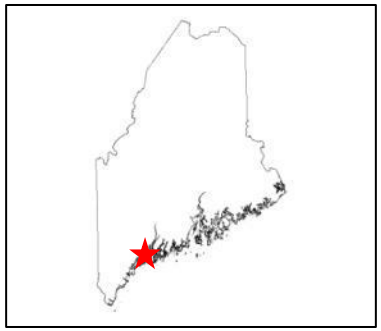
Maine Geologic Facts and Localities

March, 2009

Coastal Erosion at Crescent Beach State Park Cape Elizabeth, Maine



43° 33‘ 50.30“ N, 70° 13‘ 33.75“ W

Text by
Peter A. Slovinsky

Introduction

Crescent Beach State Park, located off of Route 77 in Cape Elizabeth, Maine, is a popular State beach, offering superb recreational beach opportunities with easy access from Portland (Figure 1). The approximate 1.4 km length pocket beach, and the adjoining smaller beach at Kettle Cove, has undergone episodic erosion, some of the most severe occurring during the May 2005 series of northeasters, and the 2007 Patriots' Day Storm.

Figure 1. Crescent Beach State Park is an arcuate-shaped pocket beach that is bound by headlands. Kettle Cove is a small pocket beach located southeast of Crescent Beach. Base imagery from MEGIS (2003).

Data

The Maine Geological Survey (MGS) used the following available data in order to document shoreline change in the vicinity of Crescent Beach State Park:

1. Aerial orthophotographs (MEGIS, June 6, 2003);
2. May, 2004 (NOAA CSC) and August, 2007 (USACE) Light Detection and Ranging (LIDAR) topographic data;
3. Post-Patriots' Day Storm field GPS survey of the edge of vegetation (5/29/2007).

In order to document changes the beach has undergone and to identify areas of significant shoreline erosion or accretion (seaward dune growth or beach upbuilding), we have used several different methods to analyze changes along the beaches and dunes in this area over the study period. The methods are described below.

Methods: Shoreline Change Rate

By comparing shorelines measured from different years, one can determine an average shoreline change rate. In order to do this, we digitized the edge of visible vegetation from the 2003 aerial orthophotographs, and compared it with the edge of vegetation from the 2007 field survey. We used the USGS Digital Shoreline Analysis System (DSAS) to cast transects and to calculate an average shoreline change rate (in m/yr, based on the data from 2003-2007). Results for Kettle Cove are shown in Figure 2.

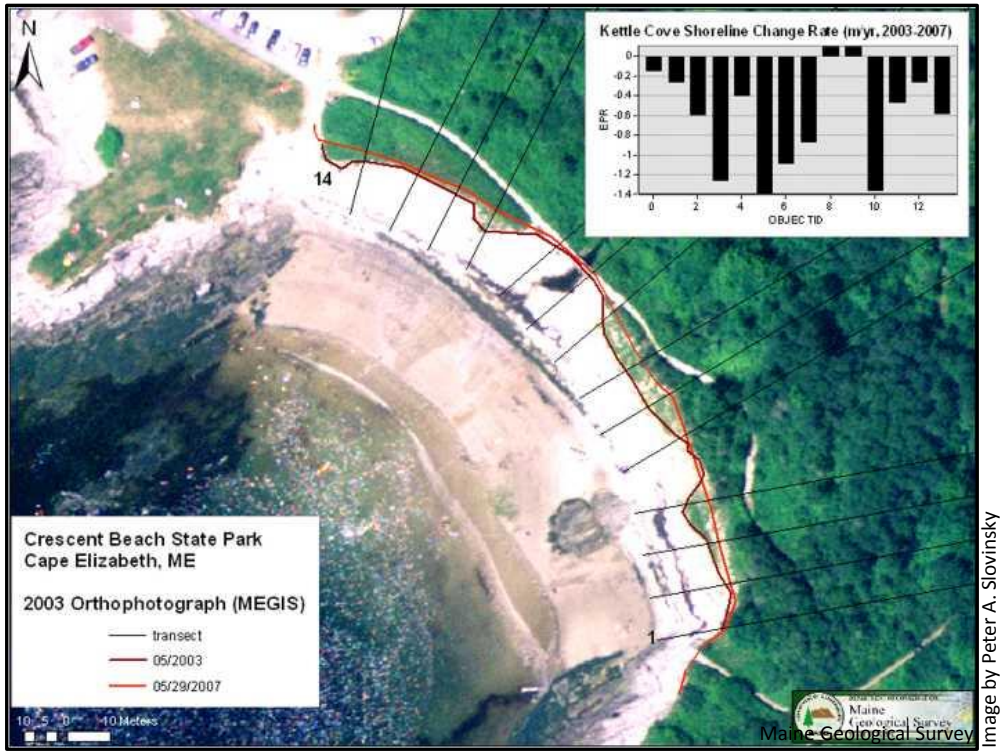


Figure 2. Shore perpendicular transects were used to determine the shoreline change rates along Kettle Cove between 2003 and 2007. The shoreline has eroded notably over that time period. Base imagery from MEGIS (2003).

