# Sand Resource Evaluation on Virginia's Outer Continental Shelf - Final Technical Report

Performance period: September 14, 2010 - October 31, 2011

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# Introduction

Since 1949, sand mined from inland borrow areas and marine deposits has been transported to vulnerable shoreline areas to help protect and preserve the coastline of Virginia. Starting in 1998, sand dredged from shoals and submerged channels on Virginia's outer continental shelf (OCS) has been used for beach re-nourishment projects and to protect the City of Virginia Beach waterfront from long shore drift and storm loss. To better understand the distribution and potential of these OCS resources for on-going and future projects, the Virginia Division of Geology and Mineral Resources (DGMR) entered into a cooperative agreement in 2010 with the U.S. Bureau of Ocean Energy Management, Regulation and Enforcement (BOEMRE, since re-organized as the Bureau of Ocean Energy Management, BOEM) to achieve the following goals:

- Create a comprehensive geodatabase of Virginia's OCS data collections;
- Complete a reconnaissance field survey of northern and southern extensions of Sandbridge Shoal;
- Migrate OCS sand data collections to the Virginia Geologic Information Catalog;
- Provide a Final Technical Report to summarize and document the results.

The cooperative agreement was initiated in September 2010 and extended through October 2011.

# Geodatabase of OCS Data Collections

The geodatabase builds upon earlier studies conducted by DGMR and the Virginia Institute of Marine Sciences (VIMS), which culminated in an initial compilation in 2006. Using these historic datasets as the base, DGMR gathered data from other available sources and compiled four primary data collections: ***Grab samples and cores, sub-bottom seismic profiles, side-scan sonar mosaics, and bathymetry***. For ease of use the data were compiled in multiple formats. Metadata associated with the individual data collections provides the user with key information such as geodetic datum, projection, and other location attributes. The geodatabase is spatially bound by Virginia's Outer Continental Shelf Administrative boundary, which is available for download as a GIS-enabled file from the BOEMRE Multipurpose Marine Cadastre http://www.marinecadastre.gov/default.aspx.

## Grab Samples and Cores

The VIMS data included 834 grab samples and 308 cores. Additional data was acquired from the National Oceanic and Atmospheric Administration (NOAA) National Geophysical Data Center (NGDC) among other sources (Table 1). The NGDC includes samples collected from Virginia's OCS and contained in the Marine Geology and Geophysics Collection. Using bounding coordinates, data was downloaded in .csv format, imported to ESRI ArcGIS and further edited to remove points outside of Virginia's Administrative Boundary. The VIMS and NGDC datasets were edited for attribute consistency and merged into one geodatabase. Individual attributes of samples are maintained in the geodatabase by sample location, and where possible include sample date, ship/cruise information, surface lithology, surface description, grain size analysis, principle investigator, links to publications or websites, and results of mineral analysis. A data dictionary was created and is included in the spreadsheet format.

### Table 1 – Grab samples and cores

| Grab Sample and Cores | |
|---|---|
| **Total samples** | 4869 |
| **Grabs samples** | 2911 |
| **Cores** | 1547 |
| **Unknown** | 410 |
| **Surface lithology** | 4125 |
| **Heavy Mineral Analyses** | 416 (5 more to come) |
| **Facilities housing data** | American Oceanographic and Meteorological Lab, USGS-Woods Hole, USGS- Columbia Environmental research Center, Virginia DGMR, Lamont Doherty Earth Observatory, National Museum of Natural History, National Oceanic Systems, USACE, Virginia Institute of Marine Sciences |

## Sub-Bottom Seismic Profiles

Sub-bottom profiles were initially compiled by VIMS in 2006. DGMR integrated points and lines delineating the extent of 147 lines of seismic data into the geodatabase (Table 2). The seismic lines in the geodatabase are fully attributed and linked to full size sub-bottom images. To facilitate future work that fully utilizes the information contained in the sub-bottom seismic profile data, DGMR loaded the seismic lines into the 3-D mapping program SMT Kingdom Suite, which will allow users to create layered maps and cross sections, and complete other analytical work such as volumetric calculations.

### Table 2 – Sub-bottom profile lines

| Sub-bottom Profile Lines | |
|---|---|
| **Total Lines** | 147 |

## Side-Scan Sonar Mosaics

Side-scan sonar mosaics are a relatively new dataset acquired from NOAA's National Ocean Systems Hydrographic Survey (NOS) database. Side-scan sonar images represent seismic attenuation swaths of the seafloor. Mosaics are a series of side-scan lines stitched together by seafloor features and relative positions. Side-scan sonar images are used to delineate features of the sea floor based upon changes in sediment grain size, packing, material and manmade objects. Mosaics were downloaded from the NOS website as files in the geotiff format (Table 3). The images were imported into ArcGIS and integrated into the comprehensive geodatabase.

### Table 3 – Side scan sonar mosaics

| Side-Scan Sonar Mosaics | |
|---|---|
| **Total area** | ~400 Miles$^2$ |
| **Surveys included From the NOS database** | F00540, H11196, H11202,H11205N, H11205S, H11206, H11207, H11207-1, H11301, H11302, H11303, H11401, H11402, H11407, H11504, H11529, H11652, H11653, H11657, H11789, H12037 |

## Bathymetry

Accurate and current bathymetry data is key to understanding the morphology of the seafloor. Bathymetry data was downloaded as .xyz files from NOAA's NOS Hydrographic Surveys as individual surveys. The individual surveys were edited for consistency, assessed for spatial and temporal relevance, and were collated into one file. (Although a survey completed in 1891 is available in a digital format, it was not included in the present data collection, Table 4). The complete .xyz file was imported into ArcGIS and transformed into a Triangular Information Network (TIN). The TIN format is similar to a digital elevation model (DEM) and can be used to describe hill-shade, slope, and elevation of the seafloor.

### Table 4 – Bathymetry data

| Bathymetry Data | |
|---|---|
| **Surveys included from the NOS database** | B00213, B00214, B00215, B00217, B00218, B00219, B00220, B00221, F00540, H04286, H05673, H05702, H05713, H05715, H05770, H05770, H05771, H05988, H05990, H05991, H05992, H05993, H05995, H06595, H08218, H09098, H09099, H09659, H09663, H09738, H09814, H09880, H09901, H09904, H09905, H09919, H09922, H09948, H09955, H09961, H09962, H09969, H09970, H09972, H09978, H09980, H09981, H10337, H10340, H11027 |

The second process was to sort the data by elevation and parse into manageable, overlapping and logical data sets. Using Golden Software Surfer ver. 9, a surface modeling and contouring application, each dataset was gridded and processed to create .xyz data files. The gridded and contoured data was exported as ESRI shapefiles into ArcGIS. Table 5 outlines the gridding parameters used to create the contoured bathymetry. Due to sparseness of data in some regions, especially in the near-shore areas, contour lines were manually edited for closure and merged for usability in ArcGIS.

### Table 5 – Bathymetry gridding parameters

| Bathymetry Gridding Parameters in Surfer 9 | | | | | |
|---|---|---|---|---|---|
| **Contour** | Intervals | Gridding method | Bin spacing | Search radius | Low Pass Filter 1 |
| **0'-50' contours** | 2' | Kriging | 75 | 500 | Yes |
| **50'-100' contours** | 5' | Kriging | 175 | 1300 | Yes |
| **100'-300' contours** | 10' | Kriging | 500 | 1800 | Yes |
| **300'+ contours** | 200' | Kriging | 200 | 500 | Yes |

