotrochammina Lobata									
Siphotrochammina sp.									
Spiroloculina atlantica									
Textularia earlandi									
Tipotrocha comprimata						1.1			
Trifarina sp.									
Trifarina angulosa									
Trochammina sp.			1.4				100.0		
Trochammina inflata									
Uvigerina auberina/peregrina									
Valvulineria sp.								0.5	
Total percent	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
Total	3	3	141	29	199	94	1	182	77

APPENDIX D

Relative abundance data expressed as percents of the 72 species which comprise two percent or more of the assemblage in any one sample.

	CS09											
Core	VC1	VC1	VC1	VC1	VC1	VC1	VC1	VC1	VC1	VC1	VC2	VC4
Midpoint	47	118	170	354	355	383	409	448	519	78	157	67
Code	1	2	3	4	5	6	7	8	9	10	11	12
Species												
Ammonia parkinsoniana	23.6	2.7	7.7	3.2	14.3	0.9	4.5	1.0	4.7	5.5	57.3	31.9
Ammonia tepida												
Ammotium salsum	1.4											
Arenoparrella mexicana												
Bolivina sp.												
Bolivina lowmani					0.9	1.4	1.4	0.5				
Buccella inusitata					1.4		0.5					
Buliminella elegantissima				0.5	0.9	0.9	0.9	3.8				
Cassidulina minuta								0.5	0.4			
Cibicides sp.						0.9	0.5					
Cibicides fletcheri					4.1							
Cibicides lobatulus				0.5	0.5				1.3			
Cornuspira planorbis							0.9					
Elphidium sp.							0.5	0.5	0.4			
Elphidium excavatum	57.6	96.6	92.3	68.1	60.8	83.2	75.1	89.5	75.7	78.7	18.8	49.2
Elphidium galvestonense	3.5									0.6	1.6	4.7
Elphidium gunteri	2.1			3.2			0.5		0.9		1.0	2.6
Elphidium mexicanum	2.1			1.1	0.5		3.6		0.9			
Elphidium poeyanum				0.5			0.5				4.7	
Elphidium transluscens									0.4			
Epistominella sp.					0.5							
Eponides repandus												
Fursenkoina sp.												
Gavelinopsis praegeri					9.2	0.9	1.4	1.4	0.9			
Hanzawaia strattoni	0.7			0.5		0.5	0.9		0.4			
Haplophragmoides sp.												0.5
Haplophragmoides wilberti												
Haynesina germanica	7.6	0.7		19.5	1.8	10.0		0.5	9.4	15.2	16.7	10.5
Jadammina macrescens												
Miliammina fusca												
Miliammina petila												
Miliolinella subrotunda							1.8	0.0				
Nonionella atlantica				1.1	1.4				0.4			
Nonionella auricula	0.7											
Nonionella opima												
Quinqueloculina bosciana						0.5	0.9	0.5				
Quinqueloculina dimidiata							0.9		0.9			
Quinqueloculina jugosa							0.9		0.4			
Quinqueloculina lamarckiana												
Quinqueloculina seminula						0.5	1.8	0.5	2.6			
Rosalina floridana				0.5	3.2		1.4	1.0				
Textularia earlandi	0.7					0.5						
Tipotrocha comprimata												
Trifarina angulosa				1.1								
Trochammina inflata												
Uvigerina auberina/peregrina												
Valvulineria sp.												
Planktonics							0.5					
Total	100.0	100.0	100.0	100.0	99.5	100.0	99.1	99.5	99.6	100.0	100.0	99.5

	CS09											
Core	VC4	VC5	VC5	VC5	VC6	VC6	VC7	VC7	VC7	VC8	VC8	VC8
Midpoint	123	57	130	224	28	229	15	49	65	21	68	160
Code	13	14	15	16	17	18	19	20	21	22	23	24
Species												
Ammonia parkinsoniana	32.0	25.0	12.9	21.7	33.3	14.1	42.9	26.2	12.1	26.7	49.4	21.1
Ammonia tepida												
Ammotium salsum												
Arenoparrella mexicana												
Bolivina sp.												
Bolivina lowmani			0.5									
Buccella inusitata	0.9					1.0						
Buliminella elegantissima			1.5									
Cassidulina minuta	0.5											
Cibicides sp.												
Cibicides fletcheri			1.0			0.5						
Cibicides lobatulus	3.2		0.5	0.5		3.4					0.6	
Cornuspira planorbis												
Elphidium sp.	0.5											
Elphidium excavatum	48.9	30.0	55.0	75.9		36.9	33.3	72.6	84.8	60.0	25.3	74.7
Elphidium galvestonense		35.0			33.3		23.8	0.6	1.5		7.1	
Elphidium gunteri	2.7		2.0	0.5	0.0	4.4			1.5	3.3	1.9	0.6
Elphidium mexicanum	2.3	5.0	4.5	0.5	0.0	1.9				6.7	3.9	0.6
Elphidium poeyanum			3.0	0.5	0.0	0.5						1.8
Elphidium transluscens			1.5	0.0	0.0	0.5					0.6	0.6
Epistominella sp.												
Eponides repandus						4.4						
Fursenkoina sp.												
Gavelinopsis praegeri	0.9											
Hanzawaia strattoni	5.9		3.5	0.5		10.2				1.7	0.6	
Haplophragmoides sp.								0.6				
Haplophragmoides wilberti												
Haynesina germanica			8.9		33.3					1.7	10.4	
Jadammina macrescens												
Miliammina fusca												
Miliammina petila												
Miliolinella subrotunda												
Nonionella atlantica			2.0			3.9						
Nonionella auricula		5.0	0.5									
Nonionella opima												
Quinqueloculina bosciana												
Quinqueloculina dimidiata												
Quinqueloculina jugosa						0.5						
Quinqueloculina lamarckiana												
Quinqueloculina seminula			0.5			17.0						
Rosalina floridana	0.9	0.0	1.5									
Textularia earlandi												
Tipotrocha comprimata												
Trifarina angulosa												
Trochammina inflata												
Uvigerina auberina/peregrina												
Valvulineria sp.												
Planktonics												
Total	98.6	100.0	99.0	100.0	100.0	99.0	100.0	100.0	100.0	100.0	100.0	99.4