Methods: Shoreline Change Rate

Changes along Crescent Beach State Park are shown in Figure 3. It should be noted that the 2003 shoreline does not correspond with 2004 LIDAR data, and that the 2007 MGS GPS field survey does not correspond directly with the 2007 LIDAR flight (see below).

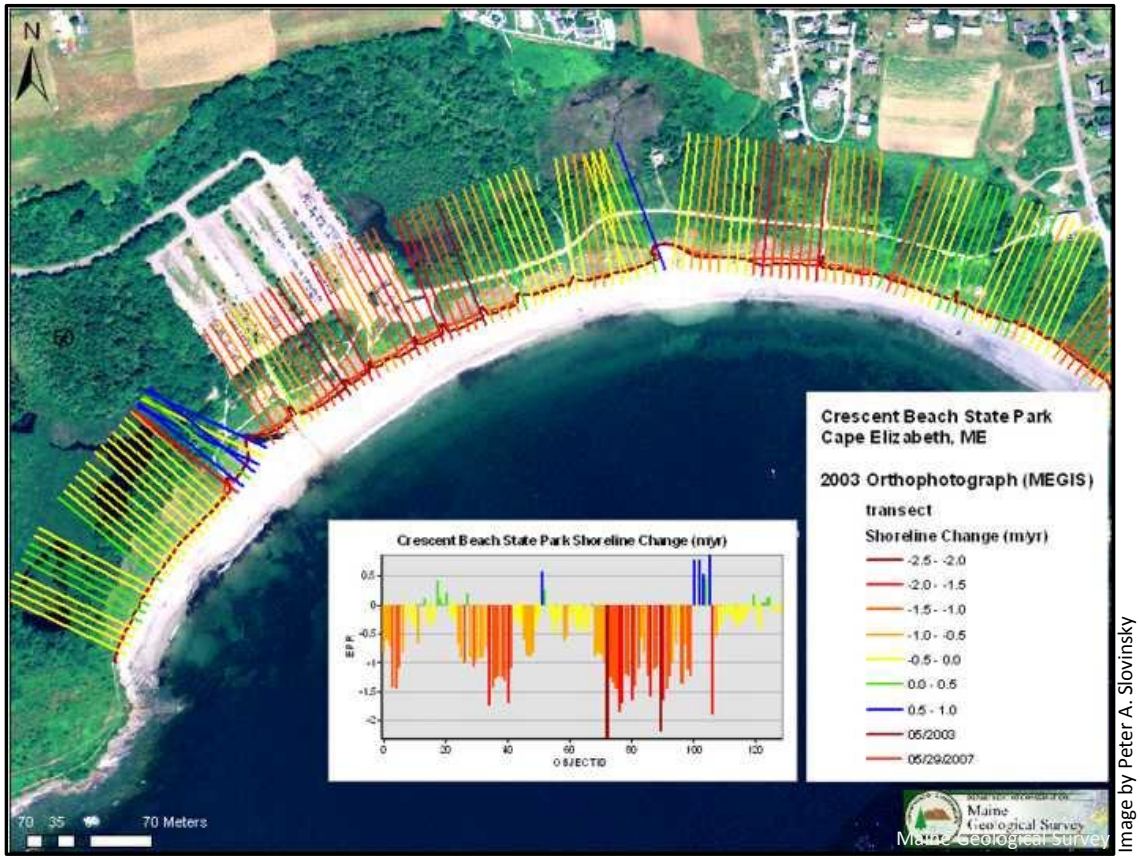


Figure 3. Color-coded shoreline change rates along Crescent Beach, calculated from data from 2003 and 2007. Transect numbering in the graph begins on the left at the east end of the beach and progresses right to the west end of the beach. Base imagery from MEGIS (2003).

