



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

**Agreement: M14AC00003 Delaware Geological Survey/University of Delaware;
Delaware Offshore Sand Resource Investigation**

Lead Agency:

Delaware Geological Survey/University of Delaware

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Summary Report

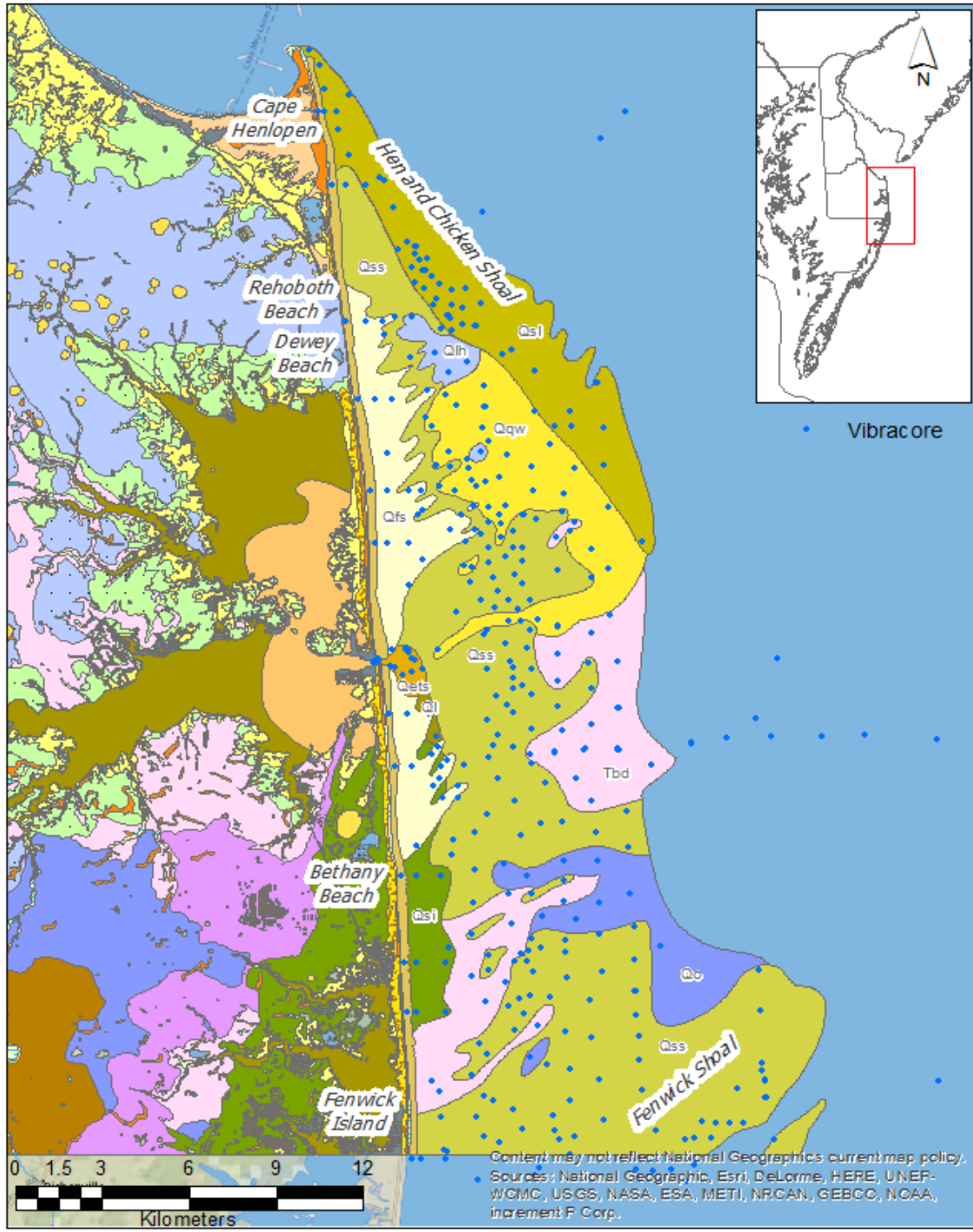
The following project deliverables and databases have been generated as a result of the Hurricane Sandy State Cooperative Agreement between BOEM and the Delaware Geological Survey. Work is proceeding on the deliverable for the project, a surficial geologic map of the area offshore of Delaware with specific focus on identification of potential sand resources for beach replenishment.