	CS09											
Core	VC9	VC9	VC9	VC9	VC9	VC9	VC9	VC10	VC10	VC10	VC10	VC11
Midpoint	106	154	197	259	483	526	630	56	113	156	222	28
Code	25	26	27	28	29	30	31	32	33	34	35	36
Species												
Ammonia parkinsoniana	38.1	11.3	37.5	8.5	28.4	50.0	89.5	5.3	27.8	18.2		29.0
Ammonia tepida	1.0											
Ammotium salsum												0.4
Arenoparrella mexicana												
Bolivina sp.										1.1		
Bolivina lowmani												
Buccella inusitata									0.3	1.1		0.4
Buliminella elegantissima									0.3			
Cassidulina minuta												
Cibicides sp.												
Cibicides fletcheri												
Cibicides lobatulus							0.8			1.6		
Cornuspira planorbis												
Elphidium sp.						2.1			0.7			
Elphidium excavatum	48.7	86.3	62.5	25.6	57.9	43.8	7.3	78.9	60.1	68.4	100.0	68.5
Elphidium galvestonense				8.5		2.1						
Elphidium gunteri	6.6			57.3	4.6		0.8	10.5	1.3	0.0		0.4
Elphidium mexicanum	2.5				1.5	2.1		5.3	3.9	0.5		
Elphidium poeyanum		2.5							1.0	0.0		
Elphidium transluscens	1.0									0.0		0.4
Epistominella sp.										1.1		
Eponides repandus										2.1		
Fursenkoina sp.										1.1		
Gavelinopsis praegeri												
Hanzawaia strattoni					0.5							
Haplophragmoides sp.												
Haplophragmoides wilberti												
Haynesina germanica	1.5				4.6		1.6		3.9			0.8
Jadammina macrescens												
Miliammina fusca												
Miliammina petila												
Miliolinella subrotunda												
Nonionella atlantica										1.1		
Nonionella auricula												
Nonionella opima										1.1		
Quinqueloculina bosciana												
Quinqueloculina dimidiata												
Quinqueloculina jugosa												
Quinqueloculina lamarckiana												
Quinqueloculina seminula					2.5							
Rosalina floridana												
Textularia earlandi												
Tipotrocha comprimata												
Trifarina angulosa												
Trochammina inflata												
Uvigerina auberina/peregrina										1.1		
Valvulineria sp.										0.5		
Planktonics									0.7			
Total	99.5	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	98.9	100.0	100.0

	CS09		CDR04				
Core	VC12	VC13	S6	S7	S8	S8	S9
Midpoint	56	34	65	15	3	167	64
Code	37	38	39	40	41	42	43
Species							
Ammonia parkinsoniana	61.8	34.0					
Ammonia tepida							
Ammotium salsum							
Arenoparrella mexicana			3.3				
Bolivina sp.							
Bolivina lowmani							
Buccella inusitata							
Buliminella elegantissima							
Cassidulina minuta							
Cibicides sp.							
Cibicides fletcheri							
Cibicides lobatulus							
Cornuspira planorbis							
Elphidium sp.		0.3					
Elphidium excavatum	23.6	63.3					
Elphidium galvestonense	7.0	1.0					
Elphidium gunteri	6.5	0.7					
Elphidium mexicanum							
Elphidium poeyanum		0.3					
Elphidium transluscens							
Epistominella sp.							
Eponides repandus							
Fursenkoina sp.							
Gavelinopsis praegeri							
Hanzawaia strattoni							
Haplophragmoides sp.					0.5		
Haplophragmoides wilberti			82.0		1.4	50.0	100.0
Haynesina germanica	1.0						
Jadammina macrescens					25.5		
Miliammina fusca					6.0		
Miliammina petila			6.6				
Miliolinella subrotunda							
Nonionella atlantica							
Nonionella auricula							
Nonionella opima							
Quinqueloculina bosciana							
Quinqueloculina dimidiata							
Quinqueloculina jugosa							
Quinqueloculina lamarckiana							
Quinqueloculina seminula							
Rosalina floridana							
Textularia earlandi							
Tipotrocha comprimata					46.8		
Trifarina angulosa							
Trochammina inflata			8.2	87.5	19.9	50.0	
Uvigerina auberina/peregrina							
Valvulineria sp.							
Planktonics							
Total	100.0	99.7	100.0	87.5	100.0	100.0	100.0

