State of Maine's Beaches in 2011

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Cover photo of Popham Beach State Park and Morse River by John Picher, Maine Department of Conservation, March 10, 2010.

Acknowledgments

We would like to take this opportunity to thank all the profile volunteers involved in this project. This report would be impossible without your efforts. The scientific understanding of the state of our beaches would be lessened without your diligent and sometimes heroic data collection throughout the year. We thank all of the groups and municipalities that, with Maine Sea Grant and the Maine Coastal Program have jointly funded the program in the last three years. We greatly appreciate the collaborative efforts of the Maine Sea Grant Program and Wells Estuarine Research Reserve that have coordinated profiling teams, conducted education and outreach programs, provided quality control on the data, and provided the Shore Stewards web site and database. We greatly appreciate the excellent field work of summer interns J. Howard (2007), K. Grasso (2008), L. Wurst (2009, 2010) and K. Marvinney (2011) surveying and mapping shoreline changes. We thank you all for a superb team effort - you have made this report possible.

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Introduction

The 2011 State of Maine's Beaches Report provides a follow up from the first report issued in 2007 (Slovinsky and Dickson, 2007), and a second report, issued in 2009 (Slovinsky and Dickson, 2009). The purpose of the report is to summarize major observed morphologic characteristics and changes of Maine beaches that are monitored as part of the State of Maine Beach Profiling Project (SMBPP, Maine Sea Grant Extension, 2003). The SMBPP utilizes trained volunteers to collect monthly beach profiles which start at a known point or benchmark (usually in the frontal dune or in a seawall) and continue shore-perpendicular to roughly the low water line. Fixed starting locations are used with the Emery Method of beach profiling (Emery, 1961). Data collected is entered by volunteers into an online database, where it is accessible for outside researchers (Maine Shore Stewards, 2007). The SMBPP is funded and managed by combined efforts of the Maine Geological Survey, University of Maine, Maine Sea Grant, and Maine Coastal Program.

The previous State of Maine's Beaches report discussed the data collection methodology used by the SMBPP program, and documented the changes that were observed in beach and dune topography at each beach profile on a year-by-year and seasonal (summer vs. winter) basis since the start of data collection (1999 for some beaches) and continuing through April 2006.

This report will build upon the last assessment, which reviewed the changes that occurred since the Patriots' Day Storm of 2007 (April 2007). This report will document additional changes at beaches since 2009, during the winter and summer months, at each location.

Spatial and Temporal Extent of Data for 2011 Report: Beach Profile Data
The locations of beaches involved in the program as of May 2011 are shown in Figure 1. Generally, there are 2-4 profiling locations along each beach. Along each collected profile, topographic (elevation) points are generally collected at approximately 3-meter (10-foot) intervals, from the starting point (usually a stake in the dune crest or mark on a seawall) seaward to the low-water line using the Emery Method of profiling.

This report will compare profile data from immediately post-Patriots' Day Storm (i.e., April or May 2007), and profile data from the subsequent closest months from 2008 through 2011, as available. Late spring is typically when the beach profile shape is lean, with little sand on the upper portion of the beach after a season of winter storms. The immediate, post-Patriots' Day storm beach profile is considered to be the starting point for recovery. Spring beach profiles that were used for this analysis are shown in Table 1. This kind of analysis builds on the work completed for the 2009 beaches report.

The report also analyzes the changes of the "summer" beach shape from 2007 through 2010, in order to investigate whether or not the typical recreational beach - usually defined by a wider, sand-rich beach profile, was able to

recover each year. Summer beach shapes are typically fully developed by August or September, after a season of gentle waves and accretion. Summer beach profiles that were used for this analysis are shown in Table 2.

For this analysis, it is important to note that some locations have been discontinued from profiling, including Fortunes Rocks Beach in Biddeford, and Western Beach in Scarborough. Other sites, such as Ogunquit, only have limited data at several profile points. Many beach profile starting points were lost in the Patriots' Day Storm, which led to some post-storm data gaps, or problems in relating profiles taken from front stakes (lost in the storm) to profiles recorded from back-stake starting points.

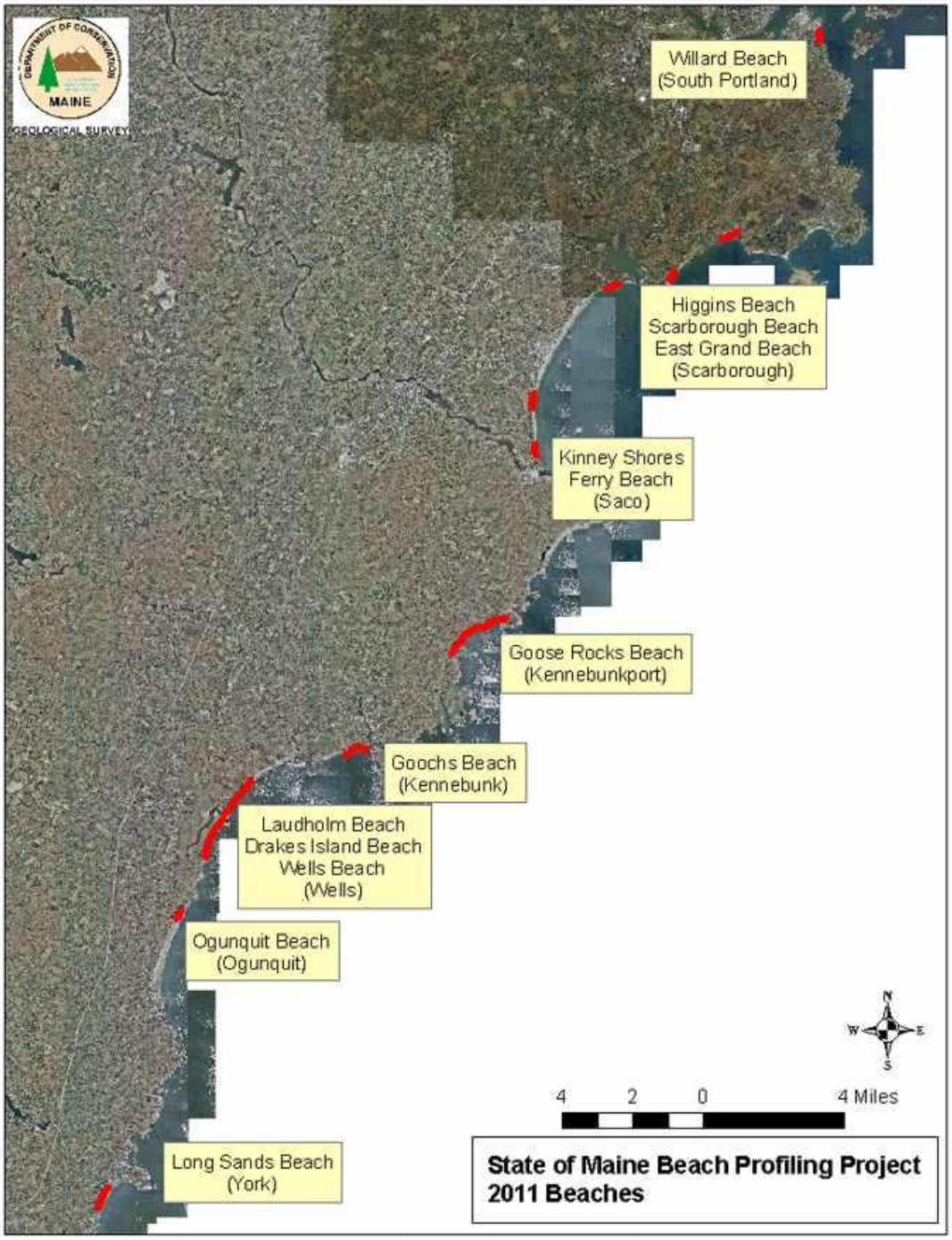

Figure 1. Locations of beaches monitored as part of the State of Maine Beach Profiling Program (SMBPP) in 2011. Base imagery from Maine Office of GIS.

Beach Name (Acronynm)	Profile Number	Date				
		2007	2008	2009	2010	2011
Willard (WI)	01	4/20	4/11	3/10	N/A	
	03	4/20	4/11	3/10	N/A	
	06	4/20	4/11	3/10	N/A	
Higgins (HI)	01	4/22	4/11	4/5	4/23	4/14
	02	4/22	4/11	4/5	4/23	4/14
	03	4/22	4/11	4/5	4/23	4/14
Scarborough (SC)	01	4/21	4/14	5/3	4/24	4/22
	02	4/24	4/14	5/3	4/24	4/22
	03	4/24	4/14	5/3	4/24	4/22
	04	4/24	4/14	5/3	4/24	4/22
East Grand (EG)	01	4/21	9/18	5/4	4/21	3/30
	02	4/21	9/18	5/4	4/21	3/30
	03	4/21	9/18	5/4	4/21	3/30
	04	4/21	9/18	5/4	4/21	3/30
Kinney Shores (KS)	01	4/22	3/6	3/16	3/8	2/25
	02	4/22	3/6	3/16	3/8	2/25
Ferry (FE)	01	4/20	4/15	5/1	4/23	4/15
	02	4/20	4/15	5/1	4/23	4/15
	03	4/20	4/15	5/1	4/23	4/15
	04	7/27	4/15	5/1	2/5	4/15
Goose Rocks (GR)	01	4/21	4/15	4/4	4/24	4/15
	02	4/21	4/15	4/4	4/24	2/26
	03	5/21	4/14	4/7	4/25	4/16
	04	4/23	4/14	4/7	5/22	4/16
Goochs (GO)	01	6/25	4/13	4/4	4/25	4/15
	02	4/22	4/13	4/4	4/25	4/15
	03	4/22	4/13	4/4	4/25	4/15
	04	4/22	4/13	4/4	4/25	4/15
Laudholm (LH)	01	6/23	4/11	5/1	4/23	4/22
	02	4/20	4/11	5/1	4/23	4/22
	03	4/20	4/11	5/1	4/23	4/22
	05	4/20	4/11	5/1	4/23	4/22
Drakes Island (DI)	01	5/14	5/1	5/20	7/16	N/A
	02	5/14	5/1	5/20	7/16	N/A
	03	5/14	5/1	5/20	7/16	N/A
	04	5/14	5/1	5/20	7/16	N/A
Wells (WE)	00	4/21	4/12	4/4	4/24	3/5
	02	4/21	4/12	4/4	4/24	3/5
	03	4/21	4/12	4/4	11/13	3/27
	04	4/21	4/12	4/4	11/13	3/27
Ogunquit (OG)	01	5/19	5/24	11/15	N/A	
	02	4/21	5/24	12/11	4/23	4/16
	03	5/19	5/24	N/A		
	04	4/21	5/24	N/A		
Long Sands (LS)	01	4/22	4/13	4/15	4/25	4/15
	03	4/22	4/13	4/15	4/25	4/15
N/A = No data available at time of report preparation.						

Table 1. Available beach profile data from the online database used for comparison of winter profiles.

Beach Name (Acronynm)	Profile Number	Date			
		200	2008	2009	2010
Willard (WI)	01	N/A			
	03	N/A			
	06	N/A			
Higgins (HI)	01	8/24	8/22	8/24	8/17
	02	8/24	8/22	8/24	8/17
	03	8/24	8/22	8/24	8/17
Scarborough (SC)	01	8/28	7/27	8/23	8/21
	02	8/28	7/27	8/23	8/21
	03	5/21	10/17	8/23	8/21
	04	8/28	7/27	8/23	8/21
East Grand (EG)	01	6/22	9/18	8/24	8/18
	02	5/21	9/18	8/24	8/18
	03	5/21	9/18	8/24	8/18
	04	5/21	9/18	8/24	8/18
Kinney Shores (KS)	01	8/27	8/28	8/20	9/10
	02	8/27	8/28	8/20	9/10
Ferry (FE)*	01	7/27	6/24	7/27	7/16
	02	7/27	6/24	7/27	7/16
	03	7/27	6/24	7/27	7/16
	04	N/A	6/24	7/27	7/16
Goose Rocks (GR)	01	8/26	8/23	8/24	8/14
	02	8/26	8/23	8/24	8/14
	03	8/27	8/26	8/24	8/14
	04	8/27	8/26	8/24	8/14
Goochs (GO)	01	8/24	9/21	8/24	8/13
	02	8/24	9/21	8/24	8/13
	03	8/24	9/21	8/24	8/13
	04	8/24	9/21	8/24	8/13
Laudholm (LH)	01	8/24	8/22	8/25	8/13
	02	8/24	8/22	8/25	8/13
	03	8/24	8/22	8/25	8/13
	05	8/24	8/22	8/25	8/13
Drakes Island (DI)	01	6/12	5/1	5/20	7/16
	02	6/12	5/1	5/20	7/16
	03	6/12	5/1	5/20	7/16
	04	6/12	5/1	5/20	7/16
Wells (WE)	00	8/27	8/23	8/30	7/16
	02	8/27	8/23	8/30	7/16
	03	8/27	8/23	8/30	11/13
	04	8/27	8/23	8/30	11/13
Ogunquit (OG)	01	N/A			
	02	8/25	7/26	12/11	7/17
	03	N/A			
	04	N/A			
Long Sands (LS)	01	8/26	8/23	7/25	8/15
	03	8/26	8/23	7/25	8/15
*2011 data included from 6/17 for Ferry Beach Saco only.					

Table 2. Available beach profile data from the online database used for comparison of summer profiles.

The 2007 Patriots' Day Storm

The Patriots' Day Storm of 2007, which was detailed in depth the 2009 report, battered the Maine coastline for days with heavy winds and rain, large waves, and a high storm surge, and had a large impact on Maine's beaches. Offshore waves during the storm reached upwards of 8 meters (30 feet), and stayed above 3 meters (9 feet) for several days, while winds were measured at 60 mph in Portland, and gusts approaching 80 mph were reported in Cape Elizabeth.

Tide gauge recordings (NOAA COOPS, 2007; Slovinsky, 2007) of water levels in Portland Harbor indicated that the storm produced a surge (an extra elevation of the sea) driven by the wind and low barometer to levels of 0.7 meters (or 2.5 feet) above that predicted. The storm surge is the difference from the predicted tide and the storm tide as recorded by the tidal gauge. The surge peaked between 10 and 11 a.m. on April 16, 2007 and remained elevated for 6 more high tides before the storm's influence abated. As a result of the high winds, waves, and tides, extensive beach erosion occurred.

The Winter of 2010

The winter of 2010 was punctuated by a series of significant storm events that left many of Maine's beaches in relatively poor shape going into the 2010 summer season. The winter of 2010 started off relatively average, with three storm events with wave heights exceeding 2 m (6 feet) in early, mid, and late January. Winter waves of this height are not out of the ordinary. However, this was due to change.

Most of February was very quiet until the end of the month. Then, a larger northeaster which started on February 24 and lasted several days struck, with wave heights peaking over 6.1 m (20 feet) on February 26 (Figure 2). The storm produced a surge of 1-2 feet which lasted from February 24 to March 1, and peaked with a large storm surge of just over 4 feet on February 26 (Figure 3). The last time a surge of over 4 feet was recorded at the Portland tide gauge was in 1947. This pushed higher than normal "spring" high tides up to or over 12 feet above MLLW (mean lower low water) 5 times between February 26 and March 4.

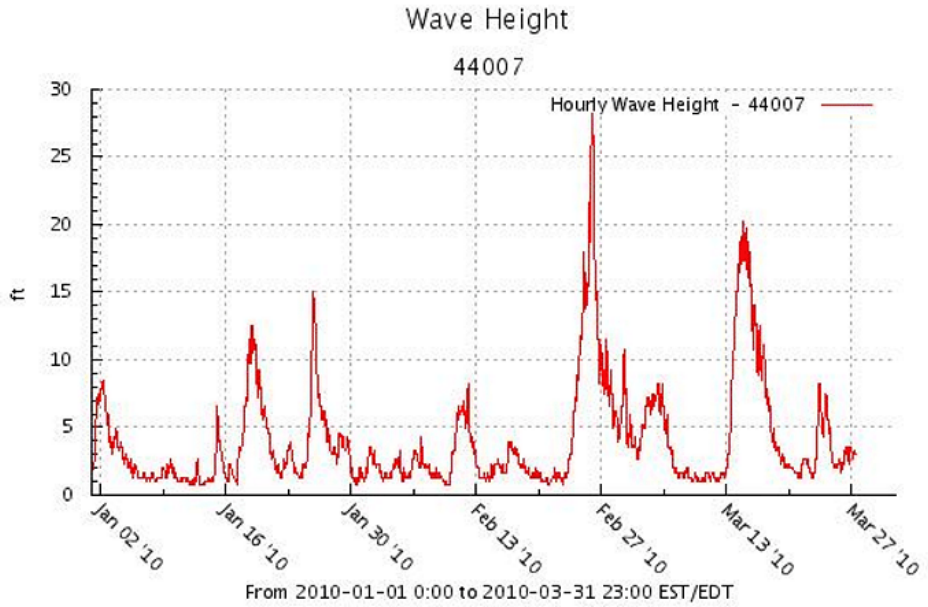

Figure 2. Offshore waves measured hourly at NOAA NDBC Buoy 44007 (red line) and GoMOOS Buoy B01 (green line) from December 2009 through the end of April 2010. Note large storm events in late February and early March. Data courtesy of GoMOOS.

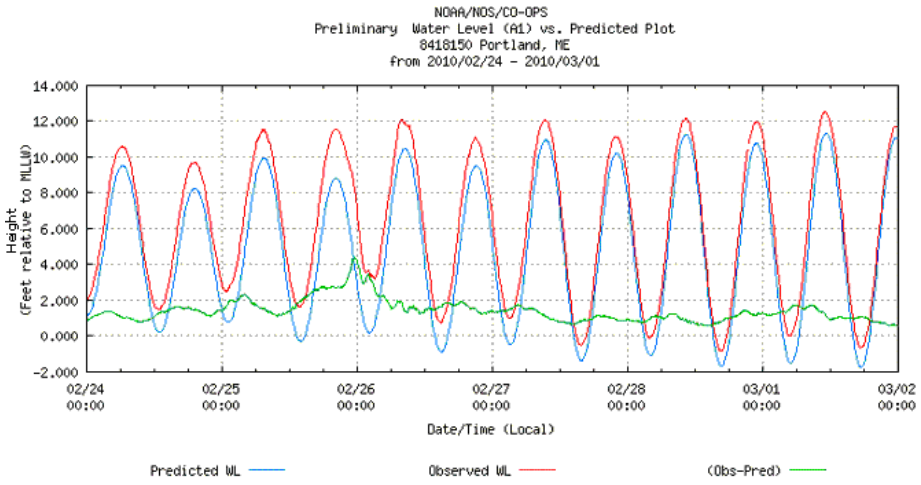

Figure 3. Tide gauge recordings of water levels in Portland Harbor (NOAA gauge 8148150) from February 24, 2010 to March 1, 2010. The predicted water level is shown in blue, while the observed water level, in red. The difference between the two (green line) is the storm surge. Note that during this time period, storm surge exceeded 4 feet on February 26, 2010, and that tides exceeded 11 feet for 10 consistent high tides, and reached or exceeded 12 feet on 5 high tides. Data from NOAA NOS CO-OPS.

Then two weeks later, another large multi-day northeast storm hit the coast. Starting on March 14, wave heights grew and peaked to 5.5 m (18 feet) on March 15, and stayed over 2 m (6 feet) until March 17. However, this event was not nearly as potent as the February storm, since it coincided with lower astronomical tides (around 8-9 feet above MLLW). Also, the surge was lower, running generally between 1 to 2 feet from March 13 to 17. Thus, total water levels remained below 11 ft MLLW for the duration of the event (Figure 4).

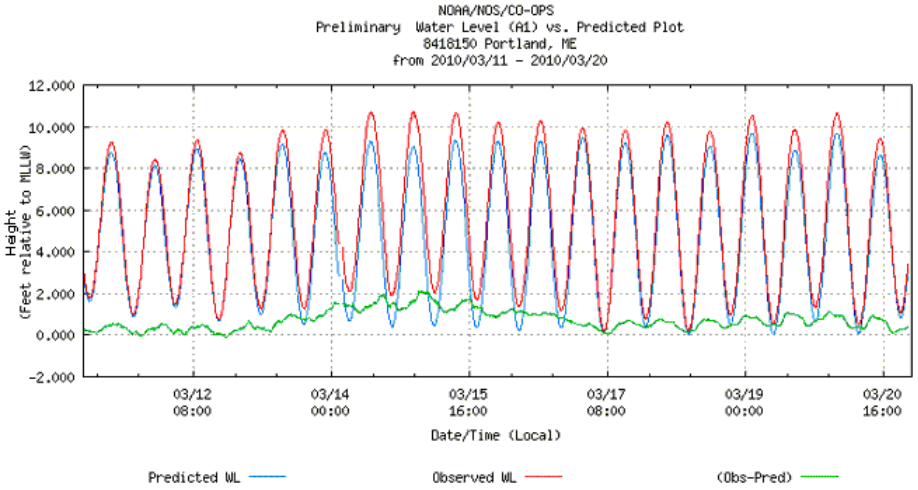

Figure 4. Tide gauge recordings of water levels in Portland Harbor (NOAA gauge 8148150) from March 11 to March 20, 2010. The predicted water level is shown in blue, while the observed water level, in red. The difference between the two (green line) is the storm surge. Note that surge reached near to 2 feet from March 14-15, 2010. Data from NOAA NOS CO-OPS.

As a result of this "one-two punch," many southern Maine beaches experienced very high levels of beach erosion. This resulted in some beaches being eroded vertically to levels even lower than the 2007 Patriots' Day Storm event, and exposed old marsh surfaces in the surf zone that had not been seen in decades (e.g., Higgins Beach in Scarborough). This also led to a generally steeper beach face, and a very low low-tide terrace at some beaches. This enhanced rip-current formation during the later summer months, which was reported in the news throughout the

summer of 2010. This phenomenon occurred at Old Orchard Beach for much of the summer, and resulted in above average lifeguard rescues.

Review of Beach Responses

This portion of the report will progress in a north-to-south format, starting with the northernmost monitored beach, Willard Beach in South Portland, and ending with Long Sands Beach, in York. No discussions of overall beach conditions and characteristics will be made, as this was completed in the initial Beaches report from 2007.

First, we will review profile changes using the immediate post-2007 Patriots' Day Storm (either from April, May, or June 2007, as data is available) with profile shapes from subsequent years from roughly the same months, through April or May 2011. This will allow us to build upon the review we completed for the 2009 report, which detailed profile recovery through April or May 2009. Review of the "winter" beach profile shapes will allow us to detail whether or not the beaches have continued to recover (or erode, or switch their recovery) from the Patriots' Day Storm event, which is considered in many locations to have created the most erosive beach profile shape over the past 4 years.

We will also review profile changes and recovery from 2007 through 2010 for the "summer beach" profile shapes at each profiling location. This will include, as data is available, profile data from August or September of each year from 2007 through 2010; unfortunately, we will be unable to include 2011 summer beach data since it has not been collected yet. It is generally not sound to compare May or June profiles with August or September profiles, since Maine beaches are typically still recovering from the winter in May and June, and fully developed by August or September. However, in specific cases such as at Ferry Beach in Saco, we decided to include analysis of profile data collected in June 2011. This was included because (a) beach profile starting pins were relocated in spring 2010, and (b) additional profile data was needed to investigate how the dune restoration project completed in that area in spring 2009 has been fairing.

As part of this review, consistent with the 2009 assessment, we assigned a "grade," based on the amount of stability or recovery (or lack thereof) exhibited by each profile for both summer and winter beach profile shapes. Then, for each beach, an average grade for the "winter" beach changes (2007 to 2011) and the "summer" beach changes (2007 to 2010) were created. Finally, an overall beach grade was assigned, as an average of all the summer and winter profile scores. Note that this grading system is qualitative, and described in Table 3.

Note that in this ranking system, we consider a score of an A or B to indicate excellent or very good recovery or growth, a C to be considered a cautionary with erosion present, and a D or F to be very cautionary or failing scores, signifying extensive ongoing erosion

Willard Beach, South Portland

Willard Beach, South Portland data was not available at the time of report preparation, therefore, it is excluded from this review. In the previous assessment, Willard Beach demonstrated very good post-storm recovery and achieved a score of an A-.

Higgins Beach, Scarborough

A total of three beach profiles (HI01, HI02, and HI03) were available for comparison (Figure 5). The profiles extend from southwest to northeast, along the beach.

Figure 5. Location of beach profiles HI01 to HI03 at Higgins Beach, Scarborough. Base imagery from Maine Office of GIS.

Winter Profile Changes

HI01 = C- (72)

Profile HI01 (Figure 6), which is located at the main seawall at Higgins Beach, received an A in the last assessment. In 2008, the beach profile showed marked recovery from April 2007, with gains in sediment along the uppermost portion of the profile, and at the 50 m mark and seaward of the 100 m mark. Note that it was impossible to compare the profiles between 2008 and 2009 since the seawall where the pin was located was reconstructed. In 2010, the starting pin was relocated as close to its original position in 2008 as possible. The 2010 profile showed significant erosion and lowering of over 1 m along its entire length in response to a very stormy winter season. This profile shape exposed the historic erosional surface i.e., large peat outcrops visible in the surf zone. Luckily, by 2011, the beach appears to have recovered from this erosive year and returned to a shape more consistent with the 2008 shape; however, it is steeper nearest the seawall, and lower seaward of the 40 m mark. This profile, although it recovered from the 2010 shape, has been eroded to just above its 2007 shape. This profile warrants caution due to its shape in 2010, and should be monitored closely to see if it maintains its elevation

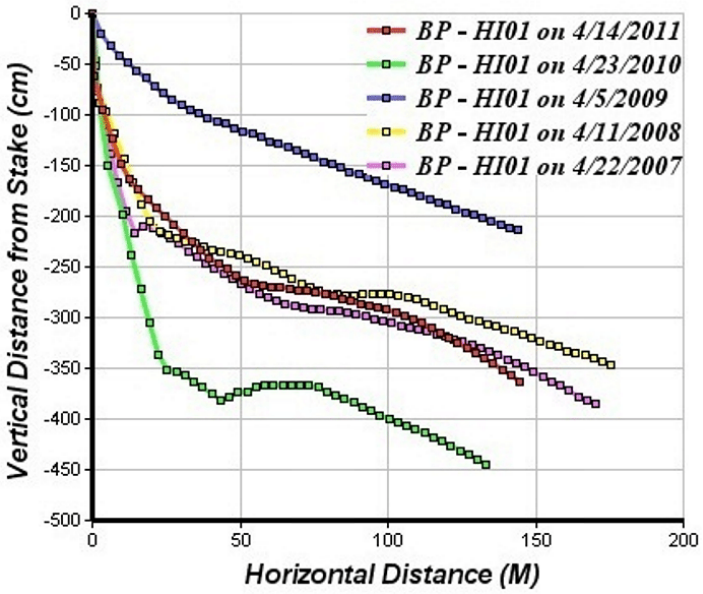

Figure 6. Winter beach profiles from Higgins Beach profile line HI01.

