MORPHOLOGIC ANALYSIS OF SHINNECOCK INLET USING MULTIBEAM SONAR SYSTEM

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Introduction

Tidal inlets are common morphologic features along the coasts of the United States. The morphology and sedimentary structures of inlets are created and constantly modified by the complex interactions of waves, tides and currents. Because tidal inlets provide conduits for the exchange of water and sediments between the ocean and bays, many of them are artificially maintained. These engineering activities also modify natural coastal processes and change the inlet sediment pathways. A thorough understanding of the magnitudes, rates and patterns of the geomorphologic changes in the inlets is central to predicting the shoreline erosion/deposition trends, to calculating sediment budgets and to characterizing migration patterns.

Typically, an inlet consists of the flood-tidal shoal, the ebb-tidal shoal, and the channel. The flood-tidal shoal is the sand accumulation landward of the inlet formed by flood-tidal currents. The ebb-tidal shoal is the sand accumulation seaward of the inlet deposited primarily by ebb-tidal currents and modified by waves. Sediment deposits can also be found adjacent to or in the channel, where they can reduce tidal flow. Long-term frequent observations are necessary to evaluate and measure how inlets evolve with time.

The EM3000 Multibeam Sonar System is designed for shallow-water seafloor mapping and to provide a rapid means of determining the seafloor morphology and sediment texture. With the application of this an other multibeam systems in coastal waters, we are able to obtain high-density and fine-resolution data of seabed with unprecedented detail (Gardner et al., 1998; Clarke et al., 1996).

Background

Shinnecock Inlet is the easternmost opening along the barrier island on the south shore of Long Island. It is located in the Town of Southampton, Suffolk County (Figure 1), and connects Shinnecock Bay and the Atlantic Ocean. The inlet was formed during Great New England Hurricane on 21-24 September 1938 and a series of structures have been built to stabilize the inlet since then. The beach adjacent to the west of the inlet experiences persistent erosion that threatens both local roads and the Fishermen's Cooperative on the bay side of the inlet. A sequence of periodic, high-resolution, shallow water Multibeam surveys has been performed in order to study the morphologic evolution and sedimentary processes in the region. The study area is approximately 3 km along shore and 1.5 km across shore, covering Shinnecock Inlet and the ebb-tidal shoal. A set of bathymetric and backscatter data have been collected and are being analyzed.

Methods

During September 26-30, 2000, the MSRC Simrad EM3000 Multibeam Sonar System was used to collect high-resolution bathymetric and backscatter data for Shinnecock Inlet and the ebb-tidal shoal. The system operates at 300 kHz and creates about 120 beams perpendicular to the ship track which results in high density water depth and echo strength data. The system has a motion sensor and positioning system to correct each depth sounding for vertical motion and resulting in a vertical accuracy of about 5-10 cm and horizontal accurary of about 1 m. Backscatter and bathymetric data were collected simultaneously during the survey.

Bathymetric data were corrected for tide and then converted to a common vertical datum NGVD29. The OMG SwathEd program was used to reduce the bathymetric and backscatter data. The depth data were gridded at a 1 m interval to create a digital terrain map (DTM) from which a contour map can be generated. Sun-illuminated images, created by shinning a synthetic sun on the DTM allows features on the seafloor, such as megaripples in the channel to be observed. The backscatter mosaic produces independent evidence about sediment type and seafloor roughness.

Supplementary data sets include an October 1998 Multibeam survey collected by MSRC which was limited to the navigation channel and a portion of ebb-tidal shoal and a May 1998 and a July 2000 SHOALS LIDAR survey provided by U.S. Army Corps of Engineers (USACE). These records provide the potential to study long-term growth patterns of the Inlet.

Initial Results

A number of features can be identified from the high-resolution bathymetric data and backscatter images created by the survey. The prominent ebb-tidal shoal is easily observed as are many smaller scale features. The latter include a cross-channel bar, megaripples in the channel, scour marks at the tips of jetty, linear depressions at the southwest edge of the shoal, a number of elongate depressions to the east edge of the shoal and large areas of high backscatter sediment south of the shoal (Figure 2).

The ebb-tidal shoal is semi-circular and skewed to the west indicating that net long shore sediment transport is east to west (Figure 2). The seaward edge of the shoal can be defined where the contour lines offshore of the ebb-tidal shoal are parallel to the shoreline. It extends to 11 m contour line offshore with seaward edge slope about 0.05. The updrift and downdrift edges can be identified by the sharp angle the contours make with the prevailing bathymetry (Stauble, 1998). It is noticed that the downdrift slopes are less steep than the updrift ones suggesting alongshore current influence is much larger than the ebb-tidal shoal topography (Figure 2).

The thawleg of the inlet is discontinuous and is interrupted by a cross-channel bar that runs NNW-SSE across the inlet. Transverse megaripples are observed in the channel with 30 cm high, 20 m long and 2 m spacing. The asymmetrical megripples with gentle slope to the north probably are due to the time-average velocity asymmetry of tidal currents and may indicate a dominate ebb tidal flow. At the tip of the west jetty, a scour hole elongated N-S can be identified indicating spatial changes in velocity in the inlet. Isolated bathymetric mounds that occur in the scour hole are about 3 m high and 18 m in diameter and may be related to jetty construction. At the tip of east jetty, a smaller scour hole is also noted with an E-W orientation (Figure 3). These features indicate a complex tide-wave interaction within the inlet.

A group of linear depressions nearly perpendicular to the shoreline are obvious in shaded relief image on the downdrift side of the ebb-tidal shoal. They are around 50 cm in height, 40 m-200 m in length with 10 m spacing. These depressions have high backscatter and are parallel to one another. A number of distinct depressions are also characterized by sun-illuminated and backscatter images at the nearshore updrift edges of the ebb-tidal shoal (Figure 4). Those elongated depressions with widths of 10-20 m and lengths of 20-40 m. The longest axis are almost perpendicular to the shoreline associated with high backscatter suggesting coarse sediment. They extends as far as 500 m offshore. These linear and elongate depressions may indicate local nearshore dynamics.

Large patches of high backscatter occur adjacent the offshore edge of the ebb-tidal shoal (Figure 5). The patches have distinct boundaries with the surrounding low backscatter areas. It is not clear yet whether those areas are associated with dredging or other processes.

Conclusions

The EM3000 Multibeam Sonar System provides a rapid means of mapping sea floor in water depth from 0.5 m to 100 m. This technique provides high-resolution bathymetric and backscatter data which are used to generate detailed images containing information abut the morphology of the seabed. The high-density data collected by this system allows the detection of many features that are not generally detected by ordinary bathymetric sounding techniques. The application of Multibeam Sonar to the measurement and analysis of inlet morphology will help to qualify inlet morphodynamics and to evaluate large scale and long term inlet evolution. The possible benefits from the bathymetry evolution study of Shinnecock Inlet are to improve our understanding of the controlling processes of sediment distribution and transport and to provide high-resolution data for modeling purposes.

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