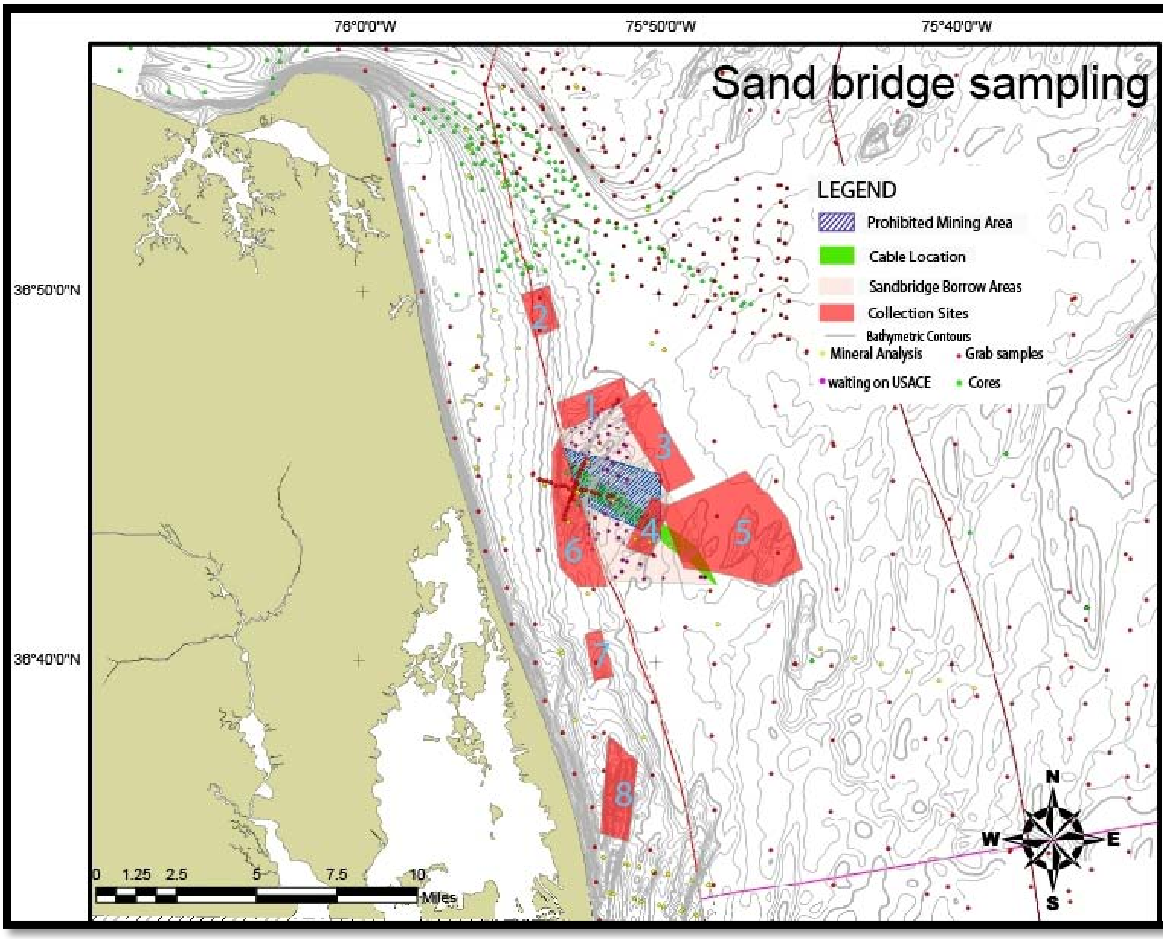
## Field Survey

In preparation for the reconnaissance field survey and data collection, DGMR closely examined the available information using the geodatabase, and selected eight primary areas of interest in the Sandbridge Shoal area. The sites were chosen using three criteria: proximity to Sandbridge Shoal and recent dredge sites, bathymetry indicating possible shoals, and where there was a dearth of sea floor sediment data. The areas of interest are shown as red polygons in Figure 1. The site numbers shown in Figure 1 indicate the order of priority for field survey purposes. Note that field data collection sites 6, 7, and 8 are located within State waters (i.e. not under Federal jurisdiction) and were thus considered lowest priority for this investigation.

Offshore field work was conducted on August 3-5, 2011 with personnel including Dennis Feeney, William Lassetter, and Rick Berquist from DGMR, Charlie Broadwater from BOEM, and Captain Jake Hiles aboard the *Matador*. The process of sampling involved the navigator using a hand held Trimble GPS unit containing location map images, coupled with a Humminbird side-scan sonar unit (Figure 2) to help identify the presence of sandy bottom substrate in the selected areas of interest. At each collection site, the ship captain would stabilize the boat and the remaining crew would drop overboard a "clam shell" grab sampler that was retrieved by hand using an attached rope (Figure 3). About 0.5 to 1 kilogram of sample was collected in heavy-duty ziplock bags. Location data was recorded from the GPS. A description of the sample material was recorded based on visual observations including the estimated grain size distribution, amount of organic material, quantity of shell material, and rough percentage of opaque heavy minerals.

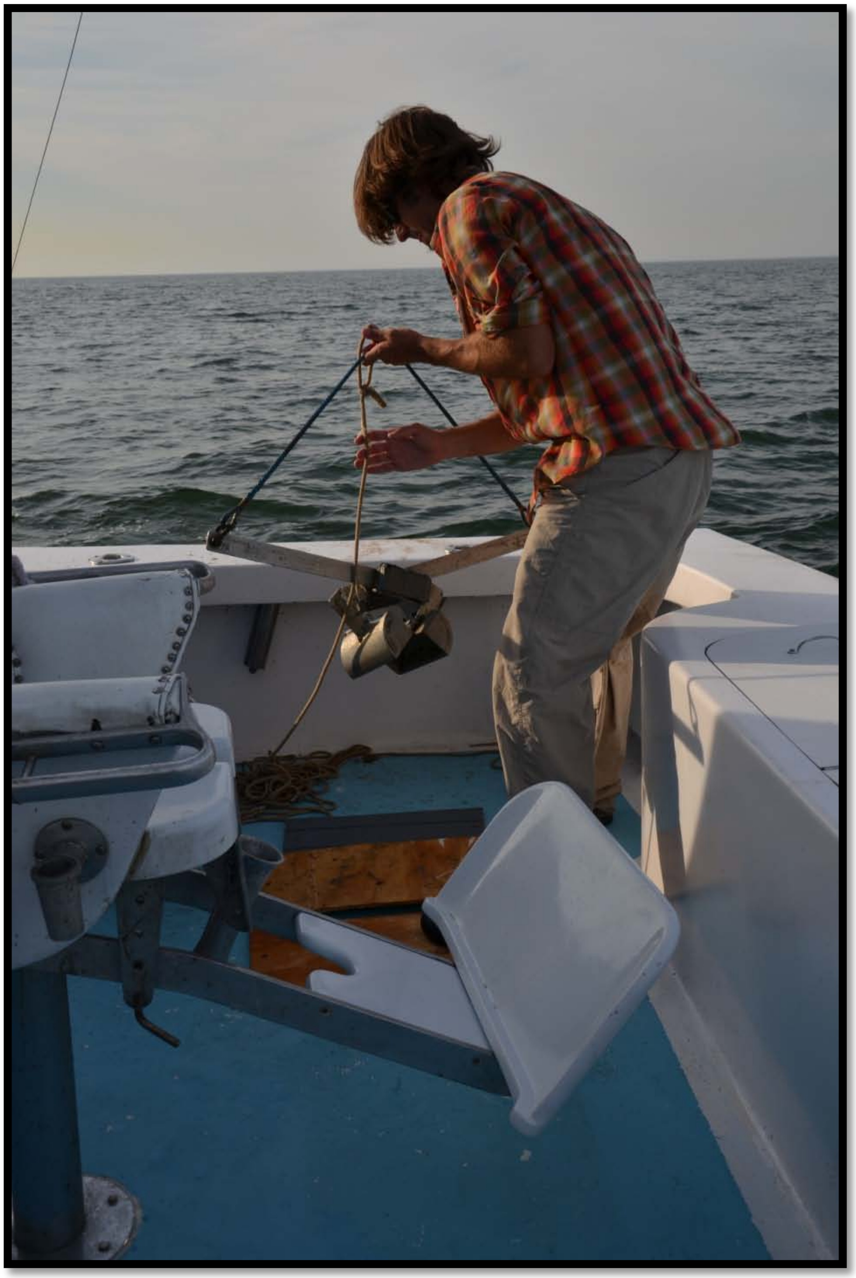
Table 6 provides a summary of field data collected for each sample. The initial plan was to collect 50 samples but the efficiency of the crew and survey allowed us to collect a total of 90 samples. In addition, three bulk samples (up to about 10-15 kilograms each) were collected in 5-gallon plastic buckets for heavy mineral analysis.