HI02 = F (55)

Profile HI02 (Figure 7), located at a smaller seawall, received a B in the last assessment. The profile exhibited relatively good recovery from 2007 to 2009. In 2010, the profile lost about 1 m of sand at the start of the profile (adjacent to the wall), and 50-60 cm of sand at the 50 to 100 m marks. Although some slight recovery was apparent by April 2011, the profile remains well below - on the order of 30-50 cm - the immediate post-storm Patriots' Day Storm profile. The fact that this profile has been so low in elevation for both 2010 and 2011 suggests that it has undergone significant erosion in the last two years.

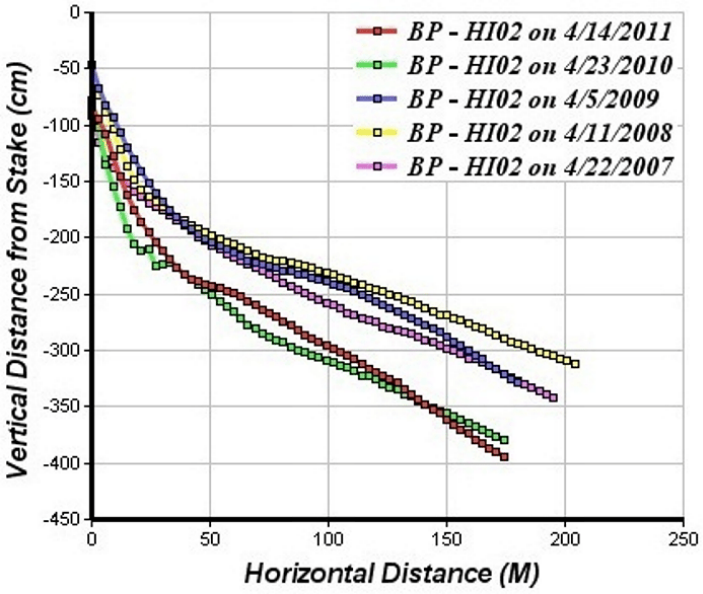

Figure 7. Winter beach profiles from Higgins Beach profile line HI02.

HI03 = B (85)

Profile HI03 (Figure 8), located in a natural dune system close to the Spurwink River, received a C in the last assessment. This profile displays the influence of the Spurwink River on trapping sediment moving in an easterly-directed longshore drift. The 2009 report indicated that the profile actually gained sediment as a result of the

Patriots' Day Storm. In 2008, the profile showed additional dune and beach berm building, along with a large offshore bar. However, the 2009 beach profile showed significant loss of sediment along the profile, especially starting near the 60 cm elevation, though there was additional seaward growth of the dune.

In 2010, additional nearshore growth of the beach occurred, between the 30 and 75 m offshore marks. Offshore loss of sediment occurred starting at the 75 m mark (at a depth near -2.25 m), and the profile here was below the 2009 elevation. This trend continued in 2011, with additional growth of the dune and beach out to about 50 m, coupled with vertical loss of the profile on the order of 50 cm, starting at roughly the 50 m mark. This profile is showing significant seaward growth of the dune and beach, but steepening and lowering of the profile in the offshore area.

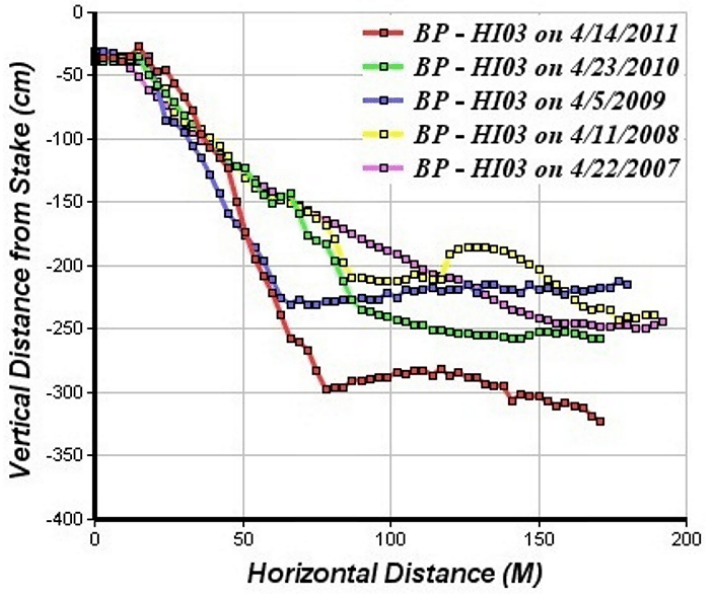

Figure 8. Winter beach profiles from Higgins Beach profile line HI03.

Winter Beach Grade = C- (71)
The winter profiles at Higgins Beach vary greatly. HI01 and HI02, both at seawalls appear to be concave, while HI03, backed by a dune, is highly variable due to its proximity to the Spurwink River. Erosion appears to be occurring at HI01 and HI02, with accretion at HI03.

Summer Profile Changes
HI01 = C (75)
From 2007 to 2008, HI01 responded relatively well, gaining in elevation along its entire length and showing a well-defined berm at the 10-25 m mark (Figure 9). It was impossible to compare the profiles between 2008 and 2009 since the seawall where the pin was located was reconstructed. By 2010, the pin was relocated as close to its original position in 2008 as possible. The 2010 profile showed loss of the berm that was evident in 2008, and erosion of the profile down to 2007 elevations out to about 25 m from the starting pin. Seaward of this, the 2010 summer profile maintained a shape almost exactly as the 2008 shape. This profile appears to have been relatively stable in the summer since 2008. However, this profile saw erosion of its dry beach berm in 2010, which reduced space for summer beach recreation. Comparison with an August 2011 summer profile is needed to see if the beam has recovered this season or if erosion has continued.

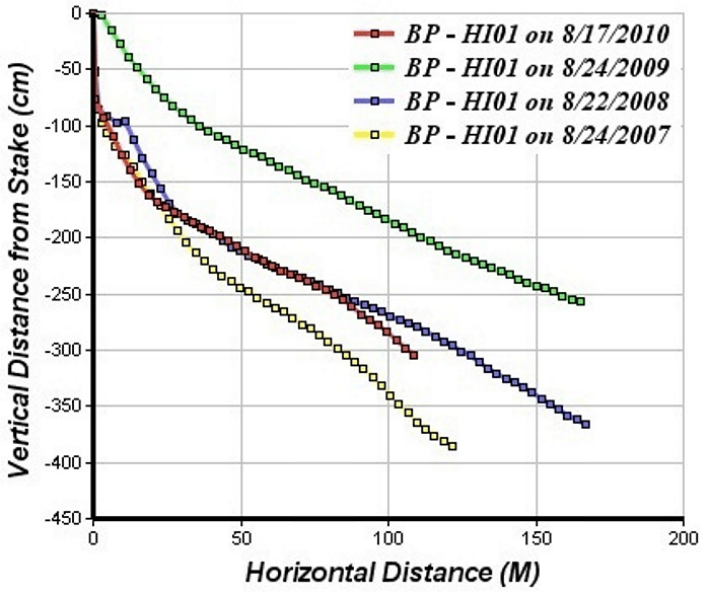

Figure 9. Summer beach profiles from Higgins Beach profile line HI01.

HI02 = F (55)

The 2008 summer profile showed stability in the berm adjacent to the seawall that had formed in the 2007 summer profile (Figure 10). A well-defined break in slope existed at the 25 m mark, marking the base of the berm and start of the low-tide terrace area. There was a slight gain in elevation seaward of this mark by 2008. By 2009, however, the profile changed shape significantly, with complete loss of the well-defined berm (the elevation of the sand at the starting point below the mark on the wall fell by about 50 cm), and flattening of the profile into the offshore. The summer of 2010 saw additional extensive erosion, with additional elevation loss of the sand near the wall, a steepening shorefront, a low berm, and increased erosion in the lower tide area of the profile. In fact, at the 50 m mark, the profile had lost almost 0.7 m vertically, increasing in loss offshore. In This profile has undergone extensive erosion since 2007, with the largest changes occurring in the 2009-2010 seasons.

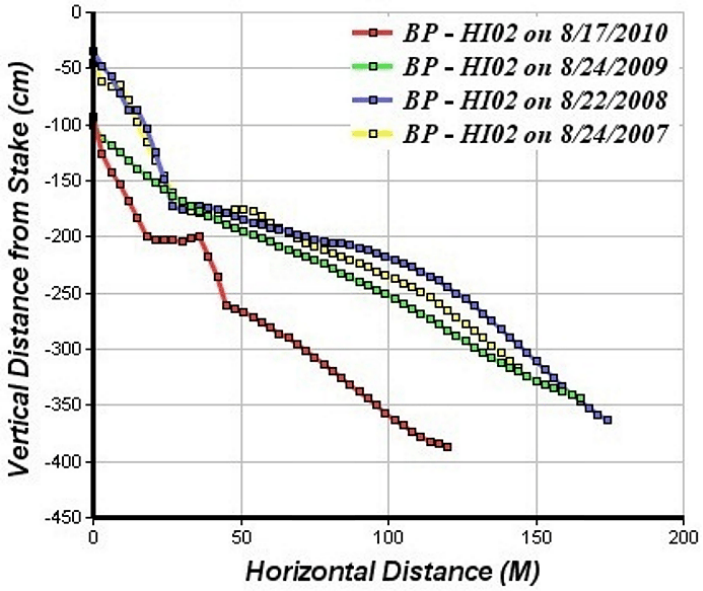

Figure 10. Summer beach profiles from Higgins Beach profile line HI02.

HI03 = A+ (98)

The 2008 profile (Figure 11) exhibited good growth, especially in the nearshore out to about the 50 m mark, with the development of a large, well-defined berm. In 2009, this berm was eroded landward, and the profile lost sediment along the majority of its shape; however, the dune had built seaward slightly. In 2010, the dune continued to prograde (build seaward), and increased in elevation. A large, well-defined berm formed seaward of the 2008 location, indicating significant accretion. The break in slope to the low-tide area, found near 60 m mark in 2008, also moved seaward. This profile is showing signs of substantial accretion, especially along the dune and upper portion of the berm, in the past few years.

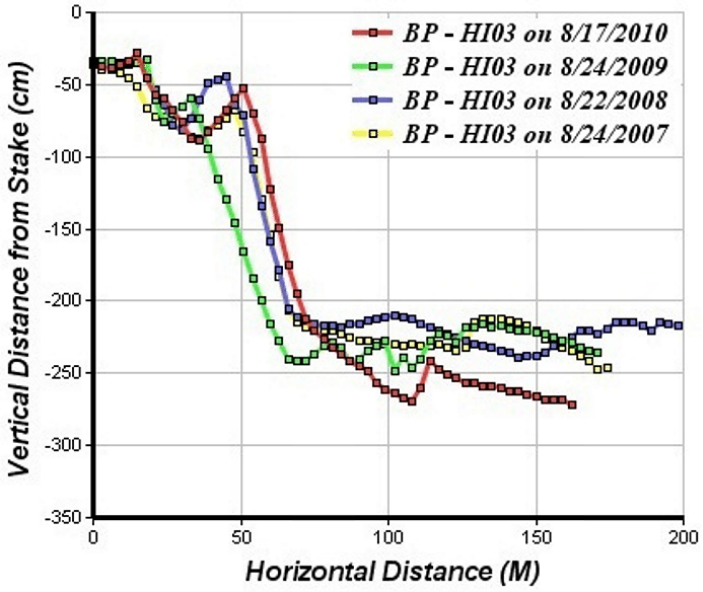

Figure 11. Summer beach profiles from Higgins Beach profile line HI03.

Summer Beach Grade = C (76)
Summer profiles at Higgins Beach typically have shown a small berm. This condition still exists near HI01, but at HI02 the berm has disappeared, consistent with erosion the rest of the profile is experiencing. Massive accretion is occurring at HI03.

Summary
Based on analysis of winter and summer profiles, it appears that Higgins Beach is showing signs of erosion, especially at its middle portion (near HI02). It appears that, since 2009, sand is being eroded from the middle portion of the beach, and moving towards the Spurwink River area. This is noted by the substantial erosion at HI02, and the large amounts of accretion of the dunes and berm at HI03. Summer beach recovery at HI01 near the new seawall appears to be potentially decreased, though this may be due to slow recovery from the 2010 winter storms; however, we are concerned about the potential impact the new seawall may be having on HI01's ability to recover. Comparison of summer profiles from 2011 is important to see if current erosive trends at HI01 and more so HI02 continue.
Overall grade = C- (73)

Scarborough Beach, Scarborough

A total of four beach profiles (SC01 to SC04, Figure 12) were available for comparison. The profiles run chronologically from northeast to southwest along the beach. Stakes at SC02-SC03 were lost after the Patriots' Day Storm and relocated in the approximate area of the previous stakes.

Figure 12. Location of beach profiles SC01 to SC04 at Scarborough Beach, Scarborough. Base imagery from Maine Office of GIS.

Winter Profile Changes

SC01 = C (75)

SC01 (Figure 13), located north of the beach access path at Scarborough Beach State Park, received a C+ in the 2009 assessment. By 2008, the profile gained slightly in elevation along its length, mostly at the berm. The 2009 profile indicated some loss in berm elevation. 2010 exhibited the formation of a berm again, while the upper portion of the profile remained relatively stable. The 2011 profile showed a stable upper portion, but loss along the lower portion of the profile. The 2011 shape appears to be more erosive than the 2008 recovered shape, but not as bad as the immediate post-Patriots' Day Storm shape. Overall changes at the profile appear to be minimal, but show a slightly erosive trend since some recovery in 2008.

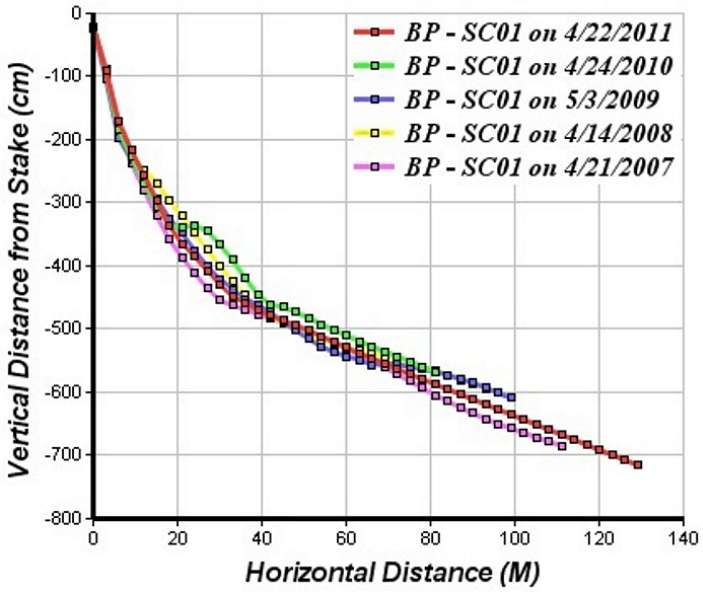

Figure 13. Winter beach profiles from Scarborough Beach profile line SC01.

SC02 = C (75)

Profile SC02 (Figure 14), located just south of SC02 but still north of the access path, received a B in the 2009 assessment. By 2008, recovery was noted along the upper portion of the profile, though the offshore portion underwent little change. Notes from the volunteers state that the pin was lost in 2009 and reset in May 2009; therefore, it is difficult to compare 2008 and 2009 data. Between 2009 and 2010, the profile lost sediment along its upper and lower portions, but did gain a notable berm near the 30 m mark. By 2011, the profile had eroded back to a shape that was just below the 2009 shape. Based on changes since the pin was moved in 2009, the profile appears to be slightly erosive.

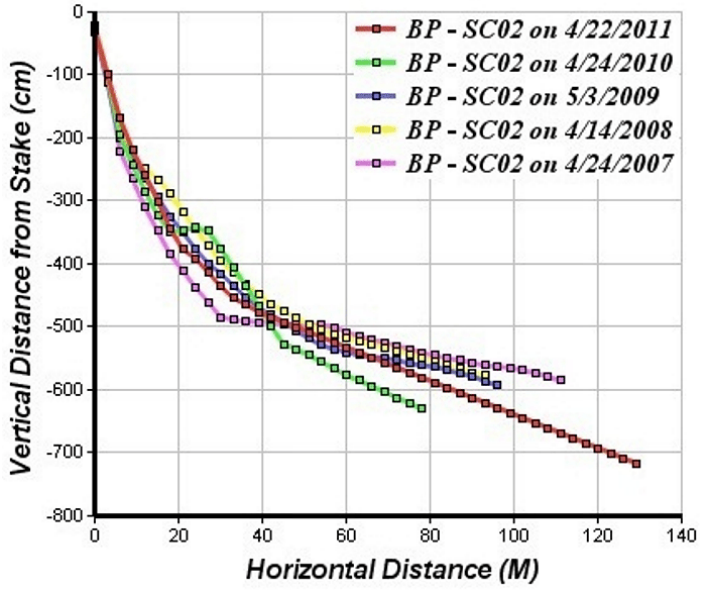

Figure 14. Winter beach profiles from Scarborough Beach profile line SC02.

SC03 = F (55)

Profile SC03 (Figure 15), located just south of the access path, received a C in the 2009 assessment. According to volunteer notes, the profile starting pin at SC03 (Figure 15) was lost during the Patriots' Day Storm. A new pin

position was located in March 2008, and this will be used as the "starting point" for profile comparison. From 2008 to 2009, the profile underwent erosion and lowered along its entire length. Recovery appears to have occurred in 2010, with elevation gains along the profile back to 2009 levels, and the formation of a notable berm at the 40 m mark. However, by 2011, the profile eroded to well below the initial 2008 elevation, and in fact, below the 2007 profile shape along its entire length. It also lost elevation at its dune. This profile is showing evidence of substantial erosion, especially in the last 2 years.

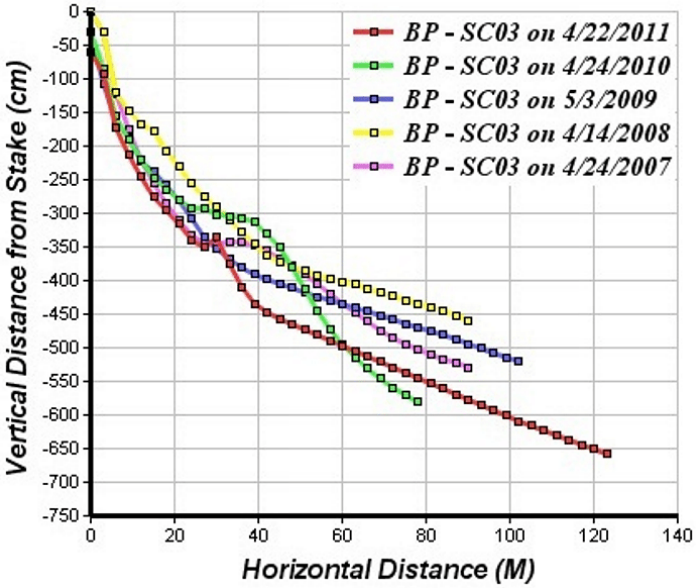

Figure 15. Winter beach profiles from Scarborough Beach profile line SC03.

SC04 = C (75)

SC04 (Figure 16) received a C in the last assessment. The profile recovered from its 2007 shape very well by 2008. This trend is consistent with SC03. However, by 2009, the profile had been eroded back to near the post-storm 2007 shape. In 2010, the profile recovered, with a notable well-defined berm near the 40 m mark. However, this was eroded mostly in 2011, and the lower portion of the profile (from about 40 m seaward) is actually lower than the 2007 post-storm shape. If we use the 2008 profile as a starting point, this profile is clearly eroding. If the 2007 profile is used, it is showing some stability, with shapes consistent in 2008, 2009, and 2011.

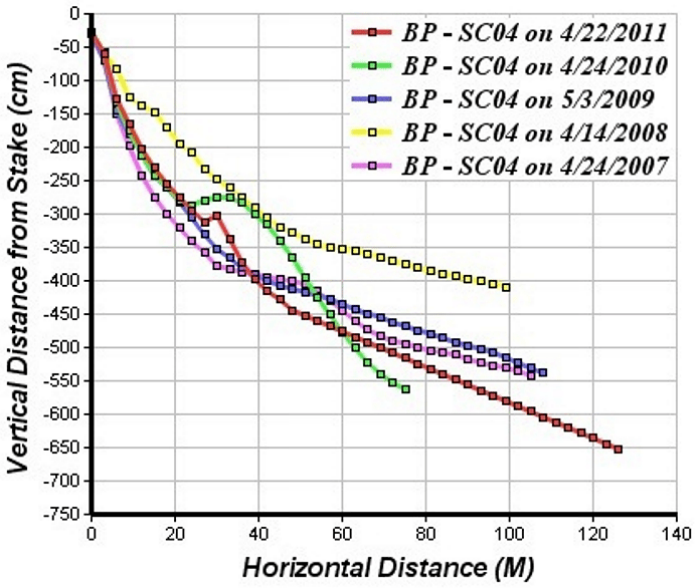

Figure 16. Winter beach profiles from Scarborough Beach profile line SC04.

Winter Beach Grade = C- (70)

2008 appears to be the best year for winter beach profile shapes at Scarborough Beach, especially south of the access path for SC03 and SC04. Recovery from the Patriots' Day Storm was solid through this year at all profile locations. Profiles north of the access path appear to undergo less dramatic changes than south of the path. Since 2008, the winter beach profiles have shown stability to slight erosion; they are clearly not accreting. The winter profiles at Scarborough appear to be eroding more than the summer shapes.

Summer Profile Changes

SC01 = B+ (88)

For SC01 (Figure 17), the summer immediately after the storm showed a well-defined berm near the 40 m mark. In 2008, this was eroded (or moved up the profile) because the upper portion of the profile gained elevation. By the summer of 2009, the uppermost portion of the profile stayed stable, but the berm area eroded. In 2010, the berm clearly recovered and moved up the profile slightly, but the profile seaward of about 45 m steepened and lost elevation. This profile is showing signs of good summer beach stability, with little dune erosion and a berm that has reappeared in 2008 and 2010.

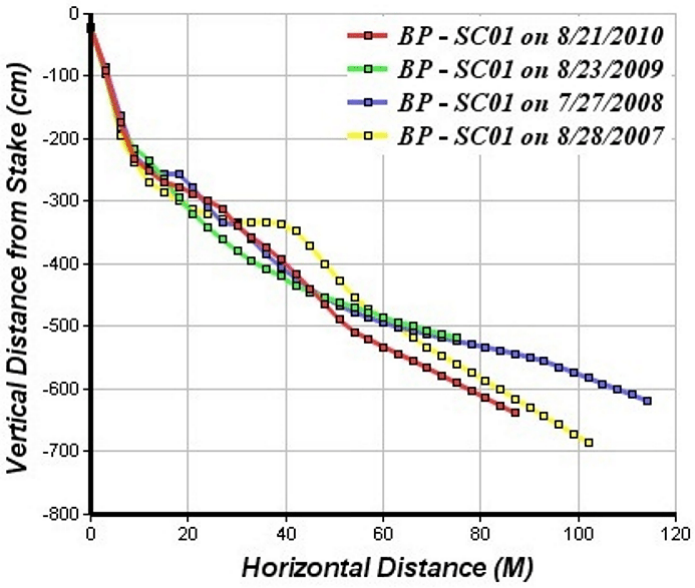

Figure 17. Summer beach profiles from Scarborough Beach profile line SC01.

SC02 = B (85)

From 2007 to 2008 (Figure 18), the summer beach profile showed the migration of the berm in a landward direction, slightly up the profile. In 2009, the profile appeared to flatten. From 2009 to 2010, the profile gained in elevation in the form of a berm around the same location of the 2008 shape, indicating good recovery. This profile appears to show good stability in the upper portion of the profile, with some deepening offshore.

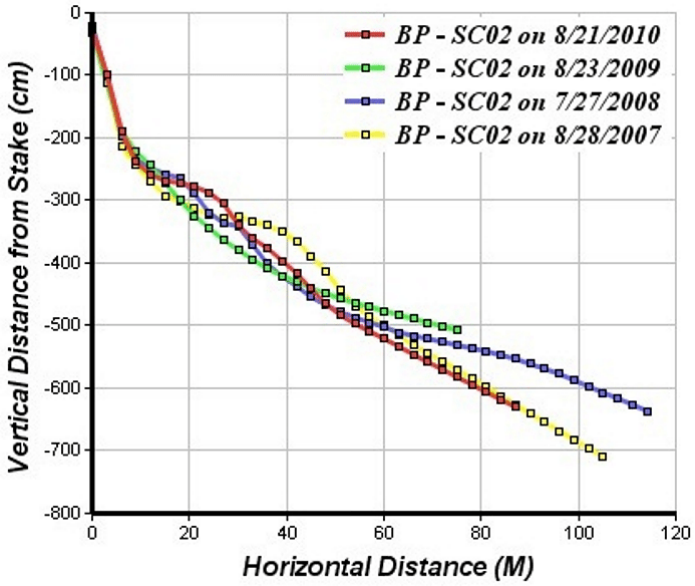

Figure 18. Summer beach profiles from Scarborough Beach profile line SC02.

SC03 = D (65)

Since a new pin position was located in March 2008, this will be used as the "starting point" for profile comparison (a "summer" date of October 2008 was the only one available for analysis). From 2008 to 2009 (Figure 19), the summer profile underwent erosion and lowered along its entire length. This trend continued in 2010, with dramatic loss in the upper portion of the profile close to 1 m in elevation at the 15 m mark. A prominent berm feature did form in 2010 at the 30 m mark, but it was much lower in elevation than in 2008. A very steep and erosive lower

portion of the profile dominated, with differences in elevation from the 2009 beach profile shape of 1 m or more. This profile is showing evidence of erosion.

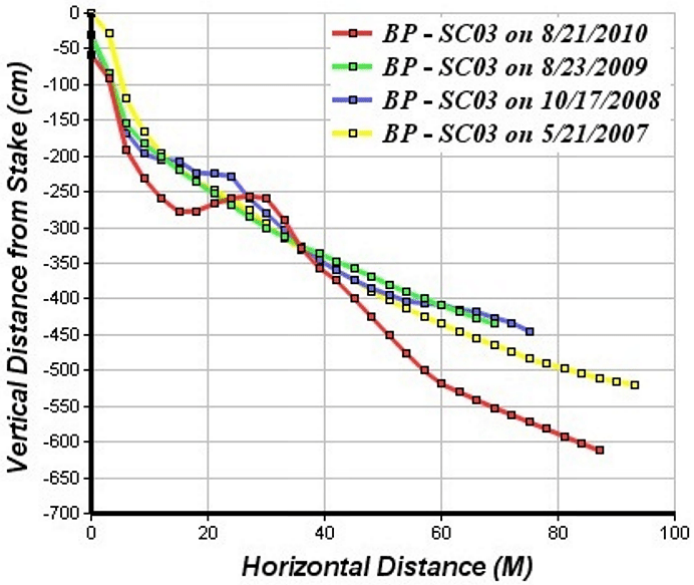

Figure 19. Summer beach profiles from Scarborough Beach profile line SC03.

