Announcement M13AS00014: Hurricane Sandy Coastal Recovery and Resiliency - Resource Identification, Delineation and Management Practices

Cooperative Agreement: M14AC00011 University of Rhode Island
Identification of Sand/Gravel Resources in Rhode Island Waters While working Toward a Better Understanding of Storm Impacts on Sediment Budgets

SUMMARY REPORT

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*** Note:** The project team is deeply saddened by the loss of Co-PI Dr. Jon C. Boothroyd, who passed away unexpectedly before the conclusion of this project. Dr. Bryan Oakley has assumed Dr. Boothroyd's responsibilities on the project. Dr. Oakely received his PhD under the supervision of Dr. Boothroyd, and has worked closely with him on numerous projects.

SUMMARY REPORT

Cooperative Agreement Outputs including Project Deliverables:

Gibson, C., and J. King, 2016. Digital ArcGIS summary map and supporting ArcGIS geodatabases of selected geologic and geophysical data for federal and state waters between 3-8 nautical miles offshore of Rhode Island. Coastal Mapping Laboratory, Graduate School of Oceanography, University of Rhode Island. Digital dataset, submitted to Chief - Marine Minerals Branch - Bureau of Ocean Energy Management, and Project Officer J. Waldner - Leasing Division - Marine Minerals Branch - Bureau of Ocean Energy Management, August 2016.

This digital database provides an ArcGIS-compatible compilation of high quality geological and geophysical data collected over several decades in federal waters between 3 - 8 nautical miles offshore of the state of Rhode Island, as well as newly collected geophysical data spanning federal and state waters off the southwest coast of Rhode Island. FGDC-compliant metadata is provided for each datalayer or dataset. A significant amount of important data collected in Rhode Island waters is publicly available through various organizations and institutions but, prior to this study, had not been compiled in a centralized location in ArcGIS format. In addition, prior to this study, metadata for these datasets was either not readily available, or not standardized into a format compatible with ArcGIS software. This database results from an in-depth review of publicly available data, both digital and analog, in the area of interest. Only datasets that were determined to be of high enough quality to contribute to a robust geologic and geophysical characterization of the project area were selected for inclusion in this compilation. Also included with the previously collected dataset are approximately 237 line-miles of new geophysical data (sidescan and subbottom sonar) collected by the project team between 2015-2016 to characterize a potential sand and gravel resource area spanning federal and state waters off the southwest coast of Rhode Island (Figure 1).

Data are compiled into an ArcMap (v. 10.2.2) "project" (*. mxd) and associated File Geodatabases (*. gdb files), with all datalayers standardized to the UTM19N, NAD83 projection system. Metadata for each datalayer is viewable through metadata tool in ArcCatalog. File geodatabases are organized into seven categories: 1) **Avoidance areas**, delineating locations of dredge disposal activity which should not be considered for sand and gravel resources; 2) **interpretative data** regarding benthic geologic environments; 3) **vibracores;** 4) **subbottom tracklines** and metadata-based information regarding the location of downloadable subbottom profiles; 5) **sidescan sonar** data; 6) **bathymetry**; and 7) **basemaps** (state outlines and other general geographic data). Unprocessed data is not included in the compilation of previously collected data. Two geodatabases focusing on newly collected data are also included: 1) **URI Surveys 2015 and 2016**, containing polygons and polyline files representing the target study area and ship tracklines resulting from the geeophysical surveys conducted by the project team during 2015 and 2016; and 2) **Resource areas**, illustrating the geographic locations of potential resource areas identified from geophysical survey data collected in 2015 and 2016. Raw and post-processed data from the 2015 and 2016 surveys that are not compatible with the ArcGIS format are included in separate dedicated folders with stand-alone metadata.

