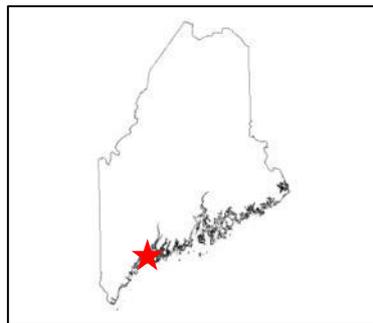


Geologic Site of the Month
August, 2011

***Shoreline Erosion at Western and Ferry Beaches
Scarborough, Maine***



43 32' 14.38" N, 70 19' 11.59" W

Text by
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Introduction

A previous Maine Geological Survey (MGS) site of the month from June 2006 ([Slovinsky, 2006](#)) provided a brief history of beach erosion at Western Beach, Scarborough. It also summarized some of the impacts of beach nourishment efforts on the size of the beach, the dunes, and bird habitat.

In December 2004, the U.S. Army Corps of Engineers dredged 90,000 cubic yards of sediment from the main channel and anchorage area of the Scarborough River, and placed the material at Western Beach as the beneficial reuse of dredged material. The design of the fill was to increase the dry beach width by adding elevation and width to the berm, the relatively flat area between the edge of high water and the dune vegetation line. As a result of the nourishment project, there was an approximate 6-acre gain in the dry beach, and a substantial gain in available habitat for endangered and threatened piping plovers and least terns.



GPS Measurements

Since the summer of 2005, MGS has been using its Real Time Kinematic Global Positioning System (RTK-GPS) to measure notable alongshore shoreline features at Western Beach, where nourishment was undertaken, and at nearby Ferry Beach, and the neighboring beach that fronts Ferry Road (Figure 1).



Figure 1. Location of study areas that have been surveyed by MGS as part of the Maine Beach Mapping Program. Surveyed areas are shown in red and include Western Beach and Ferry Beach.



Shoreline Change Analysis

This monitoring is completed as part of the Maine Beach Mapping Program (MBMAP). Surveyed features include the landward edge of the high water line, seaward edge of the vegetation line, and any fencing placed by the Maine Audubon Society for bird habitat. These surveys, on average, have been conducted on a yearly basis in order to document shoreline changes. The MGS RTK-GPS system has accuracies on the order of 2-3 cm in the horizontal and vertical directions.

Shoreline Change Analysis

In order to examine shoreline changes of the surveyed vegetation line and the high water line, MGS utilized the [USGS Digital Shoreline Analysis System \(DSAS\)](#) (Thieler and others, 2009). Surveyed positional points were imported into a GIS and converted into line files. Then, the DSAS software extension was used to compare shoreline positions and calculate the net shoreline movement (NSM, in meters) along the beach at designated transect locations at set intervals. This analysis was conducted for Western Beach along the Prouts Neck Country Club, Ferry Beach, and the neighboring beach that fronts Ferry Road.



Shoreline Change Analysis Results: High Water Line changes

Results of the analysis for net shoreline movement of the high water line are presented for the overall study area in Figure 2.