SC04 = B+ (88)

In response to the storm, SC04 (Figure 20) underwent scour in its upper portion, developed a low but well-defined berm, and exhibited a steeper lower portion. By 2008, the profile had gained some elevation in the nearshore, but flattened, with sediment gain in the low-tide area. The 2009 shape is very similar to 2008, but the small berm evident in 2008 was eroded. In 2010, a large, well-defined berm is evident near the 30 m mark - this is the highest berm of all the profiles. Closer to the dune, however, the profile saw some erosion. Also, the slope coming off the berm is equal to the 2007 profile shape, and is actually lower in elevation. This profile is showing evidence of landward berm migration, but appears to be maintaining a good berm elevation. This may be due to cobbles that occasionally move into this area.

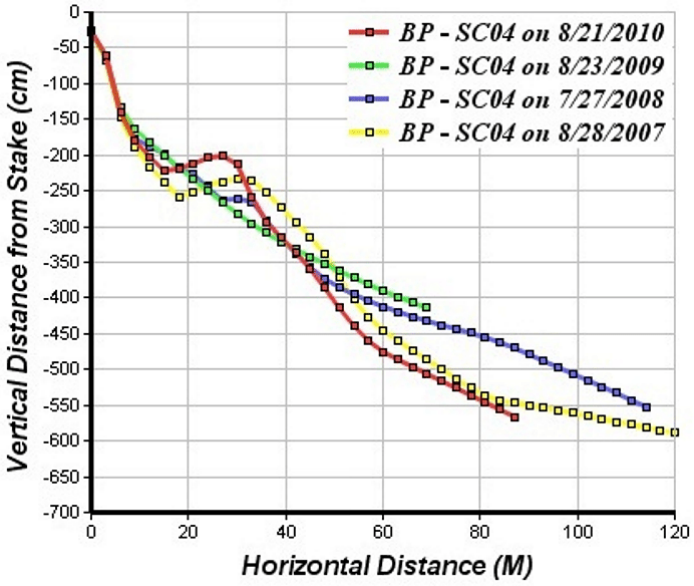

Figure 20. Summer beach profiles from Scarborough Beach profile line SC04.

Summer Beach Grade = B (82)
The summer beach shapes north of the access path appear to be somewhat stable, with slight landward migration of the berm shape. South of the access path, erosion seems more apparent, with substantial erosion at SC03, while SC04 shows landward migration of the berm, but very good elevation. It appears that the area south of the access path is undergoing a period of erosion. In general, however, the beach is showing relatively good stability in terms of its summer profile shapes, much better than the winter shapes.

Summary
Scarborough Beach appears to be relatively stable to slightly erosive, with the largest erosion occurring at the beach near SC03. It shows more erosion in winter than in the summer shapes, which appear to recover relatively well. Luckily, the beach appears to be maintaining generally good summer profile shapes, especially north of the access path.
Overall grade = C (76)

East Grand Beach, Scarborough

A total of four beach profiles (EG01 to EG04, Figure 21) were available for comparison. The profiles extend northeast to southwest along East Grand Beach, clustered together. Volunteer notes indicate that the profiling stakes at all four locations were lost in the storm. New stakes were established in approximate previous locations.

Figure 21. Location of beach profiles EG01 to EG04 at East Grand Beach, Scarborough. Base imagery from Maine Office of GIS.

Winter Profile Changes

EG01 = A (95)

Profile EG01 (Figure 22), which is the northeastern-most profile, received a C in the last assessment. By September 2008 (the earliest data available for comparison), it appears that the dune crest lost some of its elevation and moved in a landward direction, with the lower portion of the dune and beach berm migrating seaward (near the break-in-slope). The 2009 profile exhibited a slightly lower dune crest, but further seaward accretion of the dune, while the beach appears to have been eroded slightly to the 2007 profile elevation. By 2010, the profile showed substantial dune growth, but a decrease in the berm elevation, and flattening of the beach. In 2011, the dune grew slightly farther seaward, and the berm/beach developed a gentle slope, gaining elevation above all other years. This profile is showing signs of excellent recovery and continued growth.

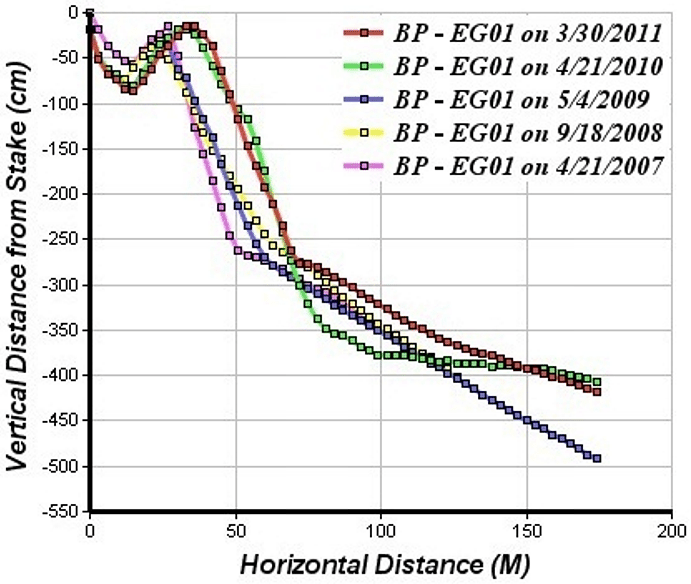

Figure 22. Winter beach profiles from East Grand Beach profile line EG01.

EG02 = A (95)

Profile EG02 (Figure 23) received an A in the last assessment. After the storm, the break-in-slope from the dune to the beach was at roughly the 50 m mark. By 2008, the profile showed extremely good recovery, with the addition of over 1 m of sediment to the berm portion of the profile. The 2009 profile eroded from the 2008 shape, losing about half of the elevation gained by the 2008 profile. However, by 2010, the dune had grown seaward and the berm had migrated seaward by about 25 m. This trend continued in 2011, with both the dune, berm, and low-tide areas gaining sediment. This profile is showing signs of excellent recovery and continued growth.

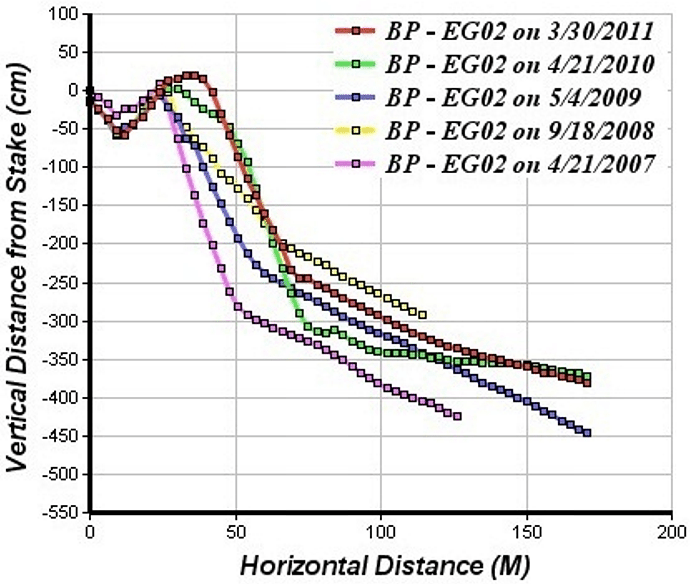

Figure 23. Winter beach profiles from East Grand Beach profile line EG02.

EG03 = A (95)

Profile EG03 (Figure 24) received an A in the last assessment. By 2008, the profile had responded well to the storm, with sediment accreting along the majority of the profile from about 25 m seaward. The dune crest, however, was about 40 cm below the post-storm crest. In 2009 the profile underwent some erosion along its lower berm and low-

tide area. However, consistent with the other profiles, it underwent very good recovery along its upper portion, in the dune area in 2010, though the berm and beach (near 60 m) steepened and lost some elevation. The lower portion of the profile (the low-tide terrace) was eroded to below post-storm 2007 shape. By 2011, the entire profile had gained in elevation, and the berm migrated about 20 m seaward of the 2007 shape. This profile is showing signs of excellent recovery and continued growth.

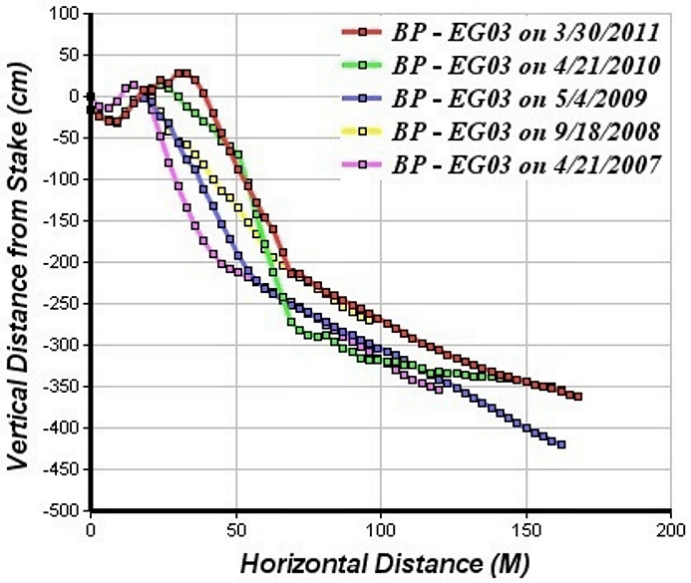

Figure 24. Winter beach profiles from East Grand Beach profile line EG03.

EG04 = A- (92)

Profile EG04 (Figure 25) received a B- in the last assessment. By 2008, the profile had maintained its post-storm dune crest, and gained additional elevation along its berm and lower portion. However, in 2009, the profile lost sand elevation from about the 45 m mark seaward, resulting in a profile shape that was actually below the level of the post-storm profile. Recovery occurred in the upper portion of the profile in the dune in 2010, but the berm portion of the profile continued to deepen. In 2011, the upper portion of the dune grew, and the berm gained elevation. However, the berm at this profile appears to have slightly lost elevation, even though it has migrated seaward. Generally, this profile is showing very good recovery and continued growth.

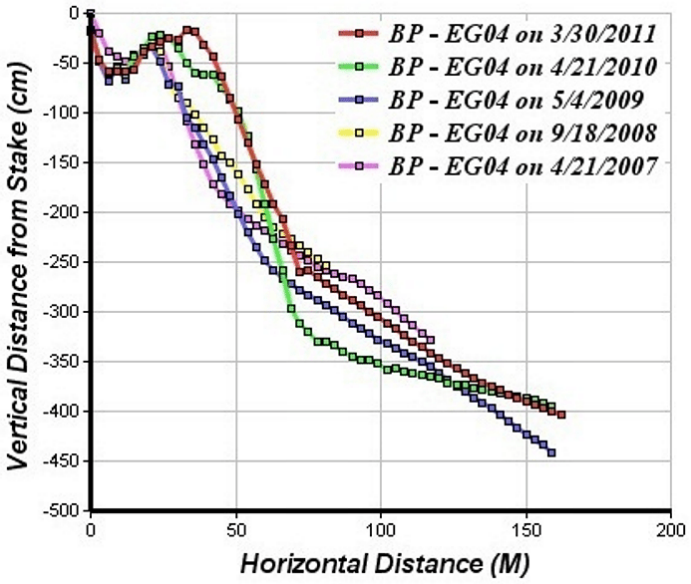

Figure 25. Winter beach profiles from East Grand Beach profile line EG04.

Winter Beach Grade = A (94)
Clearly, the winter profiles at East Grand Beach show accretion. The dune and berm appear to be migrating seaward over the past few years, indicating good growth.

Summer Profile Changes
EG01 = B (85)
By September 2008 (Figure 26), the dune crest grew, and the entire profile showed signs of recovery, with the berm increasing in elevation. The 2009 summer profile shape was almost exactly the same as 2008, indicating good summer stability. In 2010, the profile gained substantial amounts of sand in its dune, growing upward and seaward. However, the berm and beach portion of the profile lost elevation compared with 2008 and 2009. This profile is showing strong dune growth, and berm stability aside from the 2010 berm shape. Comparison with the August 2011 beach profile will help indicate if the berm recovers from the 2010 shape, though we are certain it will.

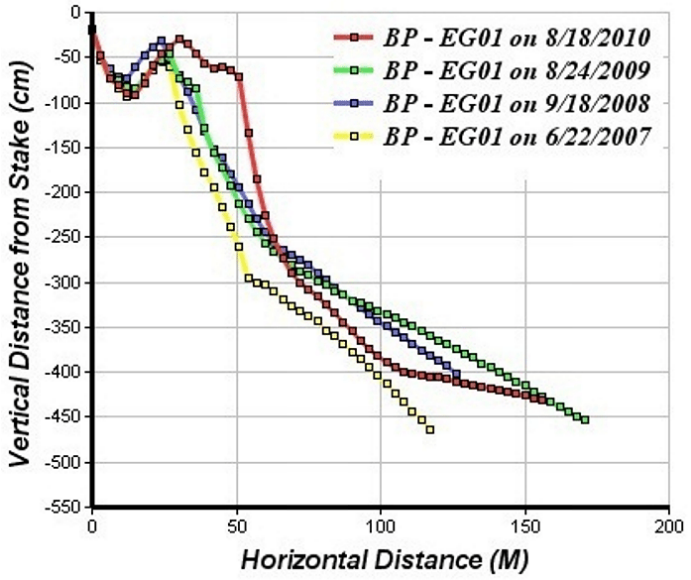

Figure 26. Summer beach profiles from East Grand Beach profile line EG01.

EG02 = B (85)

Similar to EG01, EG02 (Figure 27) showed very good recovery by summer 2008, gaining sand along its entire length. By 2009, the profile had lost some sediment in comparison. However, by 2010, the profile had grown dramatically in the dune, in both elevation and width. The berm and beach portions of the profile are lower in elevation than 2008 and 2009, consistent with EG01. This likely again is due to the 2010 winter storms, and should be monitored. We do expect the berm to recover, as this profile is showing signs of very good stability and dune growth.

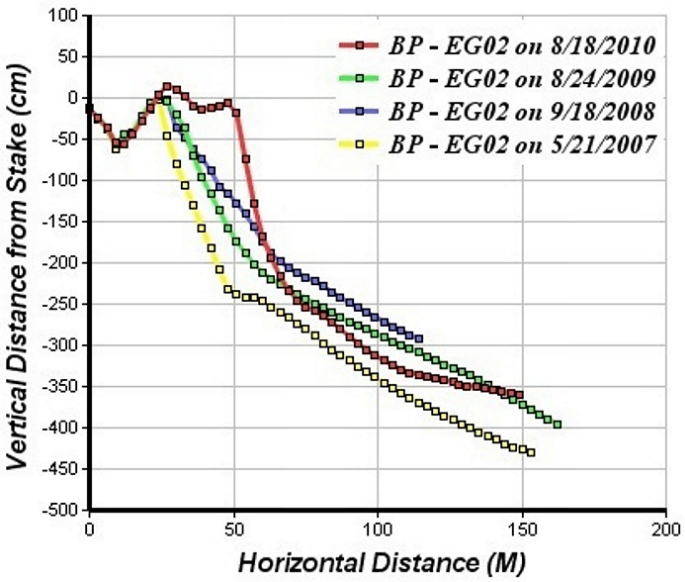

Figure 27. Summer beach profiles from East Grand Beach profile line EG02.

EG03 = A (95)

Similar to the other profiles, EG03 (Figure 28) has shown substantial recovery from its 2007 summer shape, with expansive dune growth. However, unlike the other East Grand Beach summer profiles, the berm and beach portion of EG03 (seaward of the break-in-slope at about 60 m) has profile remained stable from 2007 through 2010, while most of the other profiles experienced recovery, then deepening in 2010. This profile is showing signs of excellent stability and growth.

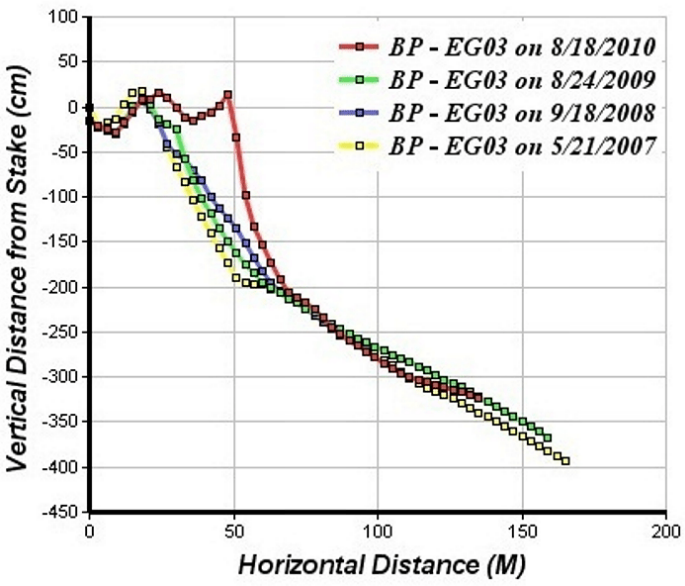

Figure 28. Summer beach profiles from East Grand Beach profile line EG03.

EG04 = A (95)

EG04 (Figure 29) exhibited a high but scarped dune in 2007, which lowered in 2008 but grew seaward and gained sand along the lower profile. In summer 2009, the profile appears to have undergone some erosion. By the summer of 2010, the dune had grown substantially seaward. The beach and berm of the profile appear to be stable. This profile is showing signs of excellent stability and growth.

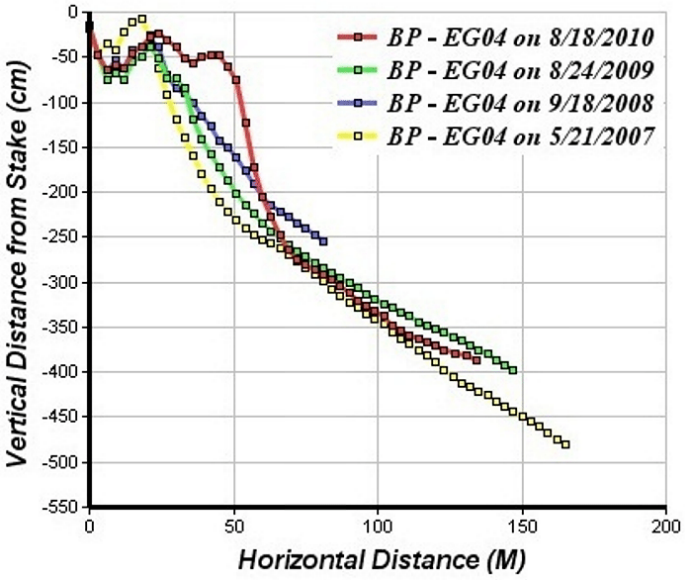

Figure 29. Summer beach profiles from East Grand Beach profile line EG04.

Summer Beach Grade = A- (90)

The summer beach shapes along East Grand Beach all indicate substantial dune growth, vertically and horizontally (seaward). Profiles EG01 and EG02 indicate some lowering of the berm in 2010, likely due to the back-to-back storms in February and March 2010. We do expect these berms will recover in 2011, though comparisons with August 2011 profiles are needed to confirm this. Profiles EG03 and EG04 show very good growth in their dunes and stable summer beach shapes.

Summary
Overall, East Grand Beach is showing excellent stability in its winter and summer beach shapes, and substantial dune growth. In fact, East Grand Beach has shown the best growth of all the beaches monitored. This is the sign of a healthy beach system due to a sediment-rich nearshore. We expect the "summer" berms at several of the profiles to fully recover by August of 2011.
Overall grade = A- (92)

Kinney Shores, Saco

A total of two beach profiles (KS01, KS02, Figure 30) were available for comparison. The profiles are located at either end of Kinney Shores, from south to north.

Figure 30. Location of beach profiles KS01 and KS02 at Kinney Shores, Saco. Base imagery from Maine Office of GIS.

Winter Profile Changes

KS01 = A (95)

Profile KS01 (Figure 31), located at the southern end of Kinney Shores in a natural dune, received a C in the last assessment. By 2008, the upper portion of the profile underwent good recovery, however lower portions still retained the immediate post-storm shape from about 20 m and seaward. In 2009, the upper part of the profile grew slightly, while the lower portion of the profile deepened to below the post-2007 storm profile shape. In 2010, the profile underwent erosion on its upper portion, the berm, while the lower portion appeared to gain some sediment. By 2011, the entire profile showed marked recovery, with gains in elevation along its entire length. This profile showed excellent signs of growth, with elevation gains in the dune and berm.

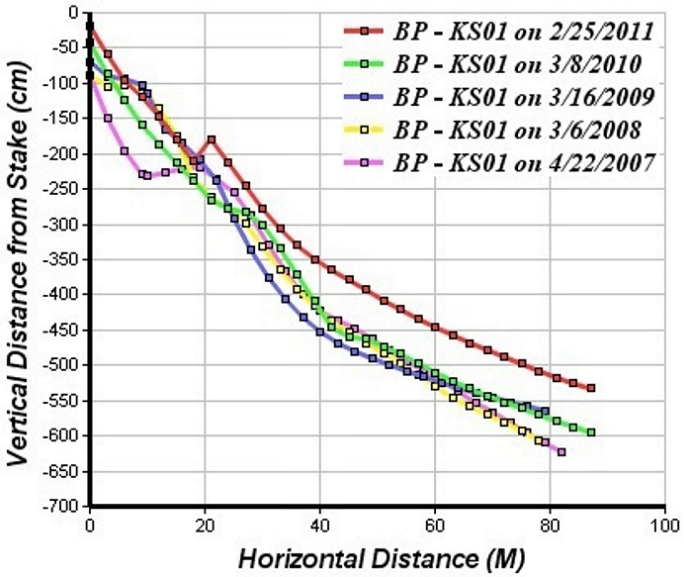

Figure 31. Winter beach profiles from Kinney Shores profile line KS01.

KS02 = C- (75)

KS02 (Figure 32), located at the northern end of Kinney Shores in a seawall with a dune, received an A- in the last assessment. From 2007 to 2008, recovery of the upper berm occurred near the 20 m mark, but there was little change in the profile from about 30 m seaward. By 2009, it appears the dune grew slightly in elevation, and the berm, between about 15 and 30 m from the pin, showed good formation and growth. The beach also grew seaward at this time, from 2007 through 2009. By 2010, the dune increased in elevation, but the berm flattened slightly, and the beach lost elevation compared with the 2009 shape. In 2011, the dune appears to have lost elevation slightly, while the berm appears to have gained in elevation. However, it appears to have migrated landward, and the beach steepened and deepened starting at around the 20 m mark, actually eroding well below the 2007 post-storm shape. Although the upper portion of the profile appears stable, the berm has moved steadily up the profile, and the beach is showing signs of erosion. This may be due to the fact that the only winter data available in 2011 was from February, which might be too early to show beach recovery during the winter months. This profile should be monitored closely to see if recovery shows, or erosion continues.

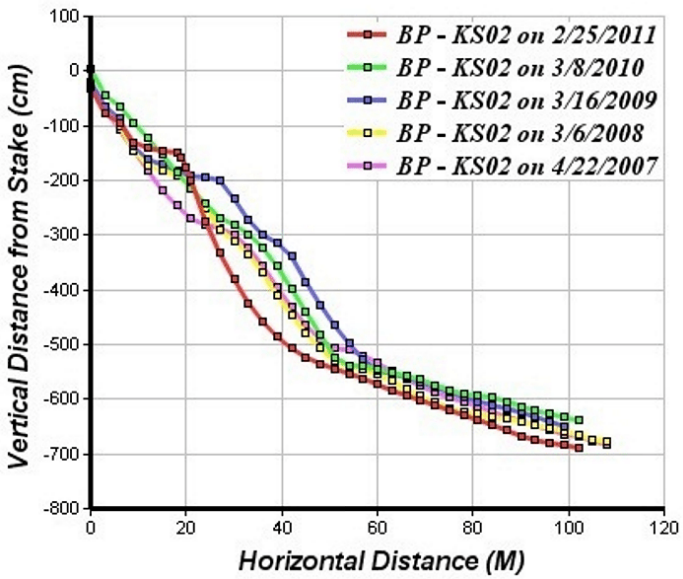

Figure 32. Winter beach profiles from Kinney Shores profile line KS02.

Winter Beach Grade = B (85)
Interestingly, KS01 and KS02 have shifted scores since the last assessment. With its position at the southern end of Kinney Shores, closer to a salient (sand shoal) and bedrock outcrop in the surf zone, KS01 may be seeing more stability and growth due to the protection offered by these features.

Summer Profile Changes
KS01 = B (85)
The 2008 summer profile (Figure 33) gained elevation along the upper berm out to about 18 m; however, the beach appeared to be slightly lower than the summer 2007 shape. The lower portion of the 2008 summer profile nearer the low-tide area, from about 40 m seaward, was higher in elevation than the 2007 profile. The 2009 profile lost sediment along its beach and berm, and gained sand seaward of the 40 m mark. In 2010, the berm sand elevations increased by about 50 cm in elevation over the 2009 shape, but the profile exhibited a steeper slope near the 40 m mark and seaward. The profile appears to have gained sediment, especially at the base of the wall and along the berm, since the summer of 2009; however it is showing a steeper foreshore slope, similar to the 2007 profile shape.

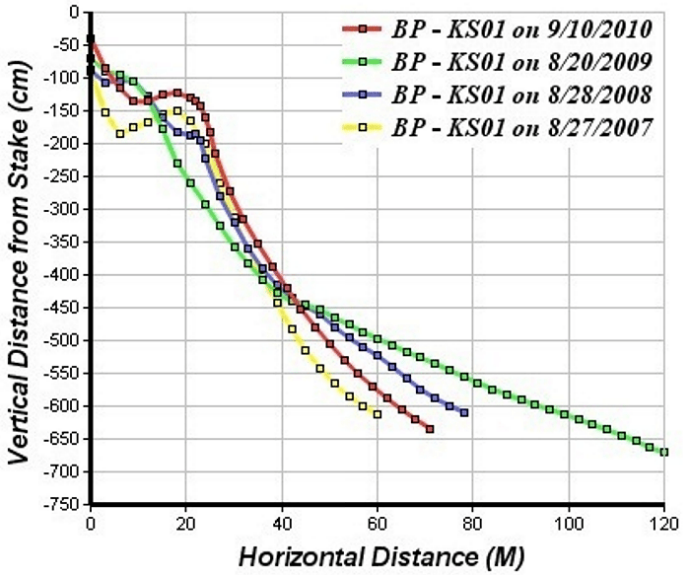

Figure 33. Summer beach profiles from Kinney Shores profile line KS01.