	NCB04							
Core	S24	S24	S25	S25	S25	S27	S34	S34
Midpoint	249	131	62	177	354	134	138	244
Code	44	45	46	47	48	49	50	51
Species								
Ammonia parkinsoniana		33.3	10.6	10.3	2.5	6.4	8.8	24.7
Ammonia tepida								
Ammotium salsum								
Arenoparrella mexicana								
Bolivina sp.								
Bolivina lowmani								
Buccella inusitata								
Buliminella elegantissima								
Cassidulina minuta								
Cibicides sp.								
Cibicides fletcheri							0.5	
Cibicides lobatulus					0.5	4.3	1.1	
Cornuspira planorbis								
Elphidium sp.			0.7					
Elphidium excavatum		66.7	71.6	89.7	87.9	39.4	34.6	57.1
Elphidium galvestonense	66.7		2.8			14.9	13.2	5.2
Elphidium gunteri			2.1		1.5		2.2	
Elphidium mexicanum			5.7			9.6	26.9	9.1
Elphidium poeyanum							0.5	
Elphidium transluscens							0.5	2.6
Epistominella sp.								
Eponides repandus						1.1		
Fursenkoina sp.								
Gavelinopsis praegeri								
Hanzawaia strattoni			0.7			8.5	5.5	
Haplophragmoides sp.			0.7					
Haplophragmoides wilberti								
Haynesina germanica	33.3		3.5		7.0	2.1	1.6	1.3
Jadammina macrescens								
Miliammina fusca								
Miliammina petila								
Miliolinella subrotunda								
Nonionella atlantica							0.5	
Nonionella auricula								
Nonionella opima								
Quinqueloculina bosciana								
Quinqueloculina dimidiata								
Quinqueloculina jugosa								
Quinqueloculina lamarckiana						6.4		
Quinqueloculina seminula						5.3	1.6	
Rosalina floridana							0.5	
Textularia earlandi								
Tipotrocha comprimata								
Trifarina angulosa								
Trochammina inflata			1.4					
Uvigerina auberina/peregrina								
Valvulineria sp.								
Planktonics							0.5	
Total	100.0	100.0	100.0	100.0	99.5	97.9	98.9	100.0

APPENDIX E

Transformed abundance data of 51 samples (only those with >15 total specimens) and twenty-five species included in the cluster analysis (only those that comprise > 2 % of the assemblage in any one sample

	CS09																
Core	VC1	VC1	VC1	VC1	VC1	VC1	VC1	VC1	VC1	VC2	VC2	VC4	VC4	VC5	VC5	VC5	VC6
Midpoint	47	118	170	353.5	354.5	383	409	448	519	78	157	67	123	57	130	224	28
Code	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
Species																	
Ammonia parkinsoniana	1.01	0.33	0.56	0.36	0.78	0.19	0.43	0.20	0.44	0.47	1.72	1.20	1.20	1.05	0.73	0.97	1.23
Arenoparrella mexicana																	
Buliminella elegantissima				0.15	0.19	0.19	0.19	0.39							0.24		
Cibicides fletcheri					0.41										0.20		
Cibicides lobatulus				0.15	0.14				0.23				0.36		0.14	0.14	
Elphidium sp.							0.13	0.14	0.13				0.14				
Elphidium excavatum	1.72	2.77	2.58	1.94	1.79	2.30	2.10	2.48	2.11	2.18	0.90	1.56	1.55	1.16	1.67	2.11	
Elphidium galvestonense	0.37									0.16	0.25	0.44		1.27			1.23
Elphidium gunteri	0.29			0.36			0.13		0.18		0.20	0.33	0.33		0.28	0.14	
Elphidium mexicanum	0.29			0.21	0.14		0.38		0.18				0.30	0.45	0.43	0.14	
Elphidium poeyanum				0.15			0.13				0.44				0.35	0.14	
Elphidium transluscens									0.13						0.24		
Eponides repandus																	
Gavelinopsis praegeri					0.62	0.19	0.23	0.24	0.18				0.19				
Hanzawaia strattoni	0.17			0.15		0.13	0.19		0.13				0.49		0.37	0.14	
Haplophragmoides wilberti																	
Haynesina germanica	0.56	0.16		0.91	0.27	0.64		0.14	0.62	0.80	0.84	0.66			0.61		1.23
Miliammina petila																	
Nonionella atlantica				0.21	0.24				0.13						0.28		
Nonionella auriculus	0.17													0.45	0.14		
Quinqueloculina lamarckiana																	
Quinqueloculina seminula						0.13	0.27	0.14	0.32						0.14		
Rosalina floridana				0.15	0.36		0.23	0.20					0.19		0.24		
Tipotrocha comprimata																	
Trochammina inflata												0.14					

