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

Cooperative Agreement M14AC00013 – Modification 02: Assessment of Offshore Sand Resources and Economic Heavy Minerals on Virginia's Outer Continental Shelf

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Summary Report

Cooperative Agreement Outputs including Project Deliverables:

Blanchette, J.S., and Lassetter, W.L., 2019, Assessment of offshore sand resources for beach remediation in Virginia: Virginia Division of Geology and Mineral Resources Open-File Report 2019-02, 24 pp and Appendices.

The Virginia Department of Mines, Minerals and Energy's Division of Geology and Mineral Resources (DGMR) and U.S. Bureau of Ocean Energy Management (BOEM) initiated a multi-year cooperative agreement in 2014 to assess marine sand resources on the Outer Continental Shelf (OCS) for future beach restoration needs. As part of the project, BOEM contracted the Chicago Bridge and Ironworks Company (CB&I) in 2015 and 2017 to collect geophysical data and sediment core samples in two study areas located three to eight nautical miles off the Virginia coast. With assistance from DGMR geoscientists, CB&I targeted the areas on the basis of existing bathymetric data indicating the presence of sand shoals. Both areas are proximal to beach areas that have significant erosion risks and have required sand nourishment in the past to protect the coastal infrastructure and habitat. The northern area (Wallops) is located offshore of Assateague and Wallops Island and encompasses about 245 square kilometers, km2 (72 square nautical miles, nm2). The southern area (Sandbridge) is offshore of Sandbridge and False Cape State Park and encompasses about 187 km2 (54 nm2).

DGMR geoscientists completed an analysis of 201 line-km (109 line-nm) of reconnaissance-scale seismic survey data collected by CB&I to assess the quality, thickness, and extent of sand deposits that could be used for beach restoration. Geophysical data analysis was accomplished using Chesapeake Technology's SonarWiz6 seismic processing software and ESRI's ArcMap GIS software. CB&I and the Delaware Geological Survey provided lithologic logs and grain size analytical data for samples taken from 15 vibracores in the two study areas.

Lithologic logs from the vibracores provided the means to correlate reflectors identified in the seismic sub-bottom data and map the distribution and thickness of sand deposits. This enabled volumetric calculations of the potential sand resources in areas containing a minimum sand thickness of 5 feet, and areas with a minimum sand thickness of 10 feet. The results of mapping show areas in which sand thickness is unlikely to occur in recoverable quantities.

Beach-quality sand occurs in Holocene-age sand shoals, sheets, and paleo-channel infill deposits above fluvial and estuarine sediments of Pleistocene and Pliocene age in both resource areas. In the Sandbridge area, we estimate about 333 million cubic yards of fine to medium grained sand with a minimum thickness of 5 feet, and 271 million cubic yards with a minimum thickness of 10 feet. The mean grain size is 0.32 mm ($\phi M=1.68$). To the north in the Wallops area, we estimate about 421 million cubic yards of fine grained sand with a minimum thickness of 5 feet, and 393 million cubic yards of sand with a minimum thickness of 10 feet. The mean grain size is 0.21 mm ($\phi M=2.44$). The preliminary volumetric estimates will require additional infill data collection and analysis to confirm viable resources.