KS02 = C (75)

By 2008, the summer profile (Figure 34) had actually migrated landward slightly, with the berm landward of the 2007 shape. The lowest portion of the profile, near the low-tide area, appears to have gained some elevation. By 2009, the landward movement of the berm continued and the berm appears to have gained some elevation, while losing some of its width. In 2010, the profile lowered and steepened, and shifted inland by about 10-15 more meters. The 2010 shape was actually more erosive than the summer 2007 post-storm shape, and lower in elevation by about 30 cm. This profile appears to be undergoing some landward migration of the berm area, though it has remained relatively stable since 2010. This profile should be monitored closely to see if erosion continues.

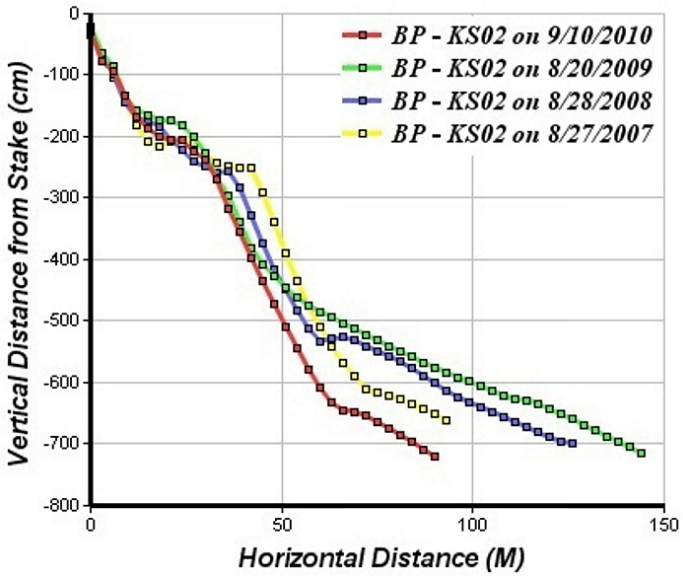

Figure 34. Summer beach profiles from Kinney Shores profile line KS02.

Summer Beach Grade = B- (80)

The summer profiles at Kinney Shores both exhibit seasonal summer berms. The berm at KS01 appears to be growing, while the berm at KS02 appears to be moving slightly landward in response to some erosion. This is a reversal of trends from the 2009 assessment.

Summary

The Kinney Shores beach profiles appear to have shifted in terms of their recovery patterns, whereas KS02 underwent good recovery in the last assessment, it appears KS01 is showing much better recovery in both summer and winter shapes in this assessment, while KS02 appears to be undergoing a slightly more erosive trend, with landward migration of its features. Additional monitoring will help determine if KS02's erosional trend continues.
Overall grade = B (83)

Ferry Beach, Saco

A total of four beach profiles (FE01 to FE04, Figure 35) were available for comparison. It is important to note that for the 2009 assessment, the profile starting points were mislabeled. FE01 should be northernmost profile starting location, with FE04 being the southernmost. All profiles start in a natural dune. The front stake at FE04 was lost during the 2007 Patriots' Day storm, and profiling was re-established at a back stake in August 2007. New back stakes were placed for profiles FE01 and FE02, and new starting front and back stakes were placed for FE03 and FE04, in May 2010. The profiles extend north to south in chronological order.

Figure 35. Location of beach profiles FE01 to FE04 (front and back stakes) at Ferry Beach, Saco. Base imagery from Maine Office of GIS.

Winter Profile Changes

FE01 = D (65)

Profile FE01 (Figure 36) received a D in the previous assessment. In response to the 2007 storm, the profile was flattened substantially, and lost about 1m in dune elevation, though there was a gain in elevation in the low tide area. By 2008, the profile maintained the post-storm shape out to about 20 m, where it appears to have lost sand in comparison with the post-storm shape. In 2009, the profile appears to have lost more elevation in its berm and along its length. The 2010 profile showed additional landward retreat and elevation loss along the entire profile. The 2011 profile migrated farther landward and lost a bit of elevation in the first few meters, then appears to have gained sand back (in comparison with the 2010 shape) along the lower berm and low tide portion of the profile. However, for the most part, the profile is below the 2008 shape, especially in regards to sand on the upper portion of the berm. The dune looks to be continually eroding landward.

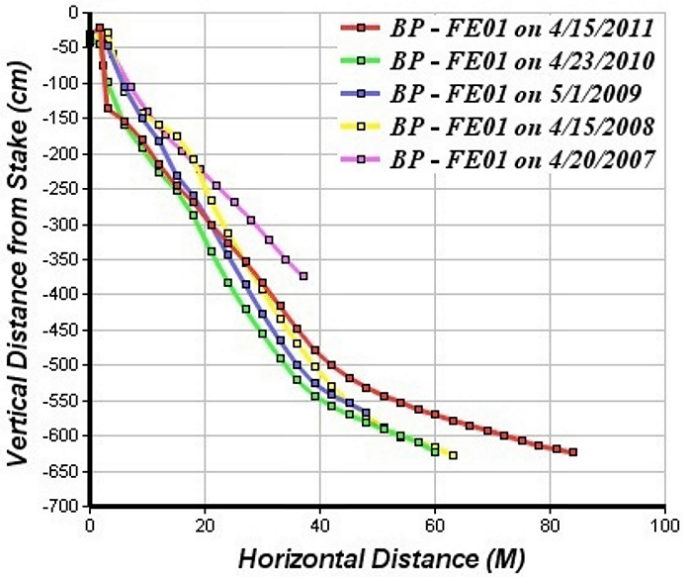

Figure 36. Winter beach profiles from Ferry Beach profile line FE01.

FE02 = C (75)

Profile FE02 (Figure 37) received a D in the previous assessment. A year after the storm, the profile showed further erosion, and transgressed farther landward along its entire length. In 2009, the profile (at the dune crest) gained in elevation and expanded seaward, while the berm and lower portion of the profile also accreted. This was due to dune reconstruction efforts undertaken by the Ferry Beach Park Association in the late winter and early spring of 2009. By 2010, the dune crest and entire beach eroded landward in response to storms. In 2011, the dune crest appeared have receded slightly, but the berm and lower portion of the profile recovered to a shape better than the 2008 post-storm shape, and almost the same as the post-construction 2009 shape. Although the profile recovered well in 2009, this was due to dune restoration; recovery in 2011 from the 2010 erosive profile shape shows that this site has likely benefited from the dune restoration project, with sediment eroded from the dune crest feeding the rest of the beach profile. We give the profile a C due to this recovery, but remain cautious regarding the long-term stability of the beach and dune at this site.

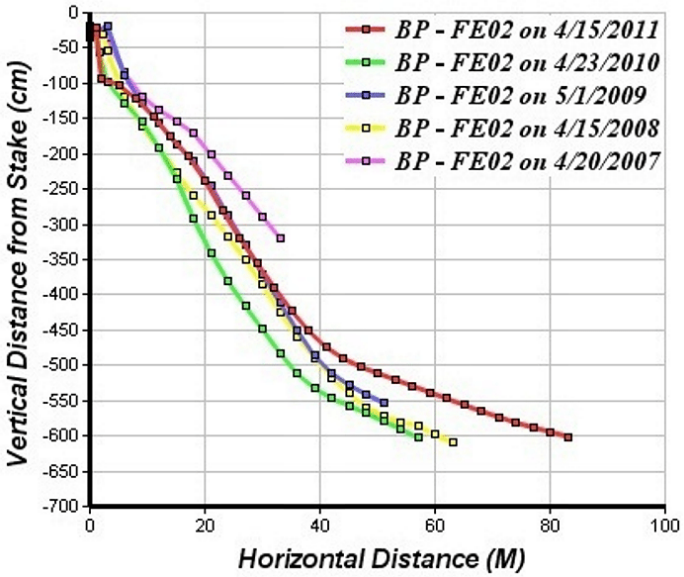

Figure 37. Winter beach profiles from Ferry Beach profile line FE02.

FE03 = D (65)

Profile FE03 (Figure 38) received an F in the previous assessment. The 2008 profile showed continued erosion and landward movement in comparison with the 2007 profile shape, with the 2009 profile showing little change, but some stability. The 2010 profile exhibited much deeper erosion, with removal of the dune and berm, and does not reflect dune restoration that occurred. This profile showed consistent erosion from 2007 through 2010. The 2011 profile, which was recorded at a new starting pin (set in May, 2010 and first profiled in July 2010), shows a well-defined dune, and a much more sediment rich profile. It is difficult to compare the 2011 shape with previous shapes since the starting pin from April 2010 was lost, and changed. However, if we compare the July 2010 profile shape with available profile data from June 2011 (see next section on Summer Profiles), we note that the profile has remained stable to slightly accretive - this an extremely positive sign, and allows us to score this profile a D instead of an F. However, we remain extremely cautious due to the past history of this profile.

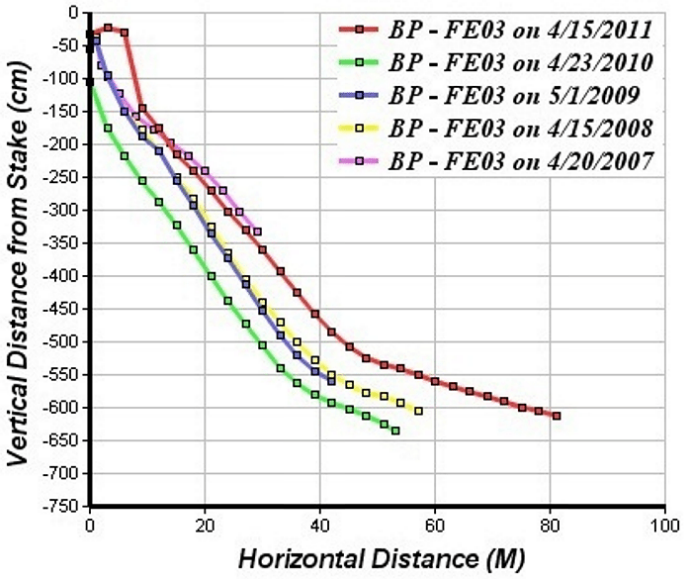

Figure 38. Winter beach profiles from Ferry Beach profile line FE03.

FE04 = C (75)

Profile FE04 (Figure 39) received an A in the previous assessment. Because the starting pin was lost in the storm and a new starting point was not used until August 2007, it is not included in this analysis. In 2008, the profile was very flat and steep, with few discernable features. Unlike the other profiles, FE04 does not seem to have much of a berm, and maintains an erosive, concave shape (although much more stable). Little change appears to have occurred in 2009, but the profile did shift slightly landward, indicating erosion. 2010 saw some erosion and deepening of the profile, especially from about 20 m seaward. Overall, the profile appeared slightly erosional from 2008 to 2010, although it is clearly benefiting from the dune restoration project and likely the sand placed by the City adjacent to the geotubes along Surf Street.

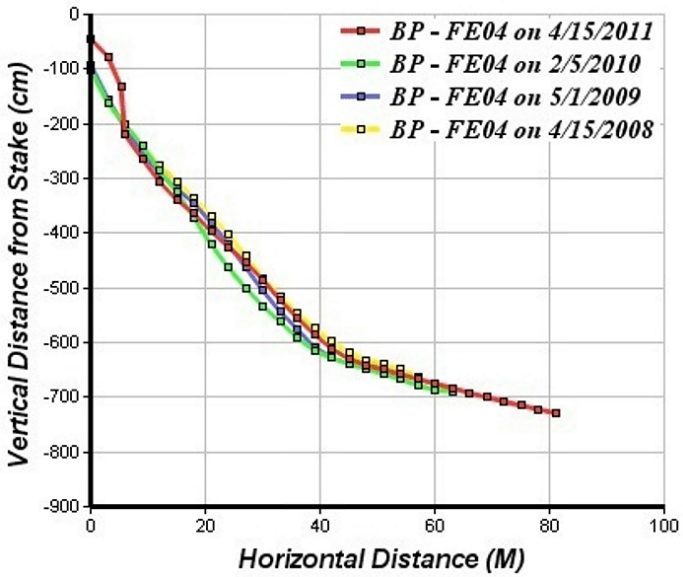

Figure 39. Winter beach profiles from Ferry Beach profile line FE04.

Winter Beach Grade = C- (70)
The winter profiles at Ferry Beach are clearly not remaining stable in the longer term period. However, there is significant impact from the dune restoration project and sand placement by the City along Surf Street. It is clear that these efforts have helped these profiles respond, with the addition of more available sediment to the profile.

Summer Profile Changes
The winter profiles at Ferry Beach are clearly not remaining stable in the longer term period. However, there is significant impact from the dune restoration project and sand placement by the City along Surf Street. It is clear that these efforts have helped these profiles respond, with the addition of more available sediment to the profile.

FE01 = D+ (68)
By July 2007 (Figure 40), the profile had a defined dune crest with a scarp, and a wide, well defined berm near the 30 m mark. By June 2008, the summer berm increased in elevation and move landward, as did the dune crest. The lower portion of the profile, seaward of 20 m, lost elevation and steepened. In 2009, the entire profile appears to have flattened and lost around 0.5 m of elevation along its length. The dune appears to have been eroded landward. The June 2010 profile showed additional dune retreat and loss of elevation along the profile. The June 2011 profile showed some recovery from the 2010 shape, with a slight increase in dune elevation, the development of a noted berm at the 10 m mark, and recovery of the profile elevation to the 2009 shape. This is a positive trend, indicating influence of the dune restoration project and the availability of more sediment to the profile. However, overall, the profile has been migrating landward, with dune and berm loss since 2007. Since 2008, the profile has appears to have maintained the same slope, but has migrated landward approximately 6 meters.

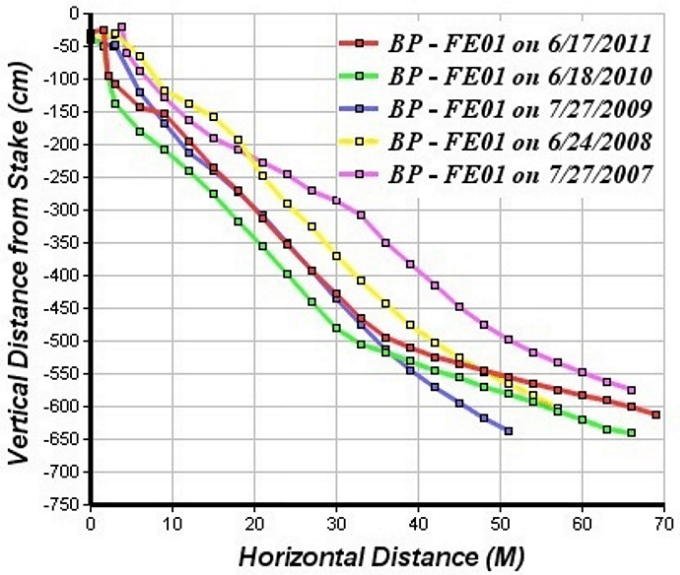

Figure 40. Summer beach profiles from Ferry Beach profile line FE01.

FE02 = F (55)

In July 2007 (Figure 41), the profile actually had a large amount of sediment. A year after the storm, in summer 2008, the profile eroded dramatically, with the loss of near 1 m of elevation at the 20 m mark, and landward migration of the dune crest. In 2009, the profile appears to have recovered somewhat, with dune growth seaward (likely due to the restoration project), and berm development. This trend continued in the summer of 2010, with additional growth of the beach seaward of the 10 m mark; however, the dune appears to have eroded farther landward. In June 2011, the dune appears to have moved slightly landward, and the berm and beach eroded slightly landward. The elevation of the low tide area, however, grew since 2010. This profile is eroding continually.

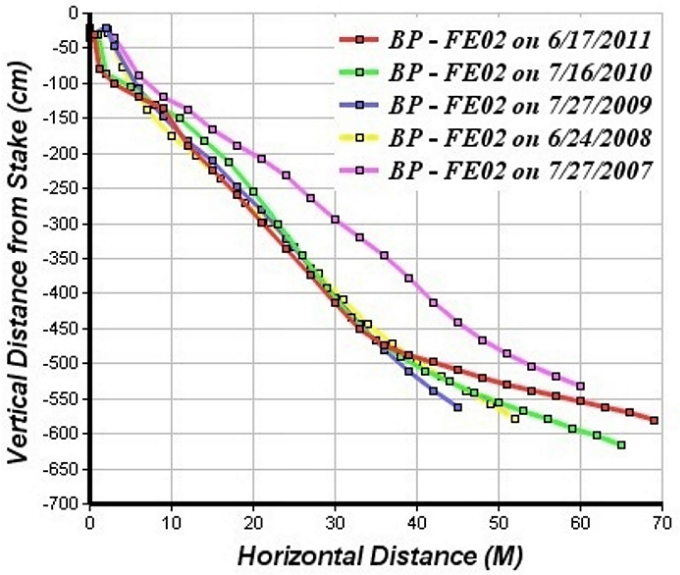

Figure 41. Summer beach profiles from Ferry Beach profile line FE02.

FE03 = C (75)

After the 2007 storm (Figure 42), the summer profile had a large amount of sediment in its berm and lower portions. The 2008 profile showed extensive erosion of the lower portion of the profile, seaward of about 8 m, while the upper

profile stayed stable. This profile shape was basically maintained in 2009, likely due to dune restoration activities which introduced new sand to the system. Note that a new starting pin was placed in May of 2010, with profiling reinitiated in July 2010. We will therefore include comparison with changes from July 2010 to June 2011. The profile shows a clear seaward movement of the dune crest by June 2011, and an increase in profile elevation along the entire profile. This is an extremely positive sign, and likely due to the dune restoration activities undertaken in conjunction with erosion of sand placed next to the geotubes at Surf Street. We are very pleased with dune recovery in 2010-2011, but remain highly concerned about the long-term history of this profile.

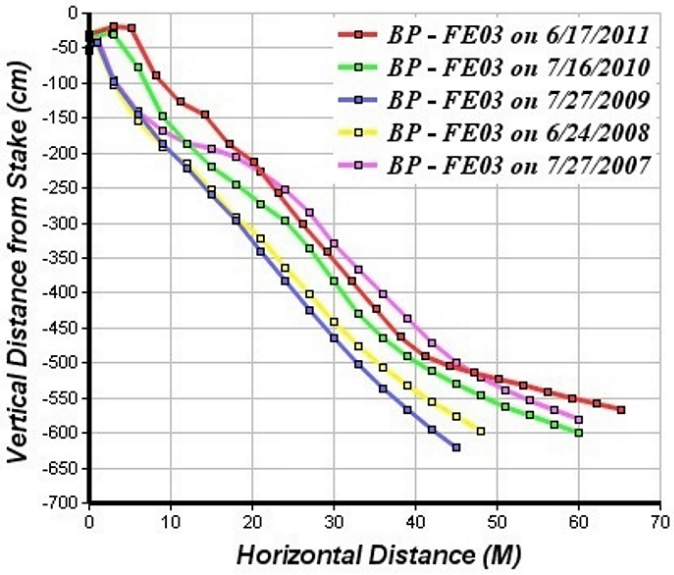

Figure 42. Summer beach profiles from Ferry Beach profile line FE03.

FE04 = C (75)

Unlike the other profiles, FE04 (Figure 43) shows little variation in its topography. From August of 2007 to 2008, the profile underwent large erosion; however, from August of 2008 to July of 2009, the profile underwent little change, with slight erosion of the beach and berm. Since the starting point was reset in May 2010, it is impossible to compare profiles from 2009 and 2010. Therefore we will compare July 2010 with June 2011. Over this time period, the profile has remained stable, with little change. This is likely due to the influence of the dune restoration project and artificial placement of sand at Surf Street, and is a very positive indication. It is clear that the dune restoration is positively influencing this profile, but based on its long term history, we are concerned about this profile.

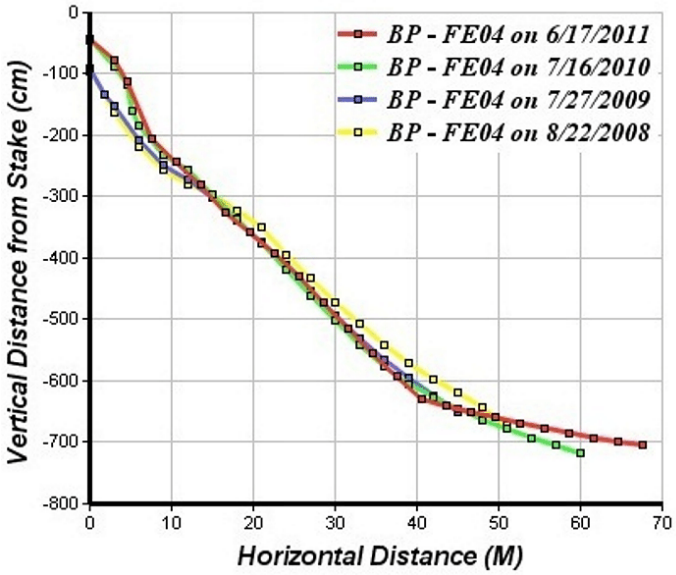

Figure 43. Summer beach profiles from Ferry Beach profile line FE04.

Summer Beach Grade = D+ (68)
The summer profiles at Ferry Beach appear to be eroding. Most try to show a berm area, though it has clearly been eroding over the past few summers. Some recovery in comparison with 2011 to 2010 profiles is noted, which is encouraging. This is likely due to the dune restoration project.

Summary
Overall, consistent with the previous assessment, the beach and dunes along Ferry Beach continue to erode. Due to some changes in pin positioning at some of the profiles, it was difficult to compare 2010 and 2011 data with that from 2007-2009. Based on some of the most recent trends observed at the profiles over the past year (namely July 2010 to June 2011), we remain cautiously optimistic that the dune restoration project and artificial sand placed by the City of Saco at the geotubes at Surf Street has helped slow the rate of erosion that has been occurring at these profiles; however, we do expect erosion to continue. Continued monitoring at these profiles is essential to tracking the changing erosion rates.
Overall grade = D+ (69)

Goose Rocks Beach, Kennebunkport

A total of four beach profiles (GR01 to GR04, Figure 44) were available for comparison. The profiles are spread along the beach, from southwest near the Batson River, to the northeast, near the Little River. It is important to note that all starting stakes were lost in the storm; however, new stakes were established by volunteers in approximate previous locations. In addition, volunteers have noted that the starting pins for profiles at GR03 and GR04 have been moved several times in late 2009 and 2010, so data may be flawed.

Figure 44. Location of beach profiles GR01 to GR04 at Goose Rocks Beach, Kennebunkport. Base imagery from Maine Office of GIS.

Winter Profile Changes

GR01 = A (95)

This profile is located adjacent to the Batson River, at the southwest end of the beach. Profile GR01 received a B- in the last assessment. The post-storm profile underwent apparent recovery by 2008 (Figure 45), with the formation of a berm and numerous swash bars, which dramatically raised the elevation of the upper portion of the profile, and along most of the remainder of the profile. In 2009, the upper portion of the profile continued to grow, while the low-tide portion of the profile lost elevation below the 2008 profile shape. By 2010, the same trend continued, but the low-tide area actually eroded to below the 2007 profile shape, starting at about 100 m from the pin. In 2011, the profile recovered well, with the low-tide elevation gaining sediment. This profile has recovered well with continued berm and dune growth. It reflects the dynamic migratory nature of swash bars at the Batson River, and will likely continue to show dramatic changes in the berm and low-tide swash bars.

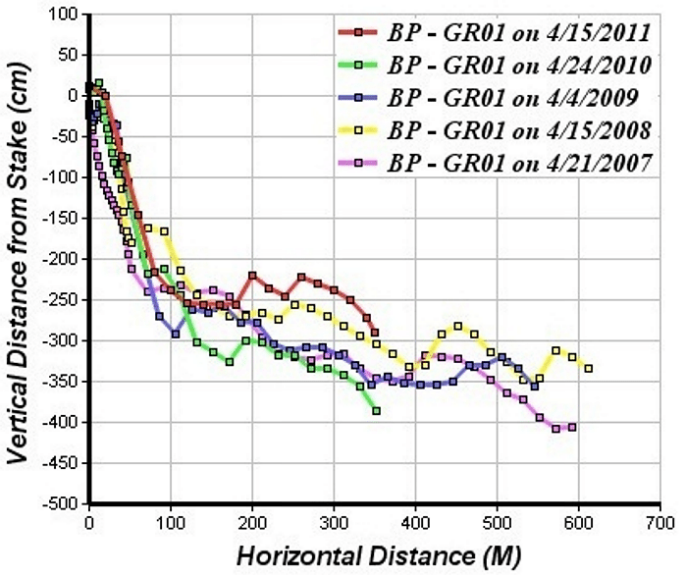

Figure 45. Winter beach profiles from Goose Rocks Beach profile line GR01.

GR02 = B (85)

GR02 is located at the central portion of the beach, in the southern cell along Goose Rocks Beach. Profile GR02 received an A in the last assessment. By 2008 (Figure 46) the profile exhibited excellent recovery, with the development of a well-defined berm. Recovery continued in 2009, with additional berm growth and elevation gains in the low-tide portion of the profile. The 2010 profile exhibited more elevation growth in the low-tide area. In 2011, growth occurred in the berm, while the low-tide portion of the profile lost some elevation, but stayed above the 2008 and 2009 profile elevations. This profile appears to be continuing to recover very well, and has undergone good growth since 2007.

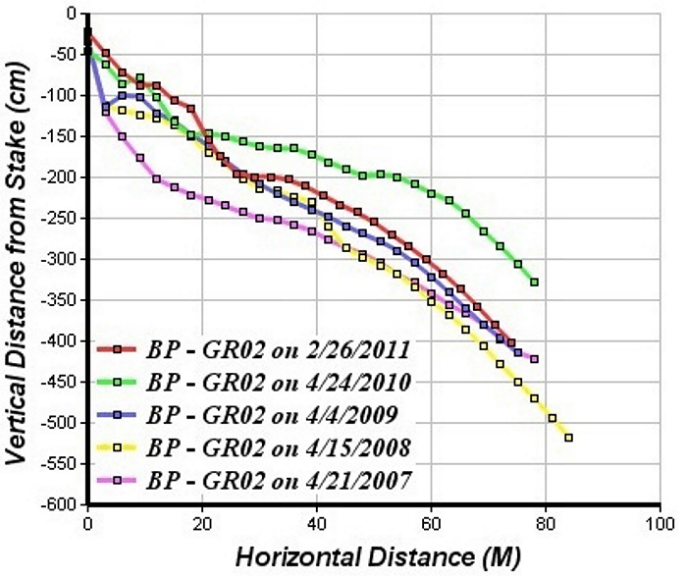

Figure 46. Winter beach profiles from Goose Rocks Beach profile line GR02.