Methods: LIDAR contour comparison

By comparing the horizontal (i.e., landward or seaward) positions of specific elevation contours on the beach and near the dune, one can determine whether or not a beach or dune is accreting or eroding. Typically, if a beach is accreting, contours will move in a seaward direction from Time 1 to Time 2. Conversely, if a beach is eroding, contours will move in a landward direction from Time 1 to Time 2. We extrapolated 0.5 meter contours from the 2004 (NOAA CSC) and 2007 (USACE) LIDAR data and compared the positions of the contours. Results for Kettle Cove are shown in Figure 4.

Figure 4. Comparison of 2004 (dashed) and 2007 (solid) contours, derived from LIDAR data, along Kettle Cove. It is clear that each contour has moved landward, indicating both beach and dune erosion. Base imagery from MEGIS (2003).

Methods: LIDAR contour comparison

Contour comparison results for Crescent Beach are shown in Figure 5

Figure 5. Comparison of 2004 (dashed) and 2007 (solid) contours, derived from LIDAR data, along Crescent Beach. Generally, contours have migrated in a landward direction, indicating net erosion. Base imagery from MEGIS (2003).

Methods: LIDAR grid comparison

By subtracting older topographic data (2004) from more recent LIDAR survey data (2007), one can visualize areas where the beach or dunes have lowered due to erosion (negative values), or built up due to accretion (positive values). Although some error from differences in processing out vegetation in creating the "bare earth" LIDAR elevations exists, this is generally considered minimal.

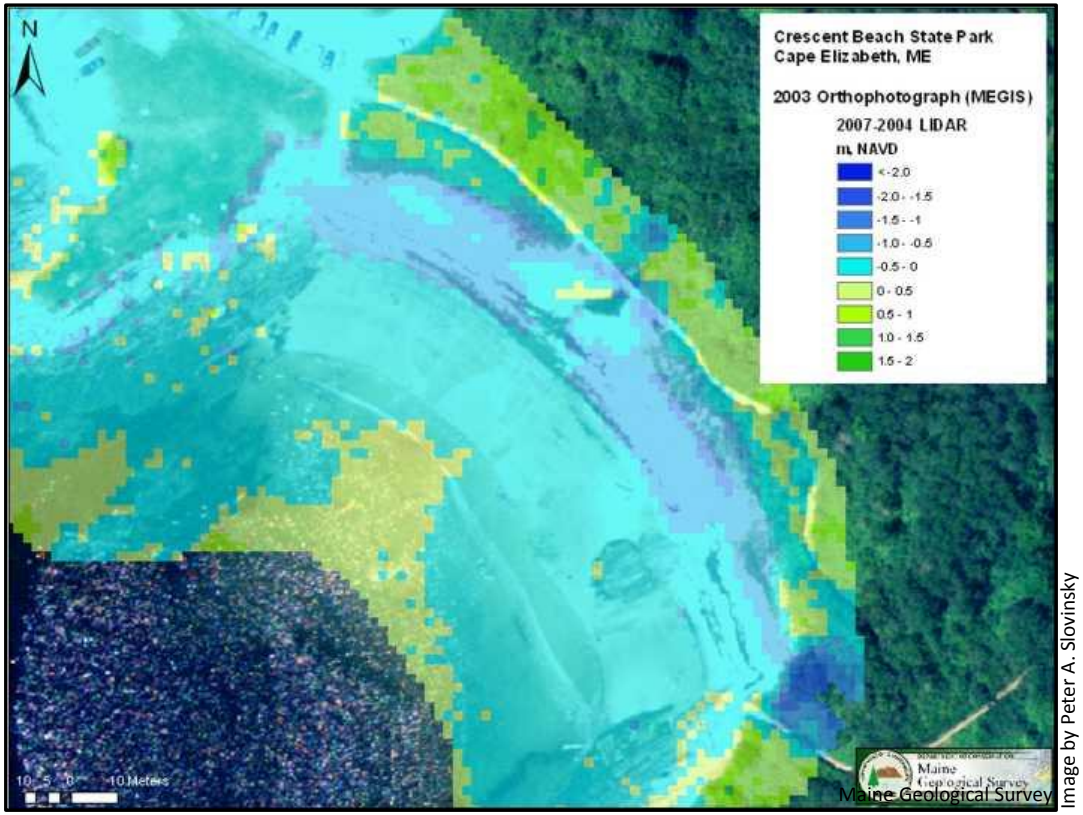


Figure 6. Subtraction of gridded LIDAR data (2007-2004) indicates areas of accretion (greens) and erosion (blues) along Kettle Cove. The majority of the beach and frontal dune has undergone erosion between 2004 and 2007. Base imagery from MEGIS (2003).