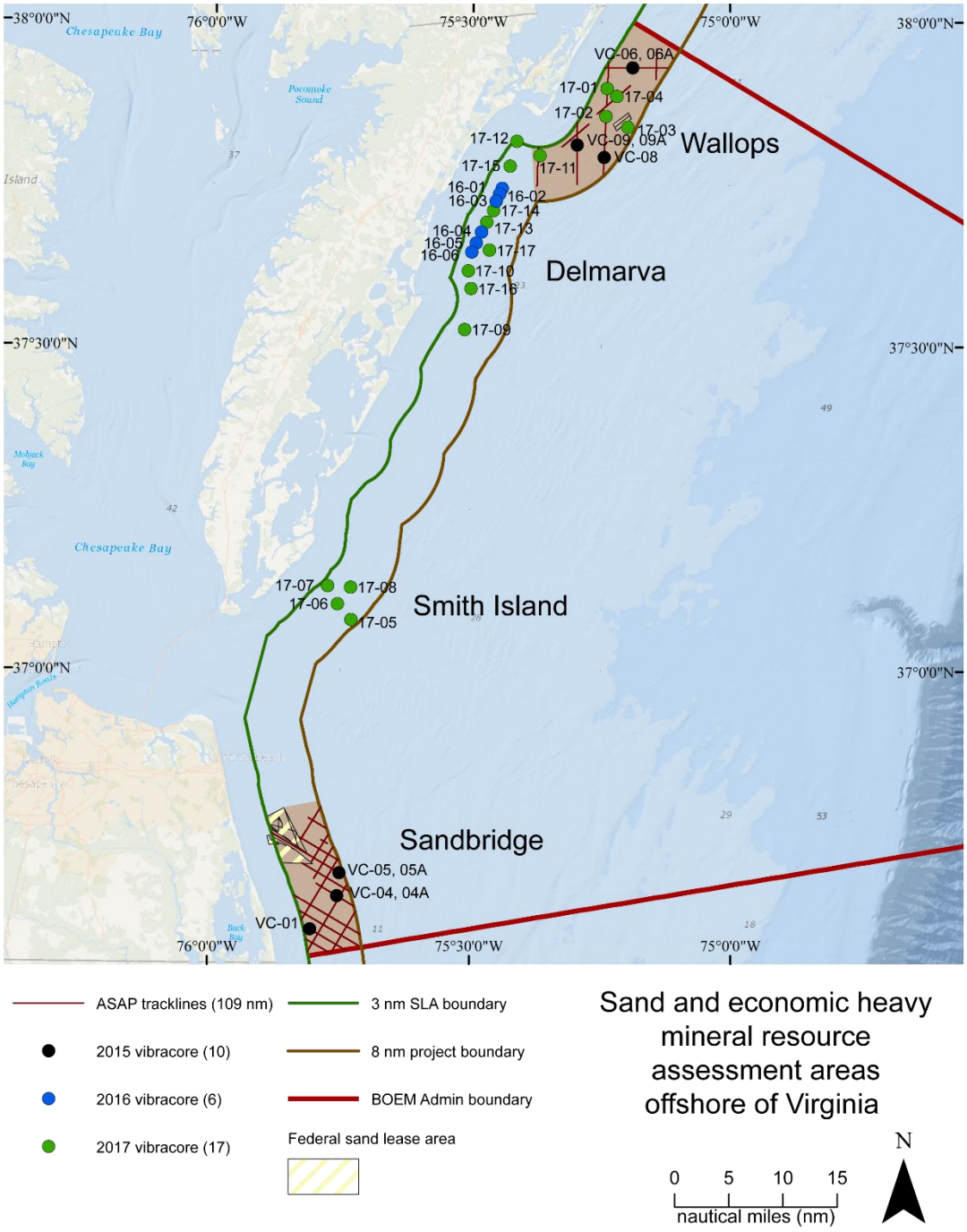

Figure 1. Marine mineral resource assessment areas evaluated as part of ASAP. Volumetric assessments of beach-quality sand were conducted in the brown-shaded areas at Wallops and Sandbridge.

Lassetter, W.L., and Blanchette, J.S., 2019, New insights concerning economic heavy minerals on the continental shelf offshore of Virginia: Virginia Division of Geology and Mineral Resources Open-File Report 2019-03, 33 pp and Appendices.

Since 2014, the Virginia Department of Mines, Minerals and Energy's Division of Geology and Mineral Resources (DGMR) and the U.S. Bureau of Ocean Energy Management (BOEM) have worked through a cooperative agreement to assess sand and economic heavy mineral resources on the continental shelf offshore of Virginia. Beach-quality sand deposits have been identified as potential resources for coastal remediation needs. Heavy minerals deposited with the sand include ilmenite (FeTiO3), rutile (TiO2), leucoxene (altered ilmenite), monazite (Ce,La,Y,Th)(PO4), chromite (Fe,Mg)Cr2O4, zircon (Zr,Hf,U)(SiO4), and others that occur in quantities ranging from trace amounts to over 10 weight percent. These minerals contain critical elemental commodities such as titanium, zirconium, chromium, and rare earth elements (REE) that have commercial value and are potentially recoverable as an integral part of beach restoration operations. Laboratory analysis of total heavy mineral (THM) concentrates from offshore samples has allowed for the quantification of the compositional variability of economic minerals, and the concentrations of the critical commodities they contain. The results also provide new information about grain size characteristics that, together with specific gravity and magnetic susceptibility, are important for the evaluation of recovery and separation methods.

