Monitoring Shoreline Change along Assateague Barrier Island: The First Trend Report

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ABSTRACT

The application of rigorous protocols to conduct shoreline surveys in the Assateague Island National Seashore of the Northeast Coastal and Barrier Network of the National Park Service has generated a dataset that permits comparisons of shoreline positions at seasonal, annual, and long-term scales. The end product of the comparisons provides insights to the sediment supply, sediment budget, and sediment transport system operating along Assateague Island. Application of the Shoreline Change Mapper in conjunction with the USGS Digital Shoreline Analysis System portrays the geotemporal relationship of change through the 5-year period of data availability. Most of the island has undergone shoreline position change greater than the measure of uncertainty associated with the protocol (10 m), with some areas gaining as much as 462 m and others losing as much as 374 m during the 5-year period. Linear regression analysis depicts the 5-year trend for the entire island as a loss of 0.95 m/yr, whereas the losses within the NPS portion of the island were 1.48 m/yr. End-Point analyses of the data identify a loss of 2.40 m/yr for the entire island and 2.53 m/yr within the NPS portion.

Additional index words: Geotemporal trends, Assateague Island National Seashore, Northeast Coastal and Barrier Network, National Park Service

Introduction
Assateague Island is a barrier island along the eastern coast of the USA, in the states of Maryland and Virginia (Fig. 1). The barrier is approximately 58 km alongshore from Ocean City Inlet to Tom’s Cove Hook. The primary geomorphological component of Assateague Island is a Holocene age barrier island that is a continuation of the barrier island system that extends southward from the headland in Delaware (Walker and Coleman 1987). The modern-day configuration of the island is a product of a 1933 hurricane that breached the ancestral Fenwick Island and created Ocean City Inlet. Construction of jetties in 1934-35 maintained the inlet and resulted in the establishment of Assateague Island. The combination of the very long jetties and the sequestering of sediment in the flood-tide and ebb-tide deltas adjacent to the inlet greatly altered the sediment supply reaching Assateague Island and extensive shoreline displacement ensued (Underwood and Hiland 1995). The effects of the inlet are still in place but are ameliorated by periodic transfers of sediment, part of the North End Restoration Project, sponsored by the U.S. Army Corps of Engineers (Schupp et al., 2007). Beginning in January 2004, sediment has been dredged from the navigation channel and from portions of the tidal deltas and placed in the nearshore of Assateague Island twice a year.

Assateague Island National Seashore, part of the National Park Service (NPS) includes the northernmost 35 km of the barrier island (Fig. 1). Assateague Sate Park has jurisdiction over a 3 km stretch along the NPS land, and Chincoteague National Wildlife Refuge occupies the southernmost 23 km of the barrier island. The data included in this report correspond to the portrayal of the shoreline position along the entire length of Assateague Island from Ocean City Inlet to Tom’s Cove Hook, compared to the changes occurring within the more limited portion associated with Assateague Island National Seashore.

The Northeast Coastal and Barrier Network (NCBN) of the US National Park Service has embarked on a long-term program to monitor shoreline position along its coastal parks. Knowledge of shoreline change is a basic element in the management of any coastal system because it contributes to the understanding of the functioning of the natural resources and to the administration of the cultural resources within the parks.

The NCBN has been gathering shoreline position collected according to Standard Operating Procedures developed by Rutgers University, that rigorously define the concepts, methods, periodicity, and techniques used for data collection (Psuty et al., 2010). The outcome of the NCBN monitoring program is a consistent, systematic, comparable, and locally-created data base of the Park’s shorelines position at different temporal scales (seasonal, annual, long-term). This information allows for analysis and interpretation of the geomorphological change throughout the Park jurisdiction, in areas of special concern, as well as general trends in parkwide response. The Shoreline Change Protocol was applied for the first time on Assateague Island National Seashore in Spring 2005. Subsequent surveys were conducted in the spring and fall through Spring 2010; they provide the temporal span for a five-year trend report.
Methods

Surveys consisted of collecting the neap high-tide swash line position along the ocean side of the island using a sub-meter-accuracy GPS unit mounted on an ATV (Figs. 2 and 3). The estimated total level of uncertainty associated with this feature-based shoreline is within 5 m, and includes the variation in both the natural creation of the swash line on the beach face and the interpretation of the position of the swash line.

Shoreline position relative to a common baseline is measured using Digital Shoreline Analysis System software, developed by USGS (Thieler et al., 2009), and the shoreline change analysis is accomplished with the Shoreline Change Mapper, an application that works within the ArcGIS software from ESRI, and developed by Rutgers University for the purpose of the Protocol (Psuty et al., 2010).

This application is also used to generate maps that depict the magnitude of shoreline change between two dates, while including lines depicting the mean difference value and the +/- 1.0 standard deviation value (Fig. 4). With these elements, spatial portrayal of change is shown relative to all other changes on the island for the same temporal span, providing a visual perspective on the magnitude and direction of the change (vectors) on a localized basis. The matrices of the difference measurements are also subjected to very simple statistical analysis to determine the mean and standard deviation values for the seasonal, annual, and endpoints comparisons.