GR03 = C- (72)

GR03 is located in the northern third of the beach, within a cove between the Little River and a salient formed by offshore outcrops. Profile GR03 received a C- in the last assessment. The beach recovered well by 2008 (Figure 47),

with the profile developing a well-defined berm, and elevation increase along the length of the profile. However, the profile was eroded by April 2009. A high berm remained, but the offshore portion of the profile was at elevations below the 2007 post-storm profile. This trend continued in the 2010 beach shape, which was lower in elevation than the 2009 shape. Unfortunately, the 2011 shape showed more erosion of the dune crest, and only a small, poorly-defined berm. However, the profile elevation did not lower any more than the 2010 level, indicating some stability. Still, this profile is showing steady erosion since 2008.

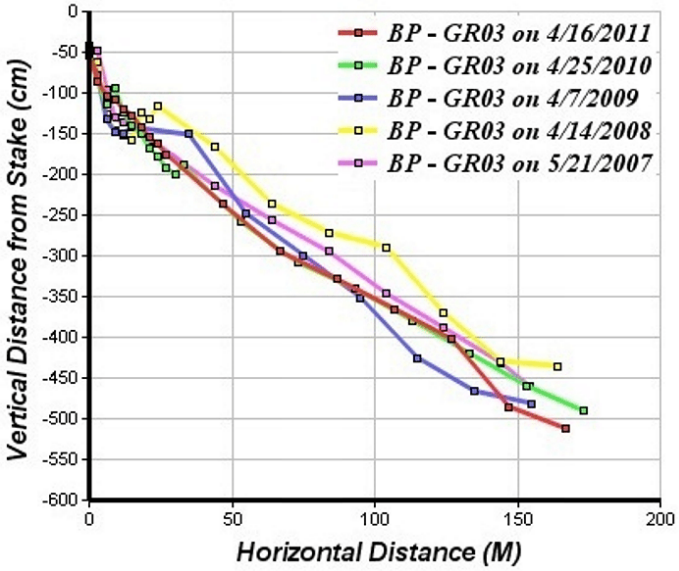

Figure 47. Winter beach profiles from Goose Rocks Beach profile line GR03.

GR04 = A (95)

GR04 is adjacent to the inlet of the Little River, at the northeast end of the beach. The profile received a B in the last assessment. The beach profile exhibited dramatic recovery in 2008 (Figure 48), with extensive elevation gains, especially seaward of the 50 m mark. In 2009, the upper portion of the profile increased in elevation substantially, by over 1 meter; however, the offshore portion (seaward of 50 m) of the profile decreased in elevation along its entire length. By 2010, the profile underwent intense erosion along its landward section, with about a 1.5 meter decrease in elevation. From about 50 m seaward (the low-tide swash platform), the profile increased in elevation. In April 2011, the entire profile had gained substantial amounts of sand, on average about 75-100 cm. The variability of this profile lends itself to proximity to the Little River and the dynamic low-tide swash platform, which receives migrating sand bars, periodically resulting in accretion or erosion. In its current trend, this profile represents marked recovery and accretion.

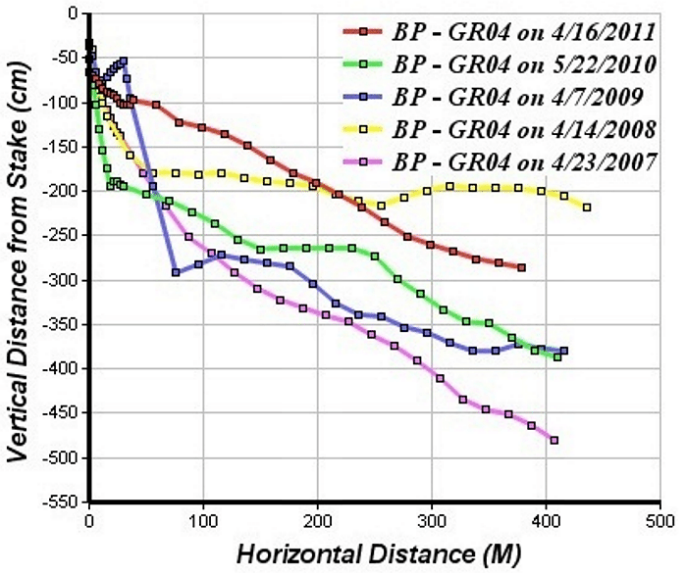

Figure 48. Winter beach profiles from Goose Rocks Beach profile line GR04.

Winter Beach Grade = B (87)

Interestingly, the winter profiles at Goose Rocks Beach show good shapes and good scores. One typically expects profiles to fair worse in winter than in summer. It is clear that the proximity to the rivers of GR01 and GR04 lend themselves to protection. Also, it appears that shoals (ebb-tidal deltas) from the rivers more positively influence the profiles in winter.

Summer Profile Changes

GR01 = C (75)

The summer 2007 (Figure 49) post-storm profile had a dune crest, and a relatively steep slope to a wide, variable low-tide terrace, with what appeared to be a large bar at the 100 m mark. By 2008, the dune crest appears to have eroded landward slightly, and the bar migrated up the profile, with a series of offshore bars moving up the profile, the dune crest recovered, but the nearshore portion of the profile, at the 100 m mark, substantially lowered, and the offshore bars appear slightly smaller than in 2009. In the summer of 2010, the profile showed some dune erosion, and little changes seaward. This profile, in terms of its summer shape, appears to be slowly migrating landward at the dune crest and nearshore portions. It also shows dynamic changes due to the influence of the Batson River and associated swash bars, which cause episodic erosion and accretion. Overall, however, it appears generally stable and we remain cautiously optimistic.

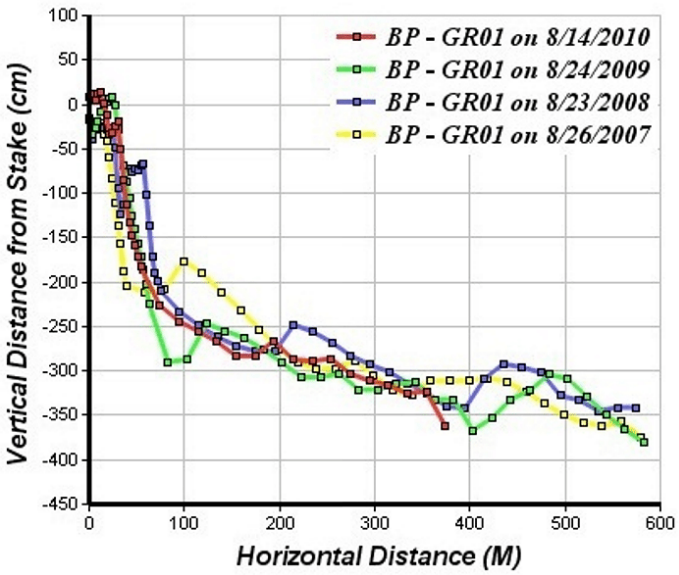

Figure 49. Summer beach profiles from Goose Rocks Beach profile line GR01.

GR02 = B (85)

By summer of 2007 (Figure 50), the profile displayed a wide, well-defined berm, and slope to the low-tide area. Within a year, the berm had flattened and gained in elevation out to about 40 m, where the break in slope occurred. In the summer of 2009, the wide, well-defined berm so evident in 2007 and 2008 disappeared. The entire profile flattened and the slope decreased, however the elevation of the most landward portion of the profile increased. By 2010, the well-defined berm had returned, maintaining its position and break in slope, but increasing slightly in elevation. The summer beach at this location appears to have maintained a good, well-defined berm over the past few years, and has generally increased in elevation since the post-2007 storm profile. This may be due to the sheltering of the cove by offshore bedrock outcrops.

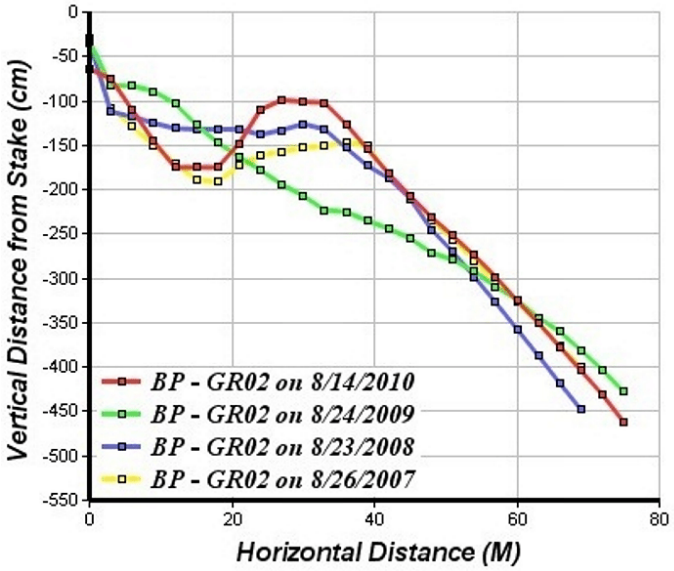

Figure 50. Summer beach profiles from Goose Rocks Beach profile line GR02.

GR03 = D (65)

In the summer after the 2007 storm (Figure 51), the summer profile had a steep slope off the dune, and a defined berm, which gently sloped offshore to the low-tide area. By 2008, the profile appears to have eroded landward, with decrease in the dune, berm, and the formation of a much steeper slope to the low-tide area. The profile recovered very well by summer 2009, with a large gain in elevation at the berm, and a return to a relatively gentle slope to the low-tide area. However, in summer 2010, the profile was massively eroded, losing over 1 m of elevation near the 40 m mark in comparison with the 2009 profile. In fact, the profile was eroded down to elevations below that of the 2008 or 2007 post-storm summer shapes. Although the profile showed good initial recovery into 2009, because of its poor performance in 2010, we remain highly cautious and give the profile a "D". Further monitoring and comparison with summer 2011 shapes is required; we also note that the profile starting point has changed several times, according to volunteers, which may impact this assessment.

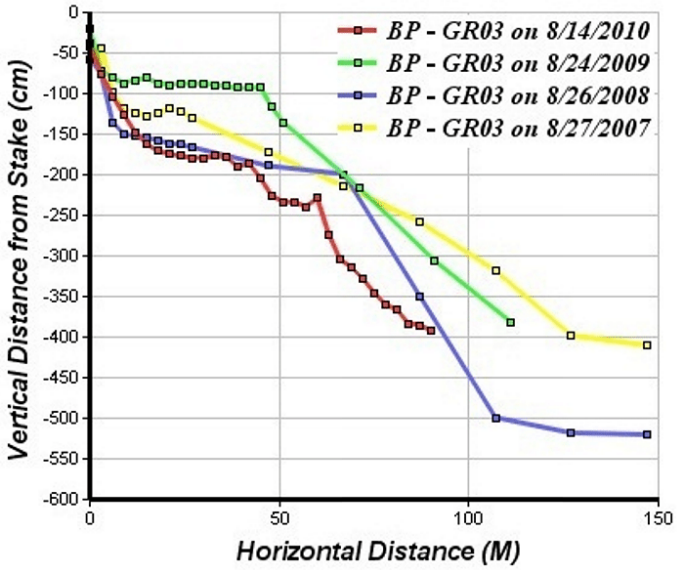

Figure 51. Summer beach profiles from Goose Rocks Beach profile line GR03.

GR04 = D (65)

Although GR04 (Figure 52) underwent very good recovery in terms of its winter shape, its summer shape appears to be suffering from intense short-term erosion. After some increased erosion in 2008, the profile rebounded dramatically in 2009, gaining nearly 1.5 m in elevation at the 100 m mark. (Note: we feel the 3 extremely high points recorded in 2009 are erroneous.) However, in the summer of 2010, the profile underwent massive erosion, lowering by over 3 m at the 100 m mark. Although this profile clearly underwent massive erosion in the summer of 2010, because of the highly variable nature of this profile due to its proximity to the river and its dependence upon the dynamic low-tide swash platform and overall retention of sand within Goosefare Bay, we do expect this profile to recover by the summer of 2011. At the same time, due to its dynamic nature, we do expect it to undergo highly variable changes (both massive erosion and accretion) in the future. Comparison with the summer 2011 shape will help determine if recovery has occurred. Because of the short-term nature of the erosive trend (2009-2010), we assign this profile a "D" instead of an "F". We also note that the profile starting point has changed several times, according to volunteers, which may impact this assessment.

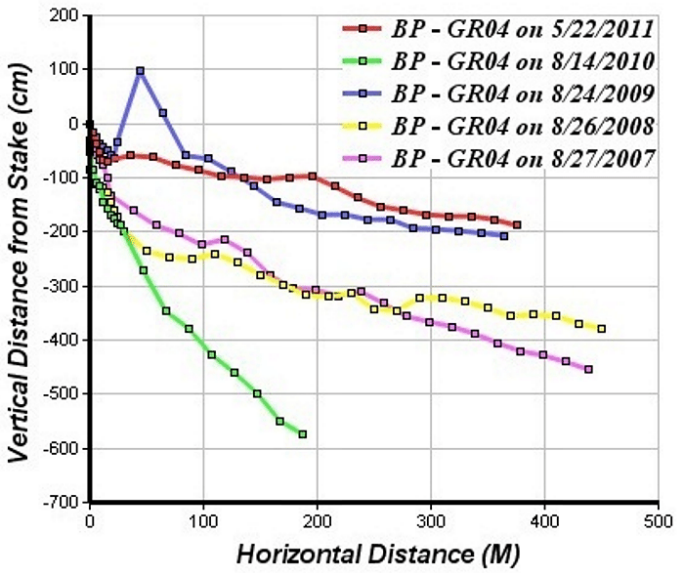

Figure 52. Summer beach profiles from Goose Rocks Beach profile line GR04.

Summer Beach Grade = C (73)
It appears that the summer profiles at Goose Rocks Beach are not fairing that well, aside from GR02. The profiles at the northern end of the beach, GR03 and GR04, appear to be undergoing summer erosion, especially from 2009 through 2010. Comparison with summer 2011 profiles is needed.

Summary
At Goose Rocks Beach, there continues to be dramatic variation in profile shapes at the end members (GR01 and GR04) due to influence of the adjacent rivers and shifting sand bars on their ebb-tidal deltas, especially during the summer months. The highly variable profiles at GR01 and GRO4 appear to have massive swings in terms of their profile shapes from year to year. These profiles appear to be fairing relatively well during the winter, yet remaining highly variable in the summer. The most stable profile at the beach appears to be GR02, which is quite protected by offshore bedrock outcrops. Part of the variability may be due to the fact that the profile starting points have varied due to loss of starting pin locations at GR03 and GR04, as noted by volunteers. The setting of newer, more permanent starting pins would aid in future analysis.
Overall grade = B- (80)

Goochs Beach and Middle Beach, Kennebunk

A total of three of four beach profiles (GO02 to GO04, Figure 53) were available for comparison. Profile GO01 was lost during the storm, and profiling was not resumed until June 2007 at this location, we use the June 2007 as the "post-storm" profile. The profiles trend west to east along the beach for GO01 to GO03; GO04 is located on the adjacent beach to the west.

Figure 53. Location of beach profiles GO01 to GO04 at Goochs Beach and Middle Beach, Kennebunk. Base imagery from Maine Office of GIS.

Winter Profile Changes

GO01 = D (65)

This profile is located at the southwestern end of the beach. Profile GO01 received an A in the last assessment. The starting pin at GO01 was lost in the Patriots' Day Storm and monitoring was resumed in June 2007. The post-storm June profile (Figure 54) displays a steep nearshore slope from the wall, and a noted berm near the 10 m mark. In 2008, the entire profile gained about 20 cm in elevation. This trend continued into 2009, with good profile stability. Additional profile growth occurred in 2010, with the upper profile (nearest the seawall) increasing in elevation. However, in 2011, the profile was eroded to or below the June 2007 profile shape, with about 50 cm loss of sand elevation adjacent to the seawall. This profile shows stability to growth from 207 to 2010; however, based on the 2011 shape, the profile clearly underwent large amounts of erosion. The question is whether or not this is representative of a new trend, or if recovery will occur by next April. At this point, because erosion cut down to or below the 2007 shape, we give the profile a very cautionary D. We are concerned about the loss of berm adjacent to the seawall.

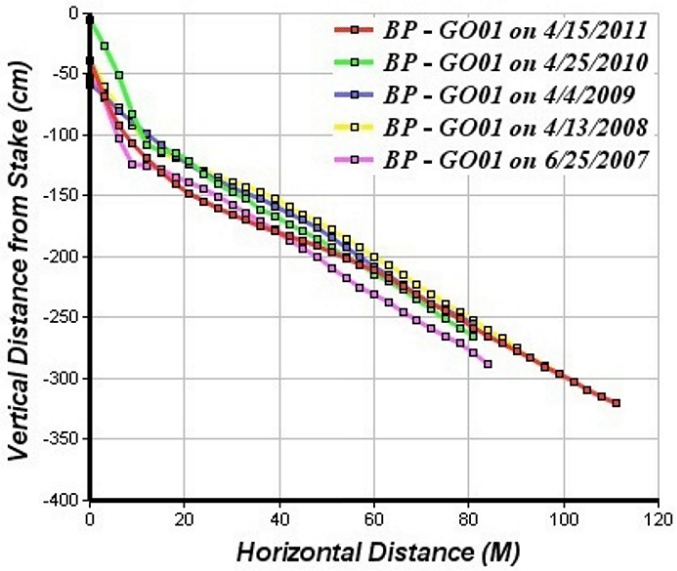

Figure 54. Winter beach profiles from Goochs Beach profile line GO01.

GO02 = B (85)

Profile GO02 is more centrally located along the Goochs Beach seawall. It received an A in the last assessment. The post-storm profile was steep, with a very low, flat berm into the low-tide area. The 2008 and 2009 profiles (Figure 55) showed good recovery, with steady gains in elevation along the profile. In 2010, the upper portion of the profile (nearest the wall) gained a good amount of sediment, while the berm deepened and lost sand, near the 20-30 m mark. In 2011, this area recovered, but the profile lost around 30 cm of elevation adjacent to the seawall. Overall, GO02 is showing relatively good signs of profile recovery and general stability in terms of its overall shape, although it has lost sediment along the seawall (the berm). We are slightly concerned about the loss of berm adjacent to the seawall.

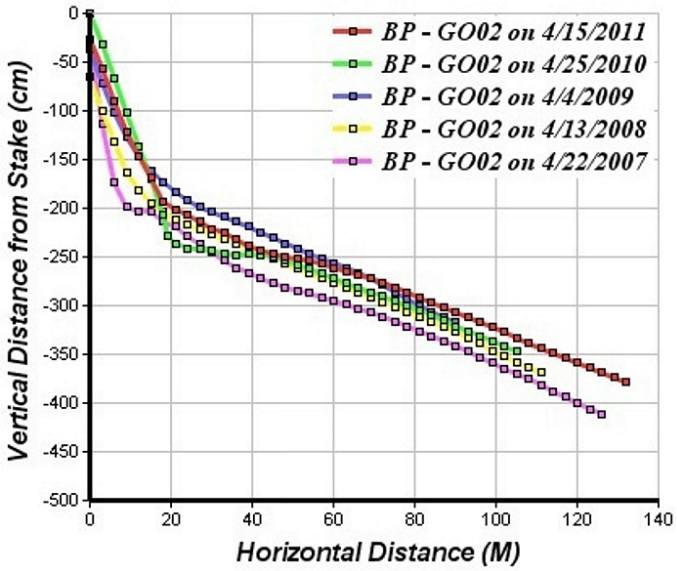

Figure 55. Winter beach profiles from Goochs Beach profile line GO02.

GO03 = C+ (78)

Profile GO03, located at the northeastern end of the beach, received a B in the last assessment. The post-storm winter profile (Figure 56) had a steep slope from the wall, which began to flatten near the 20 m mark. The 2008 and 2009 profiles showed slight, gradual recovery. The winter 2010 shape exhibited the highest level of sand adjacent to the wall, and additional slight growth in elevation along the profile. By 2011, although sand was lost adjacent to the wall at the berm (the elevation fell by around 50 cm), the lower portion of the profile gained elevation. This is consistent with GO02, which also lost sediment directly adjacent to the seawall. We are concerned about the loss of berm adjacent to the seawall, but encouraged by the amount of sand offshore.

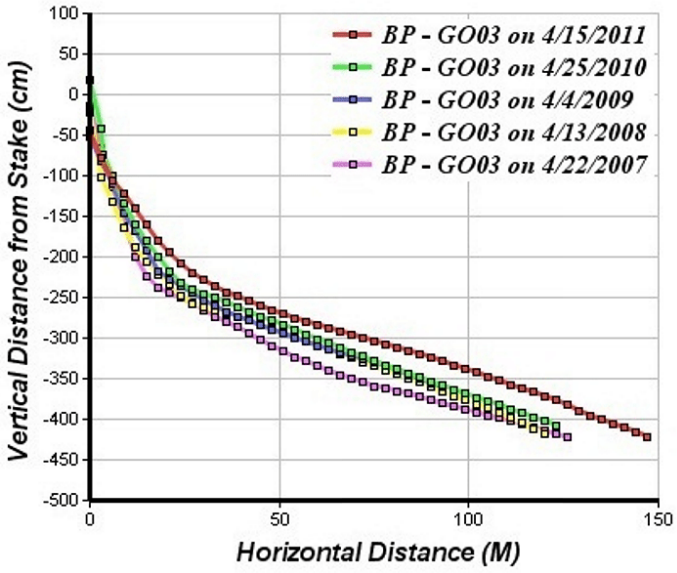

Figure 56. Winter beach profiles from Goochs Beach profile line GO03.

GO04 = B (85)

GO04, located along Middle Beach, received a C in the last assessment. The profile gained cobble and sand adjacent to the seawall from 2008 to 2009 (Figure 57), but steepened in the offshore, starting at around the 12 m mark. This offshore loss led to a cautionary grade of C. In 2010, the apparent berm that had formed was lost, but the overall profile gained elevation along its length. In 2011, a large, well-defined berm at the 10 m mark was noted, and the profile maintained general stability along its lower length. This profile did not undergo loss of sediment adjacent to the wall, as the profiles along Goochs Beach displayed. It is generally showing good recovery and stability.

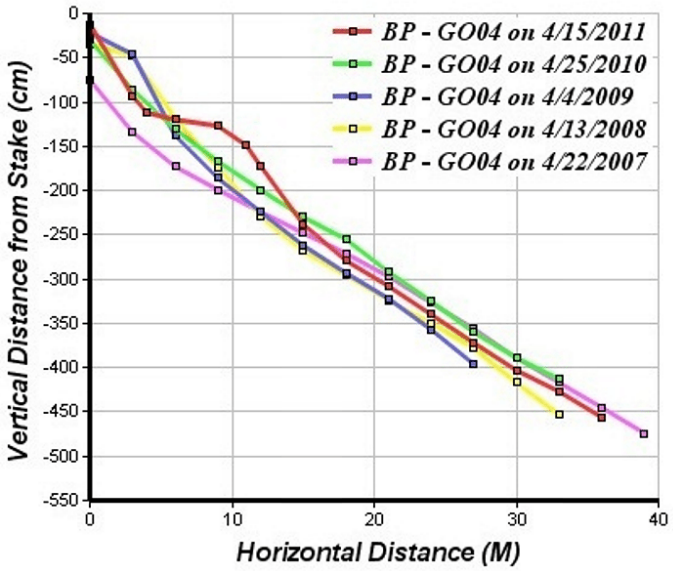

Figure 57. Winter beach profiles from Goochs Beach profile line GO04.

Winter Beach Grade = C+ (78)
Winter shapes at Goochs Beach, aside from GO04, show typical concave, relatively featureless winter shapes. Profile changes show stability to growth at the central and eastern portion of the beach, with erosion at the western portion of the beach (at GO01). Growth at GO03, stability at GO02, and erosion at GO01 indicate that sand may be migrating from west to east along the beach.

Summer Profile Changes
GO01 = D (65)
The summer 2007 profile (Figure 58) started at an elevation near 40 cm below the starting mark on the wall, displayed little berm, and continued with a gradual slope to the offshore. By the summer of 2008, the profile gained nearly 40 cm of sand at its starting point, and maintained its gradual slope to the offshore. In 2009, the profile lost sand in the nearshore portion of the profile, and lost sand adjacent to the wall. This trend continued in 2010, with the sand elevation being -50 cm at the starting point, and the profile actually eroding to below the summer 2007 profile shape. This profile clearly underwent large amounts of erosion in the summer of 2010. Based on this trend, we are very concerned about, and will be looking for, a summer berm at this location in 2011.

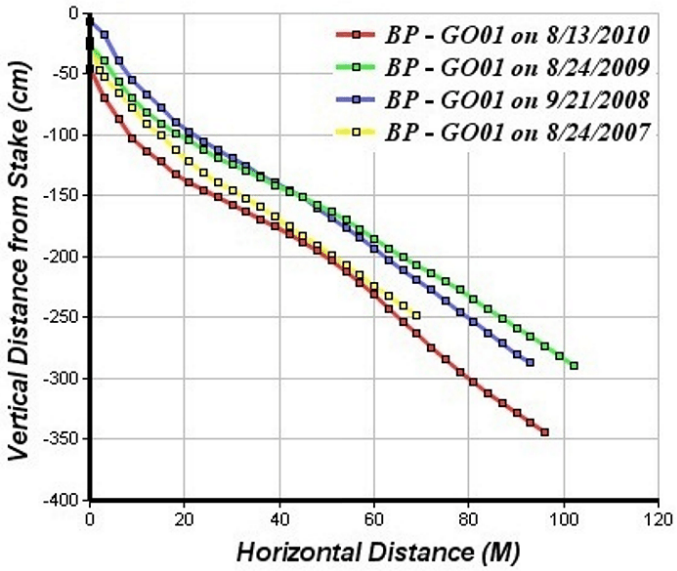

Figure 58. Summer beach profiles from Goochs Beach profile line GO01.

GO02 = A (95)

The summer, post-storm profile (Figure 59) started near -60 cm below the starting point, and exhibited a featureless, gentle slope into the low-tide area. The 2008 and 2009 profiles showed slight recovery, with steady gains in elevation along the entire profile and adjacent to the wall. In 2010, the berm, nearest the wall, gained about 60 cm of sand, with sand actually piling up above the starting point on the wall. The 2010 profile either stayed at the 2009 shape, or showed slight increases in elevation. This profile is showing extremely good summer recovery.