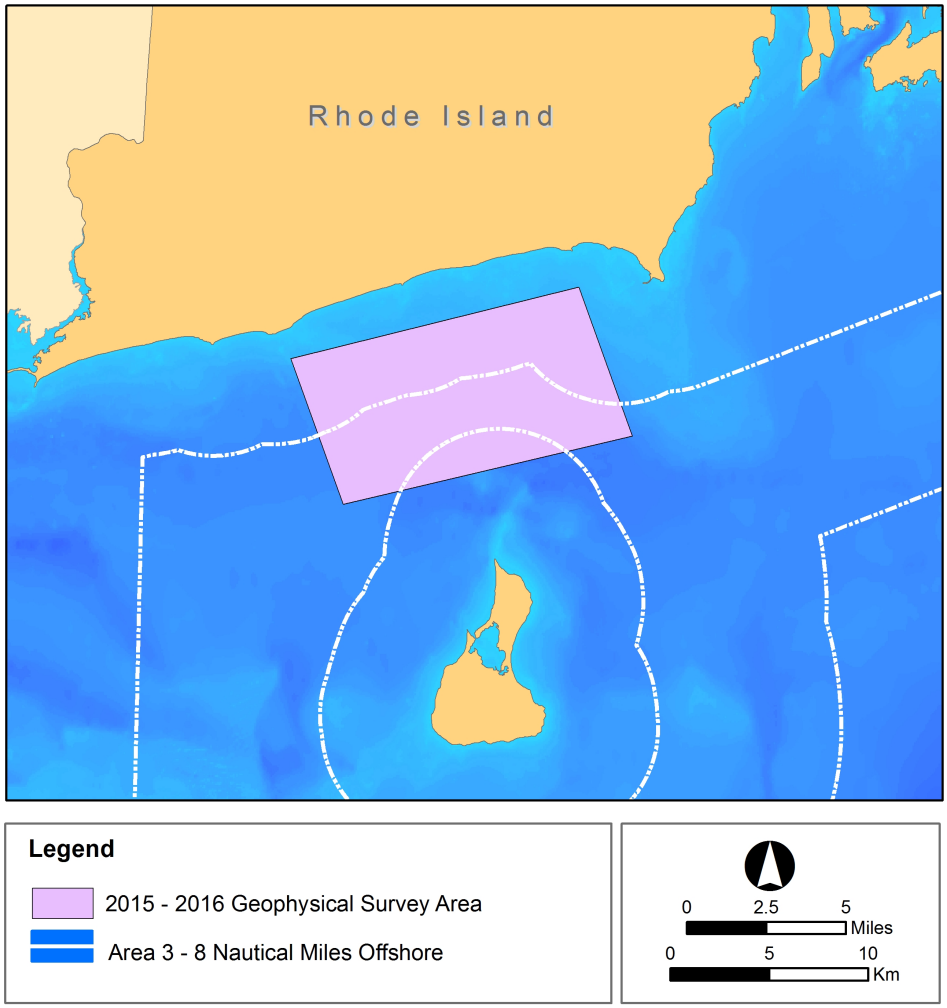

Figure 1. *Map showing the focus area for the data synthesis (white outline) between 3 - 8 nautical miles offshore of the state of Rhode Island, and the location (purple rectangle) of the 2015-2016 geophysical survey effort.*

King, J., B. Caccioppoli, J. Gardner, C. Gibson, B. Oakley, and D. Robinson, 2016. Morphological features, surficial sediment distribution, and potential sand and gravel resources in federal and state waters off the southwest coast Rhode Island. BOEM-URI Cooperative Agreement Award M14AC00011, Technical Report. Coastal Mapping Laboratory, Graduate School of Oceanography, University of Rhode Island.

A geological and geophysical mapping effort was undertaken by the Coastal Mapping Laboratory, Graduate School of Oceanography, University of Rhode Island between August 2015 and May 2016 in an effort to identify sand and gravel deposits on the Rhode Island Outer Continental Shelf that could be used as sediment borrow areas for beach replenishment. Emphasis was placed on examining an area in federal waters between 3 – 8 nautical miles (nm) offshore, however state waters (0-3 nm offshore) immediately north of the identified target area were also surveyed to further the understanding of the sedimentary environments associated with potential sand and gravel resources. Identification of a potential borrow areas were based on: 1) a literature and database review of existing geological and geophysical data in the area of interest, and the conversion/compilation of these data into ArcGIS-compatible geodatabases (included in digital format with the final technical report); 2) newly collected data resulting from geophysical (sidescan and subbottom sonar) surveys in federal and adjacent state waters (see Figure 1) which, based on examination of the data synthesis results, appeared to be a potential target for sand and gravel resources; and 3) interpretation of all compiled and collected data, and the development of ArcGIS maps indicating the geographic location of potential sediment borrow areas. This study benefited from the ability to leverage information from the ongoing Rhode Island Shoreline Change Special Area Management Plan (BeachSAMP) to estimate sand resource needs for Rhode Island beach replenishment, and from the ongoing BOEM-URI "Submerged Paleocultural Landscapes Project," to identify potential relict paleolandscape preservation and possible associated ancient Native American culturally sensitive sites within the potential borrow areas.