## Figure 1 - Sample sites in the vicinity of Sandbridge Shoal




## Figure 2 - Side scan sonar unit aboard the *Matador*

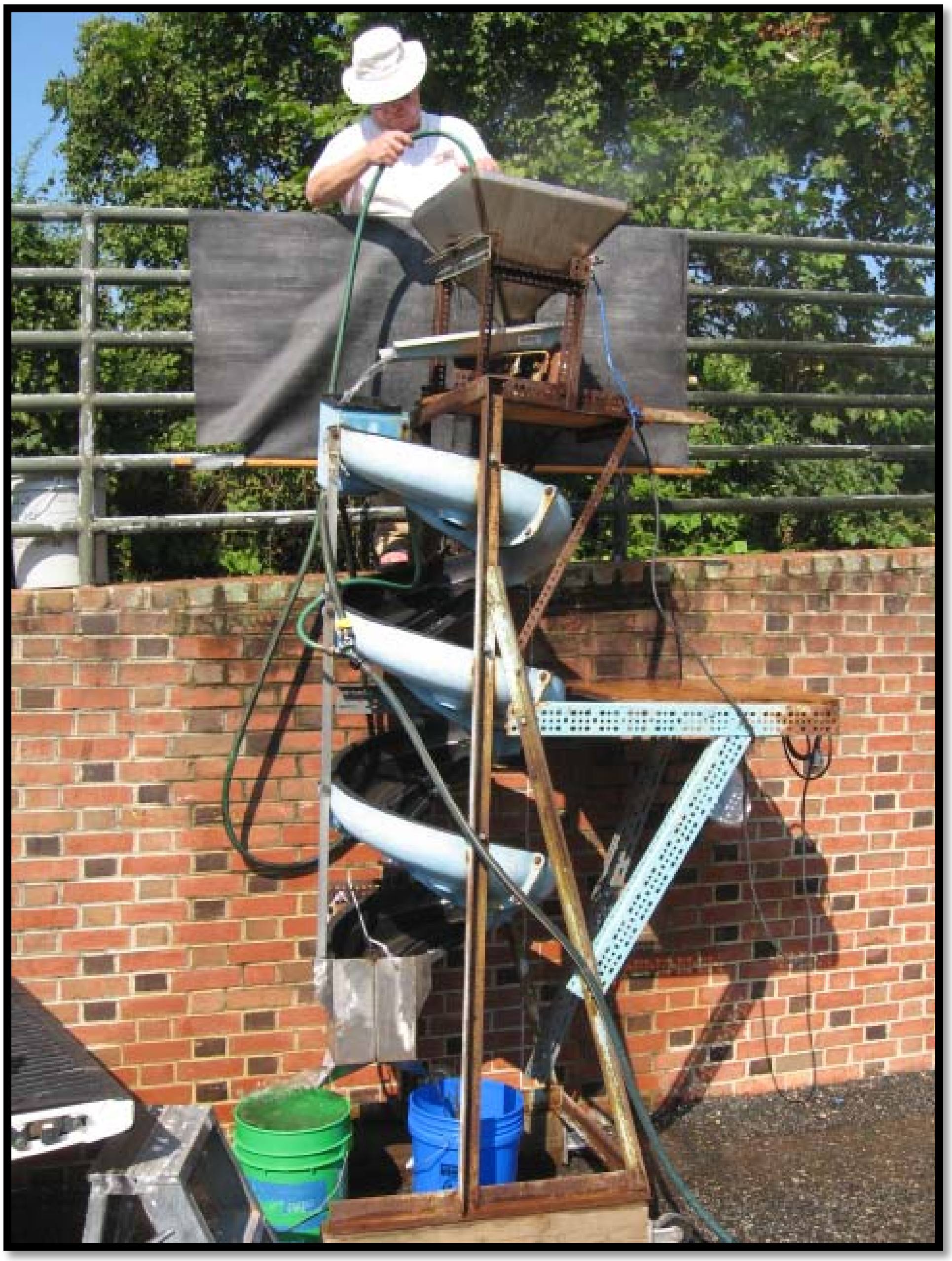
**Figure 3 - Dennis Feeney retrieving the "clam shell" sampler**



Grain size analysis was completed at the DMGR office in Charlottesville in late August. The samples were gently washed to remove organic material, oven dried and weighed. The samples were then dry sieved and individual Phi scale fractions were weighed again. Because the focus of the study is on sand fractions, all grains greater than Phi-2 (fine pebbles) and smaller than Phi-4 (silt) were respectively grouped. The results of grain size analyses are graphically presented in Charts 1 - 4.

A total of five samples were prepared for heavy mineral analysis including 3 samples collected aboard the *Matador*, and 2 additional samples from a related and ongoing VIMS study. Sample preparation was completed at the DGMR office in Williamsburg. The samples were sieved and cleaned to remove coarse and fine grain material. The samples were then run through a 3-turn Humphreys spiral concentrator (Figure 4) to collect the heavy mineral concentrate. This concentrate was submitted to Actlabs in Ancaster, Ontario Canada for heavy mineral analysis. As of the date of final preparation of this report, the analytical results were pending. The final results will be appended to this report once they become available.