Results

The resulting data sets represent the differences in shoreline position along the ocean side of the barrier island between successive surveys. They offer insights to the geotemporal dimensions of change across seasonal, annual, and long-term comparisons and reveal changes created by differences in sediment availability and intensity of formational processes. Although there are surveys and data sets describing conditions at seasonal and annual time spans, this paper concentrates on the 5-year, long-term survey data and the temporal and spatial trends that are presented in the data.

Geotemporal Pattern in 5-Year Dataset

A comparison of the shoreline position (Fig. 4) over the 5-year period tends to be representative of the trend, although it remains a
very short time span and is subject to many natural variations in
the driving forces and availability of sediment supply. There are a
large number of measurements that are greater than the measure of
uncertainty and there is a statistical validation of the tendency of
the displacement. The histogram for all of Assateague Island (Fig.
5) has a large range of values, -374.20 m to +462.06 m, because of
the erosion and deposition at Tom’s Cove Hook, and a large
standard deviation, 51.94 m. Over the span of five years, the
Maryland portion (NPS) of Assateague ranges from -36.43 m to
63.7, with a more pronounced central tendency, standard deviation
of 12.73 m (Fig.6).

Figure 4. Distribution of shoreline change along Assateague Island between Spring 2005 and Spring 2010, incorporating areas of
special concern in Panels A (downdrift of inlet), B (overwash area), and C (narrow strip at Tom’s Cove).
Presentation and Description of Trend Analysis

The span of five years is really too short to describe a ‘trend’ to shoreline change. But, it is an opportunity to evaluate the scale of variation of displacement that exists along the island. Accompanied by a nearly constant bypassing of sediment downdrift of Ocean City Inlet, there are elements of similarity and dissimilarity of shoreline response in the Maryland section and the entire Assateague Island, with the latter summation calculation incorporating the general trend as well as the large variation at Tom’s Cove Hook. There is a problem with the Spring 2006 survey that causes a large positive displacement followed by a large negative displacement as compensation. It is well-displayed in the trend graph (Fig. 7). That survey does show up as an aberration and probably should be ignored in a final analysis. Nonetheless, the linear trend of the total data set describes a negative shoreline displacement (shoreline retreat), very similar to that given by the end-point and Spring05-Spring10 trend analysis.

Three measures of the trend are depicted in Figure 7: 1) a trend based on a linear regression calculation of the 10 points of change between successive surveys, -1.48 m/yr (MD portion) and -0.95 m/yr (all Assateague); 2) a trend line connecting the rate of change in the first two surveys and the last two surveys (end point trend), -2.53 m/yr (MD) and -2.40 m/yr (all Assateague); and 3) a trend line between the first survey and the last survey during this period, -1.27 m/yr (MD) and -0.45 m/yr (all Assateague).

Interpretation of trends

Despite the relatively-short period of measurement and the inherent temporal variation, there are some interpretations that are possible with the caution of applying the uncertainty value of +/- 10 m. About half of the Maryland section of Assateague has a 5-year dimension of change that is greater than the measure of uncertainty. The area adjacent to the Ocean City Inlet is generally eroding because of the immediate effect of the jetties on alongshore transport. Downdrift from the inlet is a small positive displacement that is the location of an onshore transfer of sediment from the ebb-tide delta that is causing a very local seaward accumulation. This is also the site of periodic placement of sediment dredged from the navigation channel in the inlet.

Downdrift of the attachment is a consistent inland displacement that extends for about 9 km that is not offset by the periodic placement of dredged sediment. Beyond the erosion zone, there is some oscillatory variation that may be related to circulation cells. The middle portion of the island is where two facets merge and there are zones of erosion both updrift and downdrift of this transition between the two facets. The amount of displacement throughout the central portion of the barrier island is modest, either within or close to the uncertainty values and could be within the error range. However, the displacements at the southern terminus of the barrier island are far greater than the uncertainty and thus do depict the great amounts of deposition and erosion that is characteristic of the distal end of a barrier island. In particular, the last survey year was very energetic and was marked by both a high frequency and high magnitude of storm events. The shoreline response was consistent with the stormy conditions that mobilized and transported considerable sediment to the south (downdrift).

There are several facets to the Assateague Island shoreline, segments that have a similar orientation. The downdrift ends of the facets tend to have a local erosional/depositional conditions. The facets are extending downdrift and thus the characteristics describing the facets are slowly shifting downdrift as well.
Overall, the central tendency of the Assateague Island shoreline is a slow inland displacement, within the margin of error in this short time period, with sites at the termini of the island that are beyond the margin of error.

CONCLUSIONS

Data gathered through the application of the Shoreline Change Protocol have contributed basic information on the seasonal, annual, and long-term shoreline change along Assateague Island.

The 5-year trend report has produced a realistic geotemporal pattern of change along the barrier island and has added dimension and rates of shoreline change to the geodatabase. Despite some quirks in one of the seasonal surveys, the collection of 11 consecutive surveys provides an adequate initial portrayal of the spatial association of sediment availability in the alongshore sequence and identifies areas of special concern for management of the cultural and natural resources. The application of a consistent and rigorous protocol is providing the National Park Service with a means to evaluate shoreline change within its general mandate for improved inventorying and monitoring.

References


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