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

Agreement: M14AC00010: New Hampshire Cooperative Agreement

University of New Hampshire and New Hampshire Geological Survey
Assessment of Offshore Sources of Sand and Gravel for Beach Nourishment in New Hampshire

Lead Agency:
University of New Hampshire, Center for Coastal and Ocean Mapping

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Summary Report

Cooperative Agreement Outputs including Project Deliverables:

Ward, L.G., Johnson, P., Nagel, E., McAvoy, Z.S. and Vallee-Anziani, M., In Review, Western Gulf of Maine bathymetry and backscatter synthesis: BOEM/New Hampshire Cooperative Agreement Technical Report.

Central to any effort to develop an understanding of seafloor geology, including surficial sediments, sand and gravel deposits, and morphologic features, is high-resolution bathymetry. Therefore, as an aid in mapping the New Hampshire continental shelf geology and potential marine mineral resources (sand and gravel), all available high-resolution multibeam echosounder (MBES) bathymetry for the Western Gulf of Maine (WGOM) was synthesized and presented as a composite in a GIS environment. The WGOM bathymetry synthesis is used as a base for the development of the surficial geology and sand body maps for the New Hampshire and vicinity continental shelf. In addition, the bathymetry is web-served as part of the WGOM Bathymetry and Backscatter Synthesis on the UNH CCOM/JHC website (http://ccom.unh.edu/project/wgom-bathbackscatter). The original surveys used in this compilation were gridded from 50 cm to 25 m. However, to produce more uniform composites, a synthesis of all the multibeam surveys was re-gridded to 4 m (Figure 1). A second composite that includes older surveys that are of a lower resolution (e.g., single beam echosounder survey gridded at 40 m) was re-gridded at 8 m.

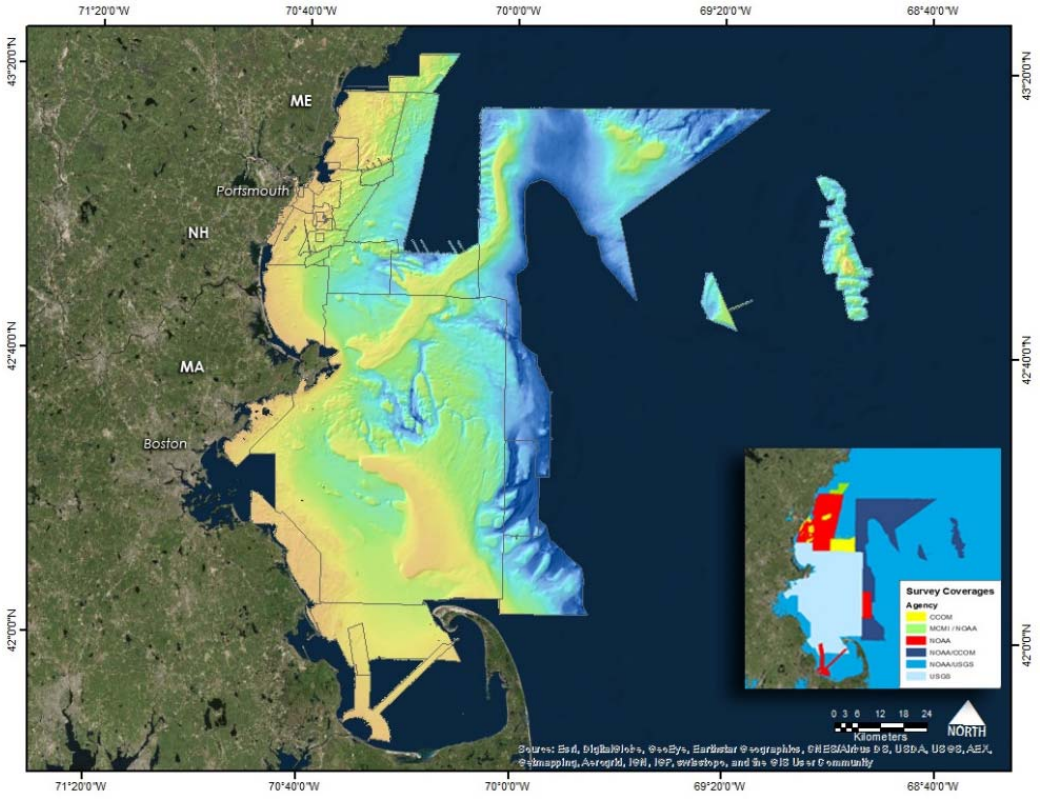

Figure 1. Western Gulf of Maine Bathymetry Synthesis. From WGOM Bathymetry and Backscatter Synthesis (http://ccom.unh.edu/project/wgom-bathbackscatter).