**Figure 4 - Rick Berquist and the Humphreys spiral concentrator**



## Table 6 – 2011 Sample information

| 2011 Sample Information | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| **SAMPLE** | Date | latitude | longitude | Water depth (ft) | Lithology 1 | Lithology 2 | Lithology 3 | Description |
| **S0083** | 8/2/2011 | 36.82658 | -75.9259 | 31 | sand | shell fragments | | Fine, dark green, shell fragments, opaques, loose |
| **S0084** | 8/2/2011 | 36.82648 | -75.9036 | 35 | sand | shell fragments | | Medium to coarse, ~10% shell fragments, ~1% opaques |
| **S0085** | 8/2/2011 | 36.8268 | -75.8946 | 34 | sand | shell fragments | gravel | very coarse, brown, opaques, varied lithology, fine gravel |
| **S0086** | 8/2/2011 | 36.82716 | -75.8905 | 36 | sand | | | well sorted, medium to fine (small fine), ~1% shell fragments, brown |
| **S0087** | 8/2/2011 | 36.82223 | -75.8904 | 36.5 | sand | shell fragments | | medium to coarse, brown, opaques ~2%, well sorted |
| **S0088** | 8/2/2011 | 36.82011 | -75.8917 | 38.5 | sand | shell fragments | | medium to coarse, light brown, opaques ~2%, well sorted |
| **S0090** | 8/2/2011 | 36.81715 | -75.8989 | 32 | sand | shell fragments | | medium, well sorted, brown |
| **S0091** | 8/2/2011 | 36.81623 | -75.9024 | 37 | sand | shell fragments | | medium to coarse, brown well sorted, opaques |
| **S0092** | 8/2/2011 | 36.81996 | -75.9042 | 38 | sand | | | fine to very fine, brown, well sorted, heavy minerals |
| **S0093** | 8/2/2011 | 36.82342 | -75.8994 | 33 | sand | shell fragments | | fine to medium, shell fragments up to 10mm, work borrows |
| **S0094** | 8/2/2011 | 36.83004 | -75.9012 | 34.5 | sand | | | medium to coarse, small shell fragments, brown opaques |
| **S0095** | 8/2/2011 | 36.83439 | -75.8951 | 42 | sand | silt | | silty sand, very fine, dark brown-dark gray, opaques |
| **S0097** | 8/2/2011 | 36.83275 | -75.903 | 38.5 | sand | | | fine to medium, heavy mineral brown |
| **S0098** | 8/2/2011 | 36.83135 | -75.9094 | 38.4 | silt | sand | clay | sticky firm, dark gray very fine sand, dark green |
| **S0099** | 8/3/2011 | 36.78288 | -75.8873 | 43 | silt | sand | | very fine, heavy mineral, small amounts of clay |
| **S0100** | 8/3/2011 | 36.78036 | -75.8842 | 44.5 | sand | shell fragments | silt | very fine to medium, majority fine, poorly sorted, dark gray, 15-20% shell fragments, sss valley |
| **S0101** | 8/3/2011 | 36.77463 | -75.8834 | 41 | sand | shell fragments | | medium to fine, 1-2% opaques, 10-20% shell, brown, sss ridge top |
| **S0102** | 8/3/2011 | 36.77771 | -75.8731 | 40.3 | sand | shell fragments | | medium to coarse, ~1% opaques, brown, shell fragments, 10-15% shell |
| **S0103** | 8/3/2011 | 36.782 | -75.8709 | 39.3 | sand | shell fragments | | medium to coarse, ~1% opaques, brown, shell fragments, 10% shell, well sorted, 4 cm shell fragments, sss-top of ridge |
| **S0104** | 8/3/2011 | 36.78729 | -75.8773 | 47.4 | sand | shell fragments | | medium-fine, ~2% opaques, brown, fine opaques |
| **S0105** | 8/3/2011 | 36.79175 | -75.8714 | 48.4 | sand | | | medium-coarse, predominantly coarse, ~2% opaques, brown varied lithology, sss- top of ridge |
| **S0106** | 8/3/2011 | 36.78655 | -75.8659 | 42.7 | sand | shell fragments | | medium-coarse, little to no opaques, sss-top of ridge |
| **S0107** | 8/3/2011 | 36.78022 | -75.8645 | 43.8 | sand | shell fragments | | medium, well sorted, opaques, brown, ~10% shell fragments |
| **S0108** | 8/3/2011 | 36.78426 | -75.858 | 44.1 | sand | shell fragments | | fine to medium, ~2% opaques, sss- on top of ridge |
| **S0109** | 8/3/2011 | 36.7903 | -75.8608 | 44.8 | sand | shell fragments | | medium to coarse, ~2-3% opaques, 5-10%shell fragments, 5% opaques, sss-on top of ridge |
| **S0110** | 8/3/2011 | 36.79476 | -75.8529 | 49.7 | sand | shell fragments | | fine to medium, shell hash, brown, sss- nose of ridge |
| **S0111** | 8/3/2011 | 36.78892 | -75.8501 | 48.7 | sand | shell fragments | | fine to medium, shell hash, brown, sss- nose of ridge |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| **S0112** | 8/3/2011 | 36.78127 | -75.8483 | 47.3 | sand | shell fragments | | fine to medium, shell hash, brown, sss- top of ridge |
| **S0113** | 8/3/2011 | 36.78001 | -75.844 | 47.6 | sand | shell fragments | | medium to coarse, opaques ~5%, shell hash, brown, sss- east of ridge |
| **S0114** | 8/3/2011 | 36.78415 | -75.843 | 45.6 | sand | shell fragments | | medium, well sorted, opaques~5%, 20% shell hash, sss- on ridge |
| **S0115** | 8/3/2011 | 36.78587 | -75.8453 | 49.7 | sand | shell fragments | | medium, well sorted, opaques~5%, 20% shell hash, sss- on ridge |
| **S0116** | 8/3/2011 | 36.78874 | -75.8372 | 48.4 | sand | shell fragments | | medium, well sorted, ~5% opaques, brown, shell hash |
| **S0117** | 8/3/2011 | 36.77567 | -75.8434 | 50.3 | sand | shell fragments | | medium, well sorted, ~5% opaques, brown, shell hash |
| **S0118** | 8/3/2011 | 36.7749 | -75.8482 | 46.1 | sand | shell fragments | | medium to coarse, ~2% opaques, shell 10-15%, brown, shell hash |
| **S0119** | 8/3/2011 | 36.77249 | -75.8504 | 43.3 | sand | shell fragments | | medium to coarse, ~5% opaques, brown, 5-10% shell fragments, shell hash |
| **S0120** | 8/3/2011 | 36.76717 | -75.8431 | 48.6 | sand | shell fragments | | medium, 10-20%shell fragments, ~5% opaques, well sorted, sand hash |
| **S0121** | 8/3/2011 | 36.76772 | -75.8289 | 50.9 | sand | | | medium, ~5% opaques, brown, well sorted, ~5% opaques |
| **S0122** | 8/3/2011 | 36.75489 | -75.8334 | 49.5 | sand | | | fine to medium, ~5% opaques, well sorted, ~10% shell fragments |
| **S0123** | 8/3/2011 | 36.75452 | -75.8245 | 54.3 | sand | | | medium, well sorted, ~5% opaques, ~5% shell fragments |
| **S0124** | 8/3/2011 | 36.74936 | -75.8129 | 53.4 | sand | shell fragments | | fine to medium, ~5% opaques, well sorted, shell fragments |
| **S0125** | 8/3/2011 | 36.74936 | -75.8129 | 53.4 | sand | shell fragments | | fine to medium, ~5% opaques, well sorted, shell fragments |
| **S0127** | 8/3/2011 | 36.74163 | -75.8377 | 45.8 | sand | shell fragments | | medium, well sorted, ~5% opaques, brown |
| **S0128** | 8/3/2011 | 36.73811 | -75.8336 | 40.4 | sand | shell fragments | | fine to medium, well sorted, ~5% opaques, brown, sss-on top of ridge |
| **S0129** | 8/3/2011 | 36.72963 | -75.8415 | 49.8 | sand | shell fragments | | fine to medium, ~10% shell, brown, well sorted, ~5% opaques |
| **S0130** | 8/3/2011 | 36.72512 | -75.841 | 51.6 | sand | | | fine to medium, ~4% opaques, ~5% shell |
| **S0131** | 8/3/2011 | 36.72043 | -75.8401 | 45.1 | sand | | | fine to medium, well sorted, shell~5%, brown, sss- on top of ridge |
| **S0132** | 8/3/2011 | 36.71656 | -75.8404 | 48.7 | sand | | | fine to medium, majority fine, brown, ~5% opaques, shell ~2% |
| **S0133** | 8/3/2011 | 36.71092 | -75.8168 | 52.8 | sand | | | fine to medium, majority fine, brown, ~5% opaques, shell ~2% |
| **S0134** | 8/3/2011 | 36.71833 | -75.8146 | 46.8 | sand | | | fine to medium, majority fine, brown, ~5% opaques, shell ~2% |
| **S0135** | 8/3/2011 | 36.728 | -75.8231 | 55.2 | sand | shell fragments | silt | fine, 5-10%shell, 5% opaques, well sorted, organic material |
| **S0136** | 8/3/2011 | 36.72954 | -75.8074 | 51.1 | sand | | | medium, ~2% shell, ~5% opaques |
| **S0137** | 8/3/2011 | 36.72273 | -75.8009 | 51.4 | sand | shell fragments | | medium to coarse, ~5% opaques |
| **S0138** | 8/3/2011 | 36.7164 | -75.8046 | 51.8 | sand | | | medium to coarse, ~5% opaques, mineral test |
| **S0140** | 8/3/2011 | 36.72063 | -75.7931 | 51.4 | sand | shell fragments | | medium, ~10% shell, ~5% opaques, Brown, SSS- flats |
| **S0141** | 8/3/2011 | 36.71559 | -75.7841 | 47.2 | sand | | | medium to fine, well sorted, ~5% shell fragments, brown, sss- east of ridge |
| **S0142** | 8/3/2011 | 36.7089 | -75.7814 | 55.4 | sand | | | medium to fine, well sorted, ~5% shell fragments, brown, sss- east of ridge |
| **S0143** | 8/3/2011 | 36.70885 | -75.7728 | 45.5 | sand | | | medium to coarse, brown, ~5% shell fragments, ~5% opaques |
| **S0144** | 8/3/2011 | 36.71543 | -75.7645 | 48.2 | sand | | | medium, brown, ~5% shell fragments, ~5% opaques |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| **S0145** | 8/3/2011 | 36.72004 | -75.7711 | 44.8 | sand | | | medium, brown, ~5% shell fragments, ~5% opaques |
| **S0146** | 8/3/2011 | 36.71975 | -75.785 | 44.5 | sand | | | medium, brown, ~5% shell fragments, ~5% opaques |
| **S0147** | 8/3/2011 | 36.73635 | -75.7723 | 55.3 | sand | | | medium, brown, ~5% shell fragments, ~5% opaques |
| **S0149** | 8/3/2011 | 36.73343 | -75.787 | 50.9 | sand | shell fragments | | fine to medium, ~5% opaques |
| **S0150** | 8/3/2011 | 36.74088 | -75.7957 | 51.6 | sand | shell fragments | | fine to medium, well sorted, ~5% opaques |
| **S0151** | 8/3/2011 | 36.73737 | -75.8082 | 48.8 | sand | shell fragments | | fine to medium, well sorted, ~5% opaques |
| **S0152** | 8/3/2011 | 36.73692 | -75.8197 | 51.9 | sand | | | fine to medium, well sorted, ~5% opaques, brown loose |
| **S0153** | 8/4/2011 | 36.75664 | -75.8602 | 41 | sand | | | fine to medium, well sorted, 3% opaques, well sorted, well rounded |
| **S0155** | 8/4/2011 | 36.69825 | -75.6975 | 50.9 | sand | shell fragments | | fine to medium, well rounded, brown, ~5% opaques |
| **S0156** | 8/4/2011 | 36.70115 | -75.7613 | 61.8 | sand | | | medium to fine, well sorted, brown, ~2% opaques |
| **S0157** | 8/4/2011 | 36.69617 | -75.7477 | 47.5 | sand | | | fine, shell ~5%, opaques ~2%, brown, well sorted |
| **S0158** | 8/4/2011 | 36.68385 | -75.7508 | 42.3 | sand | | | fine, well sorted, ~5% shell and opaques, SSS-on top of ridge |
| **S0159** | 8/4/2011 | 36.68476 | -75.7374 | 59.6 | sand | silt | | fine to very fine, ~5% shell, green to brown |
| **S0160** | 8/4/2011 | 36.66026 | -75.7472 | 50.5 | sand | | | fine to medium, ~5% opaques, ~2% shell |
| **S0161** | 8/4/2011 | 36.66931 | -75.7586 | 56.1 | sand | | | fine to medium, well rounded, 10% hell, 5% opaques |
| **S0162** | 8/4/2011 | 36.66547 | -75.7792 | 66.8 | silt | sand | clay | clay component, ~8% opaques, very fine, worm tubes, no organic smell |
| **S0164** | 8/4/2011 | 36.67479 | -75.8094 | 60.2 | sand | silt | | muddy silty very fine sand, worm tubes, firm |
| **S0165** | 8/4/2011 | 36.66194 | -75.8666 | 48.1 | sand | silt | gravel | coarse, shell hash, brown, dark gray, poorly sorted, 10-15% shell, 3% opaques |
| **S0166** | 8/4/2011 | 36.66783 | -75.8635 | 46.3 | sand | shell fragments | gravel | medium to coarse, opaques ~3%, brown to dark gray |
| **S0167** | 8/4/2011 | 36.67522 | -75.8682 | 47.5 | sand | shell fragments | silt | medium to fine, opaques~1%, shell hash |
| **S0168** | 8/4/2011 | 36.70955 | -75.884 | 47.2 | silt | shell fragments | | shell hash |
| **S0169** | 8/4/2011 | 36.71189 | -75.8695 | 48.6 | shell fragments | gravel | | shell hash, silt and very fine sand |
| **S0170** | 8/4/2011 | 36.71321 | -75.8536 | 53.1 | sand | shell fragments | | medium, well sorted, opaques ~1% |
| **S0171** | 8/4/2011 | 36.71728 | -75.8607 | 48.8 | sand | shell fragments | | medium to coarse, opaques ~3%, shell fragments ~15% |
| **S0172** | 8/4/2011 | 36.7179 | -75.8739 | 45.8 | sand | | | fine, well sorted, ~2% shell, ~10% opaques |
| **S0173** | 8/4/2011 | 36.71769 | -75.8865 | 48.5 | silt | sand | | very fine sand, brown to gray |
| **S0174** | 8/4/2011 | 36.72918 | -75.8618 | 51.9 | sand | silt | shell fragments | very fine to fine, opaques ~3%, |
| **S0175** | 8/4/2011 | 36.73027 | -75.8613 | 52.4 | sand | | | medium, organic matter |
| **S0180** | 8/4/2011 | 36.749 | -75.8853 | 39.4 | sand | shell fragments | | fine to medium, well sorted, brown, opaques ~5% |
| **S0181** | 8/4/2011 | 36.75726 | -75.8867 | 39.2 | sand | shell fragments | | medium to coarse, well sorted, brown, 5% opaques |
| **S0182** | 8/4/2011 | 36.76691 | -75.8793 | 38.2 | sand | shell fragments | | medium, well sorted, brown, ~5% opaques |
| **S0183** | 8/4/2011 | 36.77131 | -75.8628 | 44.7 | sand | | | fine to medium, well sorted, shell 10%, opaques ~5% |