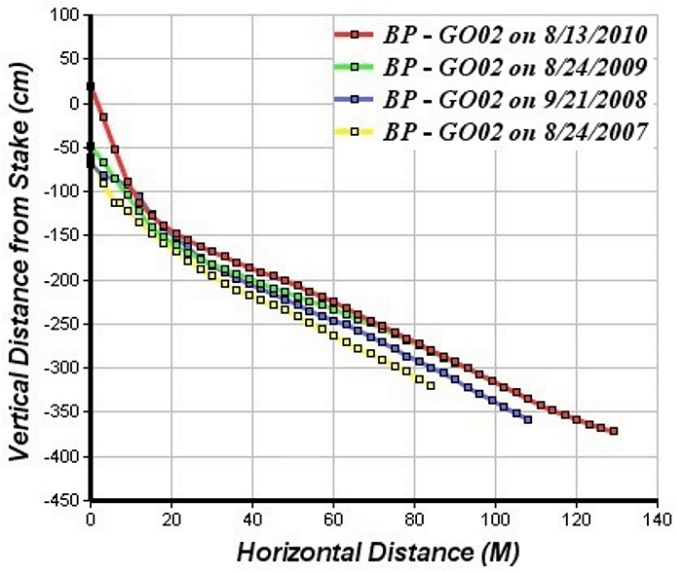

Figure 59. Summer beach profiles from Goochs Beach profile line GO02.

GO03 = B (85)

The summer shape of profile GO03 (Figure 60) appears to have undergone very little change over the last four summers. It does appear that the 2010 profile had the highest sand elevation at the start of all four years, and the most sand along the majority of the profile, even though the berm evident in 2008 was lost. In general, profile GO03 has shown signs of good stability in terms of its summer shape.

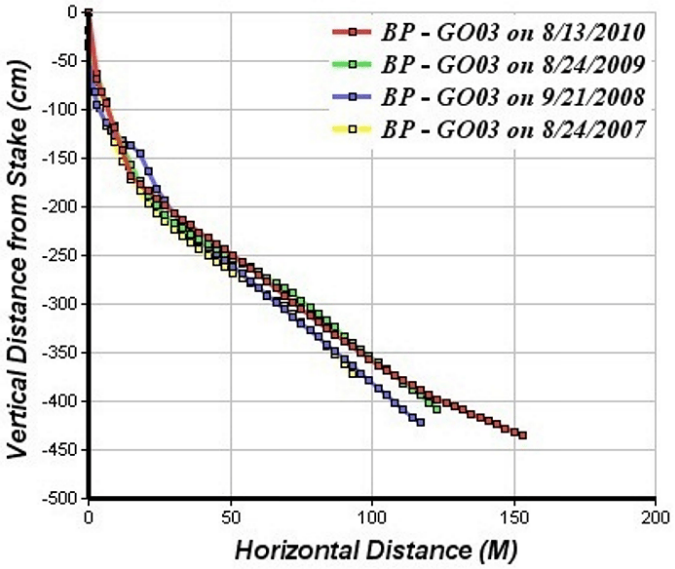

Figure 60. Summer beach profiles from Goochs Beach profile line GO03.

GO04 = B (85)

At GO04 (Figure 61), the profile appears to have remained relatively stable in the summer, with the formation (except in 2009) of a well-defined berm, and similar slope into the offshore. Summer 2009 appears to be an anomalous shape, with just a featureless slope into the offshore. By summer 2010, the profile seems to have recovered with a well-defined berm.

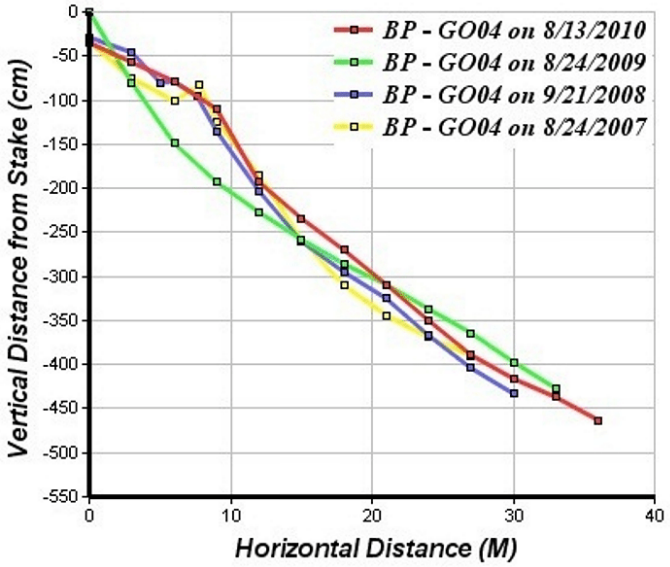

Figure 61. Summer beach profiles from Goochs Beach profile line GO04.

Summer Beach Grade = B (83)

The summer shapes along Goochs Beach appear to be generally flat, with little no berm aside from GO04, which shows a well-defined cobble berm. However, the summer beach profiles, aside from GO01, appear to be fairing very well through the summer of 2010, with most accretion at the central portion of the beach, at GO02. GO01, located at the western end of the beach, appears to be undergoing erosion based on its summer shapes.

Summary

Overall, Goochs Beach is showing relatively good stability in the central to eastern portions of the beach. Erosion is clearly occurring at the southwestern side of the beach, nearest GO01. The profiles here are relatively flat and featureless, but it appears that sediment lost in the 2010 storm has been returning to the beach.

Overall grade = B- (81)

Laudholm Beach, Wells

Four beach profiles (LH01-03, LH05, Figure 62) were available for analysis of beach recovery. At LH01, the front profile stake was lost during the 2007 storm, and profiling was resumed at the back stake in June 2007. The profiles extend along a portion of the beach nearest the Little River, from northeast to southwest for profiles LH01-LH03; profile LH05 is located slightly farther to the southwest.

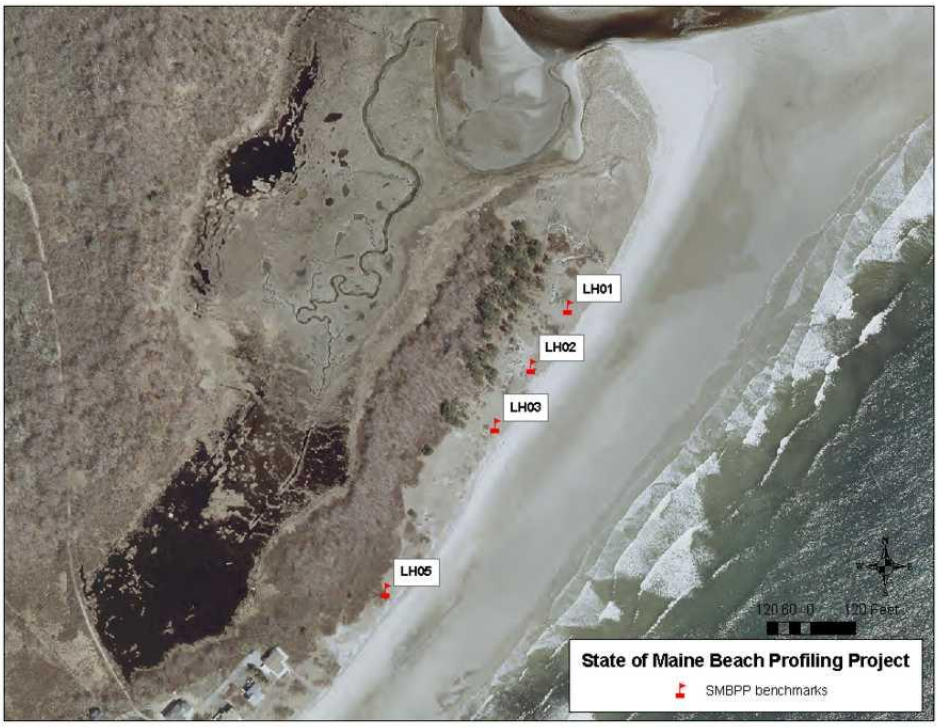

Figure 62. Location of beach profiles LH01 to LH03 and LH5 at Laudholm Beach, Wells. Base imagery from Maine Office of GIS.

Winter Profile Changes

LH01 = C (75)

Profile LH01, located nearest the Little River, received a B- in the last assessment. Based on the winter profiles available, the profile has remained stable in its first 30 meters from the pin, with a well-defined dune crest (Figure 63). Seaward of the 30 m mark, the profile has shown variability since the immediate post-2007 profile shape in terms of the depth of sand at the trough, and the elevation of sand into the low tide area. In 2008 and 2009, the profile gained elevation at the 50 m mark, and seaward of the 100 m mark. By 2010, the profile appears to have eroded slightly at its dune, and deepened at the 50 m mark by around about 1 meter in elevations - this was actually the most erosive profile of the four years. In 2011, the profile recovered slightly, with elevation gains in the offshore above the 2010 shape, but sections remained below the 2007 winter shape, and never reached the high 2008 and 2009 elevations in the offshore. The dune portion of the profile appears relatively stable, but it has undergone generally erosive changes in the past few years along the beach berm and low tide areas. The 2011 profile appears to be an "average" shape for the range of profiles from 2007 to 2011.

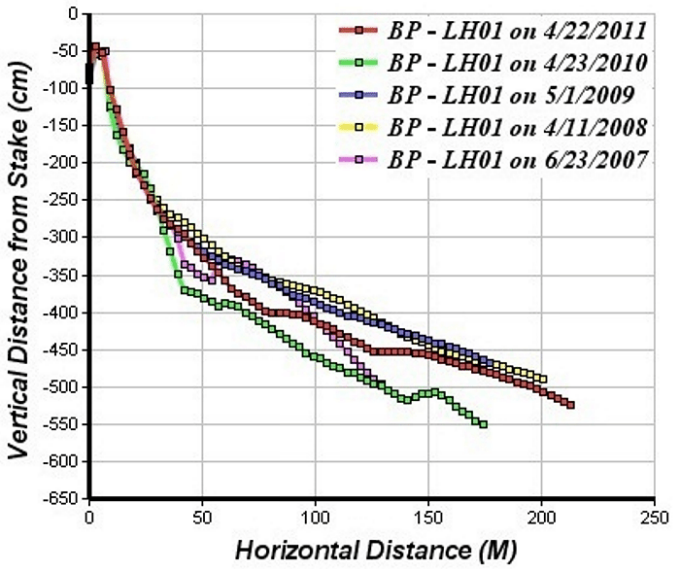

Figure 63. Winter beach profiles from Laudholm Beach profile line LH01.

LH02 = D (65)

LH02, located to the south of LH01, received a B on the last assessment. In 2008 (Figure 64), the majority of the profile demonstrated very good recovery. In 2009, the profile eroded slightly along its length, though it did maintain elevations above the 2007 post-storm shape. In 2010, consistent with LH01, the profile underwent large amounts of erosion, and eroded to its deepest point, especially along its berm, out to about 70 m for the starting point. Some recovery occurred in 2011, especially between 40 and 75 m from the starting point. However, the upper portion of the profile, nearest the dune, clearly eroded in a landward direction over the time period. The profile is exhibiting steepening in its nearshore portion, back down to or below the 2007 shape. It is showing steady erosion and landward migration that is worse than an average.

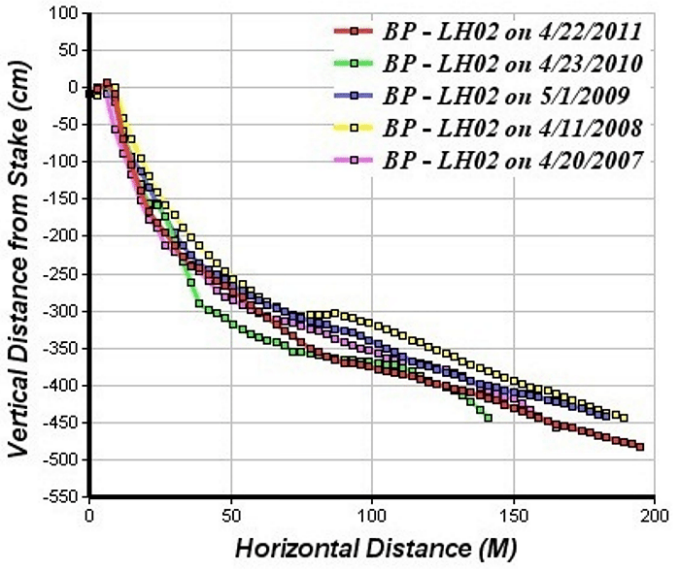

Figure 64. Winter beach profiles from Laudholm Beach profile line LH02.

LH03 = D (65)

Profile LH03, located roughly in the middle of Laudholm Beach, received a B in the last assessment. In 2008 and 2009 (Figure 65), the profile showed signs of recovery, with elevation gains along the length of the profile. In 2010, this trend continued but the dune eroded landward. However, in 2011, the profile clearly steepened, eroded landward, and the elevation decreased, although the dune edge appears to have migrated slightly seaward - this is most likely due to cobble piling near the dune. The profile is, similar to the others, showing that the berm and lower portions of the profile are undergoing significant erosion. The profile actually appears to have eroded to below the historic erosional surface (the exposed peat) in 2011, at the 70 m mark.

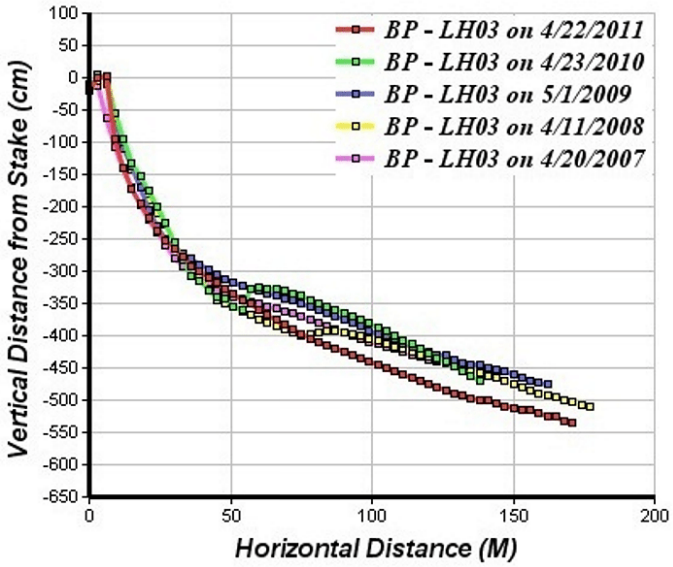

Figure 65. Winter beach profiles from Laudholm Beach profile line LH03.

LH05 = C (75)

LH05 is positioned much closer to Drakes Island Beach. The immediate, post-storm profile was extremely steep, and had a noted low dune crest. By April 2008 (Figure 66), the upper portion of the profile (out to about 40 m), had recovered very well, gained elevation, and built seaward; this could be due to cobble migration. The 2009 profile showed some dune and beach erosion along the upper portion of the profile, and did not change much in the offshore. By 2010, some slight dune erosion was noted, but a small berm built at about 20 m offshore, again most likely due to cobbles. In 2011, the profile looked roughly the same, but had migrated slightly landward in response to erosion. We suspect that some of the profile stability exhibited seaward of 50 m may actually be due to the fact that the profile may be eroded down to the marsh surface. We remain cautious about the shape of this profile, given the trend at LH03 and LH02.

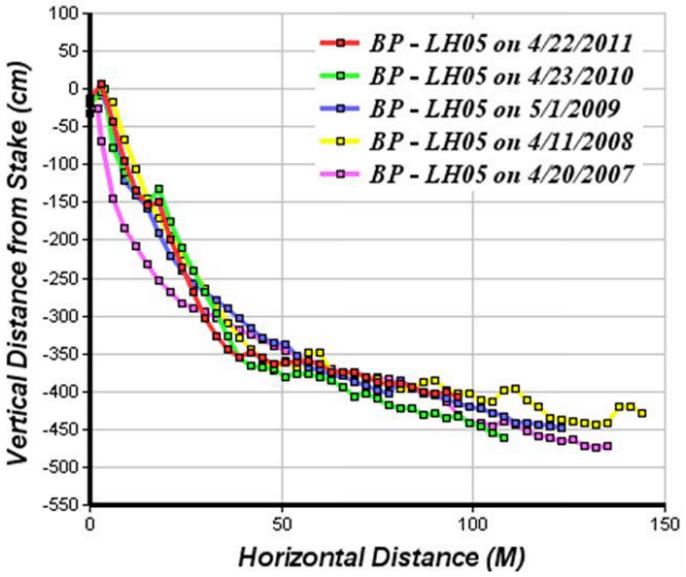

Figure 66. Winter beach profiles from Laudholm Beach profile line LH05.

Winter Beach Grade = C- (70)
The winter beach profiles at Laudholm Beach are indicating a slow, landward migration and steepening, indicating ongoing erosion. The general trend through 2009 showed good recovery, but since then, the profiles have been undergoing landward migration, steepening, and erosion, especially closer to the Little River.

Summer Profile Changes
LH01 = C (75)
The summer 2007 (Figure 67) profile showed a large berm at the 40 m mark. In 2008, the berm disappeared, and the profile deepened and migrated landward slightly. By summer 2009, the upper portion of the profile continued to erode, but the lower portion recovered and filled in. In 2010, the profile appears to have gained some elevation at the dune crest, but eroded at the berm and nearshore. It does show a good amount of sediment in the low tide area of the profile, which is a good sign - this sand may return. Although the dune crest appears to have been relatively stable, the nearshore portion of the profile - notably the berm - appears to have been lost over the past few summers. Comparison with 2011 shapes will help determine if the berm returns.

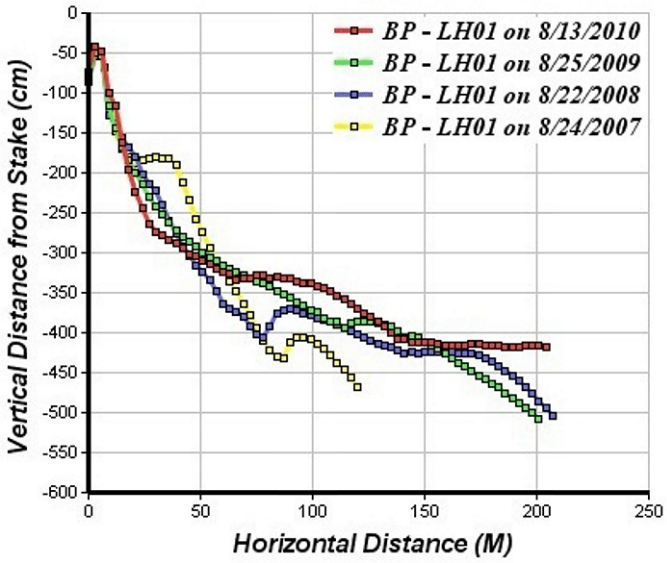

Figure 67. Summer beach profiles from Laudholm Beach profile line LH01.

LH02 = D (65)

In general, over the past four years, profile LH02 (Figure 68) exhibited a relatively stable summer dune crest, with some landward movement of the dune out to about 20 m. However, berm loss is evident over the years, with continual, steady, erosion from 2007 to 2010, located between 20 and 50 m from the starting point. Seaward of this, the profile exhibited variability. This profile is clearly showing evidence of consistent berm erosion over the past few years, most likely down to its erosion surface.

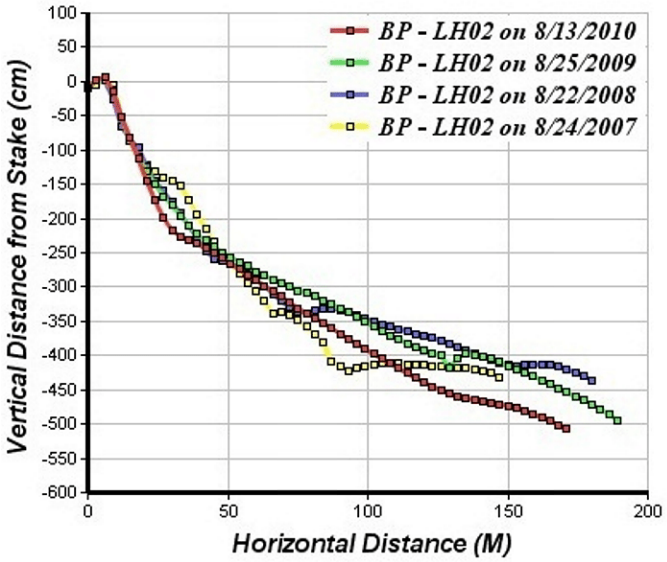

Figure 68. Summer beach profiles from Laudholm Beach profile line LH02.

LH03 = C- (72)

Consistent with the other Laudholm profiles, in the summer, LH03 (Figure 69) has shown the continual loss of the berm, positioned near the 25-30 m mark. The nodal point for the profile appears to be at the 40 m mark, where the low tide area showed more variability. The 2008 profile had the most sand stored in the low tide area, while the

2007 and 2010 profiles had the lowest amount. This summer profile is also showing berm loss over the years, but its changes do not seem as bad as LH02; also, some sediment is apparent in the offshore.

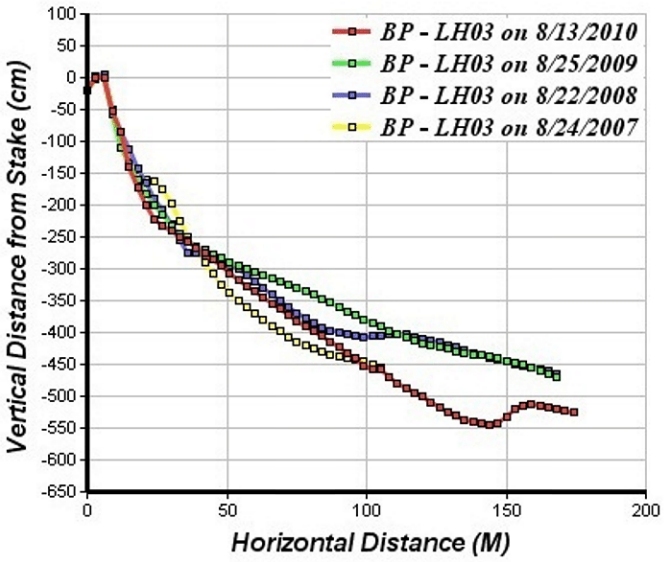

Figure 69. Summer beach profiles from Laudholm Beach profile line LH03.

LH05 = D (65)

LH05 (Figure 70) appears to also have responded over the past few years by moving landward and eroding. The entire profile, including the dune crest and berm, have moved slightly landward; however, the 2009 profile does appear to be slightly steeper than the 2010 summer shape, indicating that the profile did recover slightly in 2010. The dune crest and lower portion of the profile, out to about 80 m, however, is below the 2009 and 2008 profile elevations. It appears that LH05 has eroded down to its historic erosional surface (peat) in the low tide area of the profile. We remain very cautious as to how this profile will respond this summer.

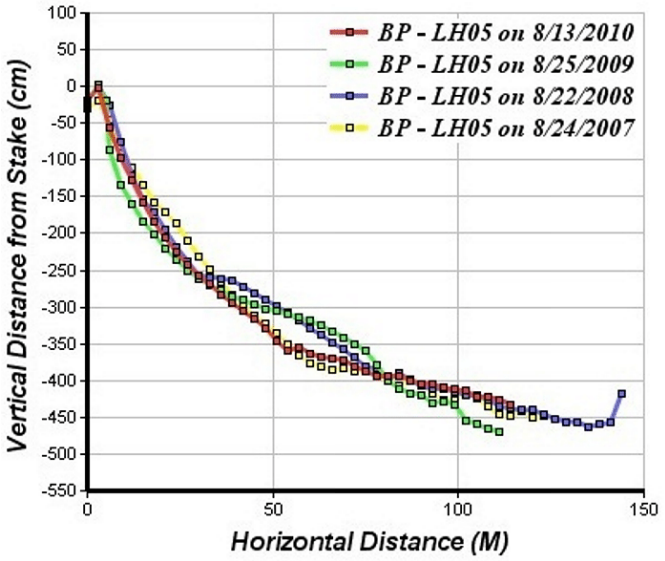

Figure 70. Summer beach profiles from Laudholm Beach profile line LH05.

Summer Beach Grade = D+ (69)

The summer profiles at Laudholm Beach appear to be maintaining their dune crests relatively well; this is likely due to cobble being pushed up to the toe of the dune. However, each profile is showing signs of consistent berm retreat, signifying erosion, over the time period from 2007-2010.

Summary

Laudholm Beach appears to be undergoing significant erosion, especially at the middle and lower portions of its profiles. In fact, it appears that many of the profiles have been eroded down below their sand and cobble layers, to (and in some cases below) the peat surface in the surf zone. Dune and upper beach stability may be influenced by the migration of cobbles up the profile, to near the toe of the dune. In addition, it appears that southerly migration of the Little River inlet channel is negatively influencing profile shapes through ebb-tidal shoal instability.

Overall grade = C- (70)

Drakes Island Beach, Wells

Four beach profiles (DI01-DI04, Figure 71) were available for analysis. It appears that no profiles were entered in the online database in 2011, so analysis will end with comparison with July 2010 profiles. The profiles are placed from the southwest, near the Webhannet River, to the northeast.

Figure 71. Location of beach profiles DI01 to DI04 at Drakes Island Beach, Wells. Base imagery from Maine Office of GIS.

Winter Profile Changes

DI01 = D (65)

DI01, which is located adjacent to the north jetty at the Webhannet River, received an A in the last assessment. The profile underwent extremely good recovery through 2009 (Figure 72), with elevation gains at the dune crest, berm, and out to the low tide area of the profile. However, in 2010, the dune lost elevation by around 40 cm, and the berm and sand gained in 2008 and 2009 was lost. In fact, the 2010 profile was below the immediate post-storm 2007 profile from about 40 m seaward. The profile displayed good recovery through 2009, and unfortunately, it seems the winter of 2010 severely eroded the profile, with little recovery by July of 2010.

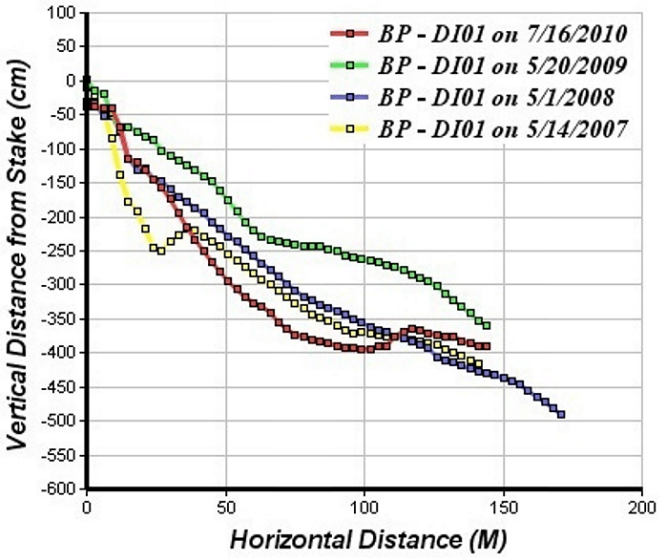

Figure 72. Winter beach profiles from Drakes Island Beach profile line DI01.