Preliminary analysis of newly collected geophysical data suggests that the target area (Figure 1) contains significant sand resources associated with glacial deltaic deposits (Figure 2). Four potential resource areas within the overall target area were delineated based on detailed examination of subbottom profile data, and the volumes of sand and gravel available in these areas were calculated. Data leveraged from the ongoing BeachSAMP project indicates that the small scale, berm-only level of replenishment extrapolated over the approximately 12.4 miles (20 km) of shoreline likely to need replenishment requires 1,700,335 yd^3 (1,300,000 m^3) of sand. Large-scale replenishment would require 7,978,495 yd^3 (6,100,000 m^3) of sand for the same area. Preliminary calculations of sand and gravel volumes potentially available in the target area indicate that this location could meet Rhode Island's beach replenishment needs. However, additional geophysical surveying, geotechnical sampling, and refined volume calculations are required to test this hypothesis, and will be conducted in Phase II of this project.

Of particular importance to BOEM and to the project team is obtaining an understanding of the potential archaeological sensitivity of the target area, to determine if sediment borrow activities are likely to disturb culturally sensitive sites. Preliminary investigations of approximately 237 line-miles of sub-bottom profile images collected in 2015 and 2016 suggest that the preservation of intact paleolandscapes in the target area may be limited, due to erosion associated with post-glacial sea level rise and contemporary oceanographic conditions. However, the project team is collaborating with BOEM and with the Narragansett Indian Tribal Historic Preservation Office

(BOEM Cooperative Agreement M12AC00016, "The Submerged Paleolandscapes Project") on a 5-year initiative to develop a science-based, standardized “best practice” methodology for identifying submerged ancient Native American archaeological resources in Rhode Island waters. A preliminary paleolandscape reconstruction and cultural sensitivity assessment for this area using the protocols being developed in the Submerged Paleolandscape Project is currently under development, and will be used to test this hypothesis during Phase II of this project.

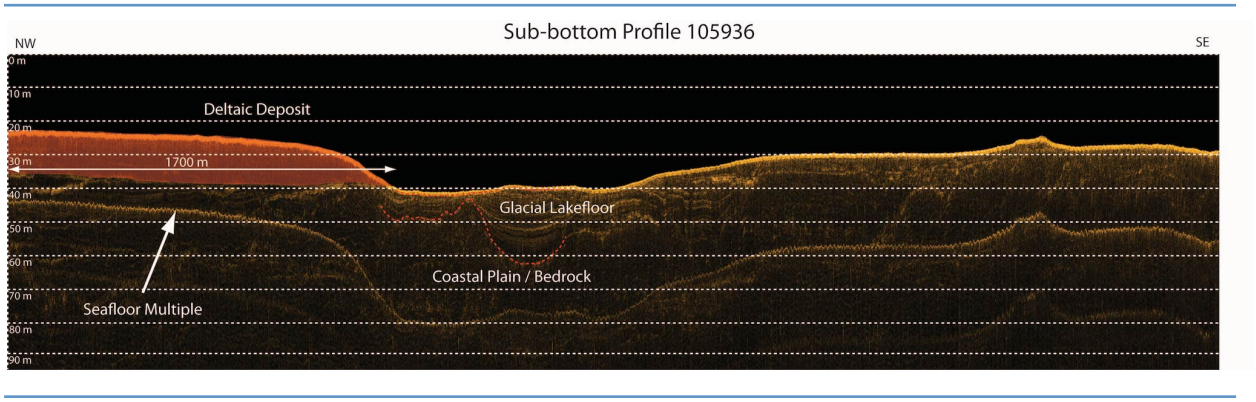

Figure 2. *Representative subbottom profile collected in a northwest/southeast orientation near the center of the target area. Note the large deltaic deposit at the upper left of the profile, which is the source of potential sediment resources.*

King, J., B. Caccioppoli, J. Gardner, C. Gibson, and D. Robinson, 2016. Identification of Submerged Relict Landscapes and Potential Paleocultural Sensitivity on the Outer Continental Shelf in Areas Targeted for Sand and Gravel Borrow Activities: Information Derived from the "Submerged Paleolandscapes Project." BOEM-URI Cooperative Agreement Award M14AC00011, Findings Report. Coastal Mapping Laboratory, Graduate School of Oceanography, University of Rhode Island.