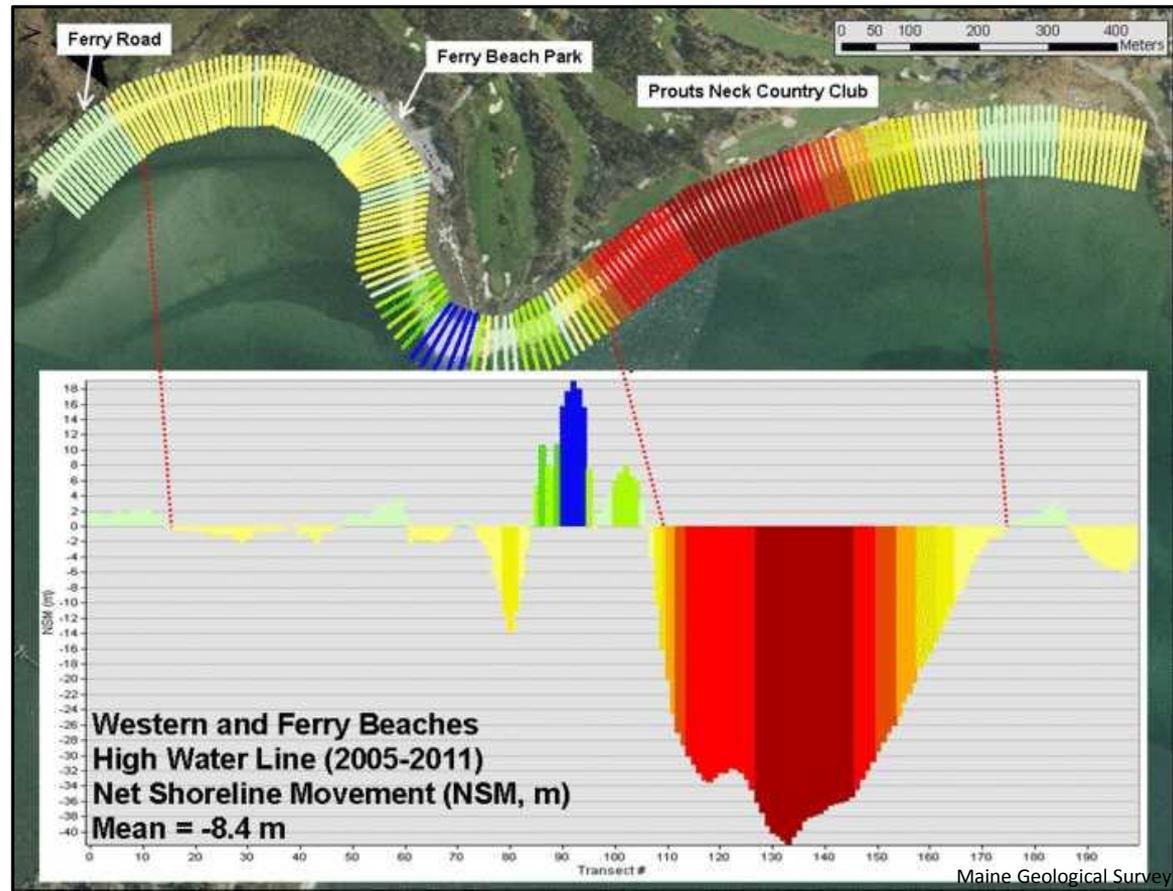


Image by P. Slovinsky; Base imagery from MEGIS

Figure 2. Color-coded transects showing net shoreline movement (in meters) from 2005-2011 of the high water line along both Western and Ferry Beaches, Scarborough.

Shoreline Change Analysis Results: High Water Line changes

The DSAS transects have been color-coded to represent different ranges of NSM, with light green and blue colored transects indicating accretion, and yellow to red colored transects indicating different levels of erosion. A corresponding graph that illustrates shoreline change data is included. Reference points, marked by dashed red lines, show the relationship between transects and the graphed shoreline change data. Note that transect and graph colors will vary for each figure shown, so pay attention to the Y-axis scale of the graphs.

For the overall study area, the mean NSM value for the high water line was -8.4 meters, indicating that as a whole, the study area has undergone substantial landward movement of the high water line from 2005-2011, indicative of beach erosion. Based on Figure 2, the high water line along Western Beach has eroded dramatically over this time period, up to 40 meters at its highest point, while accretion has occurred at the point between Ferry and Western Beach, up to about 20 meters.



Shoreline Change Analysis Results: High Water Line changes

Figure 3 shows changes in the high water line for Western Beach only.