**Chart 1 – Site 2**

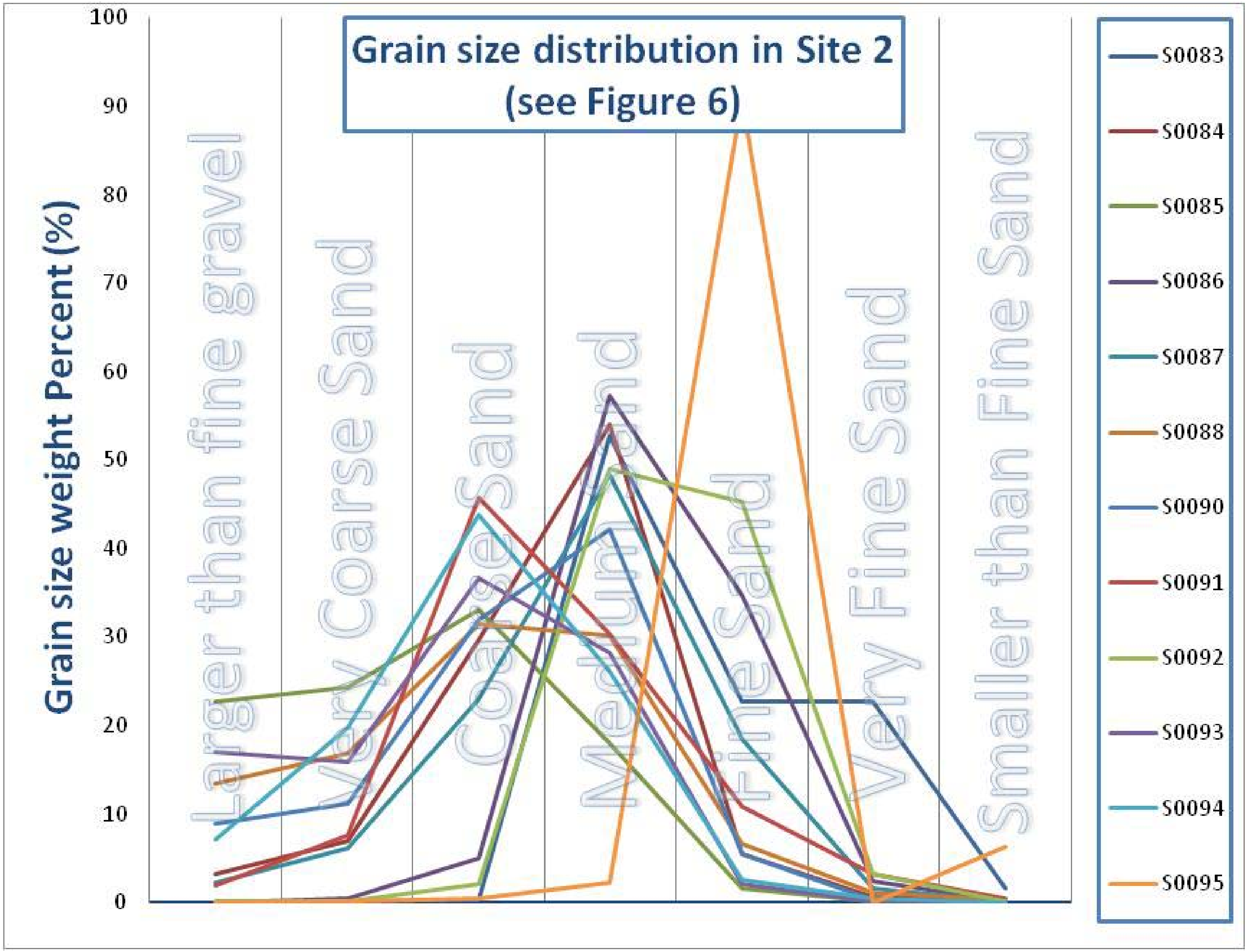
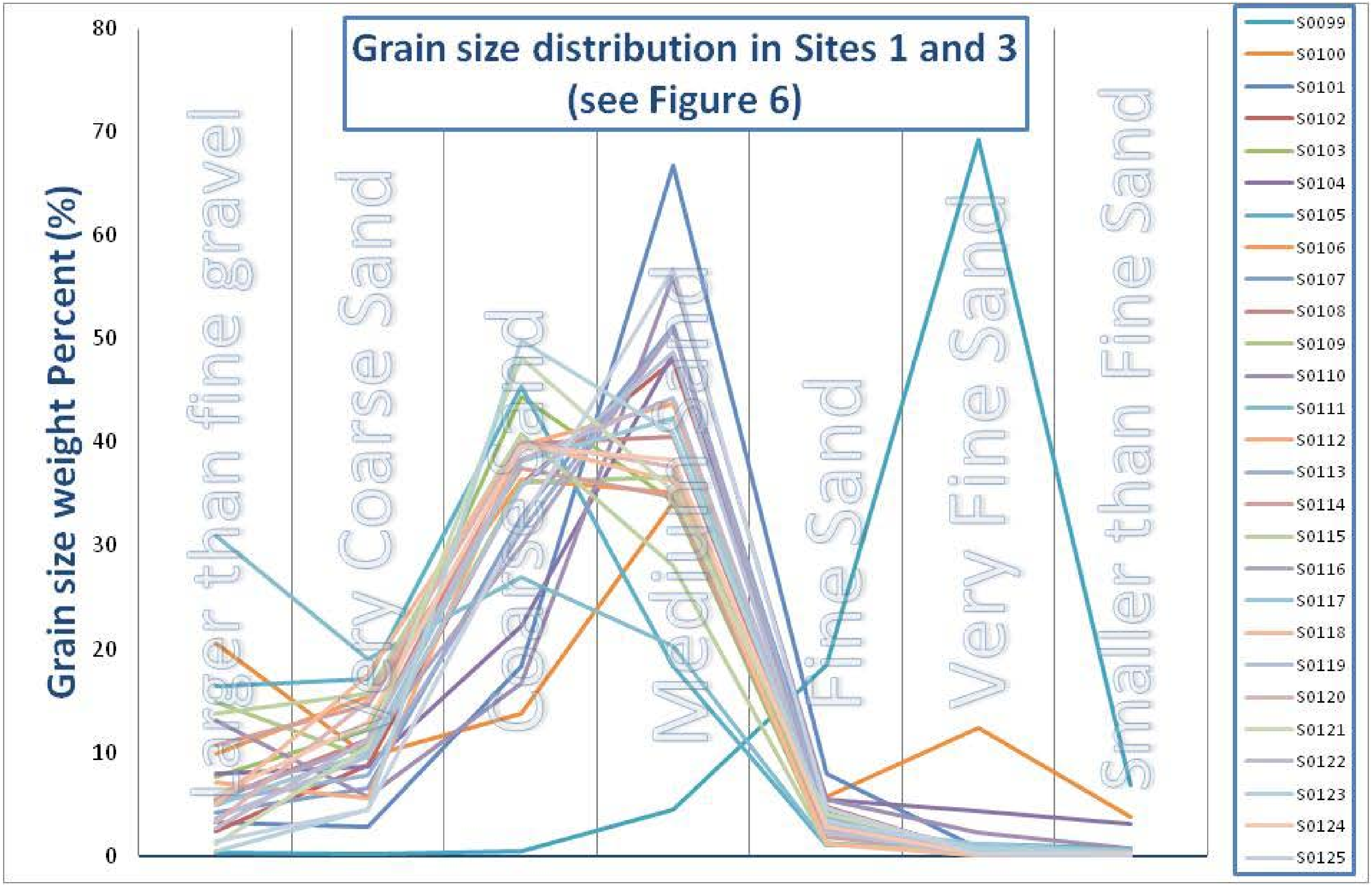