Methods: LIDAR grid comparison

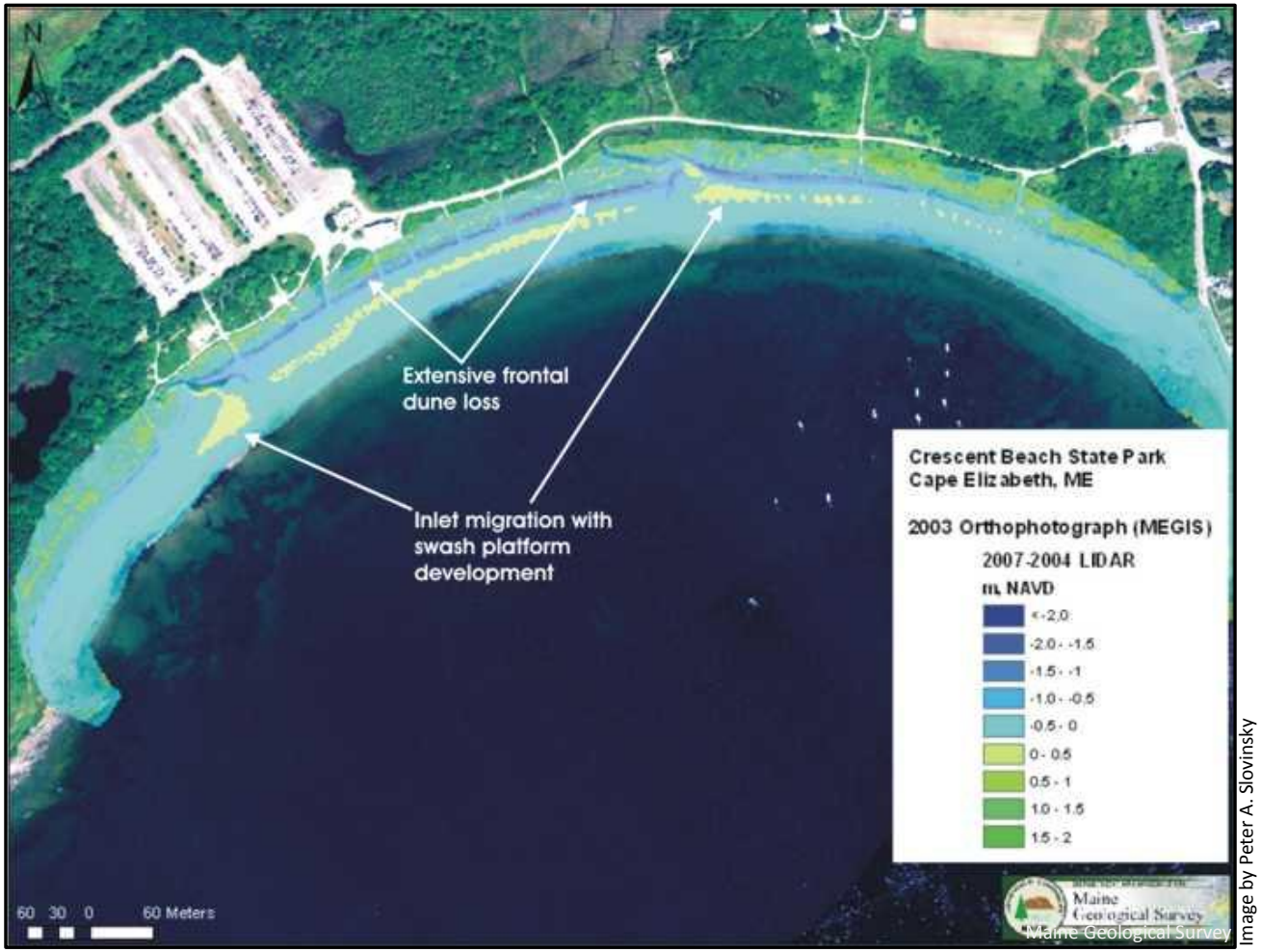


Figure 7. Subtraction of gridded LIDAR data (2007-2004) indicates areas of accretion (greens) and erosion (blues) along Crescent Beach. Along the middle section of the beach, there was a thin strip of accretion, while the frontal dunes and the remainder of the beach eroded between 2004 and 2007. Base imagery from MEGIS (2003).