	CS09																
Core	VC6	VC7	VC7	VC7	VC8	VC8	VC8	VC9	VC9	VC9	VC9	VC9	VC9	VC9	VC10	VC10	VC10
Midpoint	229	15	49	65	21	68	160	106	154	197	259	483	526	630	56	113	156
Code	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34
Species																	
Ammonia parkinsoniana	0.77	1.43	1.07	0.71	1.09	1.56	0.95	1.33	0.68	1.32	0.59	1.12	1.57	2.48	0.46	1.11	0.88
Arenoparrella mexicana																	
Buliminella elegantissima																0.11	
Cibicides fletcheri	0.14																
Cibicides lobatulus	0.37					0.16								0.18			0.25
Elphidium sp.													0.29			0.16	
Elphidium excavatum	1.31	1.23	2.04	2.34	1.77	1.05	2.09	1.55	2.38	1.82	1.06	1.73	1.45	0.55	2.19	1.77	1.95
Elphidium galvestonense		1.02	0.15	0.25		0.54					0.59		0.29				
Elphidium gunteri	0.42			0.25	0.37	0.28	0.16	0.52			1.72	0.43		0.18	0.66	0.23	
Elphidium mexicanum	0.28				0.52	0.40	0.16	0.32				0.25	0.29		0.46	0.40	0.15
Elphidium poeyanum	0.14						0.27		0.32							0.20	
Elphidium transluscens	0.14					0.16	0.16	0.20									
Eponides repandus	0.42																0.29
Gavelinopsis praegeri																	
Hanzawaia strattoni	0.65				0.26	0.16						0.14					
Haplophragmoides wilberti																	
Haynesina germanica					0.26	0.66		0.25				0.43	0.00	0.25	0.00	0.40	
Miliammina petila																	
Nonionella atlantica	0.40																0.21
Nonionella auriculus																	
Quinqueloculina lamarckiana																	
Quinqueloculina seminula	0.85											0.32					
Rosalina floridana																	
Tipotrocha comprimata																	
Trochammina inflata																	

	CS09				CDR04					NCB04							
Core	VC10	VC11	VC12	VC13	S6	S7	S8	S8	S9	S23	S24	S25	S25	S25	S27	S34	S34
Midpoint	222	28	56	34	65	15	3	167	64	249	131	62	177	354	134	138	244
Code	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50	51
Species																	
Ammonia parkinsoniana		1.14	1.81	1.25							1.23	0.66	0.65	0.32	0.51	0.60	1.04
Arenoparrella mexicana					0.36												
Buliminella elegantissima																	
Cibicides fletcheri																0.15	
Cibicides lobatulus														0.14	0.42	0.21	
Elphidium sp.				0.12								0.17					
Elphidium excavatum	3.14	1.95	1.01	1.84							1.91	2.02	2.49	2.43	1.36	1.26	1.71
Elphidium galvestonense			0.54	0.20						1.91		0.34			0.79	0.74	0.46
Elphidium gunteri		0.13	0.52	0.16								0.29		0.25		0.30	
Elphidium mexicanum												0.48			0.63	1.09	0.61
Elphidium poeyanum				0.12												0.15	
Elphidium transluscens		0.13														0.15	0.32
Eponides repandus															0.21		
Gavelinopsis praegeri																	
Hanzawaia strattoni												0.17			0.59	0.47	
Haplophragmoides wilberti					2.26		0.24	1.57	3.14								
Haynesina germanica		0.18	0.20							1.23		0.38		0.54	0.29	0.26	0.23
Miliammina petila					0.52												
Nonionella atlantica																0.15	
Nonionella auriculus																	
Quinqueloculina lamarckiana															0.51		
Quinqueloculina seminula															0.47	0.26	
Rosalina floridana																0.15	
Tipotrocha comprimata							1.51										
Trochammina inflata					0.58	2.42	0.92	1.57				0.24					

APPENDIX F

Species Reference List

Original references to the taxa identified to the species level

Acervulina inhaerens Schultze: *Acervulina inhaerens* Schultze, 1854, p. 68, pl. 6, fig. 12.

Ammonia parkinsoniana (d'Orbigny): *Rosalina parkinsoniana* d'Orbigny, 1839a, p. 99, pl. 4, figs. 25-27.

Ammonia tepida (Cushman): *Rotalia beccari* (Linne) var. *tepida* Cushman, 1926, p. 79, pl. 1, figs. 8a-c.

Ammotium salsum (Cushman and Bronnimann): *Ammobaculites salsus* Cushman and Bronnimann, 1948a, p. 16, pl. 3, figs. 7-9.

Arenoparrella mexicana (Kornfeld): *Trochammina inflata* (Montagu) var. *mexicana* Kornfeld, 1931, p. 86, pl. 13, fig. 5.

Bolivina lowmani Phleger and Parker*: Bolivina lowmani* Phleger and Parker, 1951, p. 13, pl. 6, figs. 20, 21.

Bolivina striatula Cushman: *Bolivina striatula* Cushman, 1922, p. 27, pl. 3, fig. 10.

Buccella inusitata Andersen: *Buccella inusitata* Andersen, 1952, p. 148, figs. 10a-c.

Bulimina elongata d'Orbigny: *Bulimina elongata* d'Orbigny, 1846, p. 187, pl. 11, figs. 19, 20.