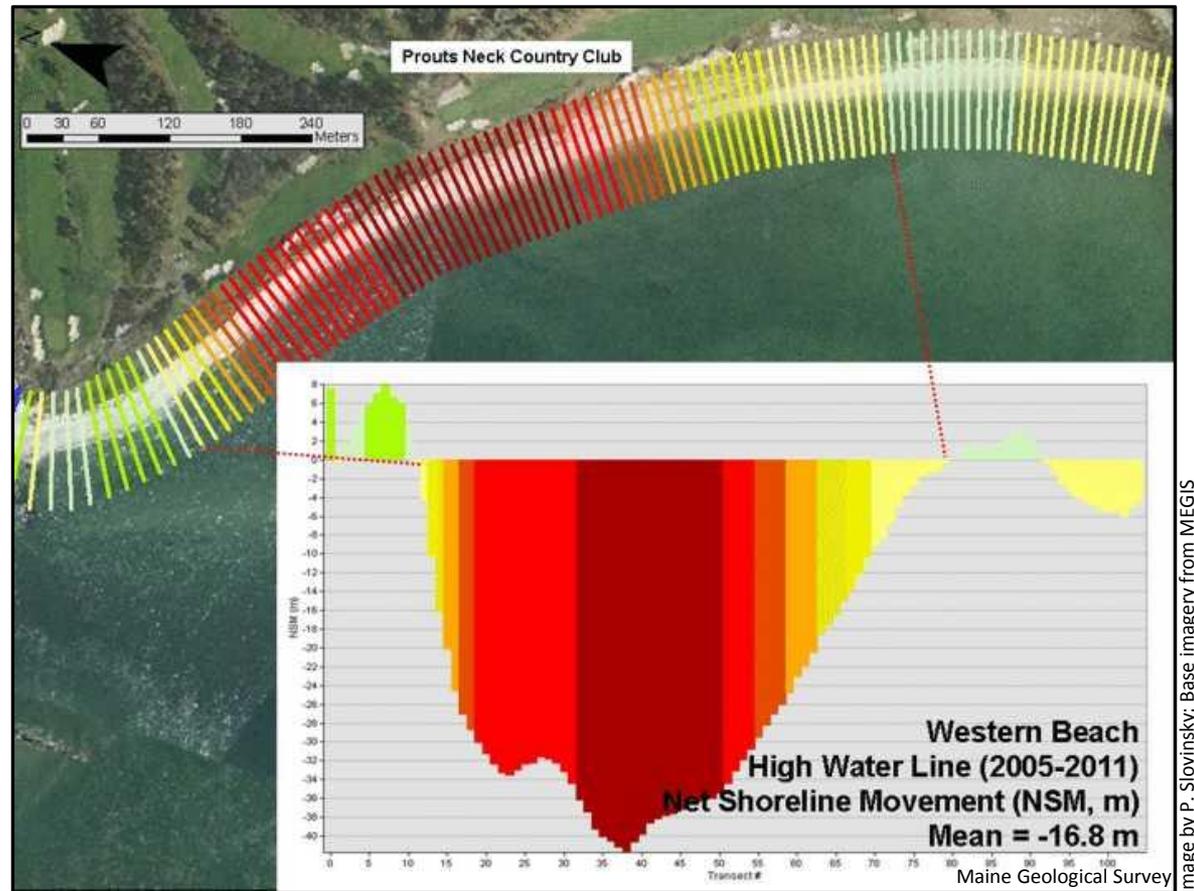


Figure 3. Color-coded transects showing net shoreline movement (in meters) from 2005-2011 of the high water line along Western Beach, Scarborough.

Shoreline Change Analysis Results: High Water Line changes

The central portion of the beach has undergone the most erosion, with the high water line receding up to 40 meters. Nodal points exist, where the trend switches from erosion to accretion; these points are marked with dashed red lines. The erosive trend switches to accretion nearest the point at the Scarborough River entrance, and at a small pocket along the eastern end of the beach. From 2005-2011, the mean NSM value for Western Beach is calculated to be -16.8 meters, indicating extensive erosion. Sand at Western Beach appears to be migrating from the central portion of the beach to the northwest (to the sand spit at the point), and slightly to the southeast, towards Prouts Neck.



Shoreline Change Analysis Results: High Water Line changes

Figure 4 shows the changes in the high water line along Ferry Beach, from the point at the river (in the south), along Ferry Beach Park, and northwesterly up along Ferry Road.

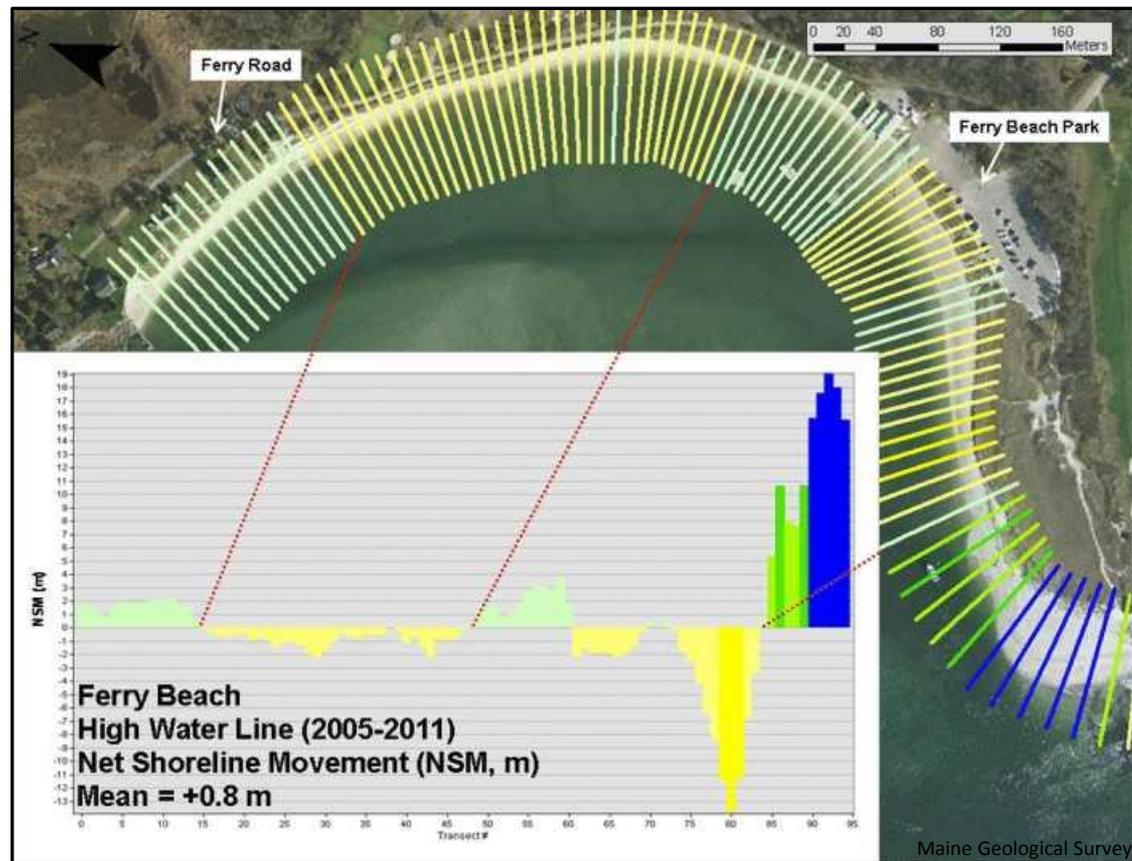


Figure 4. Color-coded transects showing net shoreline movement (in meters) from 2005-2011 of the high water line along Ferry Beach, Scarborough.

