DEPARTMENT OF ENVIRONMENTAL PROTECTION
DIVISION OF SCIENCE AND RESEARCH
NEW JERSEY GEOLOGICAL SURVEY

Geologic Framework of the New Jersey Offshore: Sand Resources in Area G

Introduction

The New Jersey Geological Survey (NJGS) and Rutgers University (RU) are investigating sand sources in the New Jersey offshore. This study is a coordinated effort between the New Jersey Department of Environmental Protection, the U.S. Department of Interior's Minerals Management Service, and the U.S. Army Corps of Engineers to acquire and interpret offshore geologic data for engineering and geotechnical professionals. Interpretation of the Pleistocene/Holocene geology of the New Jersey inner continental shelf reveals a geologic framework with a variety of depositional environments that create distinctly different sea floor morphologies. Eight areas offshore (Figure 1) have been designated as having high potential for sand resources based on water bottom topography as seen in Figure1. This publication shows the results of the geologic interpretation of seismic and vibracore data from Area"G". The preliminary analysis and interpretation of the geologic setting and stratigraphy was first presented by Uptegrove and others (1999).

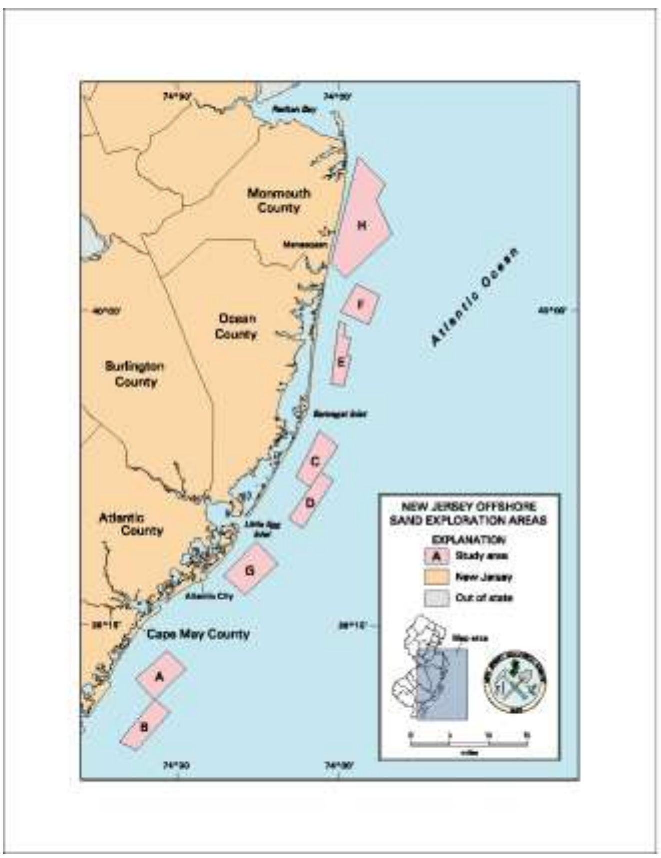


Figure 1. Showing location of Area "G"

The Present-day New Jersey Coastline

New Jersey's beaches are composed primarily of unconsolidated sand, with lesser amounts of silt and gravel, reworked from Cretaceous, Tertiary, and Quaternary coastal plain sediments (McMaster, 1954). The unconsolidated material is eroded either from onshore coastal plain formations in the northern section of the coast or from submerged coastal plain sediments that are redistributed along the coast by sediment transport.

The New Jersey coast is the landward boundary of the Atlantic continental shelf, a slowly subsiding passive margin with a low sediment supply that has undergone numerous glacially-controlled sea-level fluctuations during the Pleistocene and Holocene (Ashley and others, 1991).

Coastal plain sediments are directly exposed to wave action from Long Branch south to Point Pleasant Beach. In this part of the coast, called the headlands by Fisher (1965), the modern beach lies directly seaward of a bluff rising as much as 8 meters above mean tide level. The eroded material from the headlands is reworked by waves and is incorporated into the present-day sediment supply. Long-shore currents carry sand northward along the coast to be deposited at Sandy Hook spit or southward to be deposited on the barrier beaches or at inlets (Ashley and others, 1986).