Buliminella elegantissima (d'Orbigny*): Bulimina elegantissima* d'Orbigny, 1839b, p. 51, pl. 7, figs. 13-14.

Cassidulina minuta Cushman: *Cassidulina minuta* Cushman, 1933, p. 92, pl. 10, fig. 3.

Cibicides fletcheri Galloway and Wissler: *Cibicides fletcheri* Galloway and Wissler, 1927, p. 64, pl. 10, figs 8-9.

Cibicides lobatulus (Walker and Jacob): *Nautilus lobatulus* Walker and Jacob, 1798, p. 642, pl. 14, fig. 36.

Cornuspira planorbis Schultze: *Cornuspira planorbis* Schultze, 1854, p. 40, pl. 2, fig. 21.

Elphidium discoidale (d'Orbigny): *Polystomella discoidalis* d'Orbigny, 1839a, p. 56, pl. 6, figs. 23, 24.

Elphidium excavatum (Terquem): *Polystomella excavata* Terquem, 1875, p. 20, pl. 2, figs. 2a, b.

Elphidium galvestonense (Kornfeld): *Elphidium gunteri* (Cole) var. *galvestonensis* Kornfeld, 1931, p. 89, pl. 15, fig.1.

Elphidium gunteri Cole: *Elphidium gunteri* Cole, 1931, p. 34, pl. 4, figs. 9, 10.

Elphidium mexicanum Kornfeld: *Elphidium incertum* (Williamson) var. *mexicanum* Kornfeld, 1931, p. 89, pl. 16, fig1.

Elphidium poeyanum (d'Orbigny): *Polystomella poeyana* d'Orbigny, 1839a, p. 55, pl. 6, figs. 25, 26.

Elphidium subarcticum Cushman: *Elphidium subarcticum* Cushman, 1944, p. 27, pl. 3, figs. 34, 35.

Elphidium transluscens Natland: *Elphidium transluscens* Natland, 1938, p. 144, pl. 5, figs. 3, 4.

Eponides repandus (Fichtel and Moll): *Nautilus repandus* Fichtel and Moll, 1798, p. 35, pl. 3, figs. a-d.

Gavelinopsis praegeri (Heron-Allen): *Discorbina praegeri* Heron-Allen, 1913, p. 122, pl. 10, figs. 8-10.

Hanzawaia strattoni (Applin): *Truncatulina americana* (Cushman) var. *strattoni* Applin and others, 1925, p. 99, pl. 3, fig. 8.

Haplophragmoides manilaensis Anderden: *Haplophragmoides manilaensis* Andersen, 1953, p.22, pl. 4, figs. 8a, b.

Haplophragmoides wilberti Andersen: *Haplophragmoides wilberti* Andersen, 1953, p. 21, pl. 4, figs. 1a-g.

Haynesina germanica (Ehrenberg): *Nonionina germanica* Ehremberg, 1840, pl. 23, Ehrenberg, 1841, pl. 2, figs. 1a-g.

Jadammina macrescens (Brady and Robertson): *Trochammina inflata* (Montagu) var. *macrescens* Brady and Robertson, 1870, p. 47, pl. 11, figs. 5a-c.

Miliammina fusca (Brady and Robertson): *Quinqueloculina fusca* Brady and Robertson, 1870, p. 47, pl. 11, figs. 2, 3.

Miliammina petila Saunders: *Miliammina petila* Saunders, 1958, p. 88, pl. 1, fig. 15.

Miliolinella subrotunda Montagu: *Serpula subrotunda* Montagu, 1803, p. 521, pl. 6, fig. 4.

Neoconorbina terquemi (Rzehak): *Discorbina terquemi* Rzehak, 1888, p. 228, *Rosalina orbicularis* Terquem, 1876, p. 166, pl. 9, figs. 4a, b.

Nonionella atlantica Cushman: *Nonionella atlantica* Cushman, 1947, p. 90, pl. 20, figs. 4, 5.

Nonionella auricula Heron-Allen and Earland: *Nonionella auricula* Heron-Allen and Earland, 1930, p. 192, pl. 5, figs. 68-70.

Nonionella opima Cushman: *Nonionella opima* Cushman, 1947, p. 90, pl. 20, figs. 1-3.

Quinqueloculina auberiana d'Orbigny: *Quinqueloculina auberiana* d'Orbigny, 1839a, p. 193, pl. 12, figs. 1-3.

Quinqueloculina bosciana d'Orbigny: *Quinqueloculina bosciana* d'Orbigny, 1839a, p. 195, pl. 11, figs. 22-24.

Quinqueloculina dimidiata Terquem: *Quinqueloculina dimidiata* Terquem, 1876, p. 81, pl. 11, figs. 5a-c.

Quinqueloculina frigida Parker: *Quinqueloculina frigida* Parker, 1952, p. 406, pl. 3, figs. 20a-b.

Quinqueloculina jugosa (Chushman): *Quinqueloculina seminulum* (Linne) var. *jugosa* Cushman, 1944, p. 13, pl. 2, figs 25-27.

Quinqueloculina lamarckiana d'Orbigny: *Quinqueloculina lamarckiana* d'Orbigny, 1839a, p. 189, pl. 11, figs. 14-15.