Shoreline Change Analysis Results: High Water Line changes

Nearest the point, a sand spit has clearly formed, with seaward movement of the high water line of up to 19 meters, indicating large amounts of accretion. Meanwhile, the high water line along Ferry Beach Park appears to be moving landward, indicating erosion of the beach and loss of dry beach space. Just past the boat houses, this trend reverses, showing slight accretion. Erosion of about 2 meters has occurred along Ferry Road, but accretion at the northwestern end of the beach, nearest the houses, is apparent. This stretch of beach has a mean NSM value of +0.8 m, indicating stability to slight accretion along the beach. The sand appears to be moving from Western Beach and is being trapped in a spit at the point.



Shoreline Change Analysis Results: High Water Line changes

Figure 5 shows a close-up view of the net shoreline changes in the high water line along Ferry Road only. The southeastern portion of the beach along the road underwent clear erosion, up to about -2.2 meters; however, the northwestern portion of the beach, nearest the houses, has undergone accretion of about the same amount. The mean NSM value in this portion of the beach is 0.0 meters, indicating stability. The sand here clearly appears to be moving from southeast to northwest along the beach.

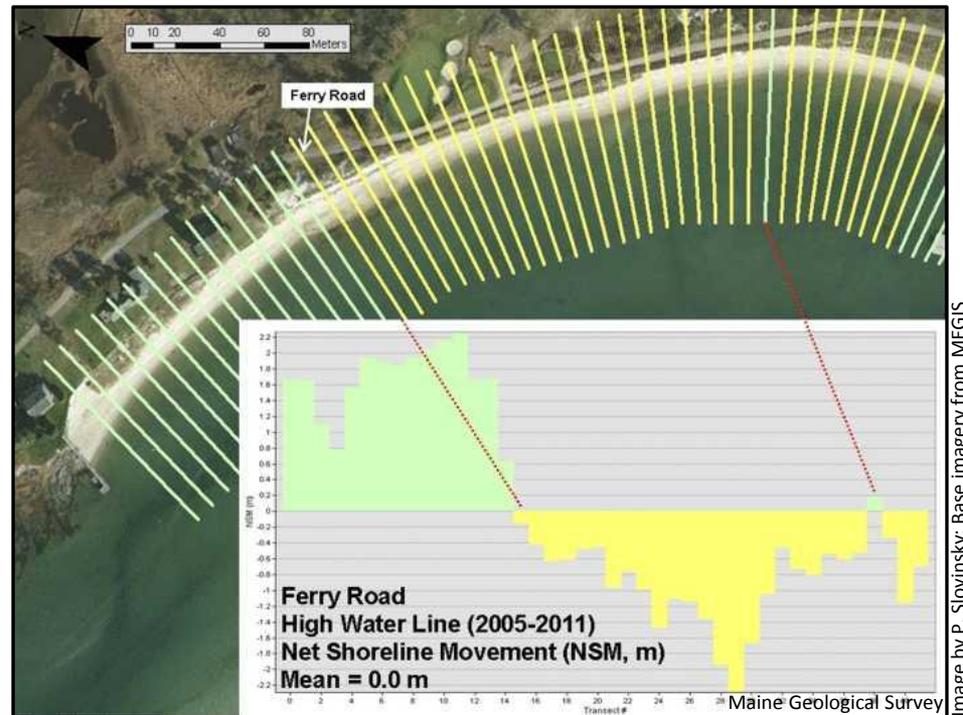


Image by P. Slovinsky. Base imagery from MEGIS

Figure 5. Color-coded transects showing net shoreline movement (in meters) from 2005-2011 of the high water line along a section of Ferry Road, Scarborough.

Shoreline Change Analysis Results: Vegetation Line changes

The results of the shoreline change analysis for net shoreline movement of the vegetation line are presented for the overall study area in Figure 6.