The Coastal Mapping Laboratory at the Graduate School of Oceanography, University of Rhode Island and its research partner, the Narragansett Indian Tribal Historic Preservation Office (NITHPO), is currently participating in a five year BOEM-funded study entitled "Developing Protocols for Reconstructing Submerged Paleocultural Landscapes and Identifying Ancient Native American Archaeological Sites in Submerged Environments" (Cooperative Agreement M14AC00011 "The Submerged Paleolandscapes Project"). Multidisciplinary field investigations of four areas located in nearshore and offshore Rhode Island waters are being conducted to develop and test "best practice" methodologies for evidence-based reconstruction of submerged paleocultural landscapes, in addition to developing, testing and refining modeling approaches for predicting the locations of ancient Native American cultural and archaeological sites submerged by post-glacial sea level rise. Results from this study will assist BOEM, individual states, and Tribal communities to develop recommended information gathering protocols and survey guidelines for identifying, avoiding or mitigating adverse effects to submerged ancient Native American cultural and archaeological sites which might be at risk from offshore development. Since sand and gravel borrow activities have significant impact on the seafloor and could cause major damage to submerged culturally sensitive sites, the information resulting from the Submerged Paleolandscapes Project is particularly pertinent to targeting locations for sand and gravel resources.

Currently, the Coastal Mapping Laboratory has identified a potential borrow site in federal and state waters off the southwest coast of Rhode Island (Figure 1, purple rectangle) which may contain adequate sand resources to meet Rhode Island's beach replenishment needs. The project team is currently assessing an initial hypothesis that relict paleolandscapes are unlikely to be preserved in the targeted resource area. A preliminary examination of all subbottom profile images obtained during the 2015 and 2016 survey seasons (approximately 237 line-miles of data) was conducted. The relatively steep topography characteristic of the deltaic deposits in these profiles strongly favors a "shoreface retreat model" of post-glacial sea level rise, and the associated erosional processes suggest that limited intact paleolandscapes may be preserved. For example, the dipping forset beds shown in Figure 3 are clearly truncated by erosion, and the topset beds appear to have been removed. Examining glacial deltas in central New England, Koteff, et al. (1981) assumed that < 2 meter of the deltaslope beds had been removed based on a detailed examination of borrow pit exposures. In addition, the ravinement surface occurs only sporadically preserved within the study area, and relict paleolandscape features appear limited to a few paleochannels. Figure 4 illustrates a representative west-to-east transect obtained in the central portion of the target area. The ravinement surface is not immediately visible in this profile and may not be preserved, suggesting that extensive reworking of marine sediments is occurring in the study area.

Additional geophysical and geological surveying planned for Phase II of this project will test the project team's initial hypothesis that intact paleolandscape preservation in the Phase I target resource area may be limited. In addition, research from the Submerged Paleolandscapes project

will be completed in late 2017, and the resulting geospatial predictive model will be available for use in Phase II of this project.

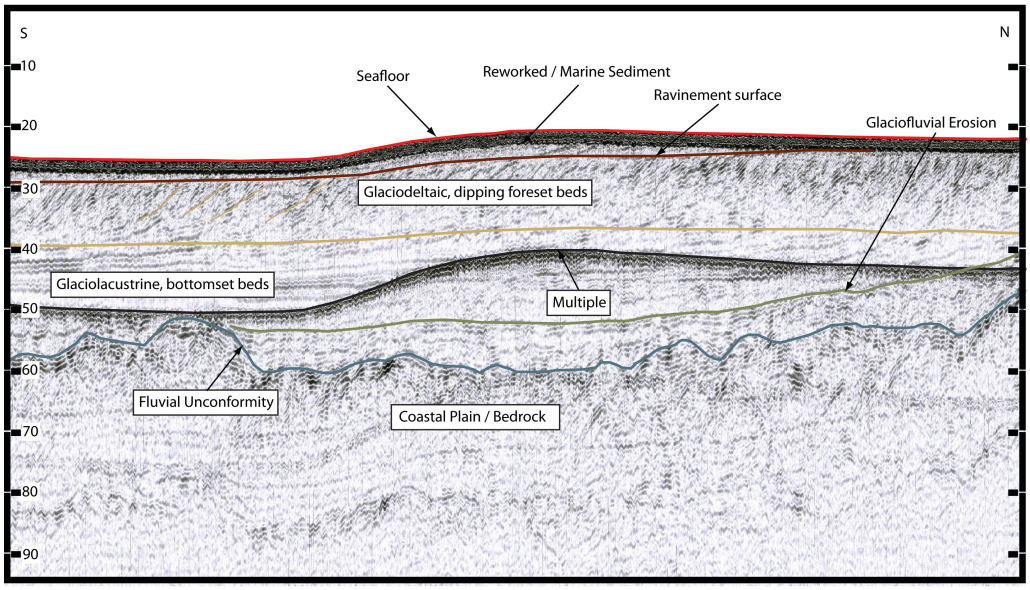

Figure 3: *Portion of representative north (left) to south (right) subbottom profile image obtained in the target area. Vertical scale is in meters below sea level. Note the eroded glaciodeltaic forset beds visible in the upper part of* the image.