Quinqueloculina seminula (Linne): *Serpula seminulum* Linne, 1758, p.786, pl. 2, figs. 1a-c.

Rosalina floridana (Cushman): *Discorbis floridanus* Cushman, 1922, p. 39, pl. 5, figs. 11-12.

Siphotrochammina lobata Saunders: *Siphotrochammina lobata* Saunders, 1959, p. 3, pl. 9, figs. 1, 2.

Spiroloculina atlantica Cushman: *Spiroloculina atlantica* Cushman, 1947, p.88, pl. 19, figs. 3-5.

Textularia earlandi Parker: *Textularia earlandi* Parker, 1952, p. 458, Parker and Athearn, 1959, p. 340, pl. 50, fig. 7.

Tipotrocha comprimata (Cushman and Bronnimann): *Trochammina comprimata* Cushman and Bronnimann, 1948b, p. 41, pl. 8, figs. 1-3.

Trifarina angulosa (Williamson): *Uvigerina angulosa* Williamson, 1858, p. 67, pl. 5, fig. 140.

Trochammina inflata (Montagu): *Nautilus inflatus* Montagu, 1808, p. 81, pl. 18, fig 3.

Trochammina ochracea (Williamson): *Rotalina ochracea* Williamson, 1858, p. 55, pl. 4, fig. 112.

Uvigerina peregrina Cushman: *Uvergina peregrina* Cushman, 1923, p. 166, pl. 42, figs. 7-10.

APPENDIX G

Pictures of Lithofacies

Sections of Lithofacies 30 cm long.