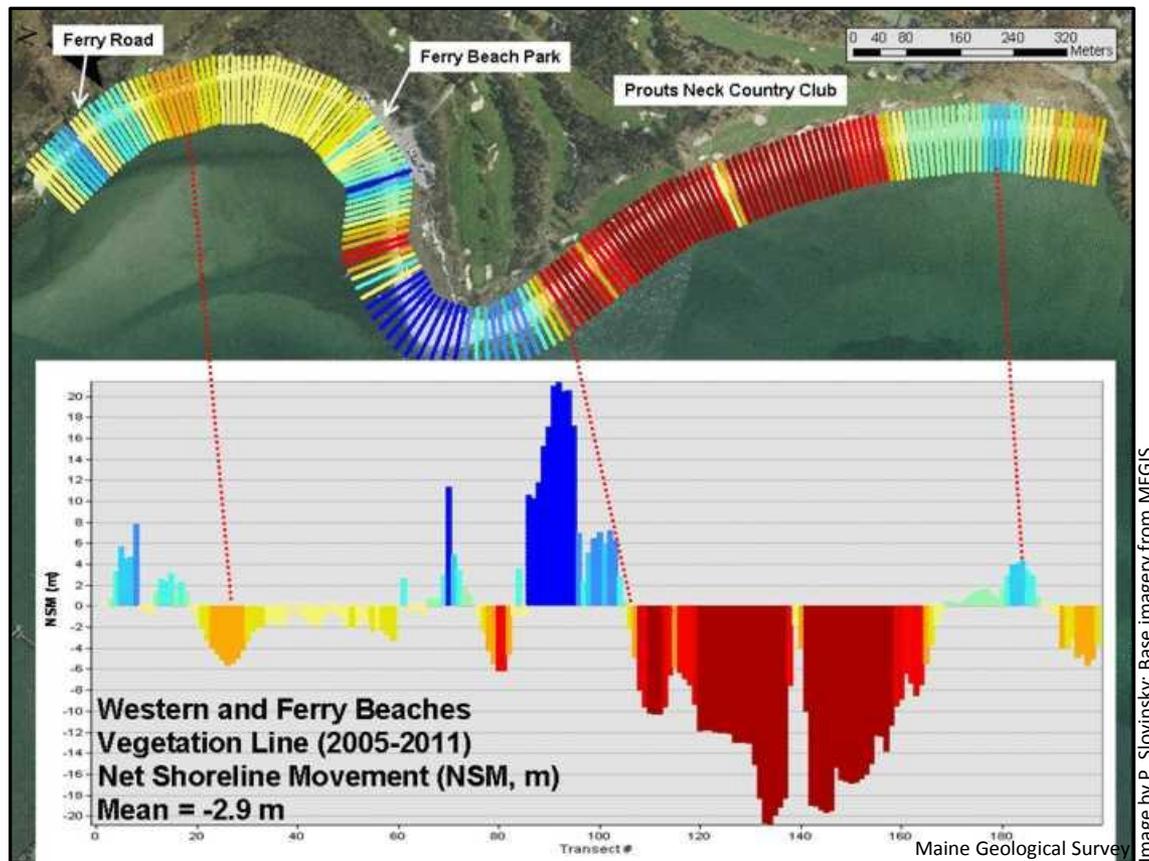


Figure 6. Color-coded transects showing net shoreline movement (in meters) from 2005-2011 of the vegetation line along both Western and Ferry Beaches, Scarborough.

Shoreline Change Analysis Results: Vegetation Line changes

Generally, the vegetation line is following the same overall trends as the high water line. That is, large amounts of dune erosion are concentrated along the central portion of Western Beach, while the dune has been prograding (building seaward) along the spit at the point between Western Beach and Ferry Beach. Along Ferry Beach, the dunes have undergone slight erosion from 2005-2011, with an isolated pocket of growth nearest the parking lot. The largest amount of dune erosion along Ferry Beach appears to be concentrated along a section of Ferry Road. The mean NSM value for the overall study area is -2.9 meters, indicating that overall, the dune is eroding.



Shoreline Change Analysis Results: Vegetation Line changes

Figure 7 shows the net shoreline movement of the vegetation line along Western Beach specifically. The dune underwent the same trend as the high water line; that is, large amounts of erosion at the central portion of the beach (up to about 20 meters), with large amounts of dune growth near the point, and slightly smaller amounts to the southeast portion of the beach. The dunes in the southeastern-most portion of the beach, nearest Prouts Neck, have eroded up to about 6 meters from 2005-2011. The mean NSM value for the vegetation line along Western Beach is -6.6 meters.