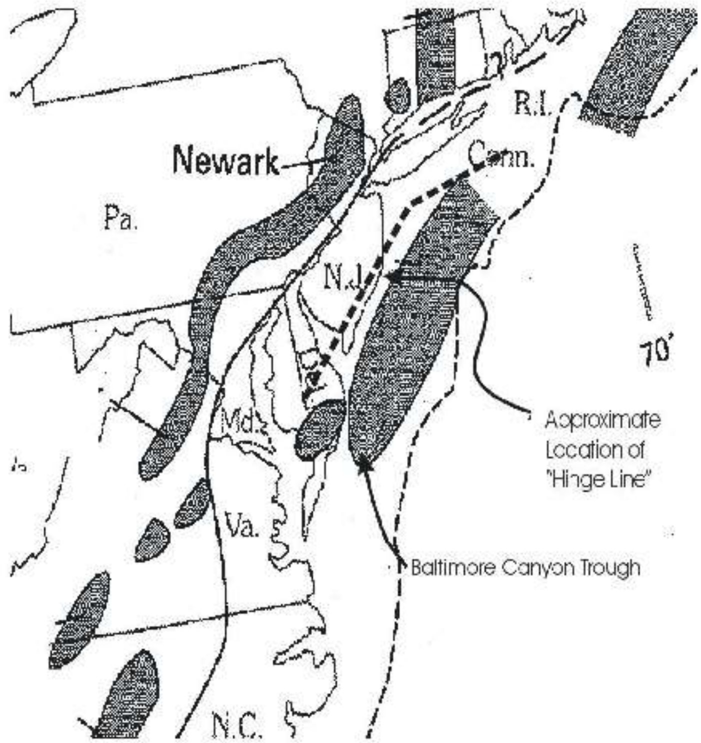
(modified from Ashley, G. M., and others, 1991)

Figure 2 Traces of paleo-shorelines from 125 and 55 thousand years ago.

There are no exposed Tertiary coastal plain sediments along the southern New Jersey coast from Mantoloking to Cape May Point. Pleistocene-Holocene sands reworked from submerged coastal plain sediments mingled with eroded northern onshore sediments form the existing barrier islands. These barrier islands range in length from 8 to 29 km.

Tectonic and Isostatic Influences

Basement geology influences the depositional regime. Subsidence of the Triassic/early to mid-Jurassic-age Baltimore Canyon Trough offshore of southern New Jersey has controlled the depositional patterns of the younger offshore sediments that have not been significantly eroded by transgressive events (Figure 2, Owens and others, 1998). Subsidence allows the accumulation of a thick Pleistocene-Holocene sediment package (up to 12m). The northwestern edge of the basin forms a hinge line extending to the northeast off Barnegat Inlet. This hinge line demarcates the eroding headlands of the northern coast from the barrier-island systems of the southern coast. The two most landward Pleistocene sea-level highstand shorelines (125 ka and 55 ka) are oriented sub-parallel to the edge of the offshore Triassic/Jurassic basin (Figure 3). The fate of the Holocene deposits in the northern coastal area is likely controlled by a combination of the tectonics of the Triassic/Jurassic basin and the isostatic response to the last glaciation (Carey and others, 1998). The flexural uplift to the north of the hinge line in the vicinity of the New York Bight is a probable explanation of sub-cropping or outcropping coastal plain sediments in the offshore with thin to non-existent overlying Holocene sand veneers. The Mesozoic basin also influenced the location and orientation of the Stage 2 glacial forebulge. Glacial rebound north of Barnget Inlet and fore-bulge collapse to the south would result in limited accomodation space for the Stage 3 and Stage 1 transgressive sediments (S.D. Stanford, oral communication., 1999).



(from Owens and others, 1988)

Figure 3. Showing generalized basement structure

The Pleistocene-Holocene Geology of the New Jersey Offshore

Transgressive Systems and Highstand Systems tracts deposits.

Work by Ashley and others (1991) provides an overview of the late Pleistocene and Holocene geology that typifies the New Jersey inner continental shelf. They note that the last two major glaciations in the late Wisconsinan (-20ka, Stage 2) and the early-mid Wisconsinan (-70 ka, Stage 4) (Figure 4A) were of a magnitude sufficient to cause global sea-level lowstands. The shoreline of New Jersey was near the continental shelf edge (Stage 2), and the middle continental shelf (Stage 4) during these lowstands. The sub-aerial erosion surfaces created on the inner continental shelf during these sea-level lowstands correspond to the Type 1 sequence boundaries of Vail and others (1977) and Haq and others (1987) (Figure 5). A type 1 sequence boundary is characterized by subaerial exposure and concurrent subaerial erosion associated with stream rejuvenation, a basinward shift of facies, a downward shift in coastal onlap, and onlap of overlying strata (Van Wagoner and others, 1988). These erosion surfaces are evident on the seismic lines as prominent, laterally continuous reflectors. The most recent of these in the New Jersey offshore is the sequence boundary between the Pleistocene and Holocene sediments. It formed when Pleistocene sediments were exposed on the shelf during the late Wisconsinan glaciation (Stage 2) (see below).

Only significantly warm periods in the Holocene interglacial (Stage 1), the mid-Wisconsinan interstadial (Stage 3) and the Sangamon interglacial (Stage5e) (Figure 4 & 4A) caused sea-level rises that left transgressive and highstand deposits on the inner shelf (Ashley and others, 1991). As the shoreline traversed the continental shelf during transgression, the areas of deposition of coastal and marine sediments shifted with it, creating a complex system of depositional and erosional features on the inner shelf (Sheridan and others, 1999). Thus, any transgressive and highstand deposits occurring on the shelf are remnants of formerly more laterally extensive depositional sequences that have been eroded by processes active during subsequent sea-level changes. It is likely that deposits from smaller sea-level highstands farther out on the shelf may have been removed by the sub-aerial erosion during Stage 2 and Stage 4 lowstands (Ashley and others, 1991).