Sand (S)
CS09-VC1
510-540 cm below MSL

Muddy Sand (mS)
CS09-VC1
273-303 cm below MSL

Shelly Sand (shS)
CS09-VC12
589-619 cm below MSL

Interbedded Sand and Mud (iSM)
NCB04-S25
325-355 cm below MSL

Interbedded Clay and Sand (iCS)
CS09-VC9
477-507 cm below MSL

Shelly Mud (shM)
CS09-VC13
637-667 cm below MSL

Sandy Mud (sM)
CS09-VC9
247-277 cm below MSL

Mud (M)
CS09-VC9
407-437 cm below MSL

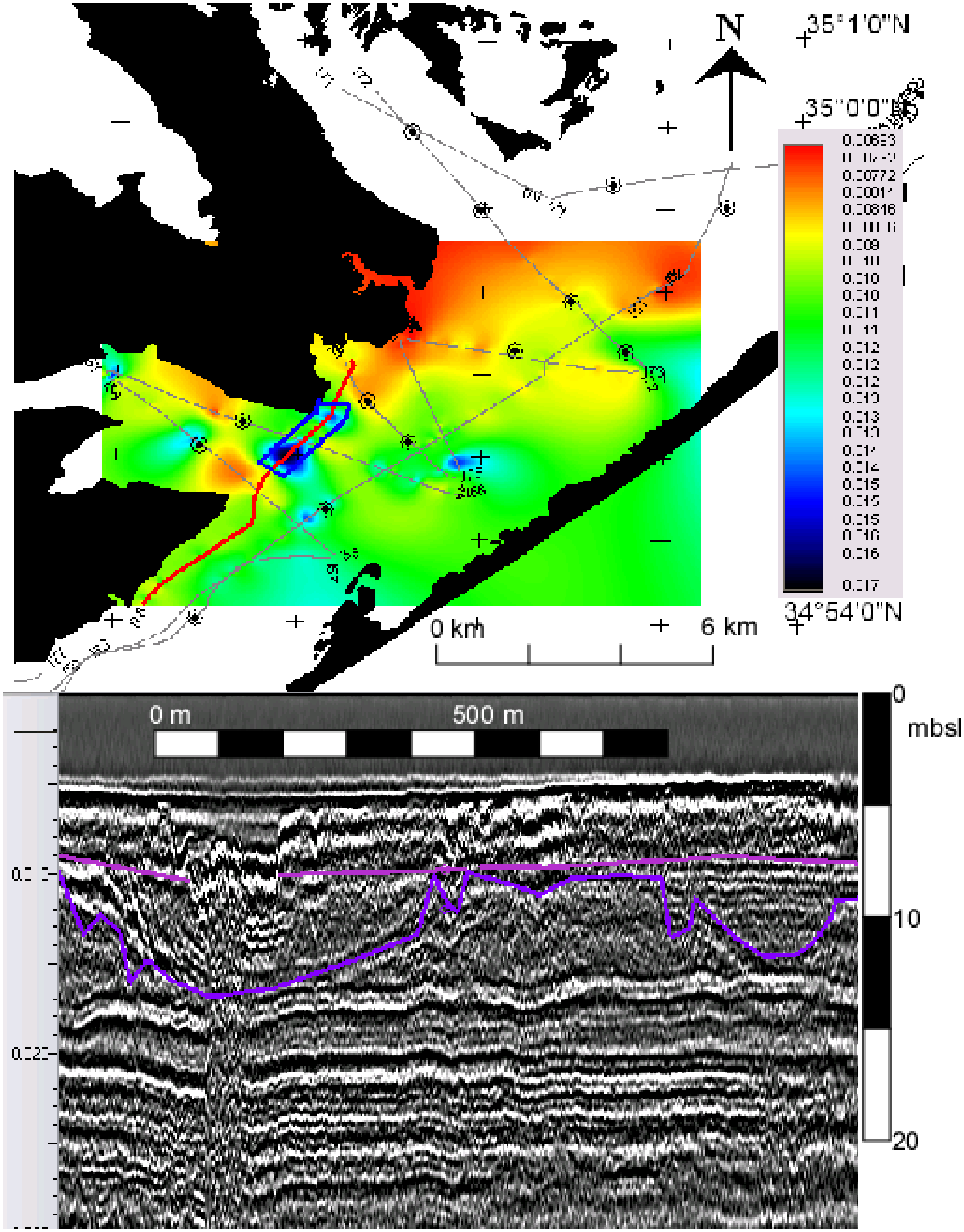
Peat
CS09-VC10
336-366 cm below MSL

Clay
CS09-VC3
444-474 cm below MSL

APPENDIX H

Results of boomer seismic data interpretation.