**Chart 2 – Sites 1 and 3**



### Chart 3 – Site 5

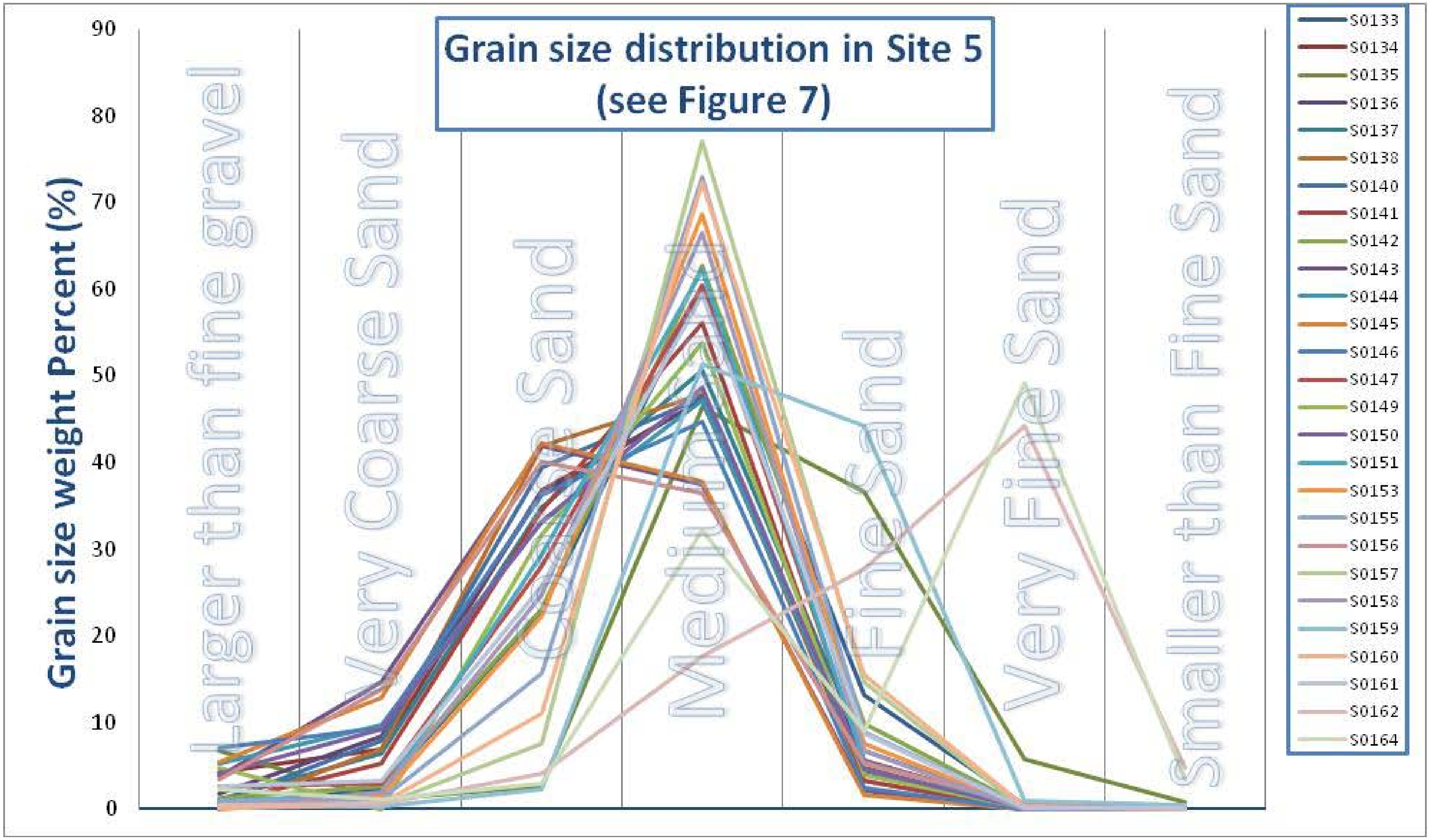
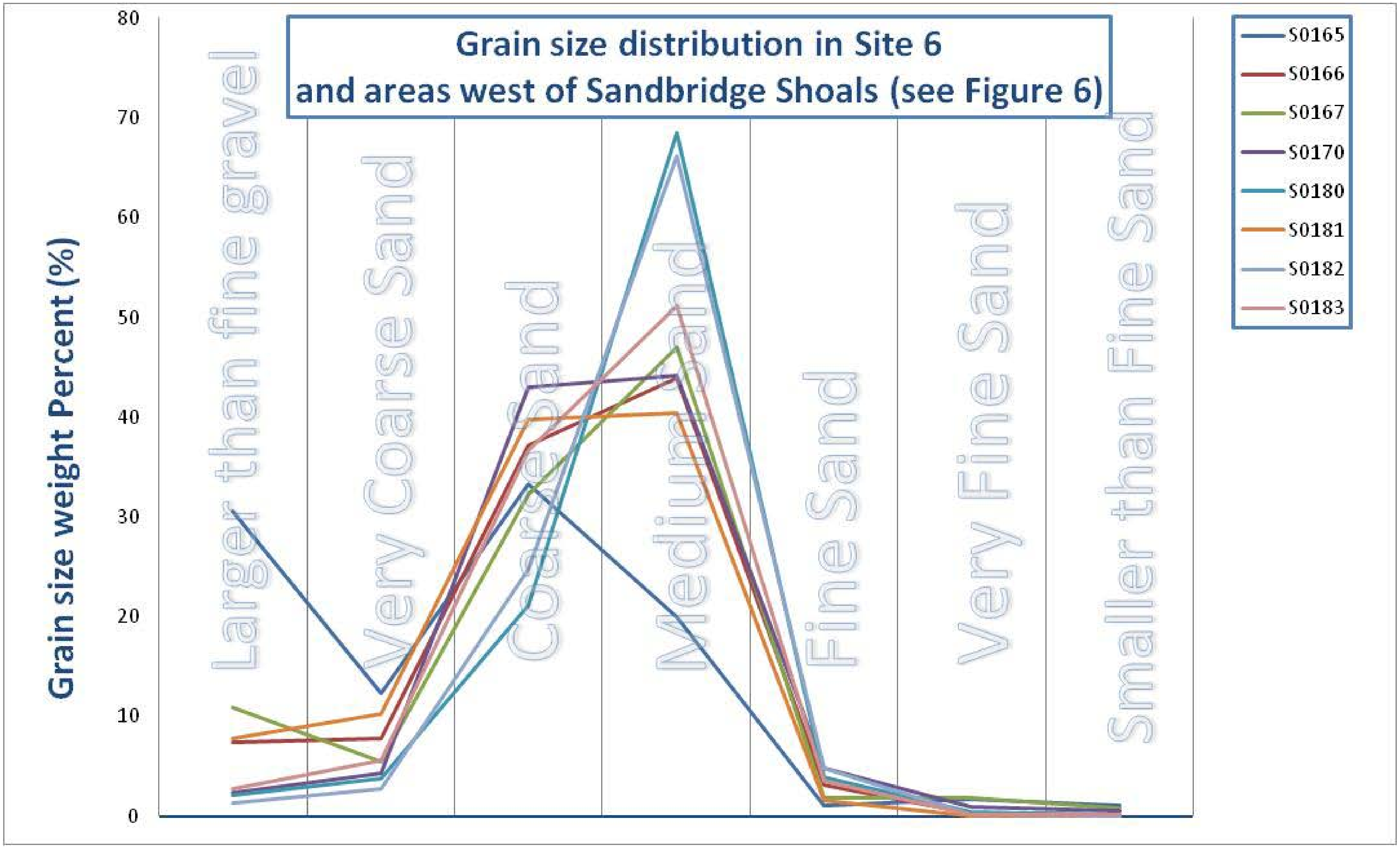