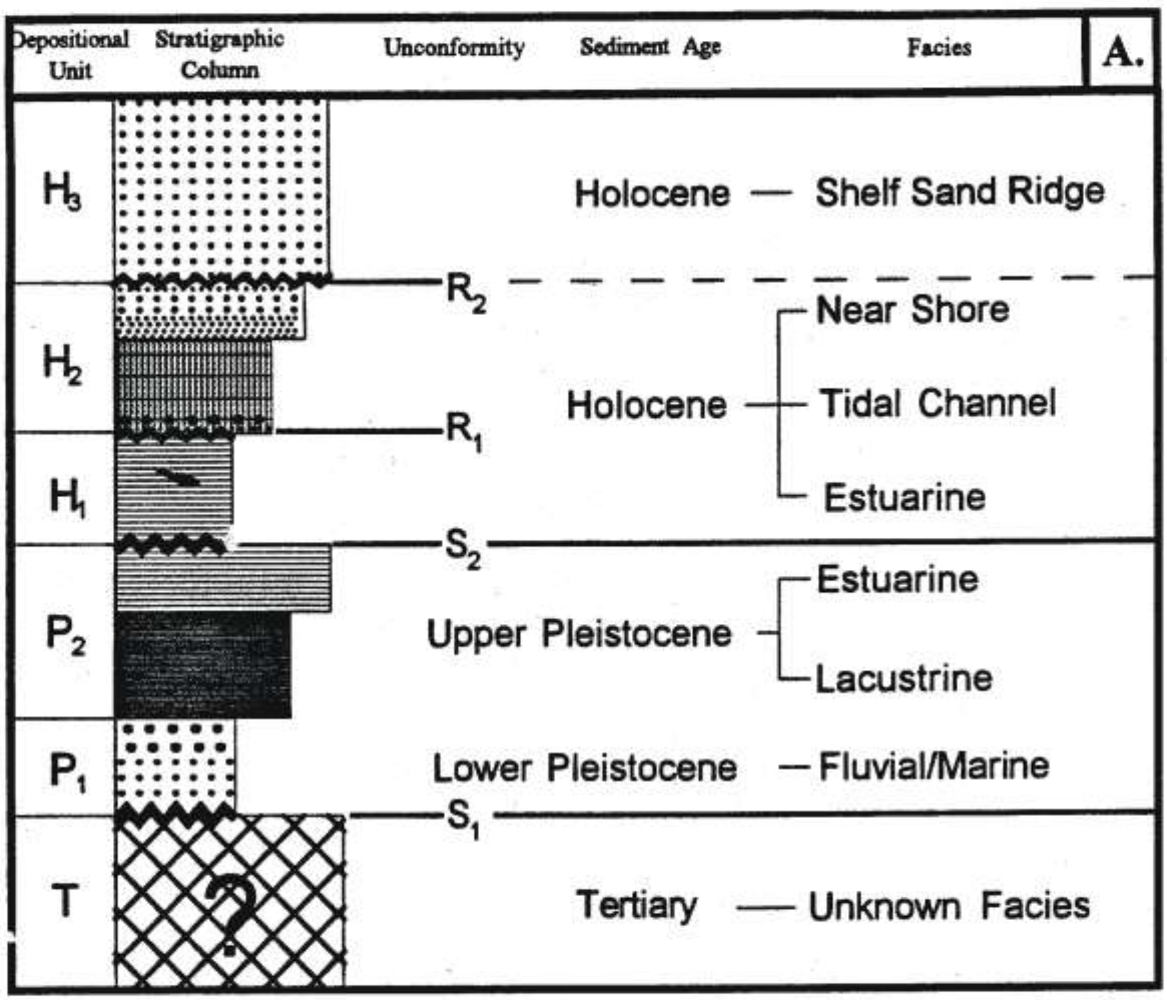
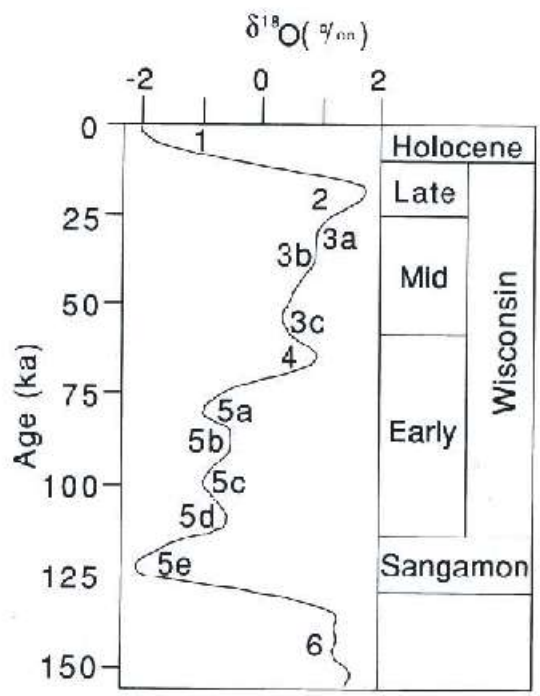


Figure 4. Generalized stratigraphic section in the New Jersey Offshore.