An extremely useful product from MBES surveys is the associated backscatter. Backscatter is the strength of the acoustic signal that returns to the transponder and is strongly affected by complex interactions with seafloor properties, such as sediment texture, roughness, or biota. In order to develop a composite of MBES backscatter in the WGOM, a subset of available MBES surveys was assembled that were available from NOS and UNH CCOM/JHC. The MBES backscatter was processed using QPS Fledermaus FMGT, then mosaicked in ArcGIS. Due to combining multiple backscatter surveys with varying frequencies, different systems, and dynamic ranges of relative backscatter intensity values, the range of pixel intensity values were normalized and standardized to create a seamless backscatter mosaic image. As a result of the poor quality of some of the original backscatter, the processing involved with the creation of the mosaic was extremely time consuming. However, the final product is useful for assessing seafloor characteristics detected with MBES backscatter (Figure 2). The backscatter layer was gridded at 2m.

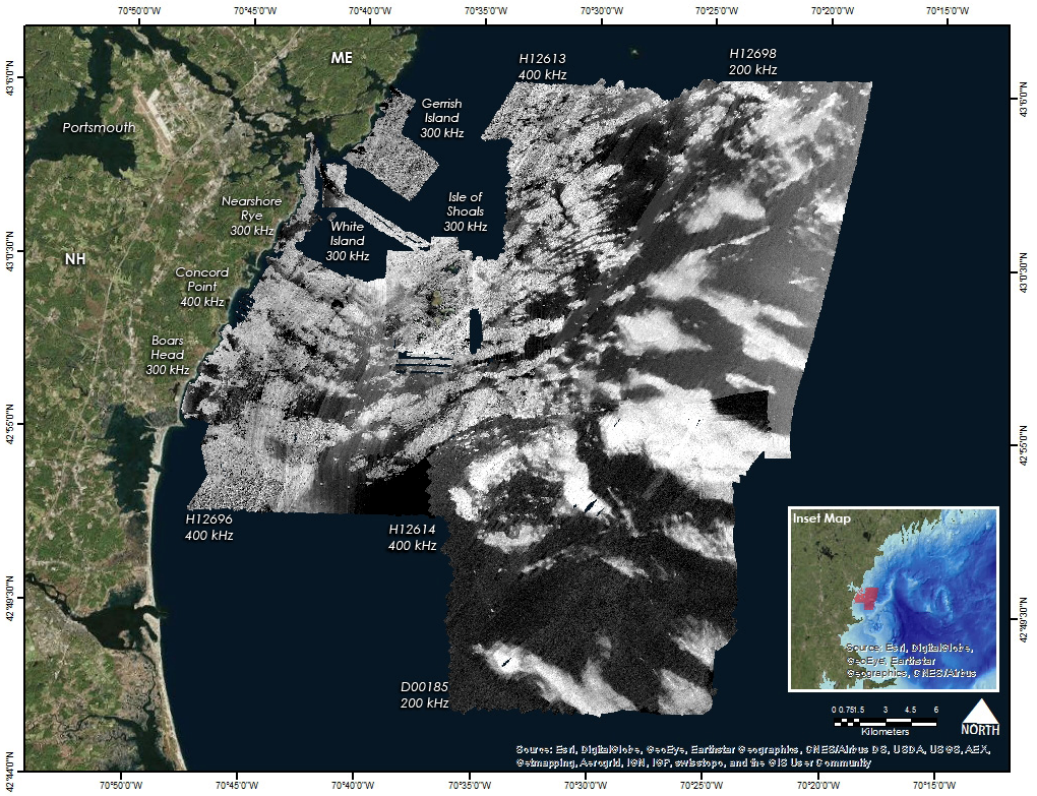

Figure 2. Western Gulf of Maine backscatter synthesis. From WGOM Bathymetry and Backscatter Synthesis (http://ccom.unh.edu/project/wgom-bathbackscatter).