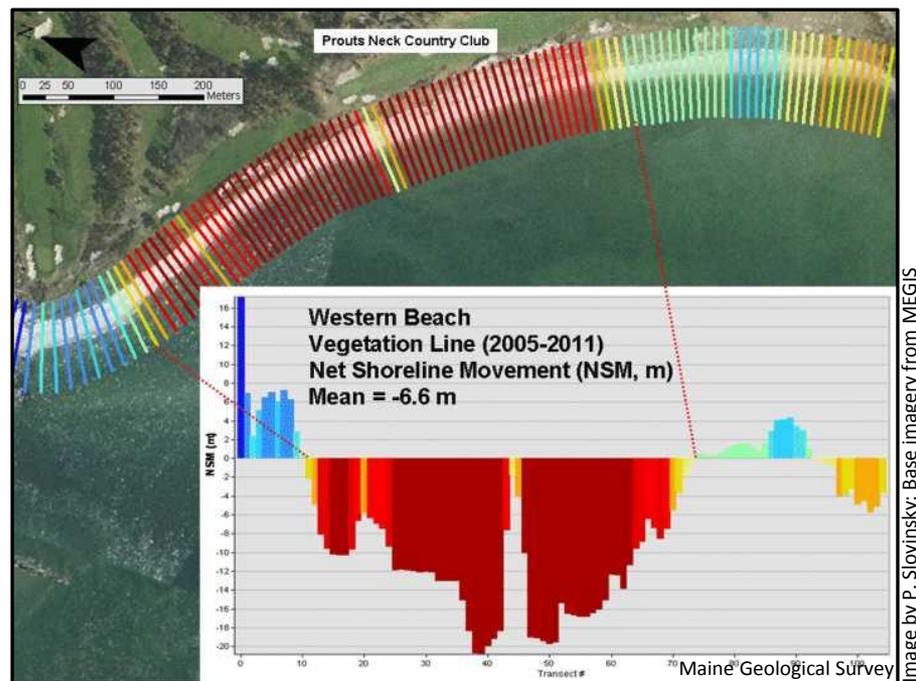


image by P. Slovinsky; Base imagery from MEGIS

Figure 7. Color-coded transects showing net shoreline movement (in meters) from 2005-2011 of the vegetation line along Western Beach, Scarborough.

Shoreline Change Analysis Results: Vegetation Line changes

Figure 8 shows the net shoreline movement of the vegetation line along the Ferry Beach area.

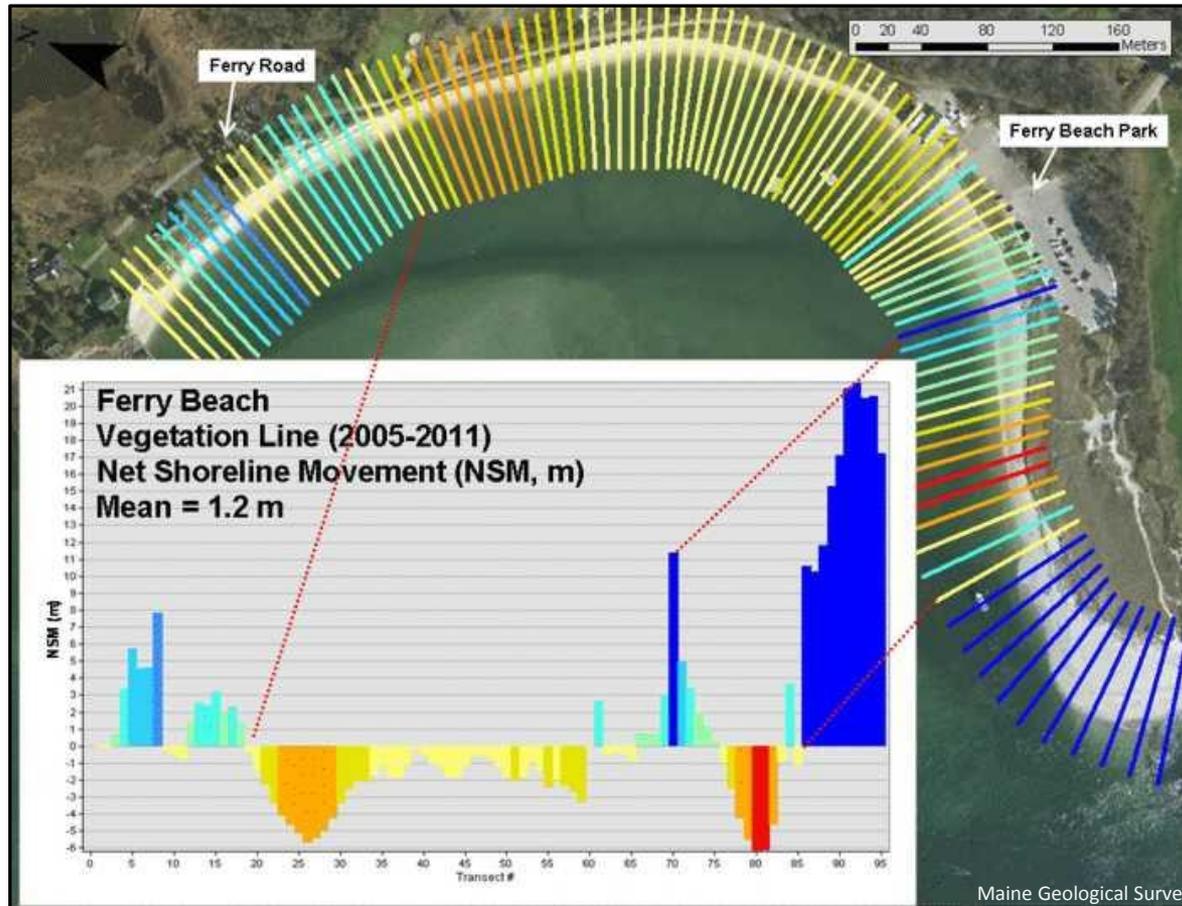


Image by P. Slovinsky. Base imagery from MEGIS

Maine Geological Survey

Figure 8. Color-coded transects showing net shoreline movement (in meters) from 2005-2011 of the vegetation line along Ferry Beach, Scarborough.