Cooperative Agreement Outputs including Project Deliverables:

Surficial geologic map offshore Delaware (Project Deliverable)

The primary deliverable for this project is a geologic map connecting the geology onshore with the geology offshore from the shoreline to a distance of approximately 7 miles that contains sand resources available for beach replenishment. By mapping the offshore geology, specific areas can be targeted for more detailed sand resource evaluation. Standard geologic mapping practices were followed. 415 geologic vibracore records were analyzed and categorized in terms of surficial geology, down-hole stratigraphy, and fossil content. Of these 415 cores, 326 cores are housed in the DGS Core and Sample Repository. These cores underwent a process of quality control and analysis to assure that they were described in detail, photographed, sampled for shell and other fossil content, and geologic units and contacts picked. All data related to the cores are managed in an Access database (see below). The cores were rewrapped in plastic tubing, cut to length, and transferred to core boxes for permanent repository storage.

The geologic map shows the distribution of sediments offshore that are part of the modern depositional regime as well as older sedimentary bodies that occur at areas of non-deposition/erosion at the sea floor. Mapping was at a standard scale of 1:24,000. The map was produced in the GIS environment using ESRI ArcMap 10.2.2. Map units are all associated with appropriate metadata using ISO formats. The agreement deliverable will be available as an ESRI GIS Geodatabase.



Geologic sketch map of onshore and offshore Delaware. Blue dots represent vibracore locations. For full details of the offshore map see Plate 1 of the project deliverable. The offshore geology is a combination of older units also found onshore and modern deposits that are the result of sea level rise and shoreline movement landward that have the older units as their sediment source.

Citation: Ramsey, K.W., Metz, T.L., and Tomlinson, J.T., 2016, Geologic map offshore Delaware from the shoreline to approximately 7 miles: Delaware Geological Survey Geologic Map, unpublished, scale 1:24,000.

Metadata. Geologic map offshore Delaware from the shoreline to approximately 7 miles: Delaware Geological Survey Geologic Map, unpublished, scale 1:24,000. This map is an extension of surficial geologic map units previously recognized and mapped both onshore and offshore. Physical core samples from the DGS repository, supplemented with lithologic logs and drilling reports, were analyzed to determine the extent of each surficial unit. Surficial units are those recognized by the DGS, including those published in existing DGS Geologic Maps or other publications by DGS authors. All samples and data records associated with geotechnical survey efforts used for this map are archived in paper and/or digital format at the DGS.

Delaware Geological Survey Stratigraphic Pick Database (DGSSPDB)