Sand Resources of Area G

Current NJGS/RU studies are developing sand resource areas offshore from Cape May to Mantoloking, NJ (Figure 1, areas labeled from "A" to "G"). Smith's (1996) composite regional stratigraphy (seen in Fig.4) is used as a template for the interpretation of the shallow geology in the southern offshore areas. The geology changes subtly from the southern offshore to the northern offshore, and our search criteria for locating offshore sand must adjust accordingly, as seen in the stratigraphy of Area G.

We find slightly different lithologies when we apply Smith's (1996) composite regional stratigraphy to Area G offshore of Brigantine, specifically: 1) the gravel that marks the S_2; 2) a lower sand layer 1-2m thick; 3) the interbedded silts, sands and clays of the estuarine deposits 1-3m thick; and 4) an upper sand layer 1-2m. thick. The S_2 is deeper, the interbedded unit is thicker and/or more variable in thickness, and the R_2 delineates the overlying sand deposits. While Smith (1996) measured sand resources referenced to the S_2, we measure the sand resource from the Holocene R_2 ravinement surface that separates the interbedded sand, silt and clay from the upper sand layer. This method excludes all the materials between the R_2 and the S_2 , consisting largely of silt and clay that is unsuitable for beach nourishment material.



Volumetric estimates for Area G are delineated from the R_2, the transgressive erosional surface created by the erosive leading edge of the marine transgression. Nearshore marine sands (the upper sand unit in the vibracores) overlie the R_2 (Figure 7).

The contoured surface (bounded by the R_2 at the base and the sediment-water interface at the top) reveals various morphological features (Figure 6A). The large, multi-fingered sand sheet to the northeast may have origins as an ebb-tidal delta. It presents the most laterally extensive area for sand dredging. Volumetric calculations based on the thickness of sediment above the R2 reflector (seen in Figure 7) are graphically represented in Figure 6.

Seismic Stratigraphy

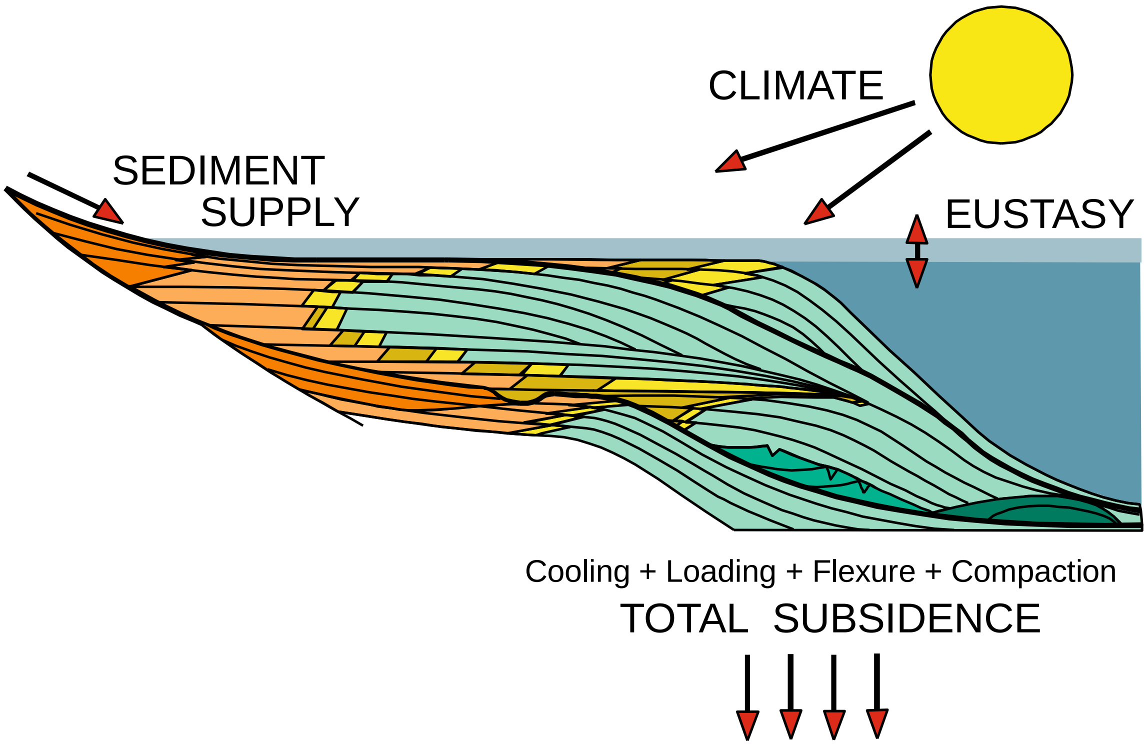
Seismic reflectors for Area G can be interpreted to depths of 25 to 30m (Figure 7). The deepest major reflector seen on the profile is formed by the aforementioned gravel layer (S_2). The gravel is fluvial, deposited on a braid plain during the late Wisconsinan glaciation and the accompanying drop in sea level (approximately 20 ka) (Ashley and others, 1991).