Shoreline Change Analysis Results: Vegetation Line changes

The dune has prograded dramatically nearest the point, with upwards of 20 meters of growth. This trend turned erosive, just around the corner, for a short stretch of the beach, but good dune growth was noted along most of Ferry Beach proper. The trend turned erosive again near the boat houses, with the dunes along this stretch and along the southeastern part of Ferry Road eroding around 2-3 meters. Along the rest of Ferry Road, erosion increased to around 4-6 meters, and a nodal point exists, where the dunes instead grew seaward up to about 8 meters, nearest the homes along Ferry Road. The mean NSM value for the vegetation line along Ferry Beach is +1.2 meters.



Shoreline Change Analysis Results: Vegetation Line changes

Figure 9 shows the net shoreline movement of the vegetation line along Ferry Road only. The dunes along Ferry Road show similar changes as the high water line, with erosion along the eastern portion of the road up to around -5 meters. A distinct nodal point is apparent (near transect 20) where this trend changes to dune growth, nearer the houses, similar to the high water line trend. The dunes here underwent growth of up to 8 meters. The mean NSM value for the vegetation line along Ferry Road is -0.5 meters.

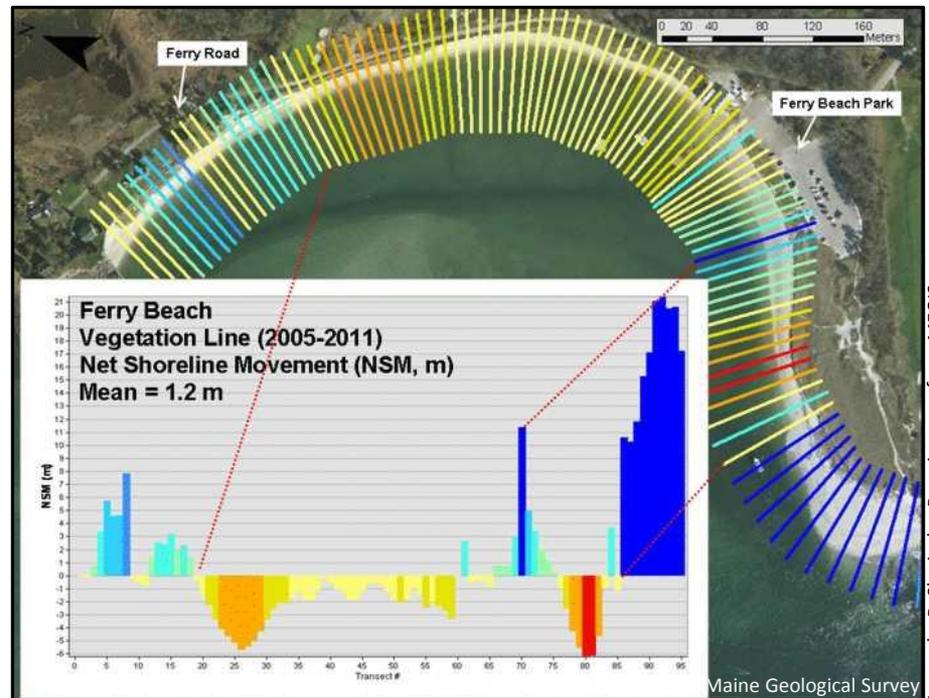


Image by P. Slovinsky. Base imagery from MEGIS

Maine Geological Survey

Figure 9. Color-coded transects showing net shoreline movement (in meters) from 2005-2011 of the vegetation line along a section of Ferry Road, Scarborough.



Summary of Shoreline Changes and Discussion

Table 1 summarizes the overall mean changes observed in the net shoreline movement of the vegetation line and the high water line for the beach system as a whole, and for each specific section of the beach. Overall, Western and Ferry Beaches are undergoing erosion of the dune and water line. At Western Beach specifically, erosion rates are higher. Along Ferry Beach, which appears to be receiving sediment from an eroding Western Beach, the high water line and dune appear to be growing overall. Along Ferry Road specifically, the mean high water line data indicates general stability, while the vegetation line is showing erosion.