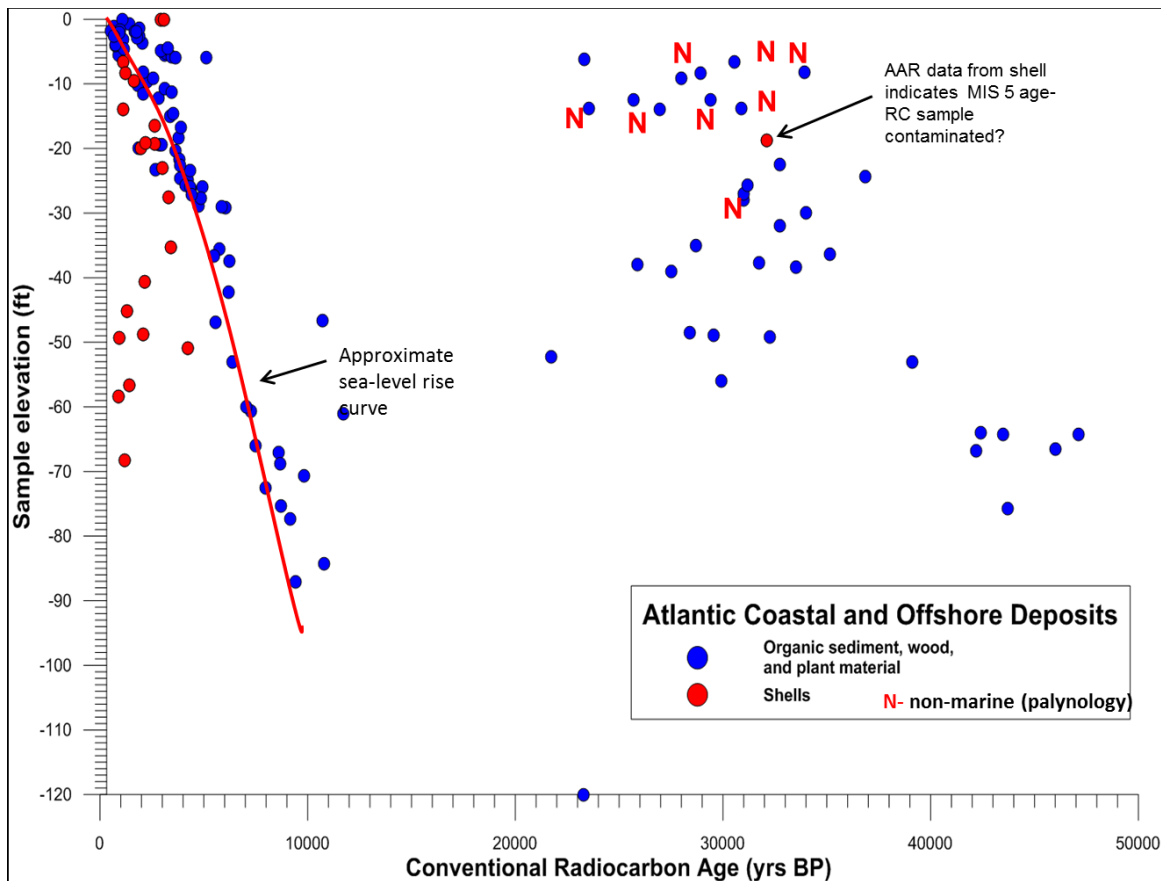
The DGSSPDB was developed to manage stratigraphic picks that were the result of surficial geologic mapping projects sponsored by the StateMap Program. A stratigraphic pick is defined as an interpretation of a stratigraphic contact, the depth and elevation of the contact, and the stratigraphic units above and below the contact. The database links to WATSYS for the primary data related to the site (e.g., outcrop, boring, hand auger). Queries have been written to create tables for specific contacts, surficial geologic units, and other necessary data. Beginning with the mapping of the central and southern Delaware Atlantic Coast, offshore vibracores were included in the database (Ramsey, 2011, Ramsey and Tomlinson, 2012). As of May 1, 2016, 6,048 sites are included in the DGSSPDB, of which approximately 300 are offshore vibracores.

Citation: Tomlinson, J.L., and Ramsey, K.W. ., 2016, The Delaware Geological Survey Mapping Stratigraphic Pick Database, version 2016.1, Delaware Geological Survey data, not web accessible, Microsoft Access 2010 relational database.

Metadata. The Delaware Geological Survey Mapping Stratigraphic Pick Database, version 2016.1, Delaware Geological Survey (DGS), not web accessible, Microsoft Access 2010 relational database. The database is a compilation of all stratigraphic picks generated by a DGS geologic mapping project. A stratigraphic pick is defined as an interpretation of a stratigraphic contact, the depth and elevation of the contact, and the stratigraphic units above and below the contact. All stratigraphic pick locations are assigned unique DGS Watsys database identifiers associated with UTM northings and eastings and land surface (seafloor) elevations (in ft). All stratigraphic units are those recognized by the DGS and published on DGS Geologic Maps or other publications by DGS authors. All data records are associated with a unique DGS Watsys database identifier and are searchable on this criterion. All original reports or copies of reports that contain the primary geologic data are archived in paper and/or digital format at the DGS.