Holocene channels cut the S_2 in the northeastern section of Area G, and are now overlain by ebb-tidal deltaic sands. These channel structures are repeatedly incised near inlets where the ebb-tidal deltas form. This interpretation corresponds to Miller and Dill's (1973) large north-south trending channel directly beneath Beach Haven Ridge. In addition to the transgressive ravinement processes at work, migrating inlet channels (shifting back and forth along the coastline) would periodically be cut off from a coarse sediment supply and then filled in with lower energy lagoonal fine sands, silts, and clays.

Volumetric estimates for Area G are delineated from the R_2, the transgressive erosional surface created by the erosive leading edge of the marine transgression. Nearshore marine sands (the upper sand unit in the vibracores) overlie the R_2 (Figure 7).

The contoured surface (bounded by the R_2 at the base and the sediment-water interface at the top) reveals various morphological features (Figure 9). The large, multi-fingered sand sheet to the northeast may have origins as an ebb-tidal delta. It presents the most laterally extensive area for sand dredging. Reconnaissance volumetric estimates indicate a sand thickness of up to 3m.

FACTORS CONTROLLING PASSIVE MARGIN RECORDS



Composite Mean Grain Size, Sediment units in Area G, offshore Brigantine, NJ				
New Jersey Geological Survey, April, 1999 - DRAFT				
	Version Verified accurate 1-27-00			
Core 1				
Sediment Unit	**Length (m)**	**Samples**	**Composite Mean ****	**Interpreted I.D.**
1	0-0.18	1000	2.10	Lower Sand
2	0.18 - 3.11	1030 -1300	2.30	Lower Sand
3	3.11 - 4.25	1330 -1420	2.55	Lower Sand
4	4.25 - 5.75	1450 -1540	2.71	Interbedded
Core 2				
1*	0.0 - 3.18	2000 -2300	2.05	Upper Sand
2	3.18 - 3.33	2330	3.96	Interbedded
Core 3				
1*	0.0 - 3.61	3000 - 3360	2.29	Upper Sand
2	3.61 - 3.9	3390	2.30	Interbedded
3	3.9 - 5.94	3420 - 3570	2.99	Lower Sand
Core 4				
1*	0.0 - 1.3	4000 - 4120	1.81	Upper Sand
2	1.3 - 4.6	4150 - 4450	2.96	Interbedded
3	4.6 - 6.18	4480 - 4600	2.82	Lower Sand
Core 5				
1*	0.0 - 3.43	5000 - 5330	2.00	Upper Sand
2	3.43 - 5.7	5360 - 5540	3.16	Interbedded
3	5.7 - 6.2	5570 - 5600	-0.03	Pleistocene Gravel
Core 6				
1*	0.0 - 1.05	6000 - 6090	2.05	Upper Sand
2	1.05 - 5.25	6120 - 6510	2.83	Interbedded
3	5.25 - 5.97	6540 - 6570	0.18	Lower Sand
Core 6A				
1*	0.0 - 2.38	6A000 - 6A210	1.76	Upper Sand
2	2.38 - 5.25	6A240 - 6A510	2.34	Interbedded
3	5.25 - 6.05	6A540 - 6A600	1.91	Lower Sand
Core 7				
1*	0.0 - 3.0	7000 - 7270	2.70	Upper Sand
2	3.0 - 6.15	7300 - 7600	2.61	Interbedded
Core 8				
1	0.0 - 2.5	8000 - 8240	1.26	Hybrid Upper Sand
2	2.5 - 4.0	8270 - 8390	1.99	Hybrid Lower Sand
3	4.0 - 6.21	8420 - 8600	2.14	Interbedded
* indicates the sand unit above the R_2 reflector				
**The Composite Mean value was generated as an average of the mean values from the individual samples, rather than a mean from one composite grain size sample.				

Sedimentology

As noted above, the vibracores collected in Area G reveal a typical sequence of units, including: 1) a basal Pleistocene gravel below the S_2 sequence boundary; 2) a lower sand unit; 3) interbedded silts, sands and clays; and 4) an upper sand unit.