DI02 = D (65)

Profile DI02 is located in the central portion of the natural dune to the north of the jetty. It received an A in the last assessment. The 2007 post-storm shape (Figure 73) had a steep slope to an apparent cobble bar formation near the 40 m mark. By 2008, the entire profile underwent accretion, with elevation being gained along the entire length. In 2009, there was some slight erosion of the profile, but it maintained its overall shape, similar to 2008. However, in 2010, the profile underwent loss along its entire length, from the dune out to the end of the profile. The erosion stayed above the 2007 erosional surface out to about 30 m, but then eroded to below the 2007 profile shape offshore. This profile is showing signs of erosion since 2008.

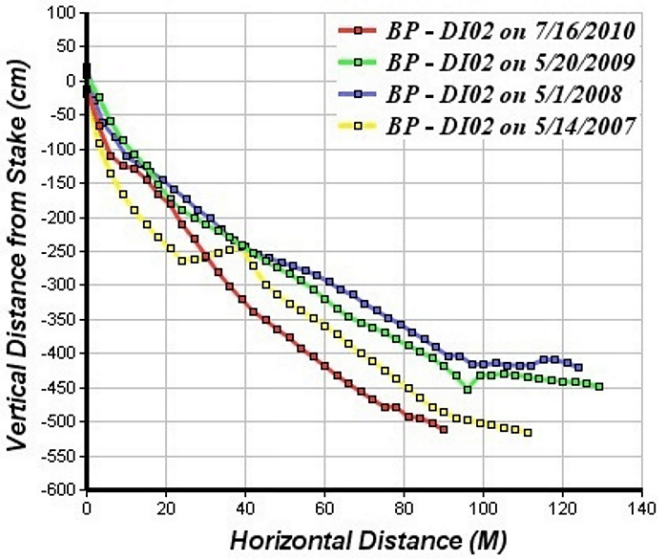

Figure 73. Winter beach profiles from Drakes Island Beach profile line DI02.

DI03 = D (65)

Profile DI03 is located at a seawall in the main beach entrance at Drakes Island Beach. It received a D in the last assessment. In 2008 (Figure 74), the profile had significantly eroded along its length, losing between 20-50 cm of

elevation, and resulting in a profile that was below the 2007 shape. In 2009, the profile recovered slightly, but still stayed below the post-storm profile shape. In 2010, significant recovery appears to have occurred; however, it appears that July 2010 data may have been collected at an arbitrary starting point on the seawall that is inconsistent with the other starting points. Notes indicate "used seawall to start as our front stake". We are unclear if this is the same starting point, or if the profilers simply forgot to measure an accurate starting elevation of the sand below the pin for the stake elevation. Therefore, no comparison can be made with 2010 data. Based on changes through 2009, DI03 will remain as a D.

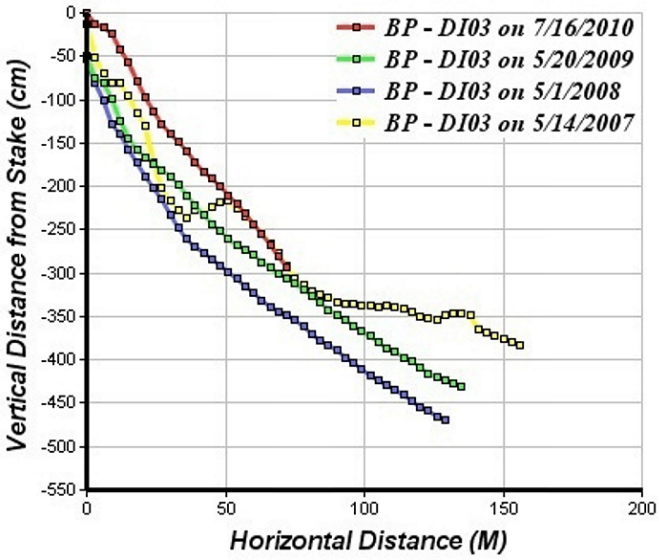

Figure 74. Winter beach profiles from Drakes Island Beach profile line DI03.

DI04 = D (65)

DI04 is located farther north along the seawalled portion of the beach, and received a D in the last assessment. Similar to DI03, the profile eroded in 2008 (Figure 75), resulting in the lowest elevations of the profiles compared. By 2009, some recovery had occurred in the offshore, though the upper portion of the profile was still below the 2007 storm shape. In 2010, data appears to be collected from either a different starting point, or collected incorrectly, as it shows a profile shape that is inconsistent with the profiles from previous years. Notes indicate "used private stairs as front starting location". We are unclear if this is the same starting point, or if the profilers simply forgot to measure an accurate starting elevation of the sand below the pin for the stake elevation. Therefore, no comparison can be made with 2010 data. Based on changes through 2009, DI04 will remain as a D.

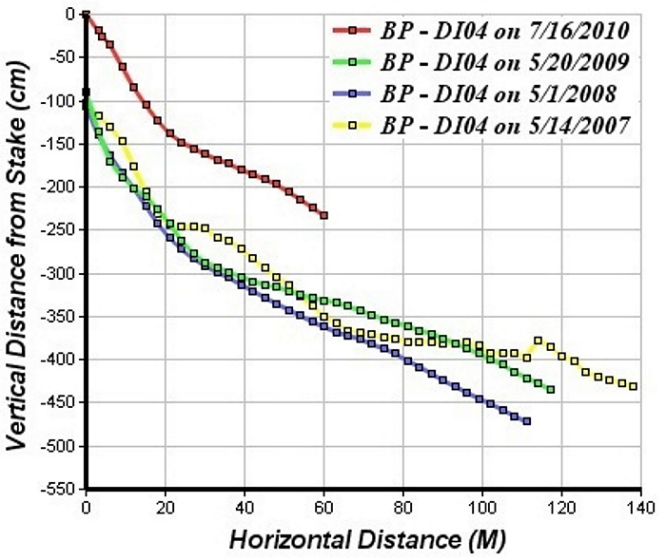

Figure 75. Winter beach profiles from Drakes Island Beach profile line DI04.

Winter Beach Grade = D (65)

The winter profiles at Drakes Island Beach appear to all be undergoing signs of erosion over the period of 2007-2010. It is impossible to compare data at DI03 and DI04 since it appears that the profile location may have moved. Profiling at this beach should be reinstated on a monthly basis in order to provide a good analysis of how the beach is faring.

Summer Profile Changes

DI01 = D (65)

The summer post-storm profile of 2007 (Figure 76) showed a small dune and little berm, and a steep slope to the low tide area. In 2008, the dune appeared to stay roughly the same, and a small berm appeared, gaining in elevation slightly over the 2007 shape from about 20 m to 70 m offshore. However, the summer beach underwent extremely good recovery through 2009, with elevation gains at the dune crest, berm, and out to the low tide area of the profile. In the summer of 2010, the dune roded back to 2007 elevations, and the berm and all sand elevations gained were lost. Seaward of about 40 m, the 2010 profile was the lowest recorded, indicating large erosion of the nearshore. When data becomes available, the summer profile from 2011 should be compared with 2010 shape to see if recovery has occurred, or if this erosive trend continued into 2011.

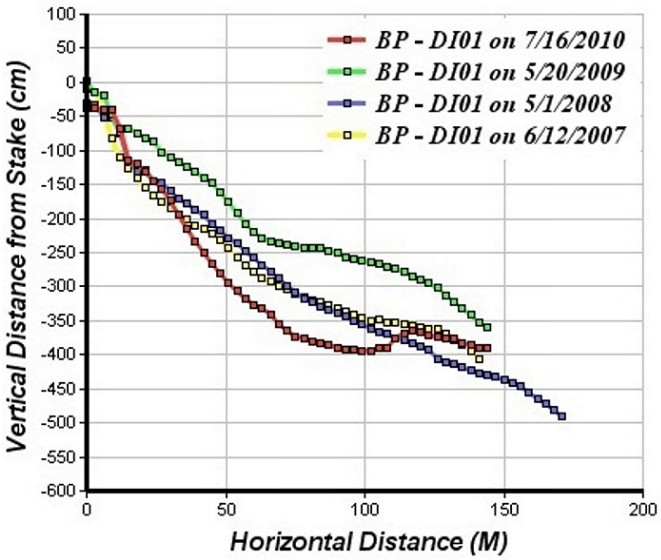

Figure 76. Summer beach profiles from Drakes Island Beach profile line DI01.

DI02 = D (65)

Similar to DI01, the summer shape at DI02 (Figure 77) underwent berm growth and recovery in 2008 and 2009, but saw significant erosion by the summer of 2010 at the dune, berm, and out to the low tide area. Elevation losses at the 40 m mark were near 80 cm, and about 1 m at the 60 m and 80 m marks. This summer shape is clearly eroding; the 2011 summer profile should be used for comparison in the future to see if the beach has recovered from 2010, or is continuing to erode.

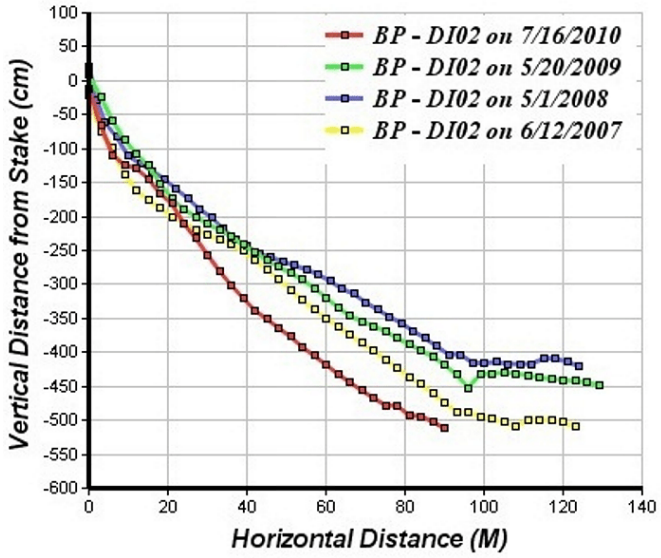

Figure 77. Summer beach profiles from Drakes Island Beach profile line DI02.

DI03 = D (65)

The summer shape at DI03 (Figure 78) showed additional loss in elevation along the entire profile in 2008, with slight recovery in 2009, but still below the summer 2007 profile shape. In 2010, significant recovery appears to have occurred; however, it appears that July 2010 data may have been collected at an arbitrary starting point on the seawall that is inconsistent with the other starting points. Notes indicate "used seawall to start as our front stake".

We are unclear if this is the same starting point, or if the profilers simply forgot to measure an accurate starting elevation of the sand below the pin for the stake elevation. Therefore, no comparison can be made with 2010 data. Based on the trend from 2007-2009, this profile is eroding. Profiling should resume in 2011 for additional comparison.

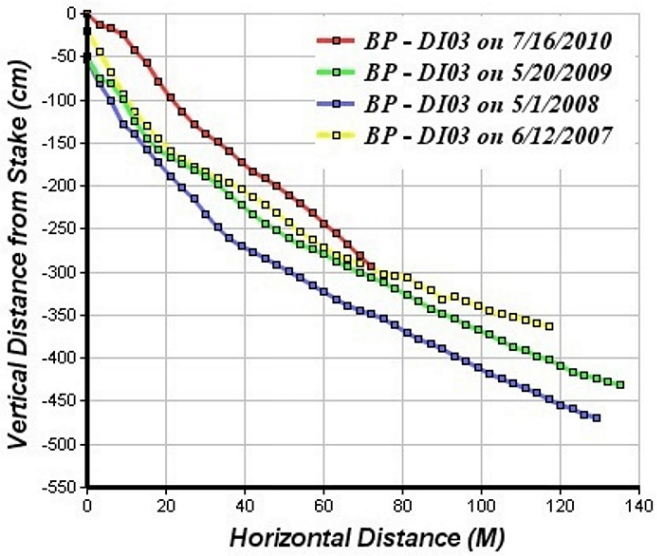

Figure 78. Summer beach profiles from Drakes Island Beach profile line DI03.

DI04 = B+ (88)

DI04 showed slight recovery by the summer of 2008 (Figure 79), with small elevation gains along the majority of the profile. In 2009, a small berm developed (near the 20 m mark), and the upper and lower portions of the profile gained sediment. In 2010, data appears to be collected from either a different starting point, or collected incorrectly, as it shows a profile shape that is inconsistent with the profiles from previous years. Notes indicate "used private stairs as front starting location". We are unclear if this is the same starting point, or if the profilers simply forgot to measure an accurate starting elevation of the sand below the pin for the stake elevation. Therefore, no comparison can be made with 2010 data. Based on the trend from 2007-2009, this profile is showing some signs of stability and growth. Profiling should resume in 2011 for additional comparison.

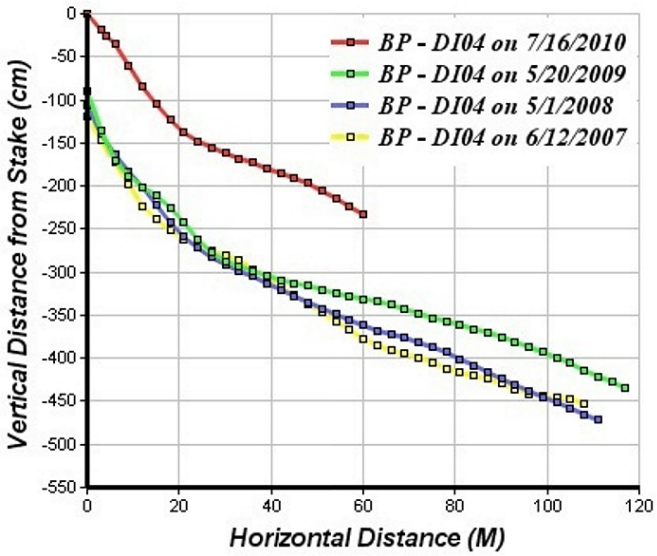

Figure 79. Summer beach profiles from Drakes Island Beach profile line DI04.

Summer Beach Grade = C- (71)
Similar to the winter profiles, the summer shapes at Drakes Island do not appear to be fairing well. Erosion appears to be occurring at each of the profiles except for DI04, which appears to be showing signs of relatively good stability.

Summary
Overall, Drakes Island Beach is showing definitive signs of erosion, in both its summer and winter profile shapes. Even profiles nearest the Webhannet River Jetties (DI01 and DI02) are showing signs of erosion. Newer data needs to made available and looked at for better analysis (past July 2010) in order to see how the beach is doing in 2011.
Overall grade = D+ (68)

Wells Beach, Wells

Four beach profiles (WE00, WE02-WE04, Figure 80) were available for analysis. The profiles are located from the southwest to northeast along Wells Beach.

Figure 80. Location of beach profiles WE00 to WE04 at Wells Beach, Wells. Base imagery from Maine Office of GIS.

Winter Profile Changes

WE00 = C (75)

Located south of Casino Point, WE00 received an A in the last assessment. After the storm, WE00 was left with a very steep profile (Figure 81), with a large erosive trough where the berm had been. Very good recovery occurred in 2008 and 2009, with the return of the berm, and a well-developed profile. In 2010, the upper portion of the profile gained sand and steepened (increasing the sand elevation at the pin by about 30 cm), but the elevation of the berm decreased slightly. In 2011, the profile lost elevation at its upper portion, and at the berm. Although a berm was still evident out to about 50 m from the starting point, the profile was eroded to below the 2007 shape seaward of this mark. Overall, WE00 showed good recovery through 2010; in 2011, the profile appears to have eroded to elevations between the 2007 and 2008 profile shapes.

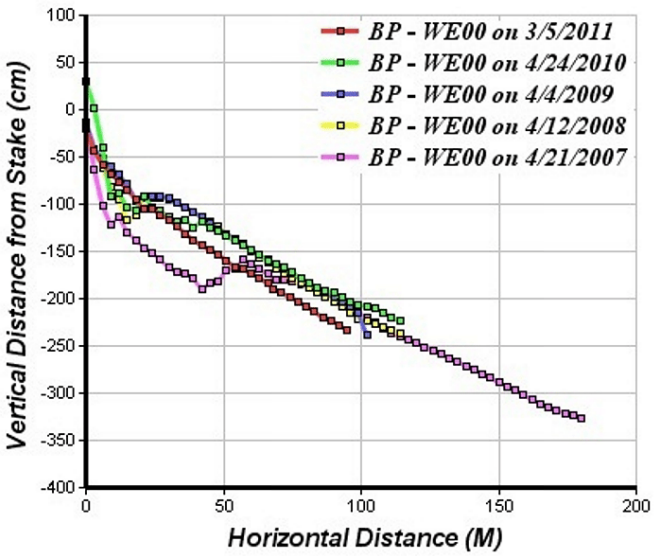

Figure 81. Winter beach profiles from Wells Beach profile line WE00.

WE02 = B+ (88)

Located north of Casino Point, WE02 received an A in the last assessment. In 2008 and 2009 (Figure 82), the profile showed steady recovery, increasing in elevation by about 1 m at the 50 m mark. Recovery continued to a high point in 2010, with the formation of a large, anomalous, well developed berm (likely comprised of cobbles) at about the 20 m mark. In 2011, this cobble berm had disappeared, but the profile stayed at or above the 2009 sand elevation. Although it has undergone berm loss in 2011 and slight lowering at its starting point, profile WE02 is showing good stability and general growth over the past four years.

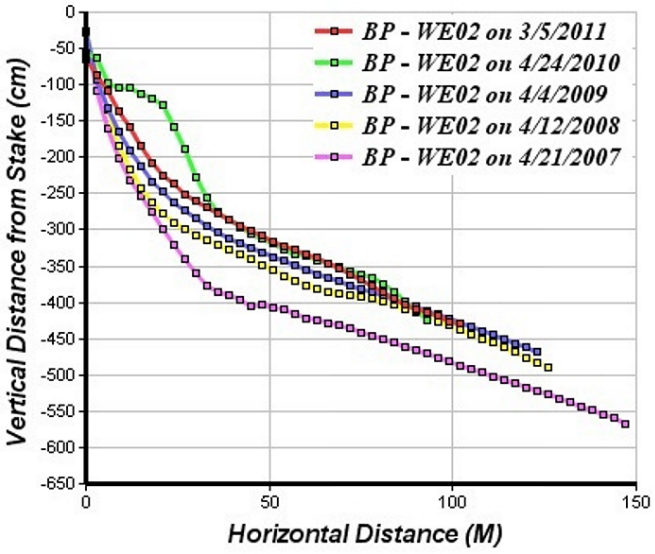

Figure 82. Winter beach profiles from Wells Beach profile line WE02.

WE03 = C (75)

WE03 is located south of the Webhannet River jetties, and received an A- in the last assessment. The post-storm profile in 2007 (Figure 83) was the lowest and most concave. By 2008, good recovery had occurred with the return of sand along the entire profile. In 2009, a berm formed near the 20 m mark, but the lower portion of the profile

eroded slightly. 2010 showed further berm growth and profile recovery in the offshore. However in 2011, the profile eroded to below 2009 levels out to about the 60 m mark, and the berm was lost. Seaward of this point, the sand elevation increased. Although recovery from the storm has occurred, this profile is currently exhibiting an erosive trend in the past year to pre-2009 conditions, and the loss of the berm apparent in 2008, 2009, and 2010 concerns us.

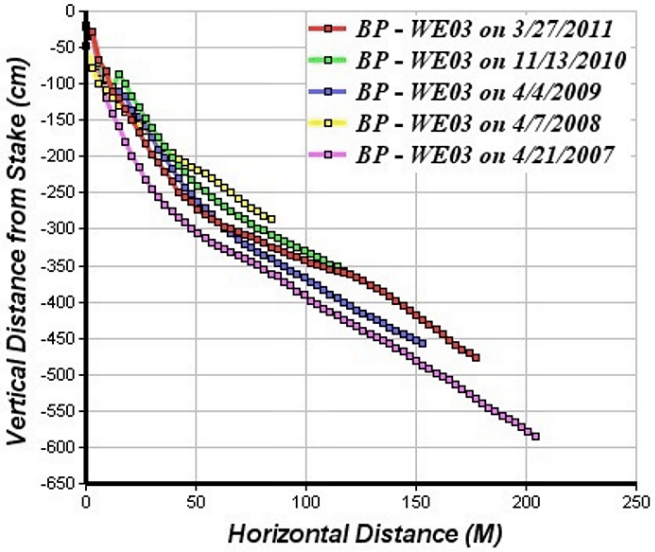

Figure 83. Winter beach profiles from Wells Beach profile line WE03.

WE04 = D (65)

WE04, directly adjacent to the Webhannet River jetties, received an A in the last assessment. This profile underwent good recovery and growth in 2008 and into 2009 (Figure 84), with additional elevation increases in the berm area. It appears 2009 had the most sand on the profile. By 2010, the berm appears to have started to erode. In 2011, the berm disappeared, the profile steepened, and eroded back to immediate 2007 post-storm elevations. This profile is currently is not showing additional signs of recovery, is currently undergoing erosion, and should continue to be monitored closely.

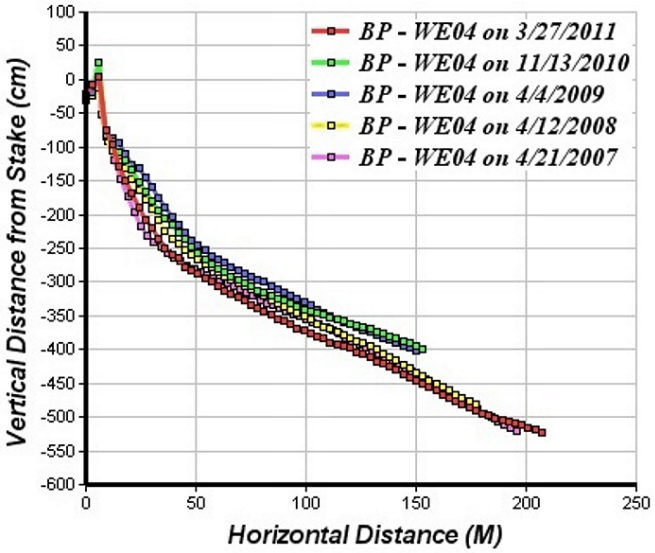

Figure 84. Winter beach profiles from Wells Beach profile line WE04.

Winter Beach Grade = C (76)
Winter profiles along Wells Beach mostly show a concave profile, aside from WE00, which appears to be influenced by cobble and underlying geology. All of the profiles appeared to recover very well through 2009. Since 2009, however, most appear to be undergoing an erosional trend, with loss of sand berms aside from WE02. Erosion appears to even be occurring adjacent to the jetties, which historically have shown good stability and even growth.

Summer Profile Changes
WE00 = A (95)
The summer shape (Figure 85) underwent good recovery in 2008, with the return of sediment along the entire profile and the development of a berm. This was eroded and flattened in 2009, but the berm clearly recovered in 2010. In 2011, the profile exhibited additional growth, increasing in elevation starting at the 20 m mark seaward. The profile is showing excellent summer increases in sediment over the past four years.

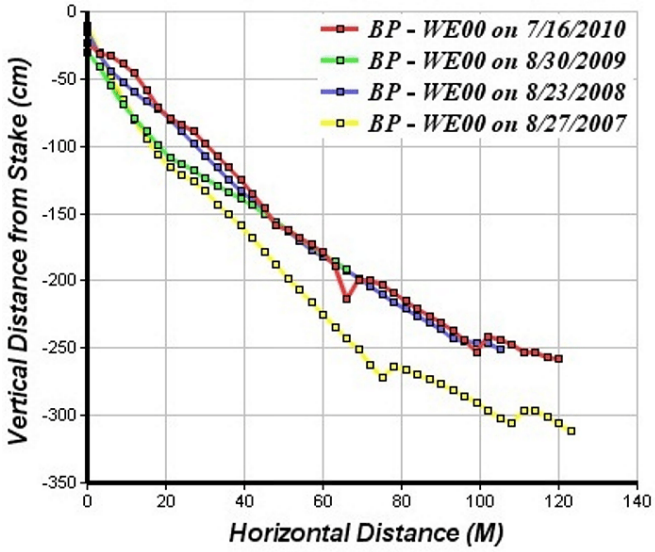

Figure 85. Summer beach profiles from Wells Beach profile line WE00.

WE02 = C- (72)
The WE02 summer profile (Figure 86), interestingly enough, appeared to be near its highest in elevation in the summer of 2007. In 2008, the profile lost elevation in the nearshore, and a notable trough formed near the 30 m mark. By 2009, a higher berm formed and the trough filled in. In 2010, the berm increased in elevation, but a large, deep trough was eroded, well below the 2008 profile shape, indicating the loss of over 1.5 m of sand near the 80 m mark. The profile also lost elevation at the starting pin. We are concerned about the elevation loss here and offshore. This profile appears to have undergone an erosive trend in 2010; comparison with summer 2011 profiles will help determine if it is recovering, or if this trend is continuing.

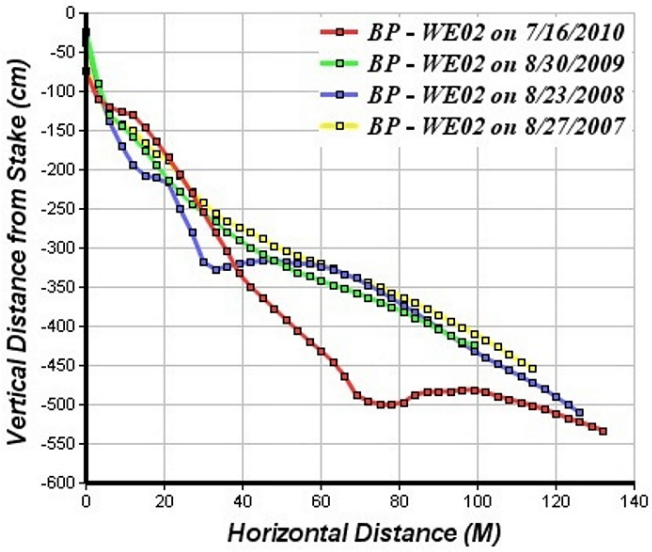

Figure 86. Summer beach profiles from Wells Beach profile line WE02.

WE03 = D (65)

WE03 (Figure 87) showed very good recovery in terms of the summer beach profile in 2008, with growth in the dune, berm, and low-tide sand elevations. In 2009, the dune increased with seaward growth, but the berm and profile underwent some erosion. In 2010, the dune had eroded, the berm lowered, and the profile steepened into the offshore, indicating landward migration and erosion. However, this profile clearly indicates consistent erosion since 2008.