The Delaware Geological Survey Delmarva Peninsula Radiocarbon Database

This Access database contains radiocarbon dates from geologic samples from onshore and offshore Delaware. As a result of the Hurricane Sandy project, the database has been expanded to include the Maryland and Virginia portions of the Delmarva Peninsula, both onshore and offshore. As of December 31, 2015, 483 radiocarbon dates are included in the inventory. All dates are related to a sample locality with geographic coordinates and land surface (or sea floor) and sample elevation as well as the type of sample dated (e.g. peat, shell, organic sediment). The dates include all data received from the analytical lab including any calibration of the dates (e.g. INTCAL13, InterCal09.14C). Below is an example of the use of the data showing all the dates taken from samples offshore. The red line on the graph is an approximate sea level curve showing the rise of sea level during the Holocene. Data can be queried by age, sample type, geographic coordinates or geographic region, or other parameters and shown related to their geographic coordinates in GIS. These data are instrumental for understanding the sea level history of the region over the past 45,000 years and in predicting future rates and effects of sea level rise. Many of the late Pleistocene dates previously considered to be marine are now interpreted as non-marine based on the pollen flora (N on graph below). This means that there are non-marine peri-glacial deposits preserved offshore.



Ramsey, K.W., 2016, The Delaware Geological Survey Delmarva Peninsula Radiocarbon Database, version 2016.1, Delaware Geological Survey data, not Web accessible, Microsoft Access 2010 relational database.