After the beach nourishment that was completed in late 2004 and early 2005, the beaches and dunes at Western Beach grew seaward dramatically. However, since the summer of 2005, the central portion of Western Beach underwent large amounts of erosion, with the dunes losing nearly 20 meters, and the high water line migrating landward upwards of 40 meters from its 2005 position.

| Beach | VEG (M) | VEG (SD) | HWL (M) | HWL (SD) |
|-------------------|---------|----------|---------|----------|
| Western and Ferry | -2.9 | 8.1 | -8.4 | 15.0 |
| Western Beach | -6.6 | 7.8 | -16.8 | 16.1 |
| Ferry Beach | 1.2 | 6.1 | 0.8 | 5.3 |
| Ferry Road | -0.5 | 3.1 | 0.0 | 1.3 |

Key:

VEG = Vegetation Line

HWL = High Water Line

M = Mean

SD = Standard Deviation

Table 1. Summarized net shoreline movement values (in meters) for the study beaches.



Summary of Shoreline Changes and Discussion

The changes along this central portion of Western Beach are reflected very well by comparing photographs taken by MGS of the beach and dune from 2005 and 2011. Figure 10 shows the beach and dune in June 2005, with a stake marking the southern limit of the beach nourishment project.



Figure 10. Photograph, looking east, along the post-nourishment beach in June 2005. Red arrows indicate landmarks for comparison with Figure 11.

Summary of Shoreline Changes and Discussion

Figure 11 shows the beach and dune condition in June 2011 from the same approximate location. The arrows in the photographs are meant to show landmarks (a patch of grass and a low area of the dune crest) which are apparent in both pictures. Note the dramatic loss and lowering of the beach, and the scarping (vertical cutting) of the dune.



Figure 11. Photograph, looking east, along the approximate same stretch of beach shown in Figure 10 in June 2011. Note loss of beach elevation, and scarping of dune.

Summary of Shoreline Changes and Discussion

Figure 12 shows the changes in bird fencing placed by the Maine Audubon Society from 2005 through 2011. In June of 2005 (blue line) and 2006 (green line), the entire central portion of the beach was fenced for habitat. In 2007 (purple line), the fencing area decreased on its northern side. No data was collected in 2008, but by 2009 (red line), the fencing was concentrated at the southeastern end of the beach. By 2010, the fenced habitat was decreased to a small section in the central portion of the beach, and around the point along the Ferry Beach side. In 2011, only a small section near the northern end of the beach was fenced for bird habitat. It is clear that the amount of available bird habitat has decreased substantially as the beach has eroded.



Figure 12. Locations of bird habitat fencing placed by Maine Audubon Society from 2005-2011.



Conclusions

Shoreline change analysis indicates that Western Beach has seen some of the worst erosion in the state over the past 6 years. Erosion has moved the shoreline to near where it was pre-nourishment, resulting in loss of the dry beach, and bird habitat that had existed for several years after the nourishment project. It appears that the erosion of the beach and dunes along the central portion of Western Beach is providing sand for substantial spit and dune growth near the point and around the corner at Ferry Beach. This is likely a result of flooding tidal currents that dominate the Scarborough River that pull sediment around the point and into the river, coupled with episodic storm erosion at Western Beach.

Along Ferry Beach, shoreline change analysis showed marked progradation of the dune and beach near the entrance to the river. Along the park, most of the dune also grew, though the high water line migrated landward, for the most part. This decreased the recreational beach space along the park. Along Ferry Road specifically, dune and beach erosion is occurring along the southeastern section, with sand migration to the northwest, with dune and beach growth nearest the homes along the road over the time period monitored.



Conclusions

Beach and dune accretion was concentrated near the point and around the corner, at Ferry Beach. This accretion is likely driven by erosion of the central portion of Western Beach, and subsequent sediment migration due to tidal currents to the northwestern end of Western Beach and to a portion of Ferry Beach. Additionally, beach and dune growth was noted in front of the homes at the northwestern end of Ferry Road.

This type of shoreline change analysis can help determine erosion and accretion patterns along the beach, which in turn, helps determine expected future nourishment lifetimes at Western Beach. It also can be used to help pinpoint where future nourishment may be placed along Western Beach in order to maximize the beach and dune shape, fill lifetime, and hence beach and bird habitat, should a future dredging project occur by the U.S. Army Corps of Engineers.



References and Additional Information

Slovinsky, P.A., 2006, [Beach Nourishment at Western Beach, Scarborough, Maine: Benefits for the Beaches and the Birds](#): June 2006 Maine Geological Survey Site of the Month.

Thieler, E.R., Himmelstoss, E.A., Zichichi, J.L., and Ergul, Ayhan, 2009, Digital Shoreline Analysis System (DSAS) version 4.0-An ArcGIS extension for calculating shoreline change: U.S. Geological Survey Open-File Report 2008-1278. [Available online. http://woodshole.er.usgs.gov/project-pages/dsas/](http://woodshole.er.usgs.gov/project-pages/dsas/)