Grids of seismic sequence boundaries.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0.010
0.011
0.012
0.012
0.012
0.013
0.014
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0.015
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0.016
0.017
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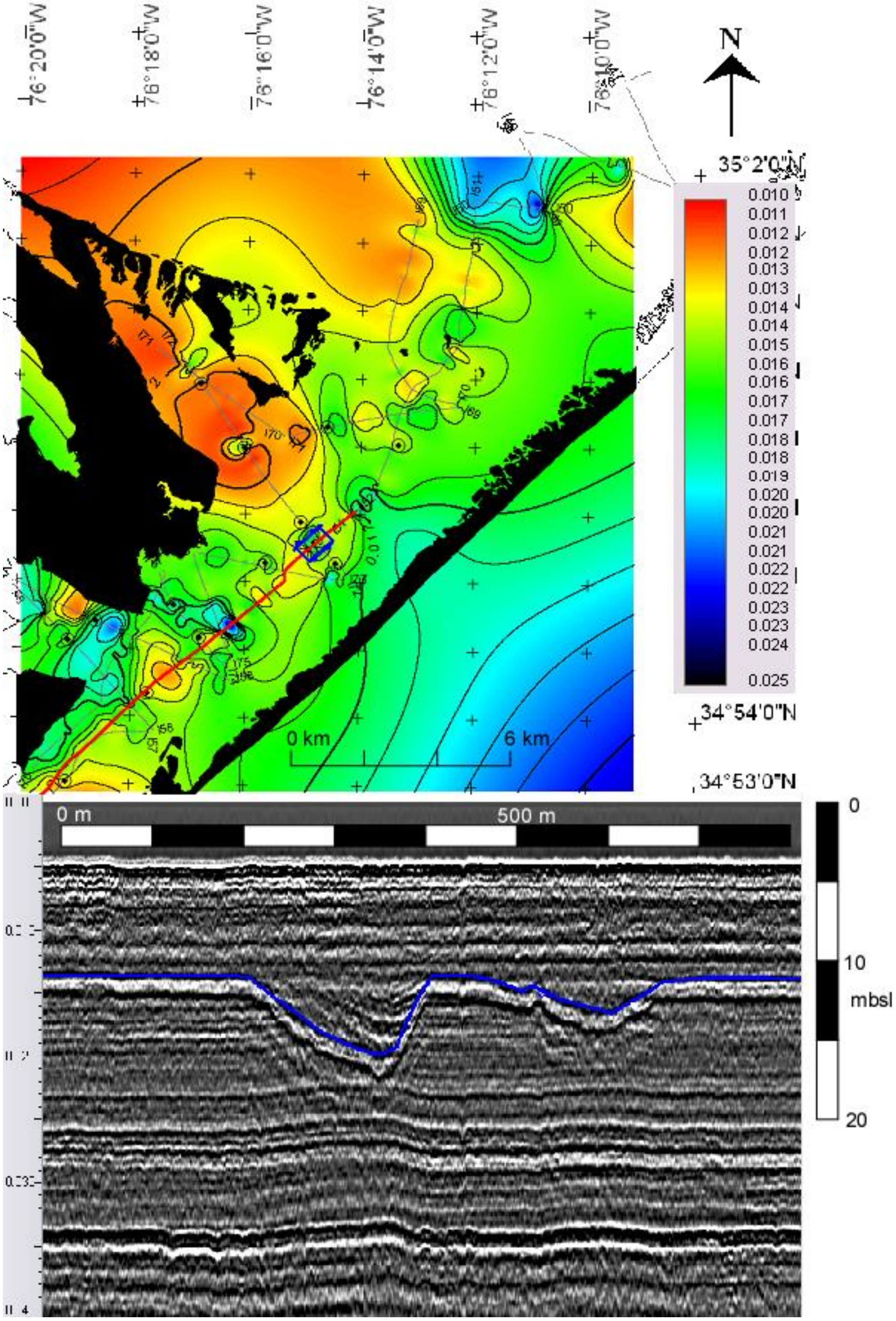
0
mbsl
10
20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N
35°2'0"N
34°54'0"N
34°53'0"N
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0.011
0.012
0.012
0.013
0.013
0.014
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0.015
0.016
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0.017
0.018
0.018
0.019
0.020
0.020
0.021
0.021
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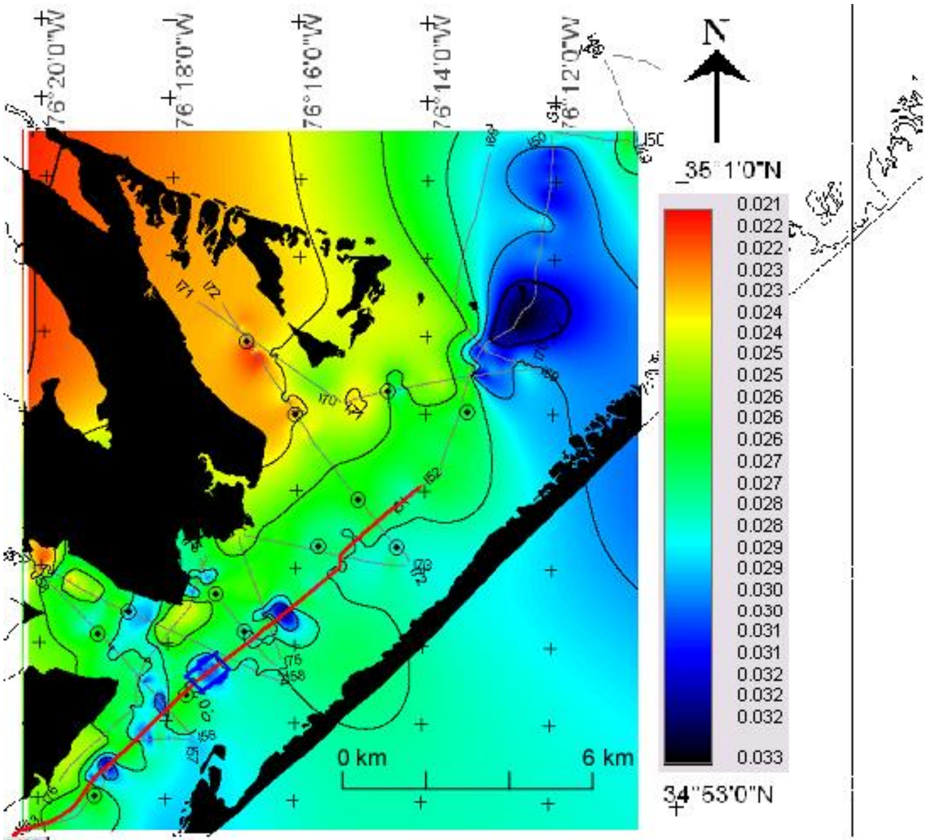
0 m
500 m
0
10
mbsl
20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76°18'0"W
76°16'0"W
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76°12'0"W
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35°1'0"N
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0.023
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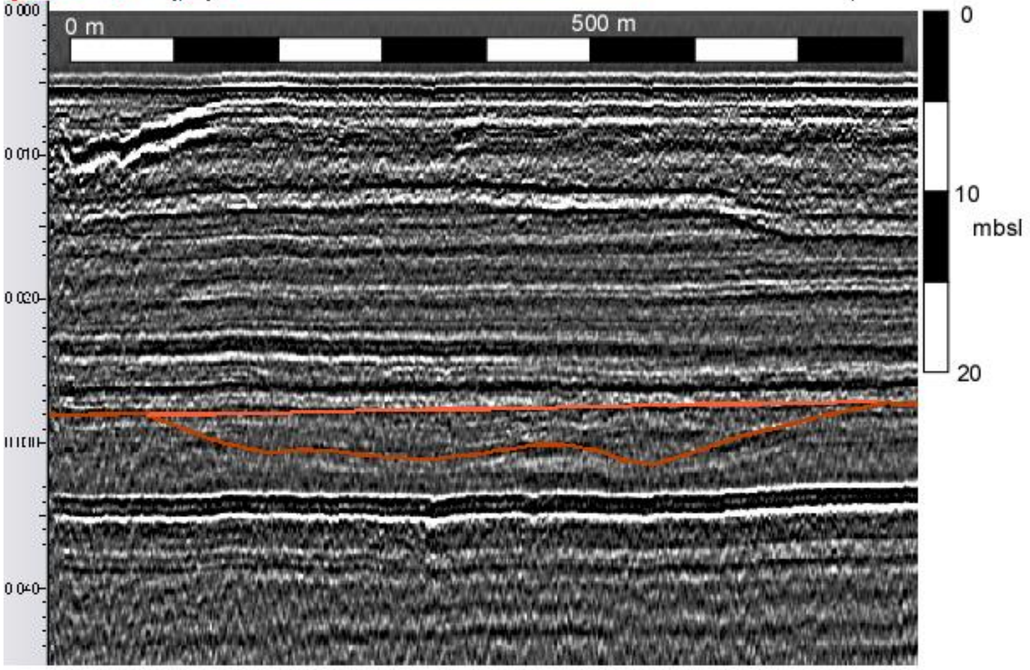
6 km
34°53'0"N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0.040
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500 m
0
10
mbsl
20