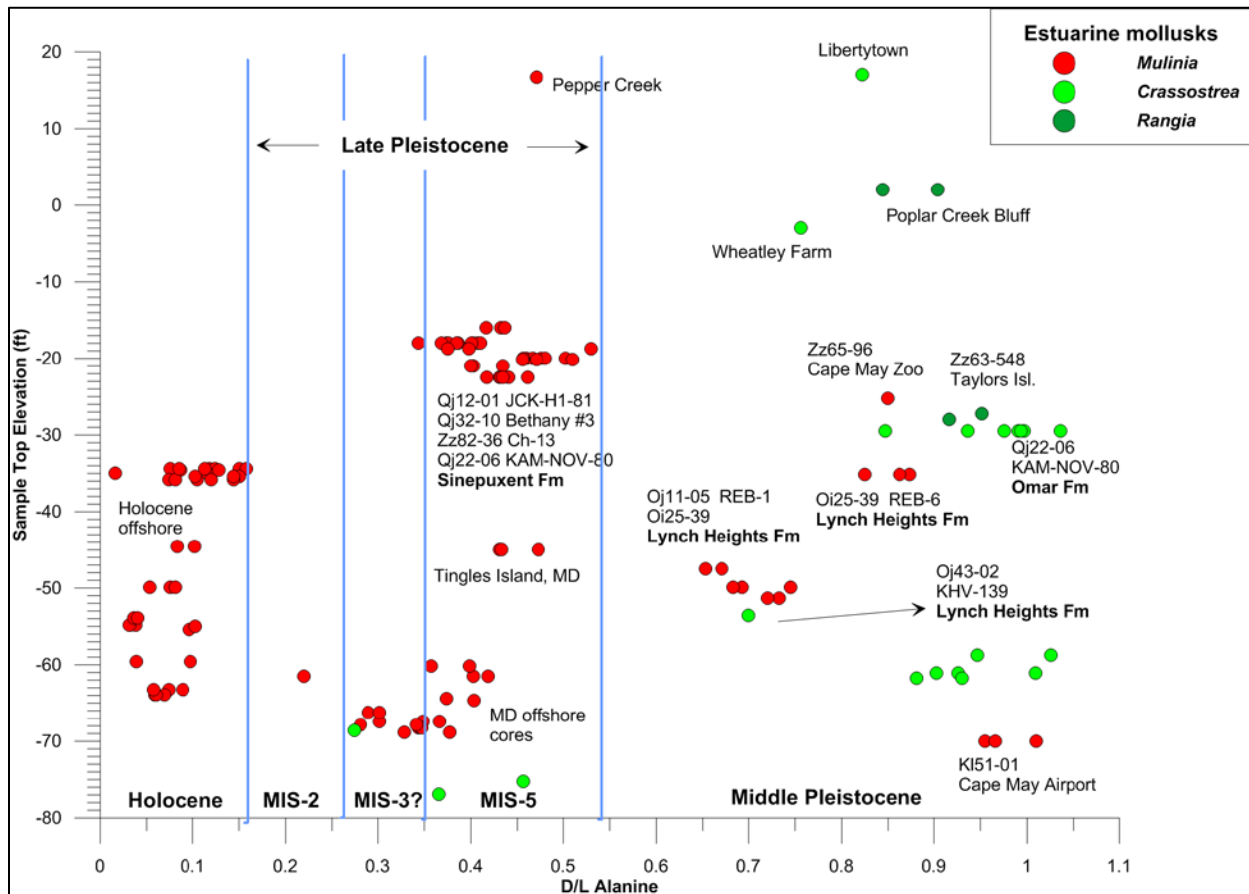
Metadata. The Delaware Geological Survey Delmarva Peninsula Radiocarbon Database, version 2016.1. Delaware Geological Survey. Microsoft Access 2010 relational database. A compilation of radiocarbon dates from geologic samples from the Delmarva Peninsula Region including the Delmarva Peninsula, offshore Delmarva Peninsula, Chesapeake Bay, offshore Virginia from Cape Henry to the North Carolina Border, and Cape May, New Jersey both onshore and offshore. Data are compiled from 65 published and unpublished sources included in the database. All sample sites are given DGS Watsys database identifiers associated with UTM northings and eastings and land surface elevations. Sample type (e.g., peat, wood, shell), top of sample elevation, elevation datum (e.g., MSL, NAVD88, NGVD29), sample interval thickness (in tenths of feet) sample identifiers (for DGS-generated samples) date collected (where known) project that generated the sample, and other data relevant to the sample are recorded. Radiocarbon date data from the radiocarbon laboratories in the database include laboratory identifier, conventional and measured radiocarbon ages, calibrated dates and dating curve intercepts, calibration method, $^{13}\text{C}/^{12}\text{C}$ ratios, analytical method, pretreatment method, and date of report and any comments from the lab regarding the sample. All original lab reports or copies of lab reports are archived in paper format and digital versions (for more recent dates). This database is an updated version of Ramsey, K.W., and Baxter, S.J., 1996, Radiocarbon dates from Delaware: a compilation: Delaware Geological Survey Report of Investigations, 54, 18 p.

The Delaware Geological Survey Delmarva Peninsula Amino Acid Racemization (DGSAAR) database

An Access database of all amino acid racemization (AAR) data from geologic samples from the Delmarva Peninsula has been constructed as a result of this project. These data have been collected by Dr. John Wehmiller, Professor Emeritus of the Dept. of Geological Sciences at the University of Delaware, and his students over the last 35 years. Dr. Wehmiller is working as a collaborator on the project. The database includes information from 282 localities from which mollusk shells have been collected and over 600 data analyses. AAR data are used as a tool for approximation of age based on racemized (D/L) ratios of amino acids from shell material. These data are the primary tool available for age estimates of estuarine and marine Quaternary deposits in the U.S. mid-Atlantic region. The age estimates are important for mapping the geology offshore of the Delmarva Peninsula and correlating it with the onshore geology. The geologic mapping is used as the framework for targeting potential sand resources offshore.