Results: Kettle Cove

At Kettle Cove, shoreline change data indicates that the edge of vegetation has receded, on average, about -0.6 m/yr for the study period. The highest rate of erosion was recorded in the central portion of the beach at transects 4-7 (Figure 2). It appears that the footpath and walkway that crosses a small creek is in jeopardy of being lost.

Comparison of individual contours along Kettle Cove (Figure 4) shows that the beach and dune system is moving in a landward direction (eroding). The 0-3 m contour lines have all migrated landward between 2004 and 2007. The largest changes occurred at the 1, 2, and 3 m contour lines along the beach berm and frontal dune.

Grid subtraction (2007-2004) shows that a large portion of the tidal beach underwent little to no change (0 to -0.5 m), with slight accretion in the offshore (Figure 6). Along the exposed beach, about 1-1.5 m of sediment thickness was lost, and up to 2 m of dune elevation was lost between 2004-2007. Some growth of the back portion of the dune does appear to have occurred.

Results: Crescent Beach

Shoreline change data is summarized in a color-coded image in Figure 3. It is clear that the majority of Crescent Beach, based on the data collected, has undergone erosion from 2003-2007. Erosion appears to have been highest along the central section of the beach, in front of the parking area, with rates at many transects calculated to be over -1 m/yr of horizontal shoreline change along this stretch. There are pockets of relative stability over the study period, located adjacent to the small freshwater outlet streams , and along the easternmost section of the Crescent Beach shoreline.

LIDAR contour data comparisons for Crescent Beach are shown in Figure 5. Contour transgression (landward movement) generally occurred along the entire beach. The 0 m contour moved landward consistently along the beach. Inspection of the 1 and 2 m contours shows little change along the central portion (in front of the parking lot) of the beach, and movement of the easternmost inlet in a westerly direction. The 3 m contour, which roughly denotes the edge of the frontal dune in 2004, receded dramatically along this same central portion, and along the eastern portion of Crescent Beach.

LIDAR subtraction data (Figure 7) shows that there were extensive areas (dark blue) of frontal dune loss between 2004 and 2007, and lowering of sand levels along much of the beach (lighter blue). Of specific note is the apparent migration (to the east) of the eastern small inlet, and to the west of the western inlet. Associated with these migrations appear to be the development of swash platforms, marked by minor accretion.

Results: Crescent Beach

Based on the above available data from 2003-2007, we can designate six distinct regions (Figure 8), three that are highly erosive (more than -1 m/yr of shoreline change), and three that are less erosive and have some aspect of accretion. The data indicates that the small inlets (swashes) play a role in influencing erosion and accretion patterns along the beach.