**Chart 4 – Site 6**



## Data Migration to Virginia Geologic Information Catalog

The Virginia Geologic Information Catalog (VGIC) is an on-line resource that is currently in development, and will serve as a distribution portal for geologic and mineral resource data to the public. Access to the VGIC is by way of the DMME web site, either using a map-based portal http://www.dmme.virginia.gov/DgmrGoogleMap/frmMain.aspx or a text-based query system https://www.dmme.virginia.gov/DgmrInquiry/frmMain.aspx.

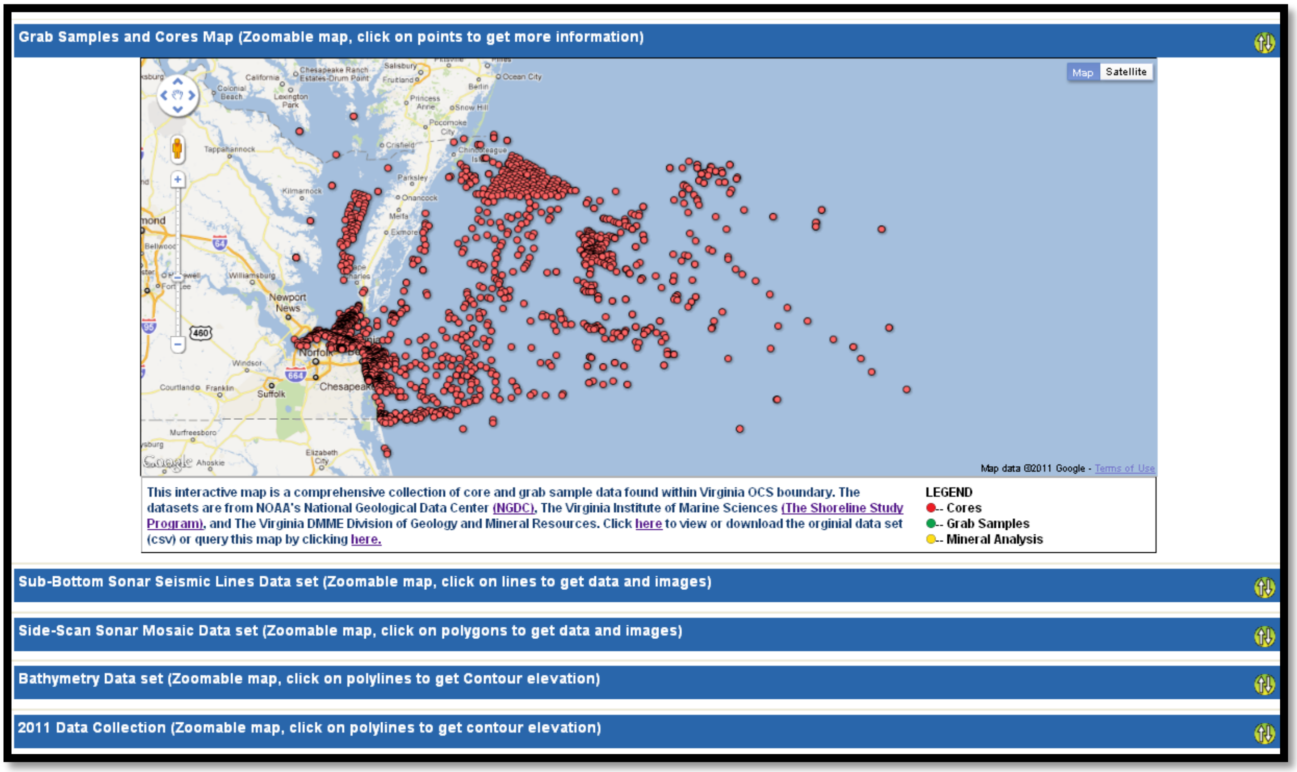
Upon final implementation, the VGIC will host all of DGMR's data collections, including access to the OCS sand resources data described in this report. For this project, DGMR also explored other options for the visualization and web distribution of the OCS sand resources data collections. A very promising technology was found using Google Fusion Tables, and for the initial web distribution, this technology was utilized.

### Google Fusion Tables

Google Fusion Tables (GFT) is a "beta" program released by Google, Inc., that allows for the distribution, visualization, and querying of datasets from a "data cloud" hosted by Google. GFT accepts user-friendly files in the KML, .csv and .txt file formats and projects spatial data using the WGS 84 geodetic datum.

To utilize this platform, DGMR re-projected the spatial attributes for the sediment samples, sub-bottom profiles, side-scan sonar, and bathymetry datasets from geographic NAD 83 to geographic WGS 84 and exported the data as KML format files. The KML files were merged with .dbf files, to provide full data attribution, and then saved in the .csv format. The data were imported to GFT and assigned a column that defines the appearance in Google Map applications. Once the data were appropriately mapped and "shared" with the public, maps were embedded into the DGMR webpage as an <iframe>. The datacenter webpage (Figure 5) was created in-house, and maximizes the exposure of the data via user-friendly Google Maps.