Below is a graph showing the D/L ratios for the amino acid alanine from Delaware onshore and offshore localities. Locality and taxa (molluscan genera) are indicated on the graph. The age of the samples increases from left to right on the graph. The usefulness of the data in mapping offshore deposits is that the samples which are Holocene (D/L ratios

less than 0.2 and independently dated by radiocarbon) can be readily differentiated from older deposits. In addition to the database, the samples from which the data were generated are now in the Delaware Geological Survey Core and Sample Repository as a separate collection called the Quaternary Shell Collection (QuatShl).



Ramsey, K.W., and Wehmiller, J.F., 2016, The Delaware Geological Survey Delmarva Peninsula Amino Acid Racemization (AAR) Database, version 2016.1, Delaware Geological Survey data, not Web accessible, Microsoft Access 2010 relational database.

Metadata. The Delaware Geological Survey Delmarva Peninsula Amino Acid Racemization (AAR) Database, version 2016.1. Delaware Geological Survey. Microsoft Access 2010 relational database. . A compilation of amino acid racemization data from geologic mollusk shell samples from the Delmarva Peninsula Region including the Delmarva Peninsula, offshore Delmarva Peninsula, Chesapeake Bay, offshore Virginia from Cape Henry to the North Carolina Border, and Cape May, New Jersey both onshore and offshore. Data are compiled from published and unpublished sources, primarily a subset of Wehmiller, J.F., and Pellerito, V., 2015, Database of Quaternary Coastal Geochronologic Information for the Atlantic and Pacific Coasts of North America (additional information for sites in Peru and Chile): Delaware Geological Survey Open File Report No. 50, 7 p and at NOAA-World Data Center <http://www.ncdc.noaa.gov/paleo/aar.html>.

All sample sites are given DGS Watsys database identifiers (DGSID) associated with UTM northings and eastings and land surface elevations. Data associated with the site included as a table are DGS AARDB site number, DGSID, localid, UDAMS (Wehmiller site identifier), geographic setting (e.g., onshore, offshore, upland for each state in the database), UTM northing and easting, land surface elevation in feet, and expanded notes regarding collection sources, dates, samples and other information about the sample site. The shell samples from which most of the data were generated are now housed in the DGS Core and Sample Repository as the Quaternary Shell (QuatShl) Collection. All shell samples in the collection are in the database as a table with data including DGSID, UDAMS whether the sample has associated AAR data, local identifiers (e.g., boring number, outcrop local name), DGS sample number, stratigraphic unit, Wehmiller sample number, date collected, dominant and other mollusk genera in the sample, and associated notes regarding the sample. The AAR data are in a table that contains the DGSID and Localid, DGS sample number, elevation from which the sample was taken, lab, lab procedure and analysis used, AA ratio type, and the lab results of the amino acid ratios for allo-isoleucine, alanine, aspartic acid, glutamic acid, leucine, phenylalanine, proline, valine, V LPG, alanine/aspartic acid, and valine/leucine. A table under construction contains the interpretations of the data regarding mollusk genera, age ranges, marine isotope stage (MIS) associations, aminozone, and any published data interpretations.

For more information regarding the Wehmiller AAR database:

Article title: AN EVOLVING DATABASE FOR QUATERNARY AMINOSTRATIGRAPHY
 Reference: GRJ30
 Journal title: GeoResJ
 Corresponding author: Dr. John F. Wehmiller
 First author: Dr. John F. Wehmiller
 Final version published online: 27-MAR-2015
 Full bibliographic details: GeoResJ (2015), pp. 115-123
 DOI information: 10.1016/j.grj.2015.02.009

<http://authors.elsevier.com/sd/article/S2214242815000170>

Delaware Geological Survey Offshore Vibracore Database

In order to organize all the geologic data associated with vibracores collected offshore of Delaware, a Microsoft Access 2010 database was constructed. This database allows for organization and analysis of all data in a single relational database rather than having separate files, spreadsheets, and folders. The database connect to both the DGS Radiocarbon and AAR databases, as well as including stratigraphic picks, core descriptions, and interpretations of depositional environments. An example of the dashboard for the database is given below.