Ward, L.G., Vallee-Anziani, M. and McAvoy, Z.S., In Review, New Hampshire and vicinity continental shelf: Morphologic features and surficial sediments: BOEM/New Hampshire Cooperative Agreement Technical Report.

High-resolution maps of the surficial geology are important to understanding the morphology, sedimentology and marine mineral resources of the New Hampshire and vicinity continental shelf. The recent development of the Western Gulf of Maine (WGOM) Bathymetry and Backscatter Synthesis (Ward, et al., In Review), along with an extensive geophysical and sedimentological archive, provide the bases for

the development of descriptions and maps of the surficial sediments and major morphologic features or geoforms. The surficial sediment maps show sediment grain size classifications using the Coastal and Marine Ecological Classification Standard (CMECS). The geoforms are identified and isolated based on expert opinion using primarily hillshade (bathymetry), bathymetric position index (BPI), and roughness. Mapped morphologic features include: bedrock outcrops; sediment draped bedrock; marine modified glacial features; marine formed features; subaqueous fan; large scale bedforms; and seafloor plain. All of the maps are developed in a GIS environment. The morphologic features identified and classified on the New Hampshire shelf show very clear trends (Figure 3). From several kilometers seaward of the Isles of Shoals to past (and including) Jeffreys Ledge, the morphologic features are very large and dominated by marine modified glacial deposits. Extending northeast and southwest of the Isles of Shoals are extensive bedrock outcrops. Landward of the Isles of Shoals to the coast the seafloor is extremely complex consisting of marine-modified (eroded) glacial features, marine formed shoals, and generally flat seafloor in between. The largest sandy shoal in the study area is located just landward the Isles of Shoals (the northern sand body). The geologic substrate group map clearly shows the complexity and heterogeneity of the NH and vicinity continental shelf, especially on the inner shelf where the seafloor can vary between gravel, sandy, or muddy sediments (Figure 4). Offshore, the seafloor again varies from gravel or gravelly sediments to muddy basins.