A total of 63 marine sediment samples were analyzed for heavy minerals during 2016-19. The samples were gathered as part of the BOEM-sponsored Atlantic Sand Assessment Project (ASAP) and the Virginia Offshore Wind Technology Advancement Project (VOWTAP). Grain size analysis of the bulk samples provided mean ϕ values for the sediments, which averaged ϕM = 2.45, indicating predominantly fine grained sand textures that are suitable for beach nourishment. The preparation of the relatively large-volume samples for laboratory analysis included a pre-concentration procedure using a three-turn Humphrey spiral. Heavy liquid separation in the laboratory further refined the concentrates, producing a sink fraction containing minerals with specific gravity greater than about 3.2. For all samples, the THM content averaged 0.60 wt% (dry weight percent of the total sample), with individual samples ranging from as low as 0.01 wt% up to 1.94 wt%. Modal mineralogical analysis showed ilmenite to be the predominant heavy mineral, averaging 23.5 wt% of THM, followed by rutile 8.7 wt%, and zircon 3.7 wt%. The sum of economic minerals in the concentrates averaged 40.5 wt% of THM.

Major-oxide and trace element geochemical analysis of the THM concentrates indicated significant enrichments in critical elemental commodities including Ti, Zr, REE, Cr, Hf, In, Nb, Sn, Ta, U, V, and W. The chondrite-normalized patterns of REE concentrations in particular provide valuable insight for further investigations of the geospatial distributions and transport processes of the minerals in the offshore environment.

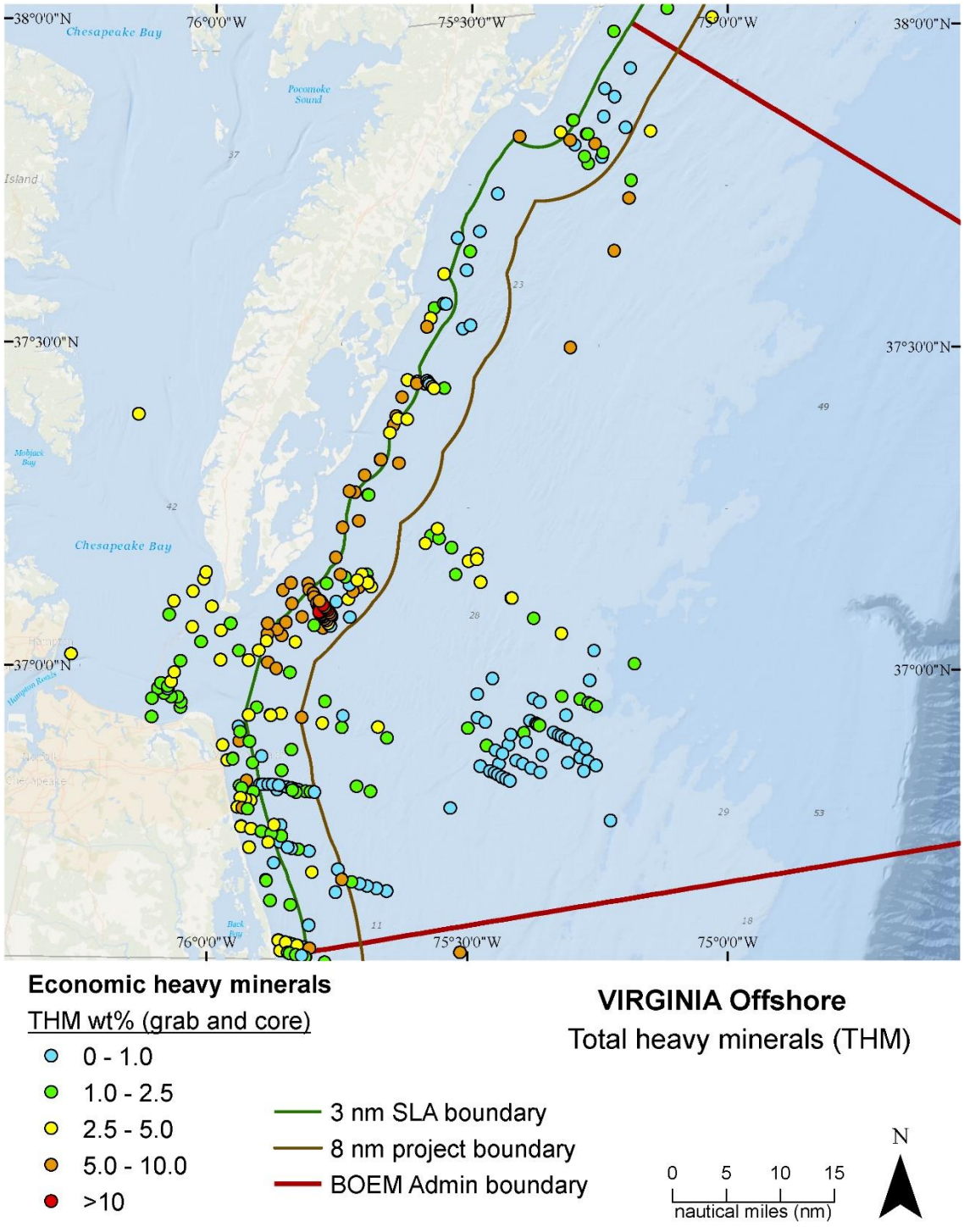

Figure 2 – Map showing sample locations from Berquist and others (2016), Berquist and others (1990), Luepke (1990), and the present study, analyzed for total heavy minerals (THM) offshore of Virginia.