### Figure 5 - Screen shot of the DGMR web page showing OCS data hosted by GFT

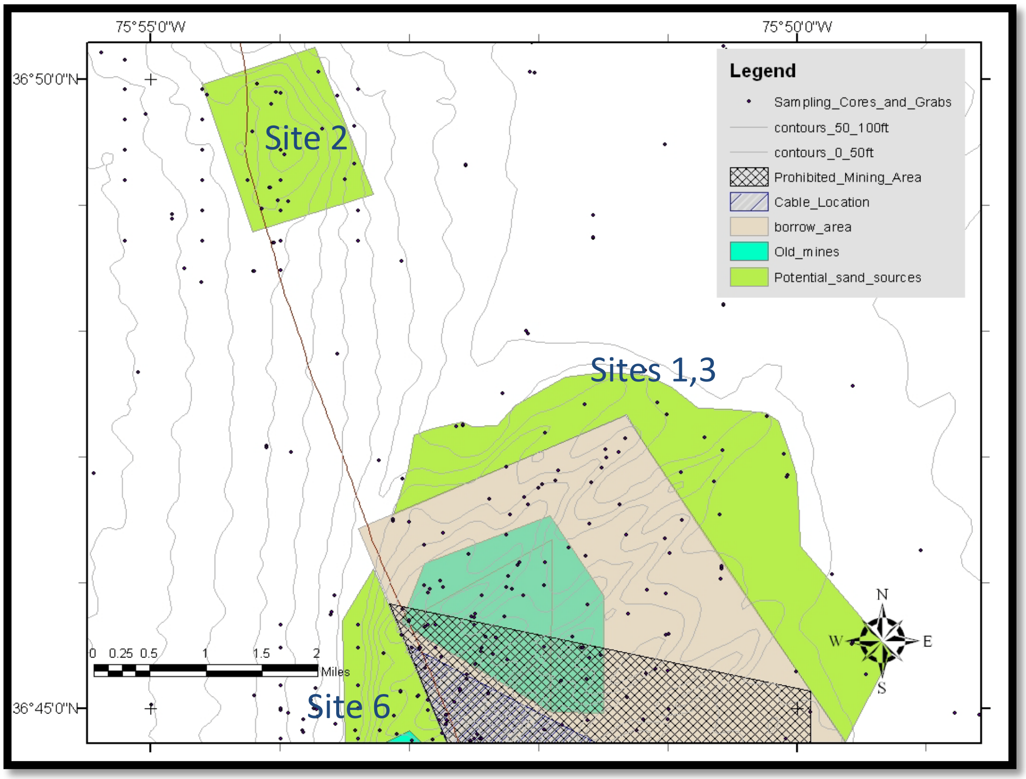



## Results

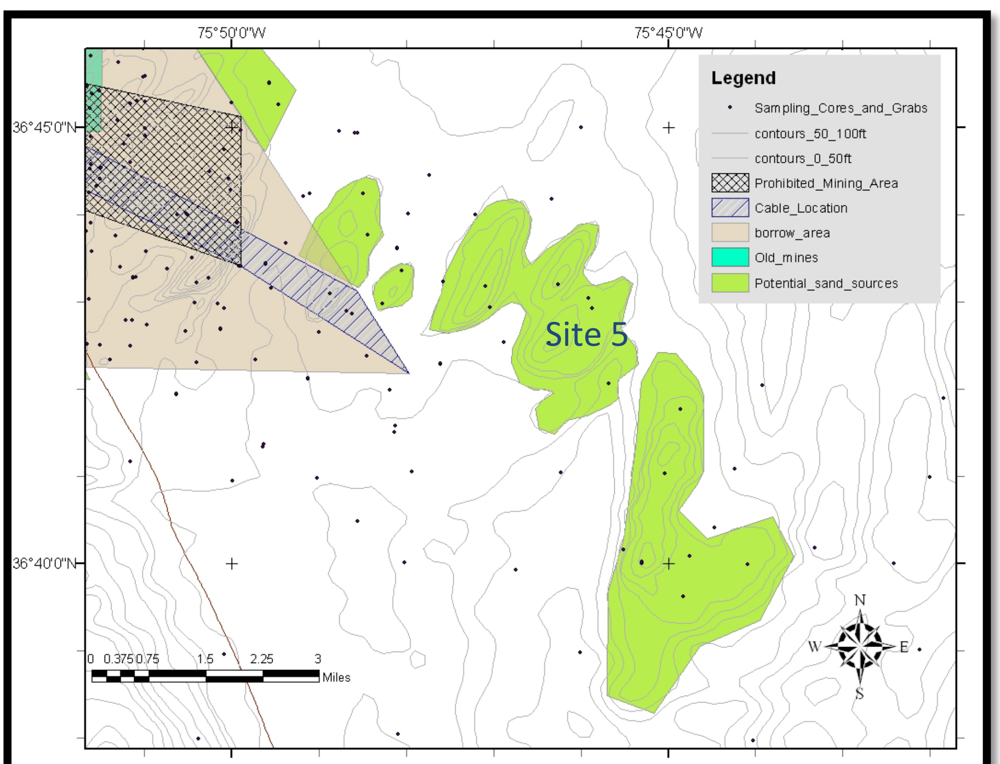
The results of grain size distribution analysis for 90 samples collected during the field reconnaissance survey confirmed our field observations that the majority of bottom sediment samples collected were composed of good-quality medium to coarse sand that would be appropriate for beach restoration projects (Charts 1-4). This result is due in no small part to the preferential selection of favorable sample locations based on real-time side scan sonar images that helped discriminate sandy bottom sediments from those composed of silt or mud. Our results highlight several areas in the northern and southern extensions of Sandbridge Shoal that offer some promise for potential economic sand resources.

The areas highlighted in green in Figures 6 and 7 represent those field collection sites (from Figure 1) that contain high quality sands in deposits that may have economic value as mineable resources. This assessment is based upon four main criteria: uniformity of sand grain size, bathymetric data that indicates significant shoaling, reconnaissance-scale side scan sonar transects that also indicate shoal patterns, and relatively close proximity to known resources that have been extracted in the past for beach nourishment projects. The extents of these sand deposits are presently limited by the lack of available high quality and current bathymetry data.

## Figure 6 - Prospective sites in the northern region of Sandbridge Shoal




## Figure 7 - Prospective sites in the southeastern region of Sandbridge Shoal



With the compilation of a vast amount of minerals data for Virginia's OCS into a comprehensive geodatabase, rigorous data processing and re-formatting, and enabling the geospatial visualization of data collections in the Google Maps framework, DGMR has provided a valuable tool for future exploration and management of offshore sand resources. Table 7 provides a summary of active web page links to the DMME web site. These links provide ready access to all of Virginia's OCS sand resources data evaluated during the course of this project.

### Table 7 – DGMR OCS web page links

| 2011 DGMR OCS Web Pages | |
|---|---|
| **Title** | **Webpage/link** |
| **DGMR OCS Sands Evaluation Page** | http://www.dmme.virginia.gov/DMR3/ocssands.shtml |
| **DGMR Data and Map Center** | http://www.dmme.virginia.gov/DMR3/ocs_map_and_data.shtml |
| **Google Fusion Table Tutorials** | http://www.google.com/fusiontables/public/tour/index.html |
| **Sediment database on Google Fusion Tables** | http://www.google.com/fusiontables/DataSource?dsrcid=1570191 |
| **Sub-bottom Profile database on Google Fusion Tables** | http://www.google.com/fusiontables/DataSource?dsrcid=1481808 |
| **Side-scan Sonar database on Google Fusion Tables** | http://www.google.com/fusiontables/DataSource?dsrcid=1482259 |
| **Bathymetry dataset on Google Fusion Tables** | http://www.google.com/fusiontables/DataSource?dsrcid=1506018 |
| **2011 Sampling dataset on Google Fusion Tables** | http://www.google.com/fusiontables/DataSource?dsrcid=1563029 |

## Future Projects

As the City of Virginia Beach and the U.S. Army Corps of Engineers continue to look for new sources of high quality sand to restore beaches along the Virginia Beach and Sandbridge waterfronts, there is enormous value in being able to accurately track and manage the inventory of previous borrow sites and future resources. Future resource assessments should include multiple vibra-core and high resolution bathymetric studies to establish baseline elevations for significant shoal areas. In addition, seasonal and storm water surveys should be conducted to assess temporal and catastrophic changes in seafloor morphology on the OCS.

With respect to heavy minerals and rare earth elements that may occur in economic concentrations in some of these sand resources, future studies could evaluate those processes that might result in the preferential enrichment of heavy minerals within the shoal morphology. Although heavy mineral extraction has yet to occur in the off shore waters of Virginia, the potential exists.

In the future, access to sand resources on Virginia's OCS may be challenged by other offshore development opportunities that might include exploration and production of wind farms, gas and oil production, tidal energy farms, transmission lines, etc. The results of this project provide a basic tool that enhances the ability for decision makers to manage these resources. As the state geological survey for the Commonwealth of Virginia, the Division of Geology and Mineral Resources is prepared to collaborate with all Federal, State, and local government agencies as well as industries with specific interests in aggregate resources on Virginia's Outer Continental Shelf.

## References

Berquist, CR, Jr. and CH Hobbs, III. 1988. Reconnaissance of economic heavy minerals of the Virginia Inner Continental Shelf. Virginia Division of Mineral Resources Open-file report 88-1. Virginia Institute of Marine Science contribution no. 1425.

Berquist, CR, Jr. and CH Hobbs, III. 1988. Study of economic heavy minerals of the Virginia Inner Continental Shelf. Virginia Division of Mineral Resources Open-file report 88-4.

Berquist, CR, Jr. (ed). Heavy-mineral studies—Virginia Inner Continental Shelf. 1990. Virginia Division of Mineral Resources, Department of Mines, Minerals and Energy, Division of Mineral Resources Publication 103.

National Ocean Service (NOS), National Oceanic and Atmospheric Administration. www.ngdc.noaa.gov/mgg/bathymetry/hydro.html

National Geophysical Data Center (NGDC), National Oceanic and Atmospheric Administration www.ngdc.noaa.gov

Virginia Institute of Marine Science (VIMS), Shoreline Studies Institute. College of William and Mary, Gloucester Point, Virginia http://www.vims.edu