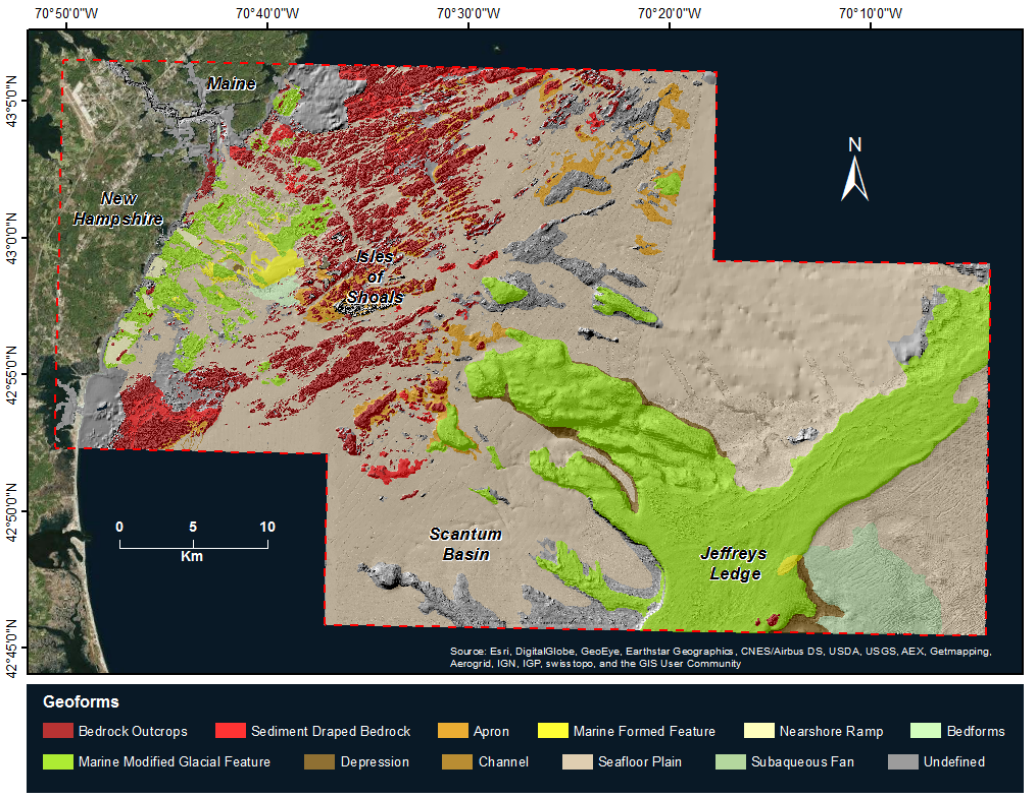

Figure 3. Major morphologic features on the New Hampshire and vicinity continental shelf draped over a shaded-relief raster surface of the bathymetry (10x vertical exaggeration).

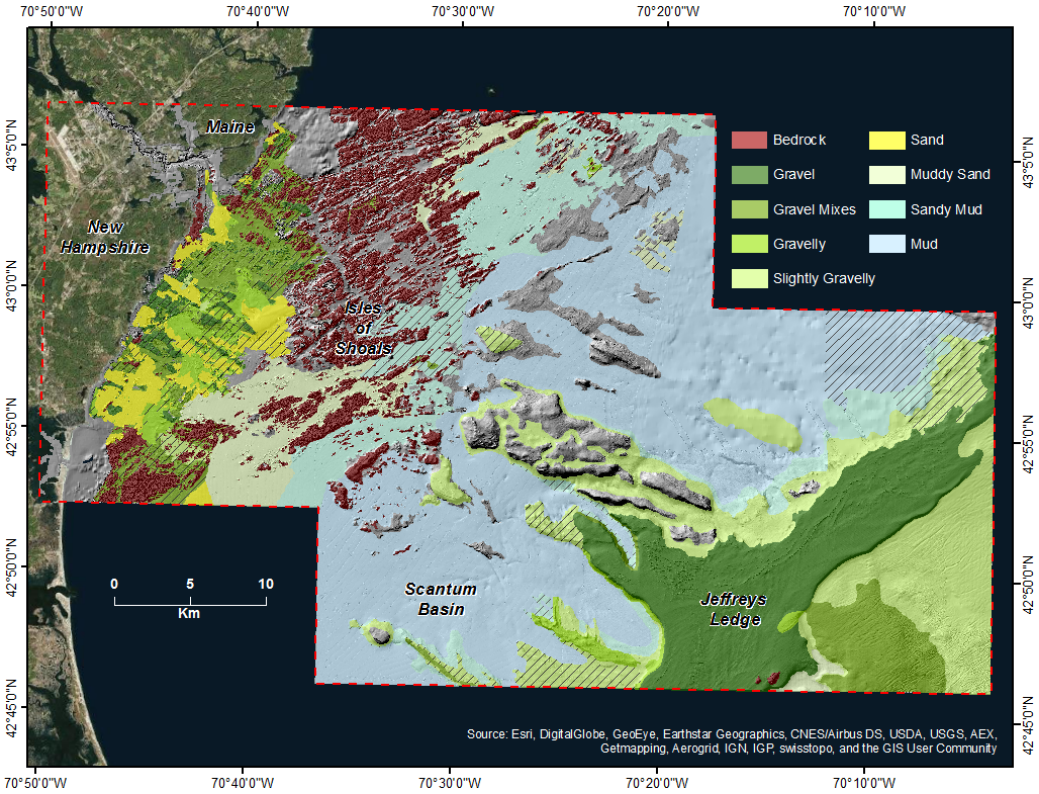

Figure 4. Surficial sediment map of the New Hampshire and vicinity continental shelf based on the CMECS classification for Geologic Substrate Groups.

Ward, L.G., McAvoy, Z.S. and Vallee-Anziani, M., In Review, New Hampshire and vicinity continental shelf: Sand and gravel resources: BOEM/New Hampshire Cooperative Agreement Technical Report.