The Basal Gravel

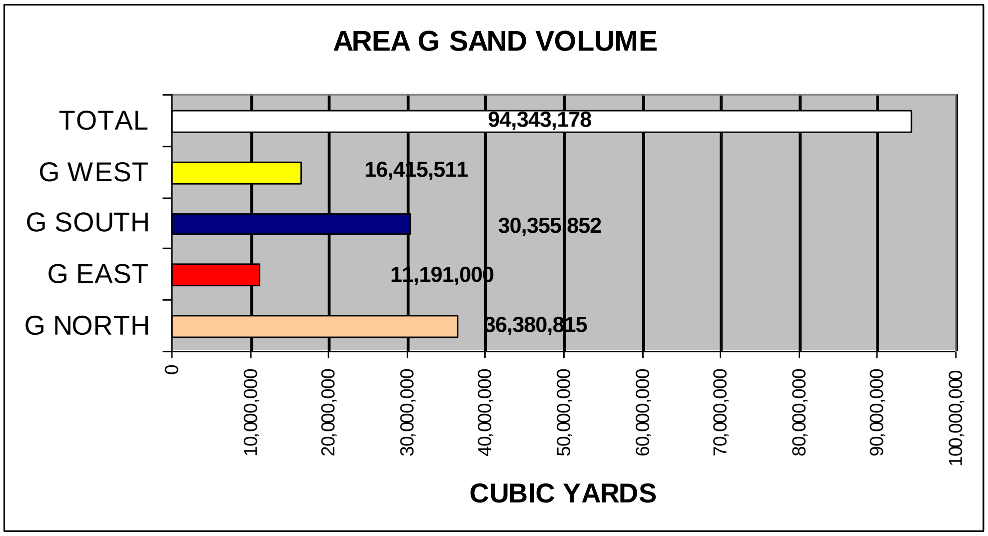
This unit is a poorly sorted sandy gravel composed of 90% quartz grains and 10% other rock fragments. Shells are absent. Pebbles are well-rounded, semi-oblate, and iron-stained, and range in size as large as 5 cm in diameter. The S_2 reflector that marks the top of this unit is the most prominent reflector on the seismic profiles.

The Lower Sand Unit

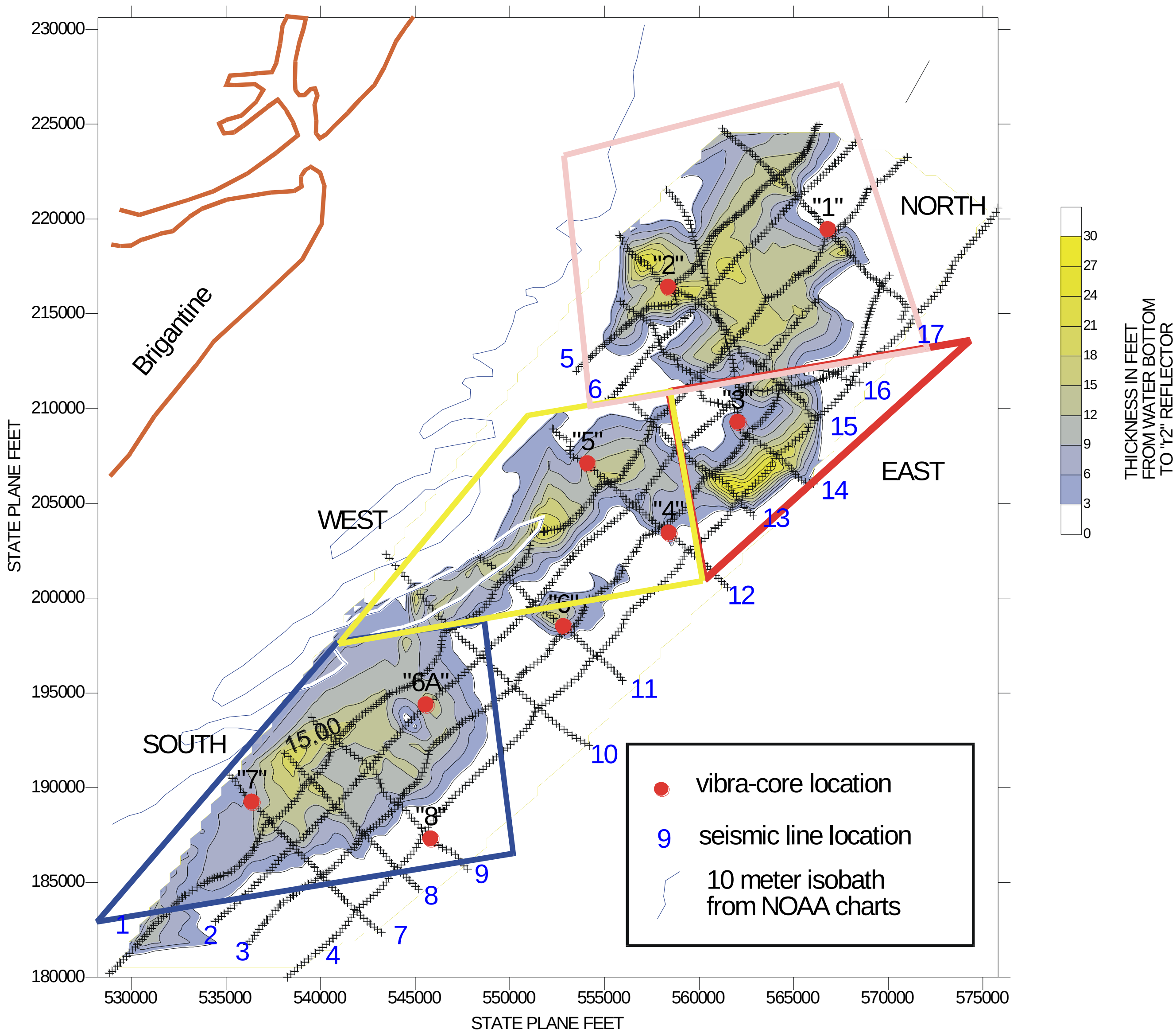
The lower sand unit that overlies the S_2 sequence boundary was deposited as sea level rose after the late Wisconsinan lowstand of 20 ka. This unit corresponds to Smith's (1996) H_1 unit, described as a sandy mud. The lower sand is the sandy depositional remnant of the transgressive systems tract, unconformably overlain by interbedded fine sand, silt and clay of the continuing Holocene transgressive event. In Core 5, the lower sand is absent and the material grades directly from the Pleistocene gravel into the interbedded sand silt and clay (Figure 8).