Berquist, C.R., Jr., and Boon, J.D., 2019, Heavy mineral distributions in offshore sediments using Q-mode factor analysis: Virginia Division of Geology and Mineral Resources Open-File Report 2019-04, 32 pp.

Q-mode factor analysis was used on six data sets to evaluate the spatial relationship of offshore sediments via heavy mineral compositions in areas of the Chesapeake Bay mouth and Virginia Continental Shelf. The investigations involved up to 36 minerals and 538 samples. Ilmenite, garnet, pyrobole (amphibole + pyroxene), and to some extent magnetite commonly define factors and end-member sample compositions. For both a small and large number of samples, sediments in the area around Smith Island Shoals and a few other remote locations are mineralogically different from other sampled areas. For most of the investigations, samples fell into offshore or inshore groups, and the inshore group might be further divided into subgroups approximately north and south of the Bay mouth. Mixing is common in the Bay mouth area and several inshore areas.

Oral presentations:

Blanchette, J., and W.L. Lassetter, 2018, Marine mineral resources on Virginia's outer continental shelf: quantifying sand deposits for coastal restoration and occurrences of economic heavy minerals [abs]: Geological Society of America Northeastern Sectional Annual Meeting, 17-20 March 2018, Burlington, VT.

Lassetter, W.L., Blanchette, J.S., and Holm-Denoma, C., 2019, Marine mineral resources on the continental shelf offshore of Virginia: new insights concerning economic heavy minerals: [abs]: Geological Society of America Southeastern Sectional Annual Meeting, 28-29 March 2019, Charleston, SC.

Lassetter, W.L., and Berquist, C.R., 2016, Assessment of offshore sand and heavy minerals on Virginia's continental shelf: 2016 Virginia Geologic Research Symposium, sponsored by the Department of Mines, Minerals and Energy, April 28, Charlottesville, VA.

Lassetter, W.L., Berquist, C.R., Kuehl, S., Goodwyn, M.H., Milligan, D., Hardaway, S., Enomoto, M., and Strand, J.S., 2016, Assessment of marine sand resources and economic heavy minerals on Virginia's Outer Continental Shelf: [abs]: American Shore and Beach Preservation Association (ASBPA), 2016 National Coastal Conference, October 25-28, 2016.

Other Related Virginia OCS Reports:

Berquist, C.R., Jr., Lassetter, W.L., and Goodwyn, M.H., 2016, Grain size distribution and heavy mineral content of marine sands in Federal waters offshore of Virginia: Virginia Division of Geology and Mineral Resources Open-File Report 16-01, 34 p.

Berquist, C.R., Jr., C.T Fischler, L.J. Calliari, S.M. Dydak, H. Ozalpasan, and S.A. Skrabal, 1990, Heavy-mineral concentrations in sediments of the Virginia Inner Continental Shelf: in Berquist, C.R., Jr. [ed.], 1990, Heavy-mineral studies – Virginia inner continental shelf, Virginia Division of Mineral Resources Publication 103, 124 pp.

Berquist, C.R., Jr., and Hobbs, C.H., III, 1986, Assessment of economic heavy minerals of the Virginia inner continental shelf: Virginia Division of Mineral Resources Open-File Report 86-1, 17 p.

Berquist, C.R., Jr., and Hobbs, C.H., III, 1988, Study of economic heavy minerals of the Virginia inner continental shelf: Virginia Division of Mineral Resources Open-File Report 88-4, 149 p.

DMME (Department of Mines, Minerals and Energy), 2012, Sand resource evaluation on Virginia's outer continental shelf – Final Technical Report: Prepared for U.S. Bureau of Ocean Energy Management, Cooperative Agreement M10AC20021 for the performance period Sept 14, 2010 to Oct 31, 2011: 19p.

Luepke, G., 1990, Economic heavy minerals in sediments from an offshore area east of Cape Charles, Virginia: U.S. Geological Survey Open File Report 90-451, 10 p.