An evaluation of sand and gravel resources on the New Hampshire and vicinity continental shelf is largely based on high-resolution bathymetry (i.e., WGOM Bathymetry and Backscatter Synthesis), surficial geology and sediment mapping, and an extensive geophysical and sedimentological archive. The most comprehensive subbottom seismic surveys of the New Hampshire shelf were conducted by the University of New Hampshire and the United States Geological Survey in 1981, 1982, and 1985 and include ~1280 km of primarily uniboom seismic profiles. In order to fully integrate these analog records with recent high-resolution bathymetry and enhance the analysis of the seismics, the analog records were converted to digital and analyzed to determine sand and gravel thicknesses based on seismic facies. These analyses were guided by the original interpretations of Birch (1984). The interpretations of the subbottom seismic profiles are hampered by positioning uncertainty and frequently by the marginal quality of the seismics. However, overall trends can be determined and potential sand and gravel targets identified for more detailed investigations. Four areas were identified for more intensive study of potential sand and gravel deposits (Figure 5). Preliminary sand thickness and sediment characteristics have been determined for these areas based on archived data. These areas, among others, are recommended for further, more detailed studies.

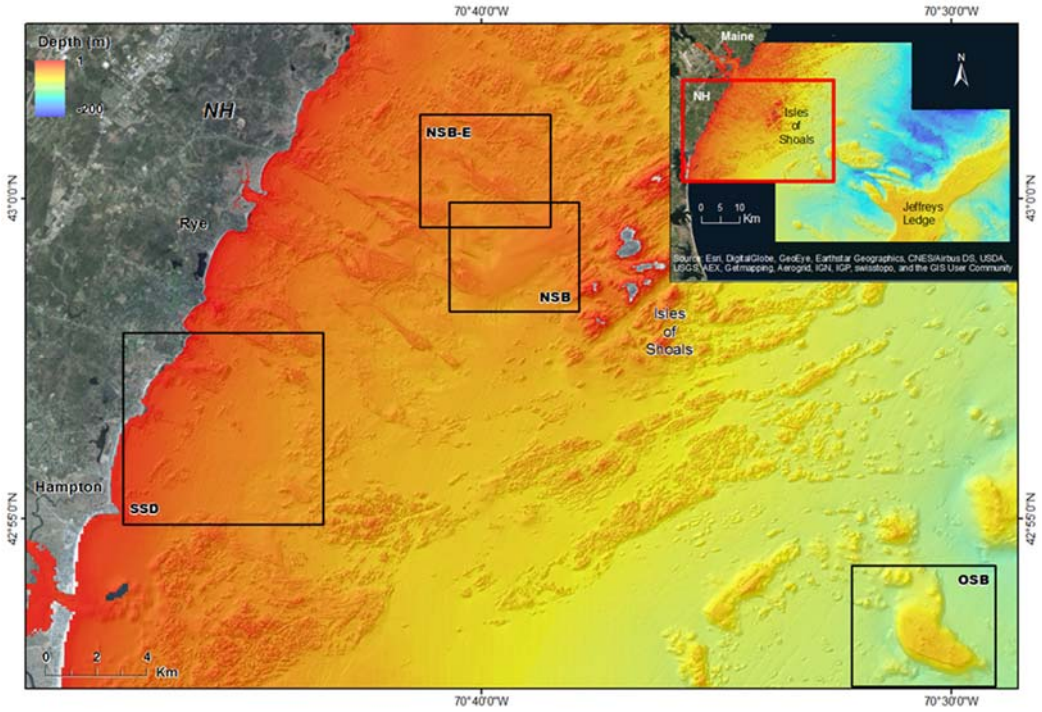

Figure 5. Location map of the focus areas (outlined in black) where sand and gravel deposits on the New Hampshire continental shelf are described in detail. The inset shows the entire region included in the overall study of the New Hampshire and vicinity continental shelf. SSD is the Southern Sand Deposits; NSB is the Northern Sand Body; NSB-E is the Northern Sand Body Extension; and OSB is the Offshore Sand Body.