The screenshot displays the 'Offshore Data Dashboard' interface. At the top, it states 'DASHBOARD DISPLAYING RECORDS OF ALL AVAILABLE OFFSHORE SAMPLE DATA' and lists data sources: WATSYS, AAR.accdb, and RadioCarbon.accdb. The dashboard is organized into several sections:

- WATSYS:** Fields for DGSID (NJ51-05), LOCALID (JCK-B3-B1), PROJECT, DRILL DATE (10/1/1981), DATE FILED (9/40719), RECORDED BY (KWR), NORTHING (4290158.5 UTM), EASTING (494240.5 UTM), ELEVATION SEA FLOOR (-30), and CORE DEPTH (27.6).
- ADAPLAE:**
 - dgsdb rock samples:** SAMPLEID (60886), START (0), STOP (4).
 - amino acid racemization dating:** AA SAMPLES (Y), SAMPLE ID (60892.10), AAR DATA (PL), DOMINANT GENERA (Organics).
 - radio carbon dating:** SAMPLE ID (Beta-5156), MATERIAL (organic mu), CALIB DATE (25960).
- DESCRI:** Summary of offshore cores with fields for START DEPTH (0), STOP DEPTH (27.6), PHOTO, LITH LOG, WELL LOG, TEXTURE DATA, POLLEN, and BOXED. Includes fields for DESCRIBED BY (tjm), DATE DESCRIBED (9/25/2015), and NOTES.
- REPORTION:**
 - lithology description:** From (0) To (1.5), Lithology Keyword (SAND, vf-c), Lithology Description (Lt Yl Brn (2.5Y 6/3)), Color (Lt Yl Brn (2.5Y 6/3)), and a text area for description: 'F-c sd, mod vl srl. Vf sd @ contact. Scat peb, rar shl (Spisula) @ 1'. Abd ohm. Fines dwn to Clay/Mud.'
 - stratigraphic picks:** From (0) To (1.5), Date Picked (27-Jan-16), Age (Hol), Strat Pick (Qs1), and Depositional Environment (Shoal prograding over Ql below. No remnant of barrier/ravinement surface).

Metz, T.L., 2016, The Delaware Geological Survey Offshore Vibracore Database, version 2016.1, Delaware Geological Survey data, not web accessible, Microsoft Access 2010 relational database.

Metadata. The Delaware Geological Survey Offshore Vibracore Database, version 2016.1, Delaware Geological Survey (DGS), not web accessible, Microsoft Access 2010 relational database. A compilation of vibracore sampling records, data, and analysis offshore Delaware and Maryland in both state and federal waters from Cape Henlopen spit in Delaware to Ocean City Inlet in Maryland along with correlating amino acid racemization (AAR) and radiocarbon (RC) data sets. All vibracore locations are given unique DGS Watsys database identifiers associated with UTM northings and eastings and land surface (seafloor) elevations. DGS identifier, sub-sample numbers, project specific records, elevation (MSL, NAVD88, NGVD29), and core length (in tenths of feet) are incorporated from the DGS Watsys database. Sample identifiers, sample types, and associated age analysis results from the DGS AAR and DGS RC databases are incorporated for reference. Completeness of offshore sampling records, including photographs, lithologic logs, consultant well logs, texture analysis data, and pollen samples, are inventoried as a summary. Lithologic descriptions, including depth interval (in feet), predominant sediment size, sediment color (Munsell color standard), and interpretation have been produced by DGS staff. Further, DGS staff interpretations of stratigraphic units include depth intervals, interpreted age, depositional environment, and subsequent stratigraphic unit. All data records are associated with a unique DGS Watsys database identifier and are searchable on this criterion. All original reports or copies of reports are archived in paper and/or digital format at the DGS where available.