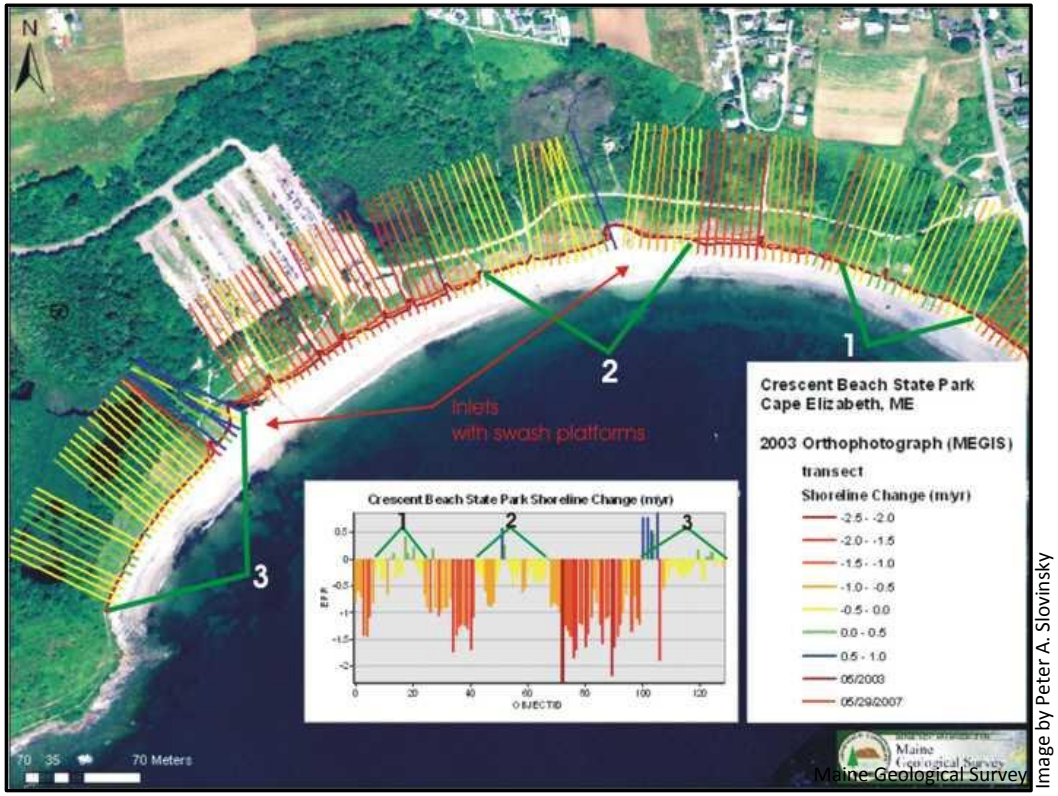


Image by Peter A. Slovinsky

Figure 8. Based on shoreline change rates from 2003 to 2007, the Crescent Beach shoreline can be divided into six distinct areas - three that follow highly erosive trends, and three that follow milder and slightly accretive trends (labeled 1, 2, and 3). Base imagery from MEGIS (2003).

Results: Crescent Beach

It appears that dune recession was most pronounced on the eastern side of Crescent Beach, with slightly less recession and some dune growth near an access path just to the west (this area is marked as region 1 in green). To the west of this is an area of increased dune erosion, with rates between -0.5 up to -1.5 m/yr recorded. The western boundary for this region is a small inlet, which generally drains freshwater marshes. Just seaward of this inlet, a swash platform is visible. On either side of the inlet (marked as region 2), the shoreline change rates appear to be lower, to slightly accretive.

A highly erosive region exists directly west of region 2. This area has undergone large amounts of erosion, with shoreline change rates over -1.5 m/yr at many transects. It appears that this area of dune and beach has been hit hardest by the storm events through 2007. Region 3, which begins at the eastern end of the western inlet, extends east to the headland. This section of the beach has been the most stable from 2003 to 2007, and has undergone the least amount of dune recession (less than -0.5 m/yr).

As the small inlets, or swashes, migrate in response to storm events, they abandon their former channels, and leave large slugs of sediment, which form swash platforms. These platforms apparently help to break up wave energy, thus minimizing the erosive effects of storms along the dunes adjacent to the inlets. This may explain why erosion adjacent to the inlets has generally been less than other areas.

Conclusions

Using available data from 2003 (aerial orthophotographs), 2004 (NOAA LIDAR), and 2007 (USACE LIDAR and MGS RTK-GPS survey), we have investigated shoreline change and topographic beach changes along Kettle Cove and Crescent Beach. The 2007 shoreline survey by MGS was completed after the 2007 Patriots' Day Storm, and therefore may not represent conditions that may be present in 2008, and may not show beach/dune recovery that did occur. However, the August 2007 USACE LIDAR data was flown in the summer, when beaches and dunes typically are at their largest.

Data indicates that acute erosion has occurred at both Kettle Cove and Crescent Beach between 2003 and 2007. Dune recession has occurred at rates that exceed -1 m/yr at both beaches, and observed beach lowering and landward contour migration support the losses observed in the shoreline change data. The small inlets along Crescent Beach appear to positively impact small portions of adjacent beach areas through the formation of ephemeral swash platforms, which change location in response to inlet channel migration. However, as the inlet channel migrates, erosion of other adjacent areas likely does occur.

Dune management at both Kettle Cove and Crescent Beach should continue to focus on the positive reuse of naturally occurring seaweed, i.e., instead of raking and removal of seaweed from the system, placement of the seaweed within the first several feet of the frontal dune. As available, funding for dune restoration should be considered at certain locations. Continued shoreline monitoring and regularly flown LIDAR surveys would help greatly with understanding future trends and help guide beach and dune management at this vital State Park.

References and Additional Information

Maine Office of Geographic Information Systems (MEGIS), 2003, Aerial orthophotographs, June 6, 2003.

National Oceanic and Atmospheric Administration (NOAA), 2004, Coastal Services Center Light Detection and Ranging topographic data.

United States Army Corps of Engineers (USACE), 2007, Light Detection and Ranging topographic data, August, 2007, courtesy of the New England District of the U.S. Army Corps of Engineers, Concord, Massachusetts.