Olson, N., Chormann, F. and Ward, L.G., In Review, New Hampshire beaches: Shoreline movement and volumetric change: BOEM/New Hampshire Cooperative Agreement Technical Report.

In order to assess the stability (landward or seaward migration) of the New Hampshire coastline and assess volumetric changes of the beaches, short-term changes (years) were analyzed using lidar data and long-term trends (decades) were analyzed using shorelines drawn from charts and orthophotography. Multiple vintages of airborne lidar spanning the last decade and a half were analyzed to detect volumetric changes between lidar surveys using a simple DEM of Difference (DoD) method. Due to the short length, the entire coast was analyzed at a fine (1-2m) spatial resolution. All beaches showed variability in trends, but most beaches had a net loss of sediment. The two largest beaches in the state (Hampton Beach and Seabrook Beach) show similar variability to the other beaches, but with more gains than losses. In addition to the volumetric analysis, shorelines were delineated from charts and orthophotography dating back to the mid-1800s, and the trend of the shoreline position determined for shore-perpendicular transects using the Digital Shoreline Analysis System (DSAS). The large southern beaches show net seaward movement (accretion) and the smaller northern beaches show a net shoreward movement (erosion), similar to the pattern seen in the lidar data. By combining the two datasets, the long-term and short-term trends of sediment budgets in New Hampshire can be summarized. A break in the process seems to occur

between the large southern beaches and the generally smaller northern beaches. Such data can provide insights for coastal managers to help focus beach management strategies (e.g., nourishment).

Figure 6: Example DoD map from Hampton Beach for the 2000-2007 time period. Red shows areas of erosion and blue shows areas of accretion. The map presented here is in draft form and is presently undergoing revisions.

Ward, L.G., McPherran, K.A., McAvoy Z.S. and Vallee-Anziani, M., In Review, New Hampshire beaches: Sediment characterization: BOEM/New Hampshire Cooperative Agreement Technical Report.

The grain size of the natural sediment on the major New Hampshire beaches under summer equilibrium conditions was determined in order to assess the sediment size that would be needed for beach nourishment. This information, in turn, provides criteria to determine the suitability of offshore sand and gravel deposits on the New Hampshire and vicinity continental shelf to be used for beach nourishment. In the summer of 2015, eight major beaches along the New Hampshire coast (Wallis Sands, Jenness Beach, Foss Beach, North Hampton Beach, North Beach, Hampton Beach, and Seabrook Beach) were sampled along three to five transects extending from the dunes or engineering structures to the low water line. At each transect, the beach was sampled at three to four locations. In addition, the beach cross-section was profiled and the location of the sediment samples on the profile were noted. Profiles were determined primarily using a GPS system on a rover (three-wheeled dolly). The sediment grain size data are archived and presented in a GIS environment.

Associated Cooperative Agreement Outputs (Presentations with Published Abstracts):

Olson, N., Chormann, F. and Ward, L.G., 2016. Change analysis of New Hampshire's beaches from multiple airborne lidar collections, historical charts, and orthophotography: Abstracts, Geological Society of America (GSA) Annual Meeting, Northeastern Section, Albany, New York, March 21-23.

The stability of the New Hampshire coastline and volumetric changes of the beaches were analyzed using lidar data, charts, and orthophotography. Multiple airborne lidar surveys conducted over the last decade and a half were analyzed to detect changes in volume of sand and gravel beaches using a simple DEM of Difference (DoD) method. Changes in shoreline position were determined for shore-perpendicular transects using the Digital Shoreline Analysis System (DSAS) for the period from the mid-1800s to present.

McPherran, K. and Ward, L., 2016. Observations of seasonal changes and storm effects on a bedrock-influenced, paraglacial coastal system: New Hampshire: Abstracts, Geological Society of America (GSA) Annual Meeting, Northeastern Section, Albany, New York, March 21-23.

Monitoring stations were established along the New Hampshire coast to study beach morphology, volumetric changes, and sediments. Beach profiles were measured primarily utilizing a GPS rover system. The beach profiles and sediment samples were used to characterize the beach morphology and sediment grain size.