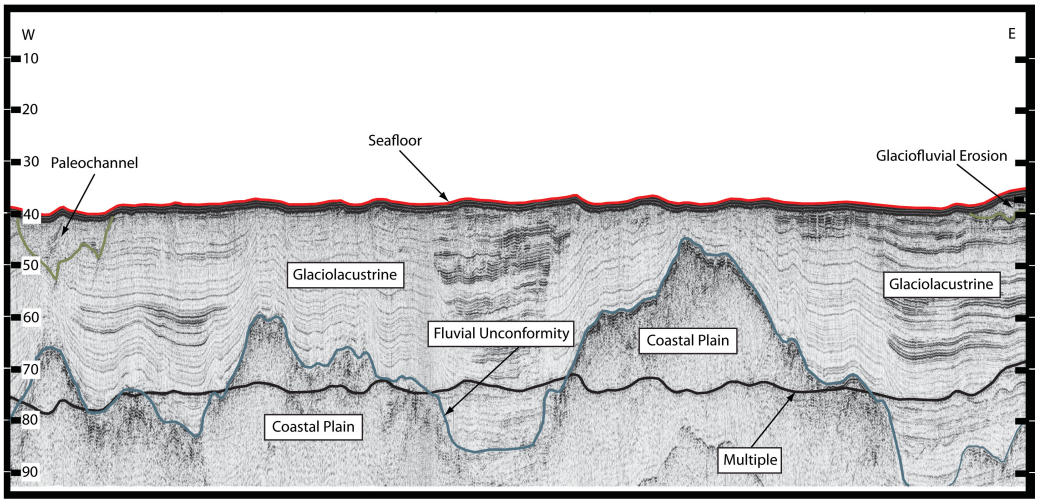

Figure 4: *Portion of representative west (left) to east (right) subbottom profile image obtained in the target area. Vertical scale is in meters below sea level. Note the absence of an identifiable ravinement surface.*

Oakley, B., and J. King, 2016. Estimating Necessary Volumes of Sand for Beach Replenishment Along the Rhode Island South Shore: Data from the Rhode Island Shoreline Change Special Area Management Plan ("BeachSAMP"). BOEM/Rhode Island Cooperative Agreement Award M14AC00011, Findings Report. Coastal Mapping Laboratory, Graduate School of Oceanography, University of Rhode Island.

The Rhode Island Coastal Resources Management Council (RI CRMC), the University of Rhode Island Coastal Resources Center, and Rhode Island Sea Grant are currently undertaking a multidisciplinary science-based coastal management project known as the Shoreline Change Special Area Management Plan, (aka The "Beach SAMP"). The main goals of the Beach SAMP are to gather new data on impacts of sea level rise, storm surge and coastal erosion, provide educational outreach to the public and municipalities, create a policy framework for dealing with shoreline change and develop tools and best practices to deal with shoreline change in Rhode Island. As part of the evaluation of best practices to mitigate the impacts of shoreline change, estimations of the sediment volume needed to replenish beaches along the Rhode Island south shore were calculated.

The volume of sand needed to replenish the developed beaches along the Rhode Island south shore was calculated as a simple volume of sand ([yd^3][m^3]) per yard (meter) of shoreline length. While the entire shoreline between Napatree Point and Point Judith encompasses 23.6 miles (38 km) of linear shoreline, the undeveloped barriers (Napatree, Mashaug, Quonochontaug, East Beach, Quonochontaug and Moonstone ([9 miles] [14.5 km]) were excluded from the volume calculations in this report. Under the current coastal regulations and property ownership, these barriers will remain undeveloped in the near future, and natural processes should be allowed to continue to operate on these barriers without replenishment. The till, boulder, and discontinuous bedrock headlands ([3.4 mi] [5.5 km]) (Weekapaug, Green Hill, Point Judith and portions of Watch Hill and Quonochontaug) were also excluded. Additionally, while not part of the Rhode Island south shore, Scarborough State Beach ([0.9 mi] [1.5 km]) and the portion of the Narragansett Barrier that encompasses Narragansett Town Beach ([0.6 mi] [1 km]) were included in this analysis as beaches that will possibly be replenished in the future. Taken together, this represents a potentially replenished shoreline length of approximately 12. 4 miles (20 km).