The Interbedded Unit

The interbedded (and sometimes rhythmically interbedded) fine sands and clays that overlie the lower sand (or directly overlie the S_2) were deposited in the lower energy environment of a Holocene back-bay/lagoon. Vertical root structures and particles of peat/organic material are abundant in some of the silts and clays. Shell material and burrows are common. We correlate this unit with material from the analogous unit of Ashley and others (1991), defined as Depositional Sequence II, Lower Unit, dated at 8810 $\pm$ 170 yr B.P. The interbedded unit was likely deposited during the period of rapid rise in relative sea level from approximately 12,000 to 5,000 yrs B.P. Holocene dates in this unit are reported by Snedden and others (1994) at Peahala Ridge offshore of Long Beach Island (3710 – 5900 $\pm$ 150 yrs B.P.) and Swift and others (1984) at Beach Haven Ridge offshore of Little Egg and Beach Haven Inlets (6685 – 8595 $\pm$ 170 yrs B.P).



Area "G" Sand Thickness Map



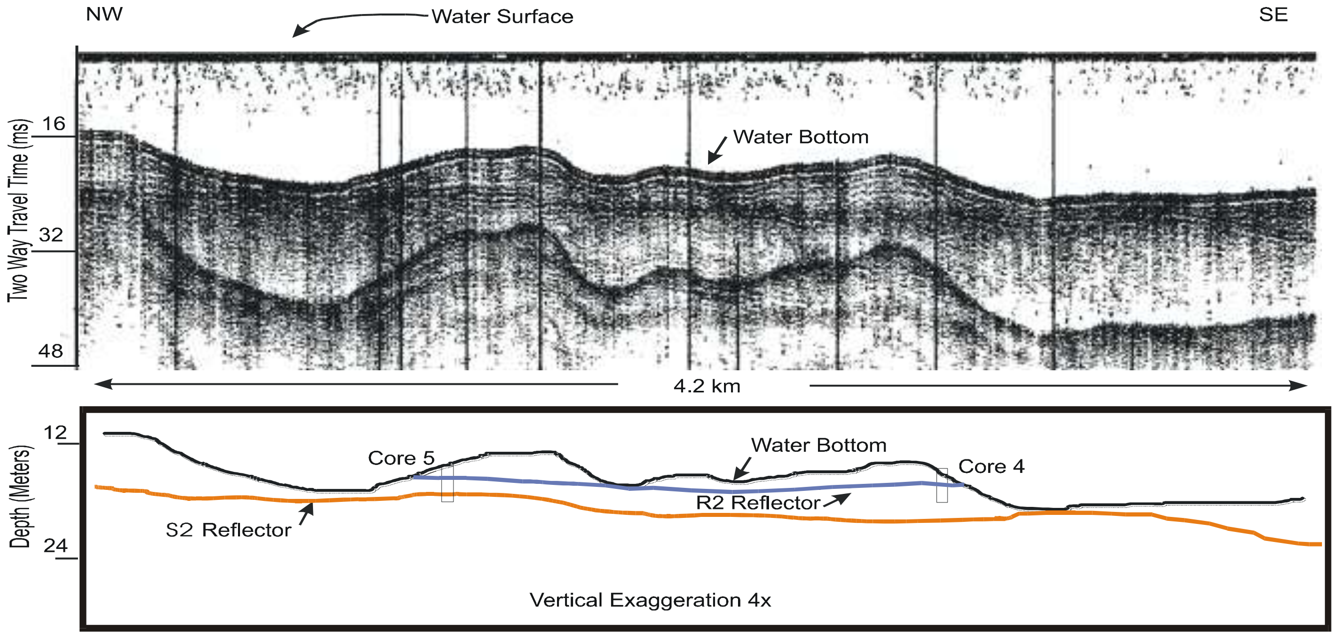
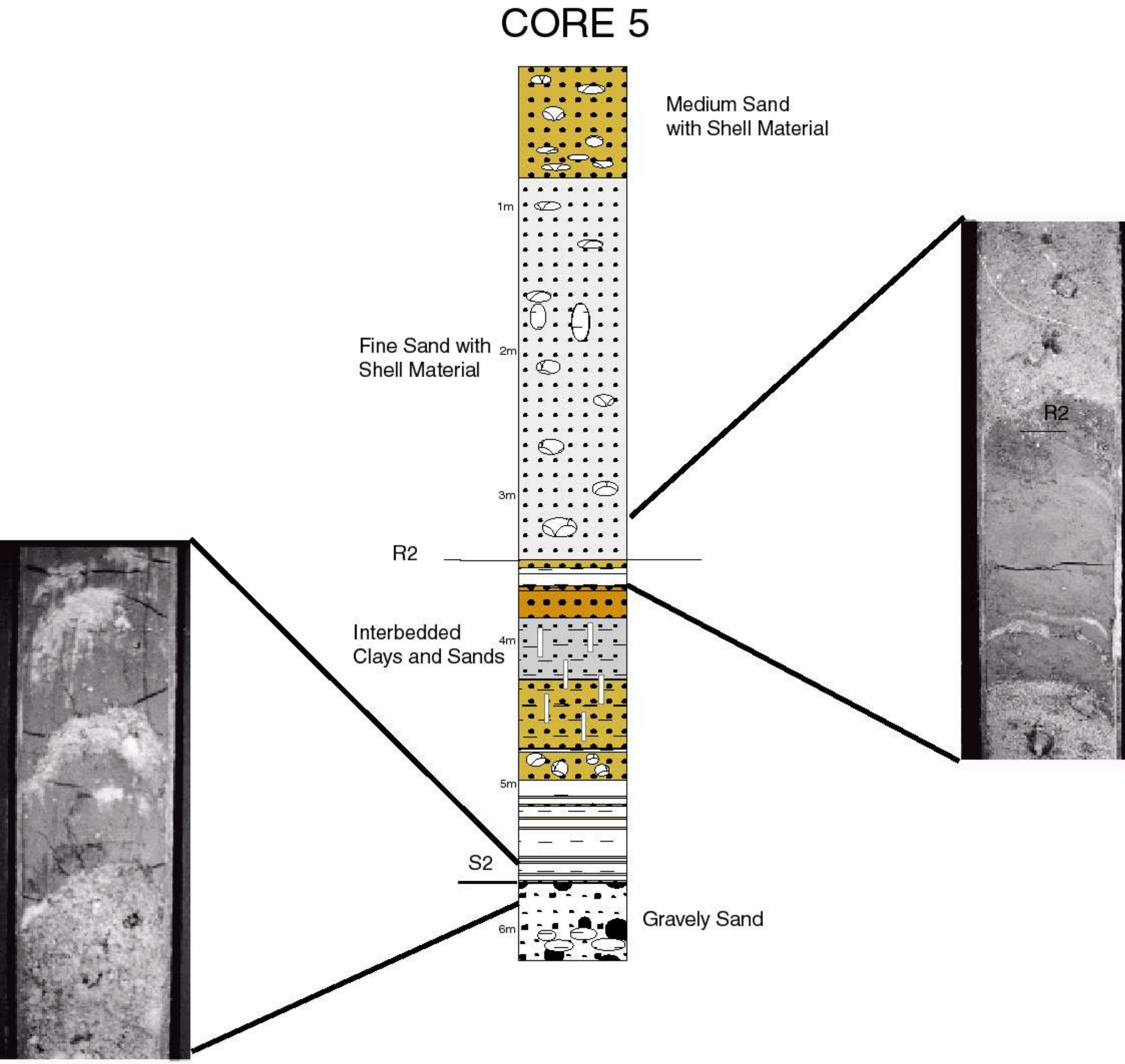


Figure 7. Seismic line 12 with interpreted results.


CORE 5
Medium Sand
with Shell Material
1m
Fine Sand with
Shell Material
2m
3m
R2
Interbedded
Clays and Sands
4m
5m
S2
Gravely Sand
6m
R2

Conclusions

Distinct depositional environments in the northern and southern offshore regions have a substantial impact on the formation and preservation of sand shoals. The predominantly erosional regime of outcropping Tertiary coastal plain deposits in the northern offshore area contrasts with the mainly depositional regime of Holocene sand shoals associated with shifting inlets in the southern offshore area. This interpretation directs us to look first for sand in the southern offshore.

The Holocene transgressive ravinement surface (R_2) separating estuarine sands, silts, and clays from overlying sands offshore of Brigantine provides a distinguishable surface on the seismic and vibracore data for delimiting sand resources. The contoured surface of from the R_2 to the sediment-water interface in Area G reveals an ebb-tidal delta and remnants of shore-attached and shore-detached ridges.

Future work in the northern coastal area will provide the opportunity to add some insight to the offshore geologic framework. Initial seismic exploration reveals mainly Pleistocene/Holocene channel-fill deposits, outcropping coastal plain units of varying lithologies, and relatively thin and discontinuous Holocene sand veneers.

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