Ward, L.G., McAvoy, Z.S., Vallee-Anziani, M., Nagel, E. and Nifong, K., 2015, Depositional systems on the northern Massachusetts and New Hampshire inner continental shelf: Use of high resolution seafloor mapping to understand impacts of glaciation, marine processes and sea-level fluctuations: Abstracts, Geological Society of America (GSA) Annual Meeting, Baltimore, Maryland, November 1-4, volume 47, number 7, p.264.

Depositional features on the continental shelf off northern Massachusetts and New Hampshire are dominated by remnant glacial features (e.g., drumlins, subaqueous deltas, moraines) that have been significantly modified by marine processes as sea level fluctuated following deglaciation. Apparent glacial deposits (e.g., drumlins) have been eroded leaving very coarse lag deposits while supplying sand to develop wave-formed features (shoals?). Of particular interest is a large sand body that is ~3.2 km in length, ~1.3 km in width, and has a maximum relief of ~7 m (in comparison to the surrounding seafloor). The sand body appears to extend between two eroded drumlins. The Quaternary geology of the New Hampshire and vicinity shelf exemplifies the interplay between glacial features, sea-level fluctuations, and modifications by marine processes.

Nifong, K. and Ward, L.G., 2015, Development of late Quaternary depositional history of Portsmouth Harbor, NH: Abstracts, Geological Society of America (GSA) Annual Meeting, Baltimore, Maryland, November 1-4, volume 47, number 3, p. 264.

The sedimentological and stratigraphic characteristics of Portsmouth Harbor, New Hampshire and the adjacent inner continental shelf were described using high-resolution multibeam echosounder (MBES) bathymetry and backscatter, side scan sonar (SSS), subbottom seismics, videography, and bottom

sediment samples in order to develop a depositional model and assess the late Quaternary geologic history. Several major depositional environments were identified within Portsmouth Harbor, including coarse channel lags, sand wave fields, and extensive bedrock outcrops that strongly influence the channel configuration. At the mouth of the harbor, an apron of low intensity backscatter, composed of fine sand, extends offshore onto the inner shelf. The inner shelf shows mixed high and low intensity backscatter reflecting bedrock outcrops interspersed with fine to coarse sand and gravel fields. Determination of the surficial geology based on the high resolution bathymetry, SSS, and direct sampling, coupled with an assessment of the underlying seismic stratigraphy, enhances the development of a depositional model.

Ward, L.G., McAvoy, Z.S., Johnson, P. and Greenaway, S.F., 2015. Use of high resolution bathymetry and backscatter for mapping depositional environments on the New Hampshire continental shelf: Abstracts, Geological Society of America (GSA) Annual Meeting, Northeastern Section, Bretton Woods, New Hampshire, March 23-25, volume 47, number 3, p. 85.

The New Hampshire continental shelf is extremely heterogeneous and includes extensive bedrock outcrops, sand and gravel deposits, and muddy basins. Many of the depositional features are glacial in origin and have been significantly modified by marine processes as sea level fluctuated since the end of the last major glaciation. Synthesis of the MBES bathymetry and backscatter, coupled with an extensive archived database consisting of subbottom seismics, bottom sediment grain size data and vibracores, is being used to develop new surficial geology maps and significantly improve our knowledge of the character and origin of the major depositional features of the New Hampshire shelf and vicinity (with support from the Bureau of Ocean Energy Management). Included are a number of large glacial features (e.g., drumlins) covering the bedrock that have been modified by marine processes (waves and currents).

Associated Cooperative Agreement Outputs (Web Served Databases):

WGOM Bathymetry and Backscatter Synthesis:
http://ccom.unh.edu/project/wgom-bathbackscatter

Synthesis of high resolution bathymetry and backscatter for the regions of the Western Gulf of Maine. Web served by the University of New Hampshire Center for Coastal and Ocean Mapping/Joint Hydrographic Center. Active as of December 2015. Full description provided in Ward, L.G., Johnson, P., Nagel, E., McAvoy, Z.S. and Vallee-Anziana, M, In Review, Western Gulf of Maine bathymetry and backscatter synthesis, BOEM/New Hampshire Cooperative Agreement Technical Report.