Various levels of replenishment, ranging from small-sale replenishment (widening the berm with no significant additions to the foredune/dike), to large-scale projects (constructing dikes and significant berm widening) were considered. The small-scale, berm only replenishment was based on the average alongshore volume of sand placed on Misquamicut State Beach in May 2014 ([85 $yd^3\ yd^{-1}$] [65 $m^3\ m^{-1}$]). Large-scale replenishment was considered as significant widening of the berm and enlargement of the foredune/dike, similar to the model presented for Mantoloking, NJ (USACE, 2013b), and represents an increase in 400 $yd^3\ yd^{-1}$ (305 $m^3\ m^{-1}$). A 'moderate' scale replenishment volume with an arbitrary volume of 200 $yd^3\ yd^{-1}$ (150 $m^3\ m^{-1}$) was included in the subsequent calculations.

Project cost was estimated based on the two possible sources of sediment using recent local and regional projects, and were averaged as a 'total cost' (i.e. the project cost/volume of sand). The cost for upland sources was based on the 2014 replenishment of Misquamicut State Beach ([\$36 yd^{-3}] [\$47 m^{-3}]). Costs for offshore sources of replenishment sand vary from \$5 to \$15 yd^{-3} (\$6.5 to \$20 m^{-3}) (Kana, 2012). Recent projects in New Jersey utilizing offshore sources have averaged \$12 to 15

yd^{-3} ($16 to $20 m^{-3})(Keiser, 2009). The cost for offshore sources was assumed to be $15 yd^{-3} ($20 m^{-3}) for this report. This analysis omits mobilization costs that have ranged between $3 - 5 million on recent projects (J. Waldner, personal communication, August 2016). The cost of mobilization could be mitigated either by building several smaller projects within a region, or by undertaking larger projects.

The small scale, berm-only level of replenishment extrapolated over the 12.4 mi (20 km) of shoreline likely to be replenishment requires 1,700,335 yd^3 (1,300,000 m^3) of sand. Large-scale replenishment would require 7,978,495 yd^3 (6,100,000 m^3) of sand for the same area. Estimated costs vary depending on sediment source and cost per yard; for upland sources, the total cost range from $61,100,000 to $287,000,000 for small-scale or large-scale replenishment respectively. Total estimated costs range from $26,000,000 to $122,000,000 utilizing offshore sources of sand. Table 1 summarizes the average alongshore volume, total volume and assumed cost for the three replenishment scenarios. These estimates were utilized by the project team to pose the preliminary hypothesis that the target areas identified off the southwest coast of Rhode Island (Figure 1) may contain enough sand to meet Rhode Island's beach replenishment needs. However, additional geophysical surveying, geotechnical sampling, and refined volume calculations are required to test this hypothesis, and will be conducted in Phase II of this project.

Table 1: *Average replenishment volume, total sand volume and estimated project costs for the three replenishment scenarios.*

Scenario	Average Replenishment Volume yd^3 yd^{-1} (m^3 m^{-1})	Total Volume (yd^3)	Total Volume (m^3)	Cost (upland source; $36 yd^{-3} ($47 m^{-3})	Cost (offshore source; ($15 yd^{-3}) ($20 m^{-3})
Low	85 (65)	1,700,335	1,300,000	$61,100,000	$26,000,000
Moderate	200 (150)	3,923,850	3,000,000	$141,000,000	$60,000,000
High	400 (305)	7,978,495	6,100,000	$286,700,000	$122,000,000

REFERENCES

Kana, T.W., 2012, A brief history of beach nourishment in South Carolina, Shore and Beach, v. 80, no 4.

Keiser, B., 2009, Barnegat Inlet to Little Egg Inlet Long Beach Island – Harvey Cedars Storm Damage Reduction Project Overview (Presentation) http://www.nj.gov/dep/ec/docs/harvey_cedars_overview.pdf

Koteff, C., and Pessl, F., 1981, Systematic ice retreat in New England: Geological Survey Professional Paper 1179: Washington, D.C., United States Government Printing Office, p. 1-20.

USACE (2013b), Manasquan Inlet to Barnegat Inlet Storm damage reduction project Ocean County, NJ, Draft environmental assessment (EA), U.S. Army Corps of Engineers, Philadelphia District.