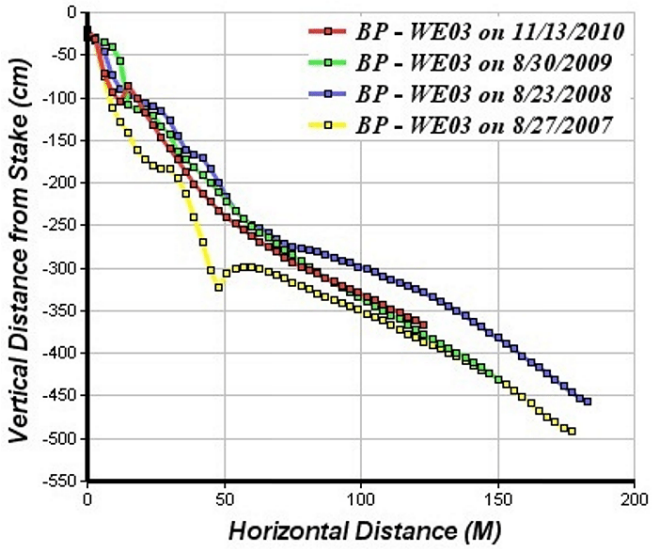

Figure 87. Summer beach profiles from Wells Beach profile line WE03.

WE04 = B (85)

By the summer of 2008, WE04 (Figure 88) showed its most sediment rich profile, showing recovery of the dune and developing a well-defined berm. In 2009, the profile eroded landward, and the elevation of the berm was lost. By November 2010, the dune had clearly gained elevation, and there was some slight recovery in the berm, and stability

consistent with the 2009 profile shape out to the low-tide area. This profile is showing general signs of summer stability, even though it is showing some signs of steepening in the nearshore.

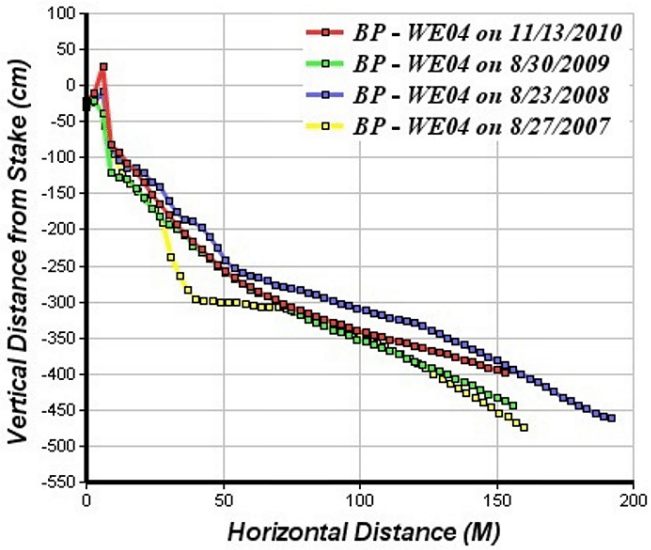

Figure 88. Summer beach profiles from Wells Beach profile line WE04.

Summer Beach Grade = C+ (79)
Summer profiles at Wells Beach appear to be doing better than winter profiles, with some signs of stability, even though erosion seems to be occurring at the central portion of the beach, indicated by changes from 2009-2010 at WE02 and WE03. It appears that 2008 was the best year for profile shapes along Wells Beach. Comparison with summer 2011 profiles will help further quantify these changes.

Summary
Overall, Wells Beach appears to be showing erosion in its middle two profiles, specifically during summer months. The two end profiles appear slightly more stable during the summer. Berm loss and profile deepening appear to be issues in the past year or so. We recommend an additional two profiles be established in the center section of Wells Beach to document trends over the full beach length.
Overall grade = C+ (78)

Ogunquit Beach, Ogunquit

Along Ogunquit Beach, there are four beach profiles (OG01 to OG04, Figure 89). They are spread along a short stretch of the northern portion of the beach, from north to south. However, no data from 2010 or 2011 was available via the Shore Stewards website for OG01. No data was available from 2009, 2010, or 2011 for OG03 or OG04. Therefore, the review is limited to changes only at OG02.

Figure 89. Location of beach profile OG02 on Ogunquit Beach, Ogunquit. Base imagery from Maine Office of GIS.

Winter Profile Changes

OG02 = D (65)

Profile OG02 is located near the wastewater treatment plant at the northern end of the beach. This profile received a C in the last assessment (with analysis through 2008 only). Interestingly, the 2007 beach profile (Figure 90) appeared to have the highest elevation of sand on the beach out to the low water mark. In 2008, the upper portion of the profile (40 m landward) either remained stable, or had gained elevation, especially nearest the starting stake. Offshore, however, seaward of the 40 m mark, the 2008 profile lost elevation, and remained below the 2007 post-storm profile. In 2009, the dune appears to have been eroded significantly, losing elevation near the starting pin, at the dune crest, at the berm, and along the entire profile. This erosion continued in 2010, with additional loss of the berm, steepening of the profile, and loss of elevation offshore. However, the dune crest appears to have stabilized. In 2011, the dune crest appears to have stayed stable, and the berm and lower portions of the profile recovered to about 2009 profile elevations. However, this profile is showing signs of continuous erosion, with only slight recovery in 2011.

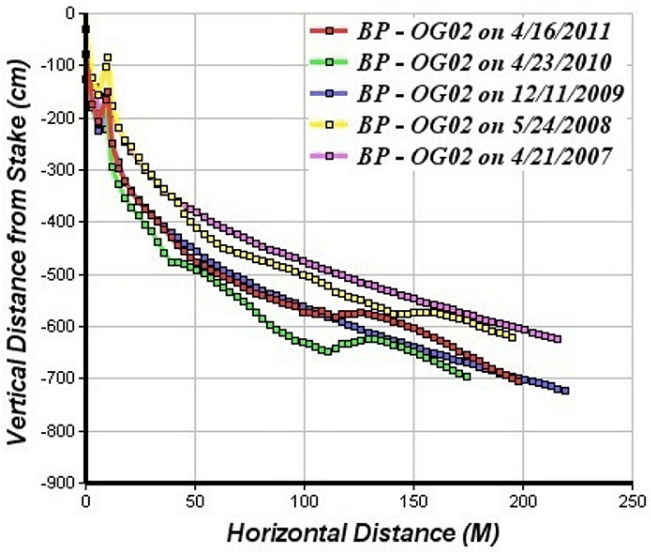

Figure 90. Winter beach profiles from Ogunquit Beach profile line OG02.

Summer Profile Changes

OG02 = D (65)

In terms of summer changes, profile OG02 (Figure 91) has been showing gradual erosion. Again, the post 2007 storm summer profile, similar to the winter profile, had the highest elevation of sand on the beach, and the highest dune crest. By summer 2008, the dune crest appears to have lowered substantially, but the profile remained stable in the offshore. In the 2009 (recorded in December, the only profile available), the dune crest lost additional elevation, and the entire profile lost elevation along its length. In July 2010, the dune crest remained stable, but the profile steepened. Some sand returned to the profile in the form of a series of evident swash bars, located at about 40 m and 90 m from the starting point. Although it showed some stability in 2009-2010, this profile is showing extensive signs of erosion, with substantial lowering of dune elevation, berm, and profile elevation since 2008. Comparison with summer 2011 profiles will help determine if this erosive trend is continuing.

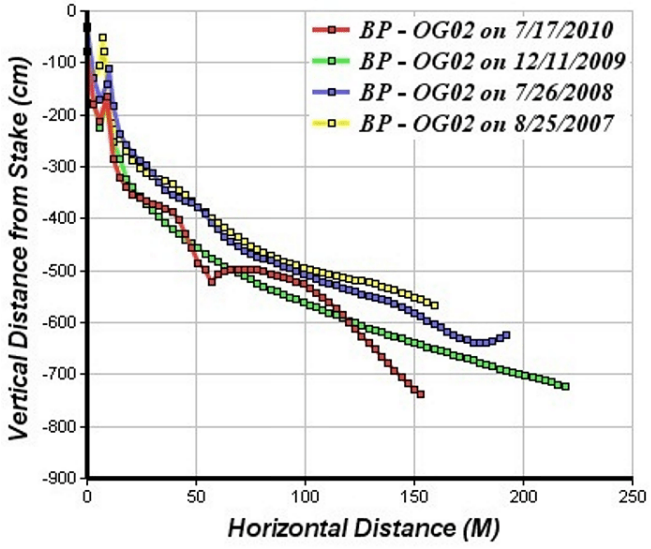

Figure 91. Summer beach profiles from Ogunquit Beach profile line OG02.

Summary
At Ogunquit Beach, it is difficult to come to general conclusions based on a single profile along such a long stretch of beach. However, based on analysis of a single profile (OG02), extensive, continued erosion of the dune, berm, and lower portions of the profile are occurring. Some recovery was noted in the spring 2011 and summer 2010 profile, but the overall trend is erosion. Beach profiling needs to be restarted at the other profile points to get a better understanding of the changes. We also recommend that the beach profile starting locations be spread along the beach to get a better representation of beach changes.
Overall grade = D (65)

Long Sands Beach, York

Two beach profiles (LS01 and LS03, Figure 92) were available for comparison. Profile LS02 was lost during the Patriots' Day Storm of 2007, and profiling not resumed. The profiles are spread from northeast to southwest along the beach.

Figure 92. Location of beach profiles LS01 and LS03 at Long Sands Beach, York. Base imagery from Maine Office of GIS.

Winter Profile Changes

LS01 = A (95)

Profile LS01 is located in the northern half of Long Sands Beach and starts in the seawall. This profile received a B in the last assessment. The 2008 one-year post storm profile (Figure 93) was stable along the berm, but showed marked erosion seaward of about the 20 m mark, with the majority of the profile elevations being below those of the immediate post-storm profile. However, the 2009 profile underwent dramatic elevation gains, especially in the berm portion of the profile out to about 50-60 m from the starting point. However, in 2010, the berm underwent significant erosion, losing almost a full meter of elevation near the 20 m mark; offshore, the profile stayed relatively stable. Luckily, in 2011, the profile rebounded, and gained sand at the berm back to the high 2009 elevation out to about 25 m; seaward of this, the profile actually gained sediment slightly along its length. This profile is showing good signs of recovery, and stability, with good recovery from the erosive 2010 season.

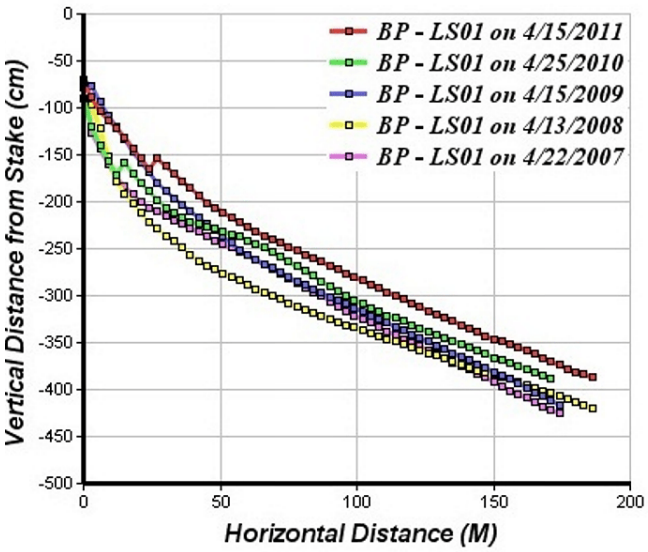

Figure 93. Winter beach profiles from Long Sands Beach profile line LS01.

LS03 = C (75)

Profile LS03, which is located at a natural cobble dune and beach area south of the bath house, received a B in the last assessment. The 2008 profile (Figure 94) showed slight berm recovery and a gain in elevation of sediment in the offshore portion of the profile, from about 50 m seaward. By 2009, the profile developed a distinct berm feature at the 20 m mark, and although the nearshore developed a steeper slope, the offshore portion of the profile (40 m and seaward) increased in elevation. By 2010, the berm was eroded, and the offshore portion of the profile, from about 40 m seaward, lost large amounts of sand in comparison with other years. This loss resulted in a profile elevation well below that of the 2007 storm. In 2011, the profile showed good stability, with maintenance of the 2010 shape in the berm area, and gains in elevation back to roughly 2008 levels in the low-tide area of the beach. Although this profile is not necessarily growing, it is showing signs of relative stability, although it did lose sand compared with the 2009 shape.

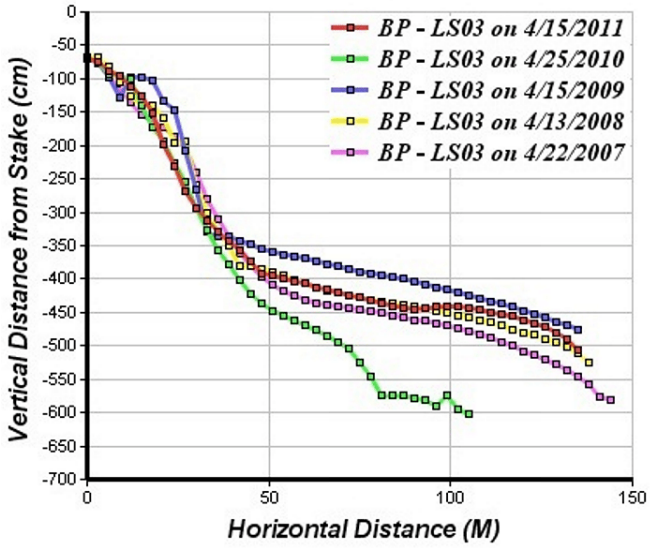

Figure 94. Winter beach profiles from Long Sands Beach profile line LS03.

Winter Beach Grade = B+ (87)
The profiles at Long Sands Beach, though quite different (one being a cobble dune and one starting at a seawall), have shown good stability to growth during the winter seasons.

Summer Profile Changes
LS01 = D (65)
The summer beach profile at LS01 (Figure 95) has a relatively flat, featureless, concave shape. It displayed marked stability from 2007 through 2009. However, in 2010, the berm migrated upslope slightly, lowered where it had been, and there were elevation losses along the profile into the offshore to 2007 levels. This profile showed decent stability in its lower portions, but has undergone relatively consistent berm loss and lowering, starting in 2009. The 2010 summer profile is actually below much of the post-2007 summer profile. The profile should be compared with August 2011 data in order to determine whether or not this erosive trend has continued.

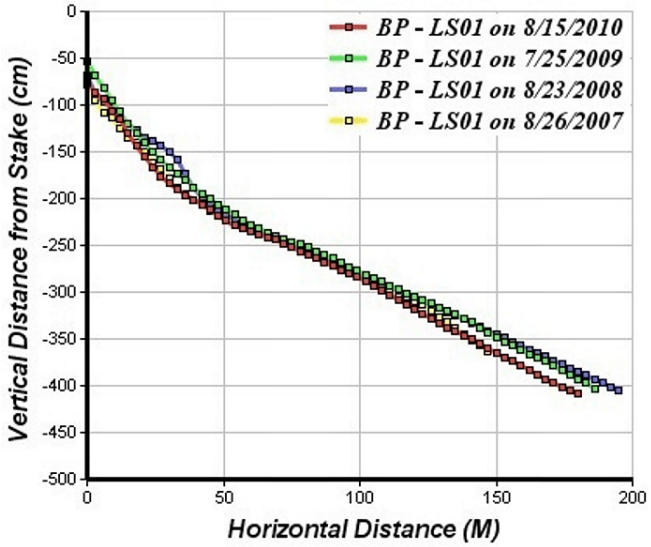

Figure 95. Summer beach profiles from Long Sands Beach profile line LS01.

LS03 = D (65)
The upper, berm portion of the profile (Figure 96), out to about 25 m, has shown stability over the years, but appeared most well defined in the summer of 2009. Since then, it has receded, but maintained its overall shape very well. Seaward of about 40 meters, which is roughly the break in slope to the low-tide area, the profile has varied in elevation by about 50 cm over the years. It was lowest in elevation here in 2007 and 2010, but showed some growth in 2008 and 2009. The 2010 profile indicates that the summer shape here has undergone continual erosion since the summer of 2008, which concerns us.

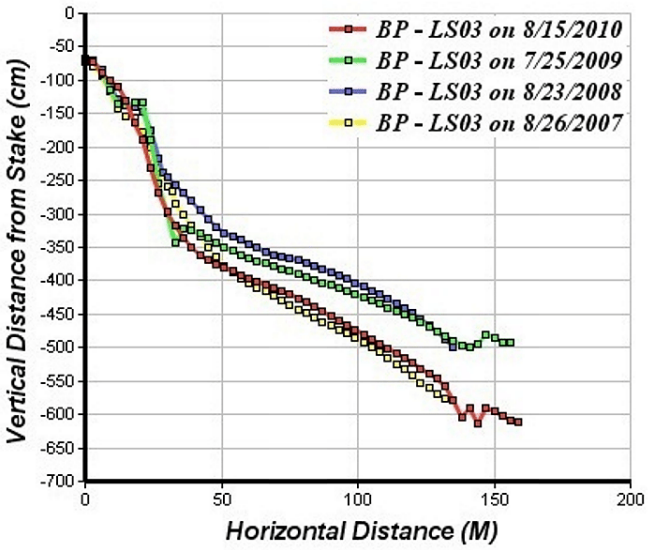

Figure 96. Summer beach profiles from Long Sands Beach profile line LS03.

Summer Beach Grade = D (65)
Summer beach recovery at Long Sands Beach was good through 2008; however it appears that the profiles have been undergoing slow erosion since 2008, with lowering of the profile in 2009 and continued lowering in 2010. Comparison with August 2011 data is needed. It is clear from the data that LS01 undergoes changes on a much smaller scale than LS02. We are concerned about the summer berm viability at Long Sands Beach.

Summary
We are most concerned about the summer changes noted at Long Sands since 2008; the 2009 assessment noted a B for this beach, mostly due to very good recovery into 2008. 2008 showed the best profile shapes at Long Sands; in general, since then, the profiles have been eroding and lowering, with relatively consistent erosion, especially of the summer profile. The higher winter scores at this beach may be indicated by false stability. This could be caused by the beach being eroded to a ravinement surface (subsurface geology), which thus prevents deeper winter erosion, and gives a sense of profile stability. Long Sands Beach receives a very cautionary C.
Overall grade = C (75)

Beach Grading Summary and Discussion

In the 2009 assessment, the beaches in southern Maine showed relatively good recovery from the Patriots' Day Storm of 2007, scoring an overall grade of a B/B-. Many beaches saw substantial recovery by 2008. In fact, for many locations, 2008 appeared to be the most accretive year of the past four years of profile collection. This was an extremely positive sign, as it showed that the profiles, which underwent massive erosion caused by the Patriots' Day Storm, could recover within one year of the storm.

For many locations, this recovery occurred into 2009, though some areas started to see a reversal in profile growth, and started to experience erosion. For these profiles, this may have resulted from impacts from a series of spring storms in 2009. Similarly, in February and March 2010, a series of very strong northeast storms caused large amounts of erosion at many of the profile locations. This was evident in some of the winter profile shapes, but also carried over into the summer with lean recovery of many of the profiles.

For example, profile HI02 at Higgins Beach in Scarborough showed very good recovery in the last assessment, scoring a B, with good profile recovery through April of 2009. However, by April of 2010, the profile underwent massive erosion due to the winter storms of 2010. This erosion was followed by very poor recovery in the summer of 2010, so the profile was set up for a very tough winter of 2011. Sure enough, the April 2011 profile shape showed little recovery from the severely eroded shape of April 2010. As a result, this profile scored an F for its summer and winter shapes.

Of course, one of the limitations of using "snapshot" points in time (such as the same month through consecutive years, as is the case in this report) is that the analysis may miss, or overly weigh, a certain profile shape that was influenced by an event immediately preceding the recording of the beach profile, when a month later, the profile may show full recovery.

The 2011 Highs and Lows

The Maine beaches, in 2011, scored an overall C, with a numerical grade of 77. This is down from the 2009 assessment, in which the beaches averaged a low B.

Table 4 shows the final scores for each beach, based on their summer and winter scores, ranked by the high score to low score, including the numerical score. Each numerical score has been color-coded to represent the corresponding grade: green (A or B); yellow (C); and red (D or F). Table 5 shows the overall averaged letter grades from 2011 in comparison with 2009 scores and indicates the trend from 2009-2011 for each beach.

Beach Name (Acronym)	Winter	Summer	2011
Willard (WI)			
Higgins (HI)	71	76	73
Scarborough (SC)	70	82	76
East Grand (EG)	94	90	92
Kinney Shores (KS)	85	80	83
Ferry (FE)	70	68	69
Goose Rocks (GR)	87	73	80
Goochs (GO)	78	83	80
Laudholm (LH)	70	72	70
Drakes Island (DI)	65	71	68
Wells (WE)	76	83	78
Ogunquit (OG)	65	65	69
Long Sands (LS)	85	65	75
Overall Grade(LS)	76	76	76

Table 4. Comparison of winter, summer, and overall 2011 numerical scores.

Beach Name (Acronym)	2009 Overall	2011 Overall	Trend
Willard (WI)	A-	N/A	N/A
Higgins (HI)	B	C-	-
Scarborough (SC)	C+	C	-
East Grand (EG)	B	A	+
Kinney Shores (KS)	B	B	same
Ferry (FE)	C-	D	-
Goose Rocks (GR)	B-	B-	same
Goochs (GO)	B	B-	-
Laudholm (LH)	B	C-	-
Drakes Island (DI)	B-	D+	-
Wells (WE)	A	C+	-
Ogunquit (OG)	B-	D	-
Long Sands (LS)	B	C	-
Overall Grade(LS)	B-	C	-

Table 5. Comparison of overall 2009 and 2011 scores, with the general trend.

Based on winter profile shapes through the winter of 2011, the top scoring beaches were East Grand Beach in Scarborough, Goose Rocks Beach in Kennebunkport, and Kinney Shores in Saco and Long Sands Beach in York (tied for third). However, based on summer profile scores, the top three beaches include East Grand Beach in Scarborough, Goochs Beach in Kennebunk, and Wells Beach, Wells. Overall (including both winter and summer profile analysis), the top three scoring beaches were East Grand Beach (92, A-), Kinney Shores (83, B), and Goose Rocks Beach (81, B-). Note: it is important to note that results at Goose Rocks may be inaccurate due to profile starting point relocation for several of the pins in 2010.

Review of the data indicates that only one beach had all profiles score an excellent (A) for both summer and winter profiles - that was East Grand Beach in Scarborough. Situated at the northern end of Saco Bay, this section of the shoreline underwent substantial dune and berm growth, and relatively stable berm and beach formation from year-to-year. As noted in the previous assessment, this beach is fortunate enough to be the recipient of sediment migrating from the southern portion of the bay. The next closest beaches in terms of overall score were Kinney Shores (83, B), Goose Rocks Beach, and Goochs Beach, which both scored a low very good (B-). This concerns us, since these are all lower levels of what we would consider to be "very good" on the scale.

The majority (11 of 13 or 85%) of beaches scored in the green range in the 2009 assessment - that is, an A or a B. The remaining 2 beaches scored in the yellow range. In the 2011 assessment, only 4 beaches of 12 (33%) scored in the green range, while 5 beaches (42%) scored in the yellow range, and 3 beaches (25%) in the red range. Of all the beaches, only one had an increase in score (East Grand Beach), and only 2 stayed the same, with similar scores from 2009 (Kinney Shores and Goose Rocks Beach, see Table 5). The rest of the beaches had scores in 2011 that were lower than in 2009.

The beaches with the biggest changes in overall grades from the 2009 assessment were: Higgins Beach (B to a C-); Laudholm Beach (B to a C-); Drakes Island Beach (B- to a D+); Wells Beach Beach (A to a C+); and Ogunquit Beach (B- to a D).

Beaches with only minor, yet decreasing trends in grades were: Scarborough Beach (C+ to a C); Ferry Beach (C- to a D); Goochs Beach (B to a B-); and Long Sands Beach (B to a C).

Seasonality

Analysis of seasonal profiles, winter vs. summer, showed that in general, winter profiles maintained a low, concave up shape, with sand in the offshore. Conversely, in the summer, a berm typically developed, and sand moved up the beach profile, forming a more convex shape. This was especially notable in the profiles that scored higher (East

Grand Beach, Kinney Shores, etc.), as opposed to those that scored lower. This seasonal shift is very important, and the ability of a profile to lose sand in the winter, and gain it back in the summer, lends itself to a healthy beach system. When sediment is lost in the winter, and not regained in the summer, the berm has difficulty forming, and the profile will undergo erosion, especially in comparison with the previous summer's shape.

This is evidenced in the seasonal data in this assessment. Although the overall grades were the same for winter and summer (an average of 76), an interesting finding was that, in general, many profiles scored slightly better for their winter shapes, as opposed to their summer shapes. This may be due to the fact that in the winter, the profiles were eroded to nearly the same point, bringing them slightly closer to an erosional equilibrium point, with less room for great variability. When the summer returned, the profile did not have the same amount of sand returning as the previous summer, resulting in a worse summer score.

This was mainly due to the fact that the summer berm, apparent in previous years, was small or absent coming into the summer of 2010 at many beaches. For example, Kinney Shores in Saco scored more poorly based on its summer shapes, than it did its winter shapes. Again, we feel this is likely due to the winter 2010 storms, which eroded many profiles quite deeply. It will be interesting to compare summer 2011 profiles with those of 2010, to see if beaches that have not fared so well have recovered by this summer.

Also, it is possible that profiles, in the winter, are reaching a ravinement (erosional) surface or underlying geology (historic peat surface or rock outcrops); because these surfaces do not erode easily, they give a sense of profile stability in the winter. This may explain why some beaches, such as Long Sands Beach in York, and at Wells Beach in Wells, have exhibited better winter stability and scores than summer stability and scores.

One of the lows of this assessment was the overall trend of ongoing erosion, of both dunes and summer berms, over a period of a few years (e.g., 2008-2010, or 2008-2011). It seems like the 2008 year produced many of the profiles with the most sediment, and thus, the most healthy shapes. The recent trend of erosion in 2009 that has continued into 2010, and for some locations into 2011, is very concerning.

Sea Level Impacts?

As noted throughout this report, the winter storms of February and March 2010 had significant impacts on the shapes of beaches going into the spring and summer. This led to many low-scoring summer beach profile shapes.

We took a closer look at recent sea level trends in order to investigate whether or not sea level may be influencing the recent erosion. Historically, based on yearly averaged sea level measurements, Maine has been recording sea level change rates similar to that of the global ocean over the past century (around 1.8 mm/year), as measured by the tide gauge in Portland (Figure 97). Satellite altimetry measurements of the global oceans from 1993 through 2011 indicate that there has been an acceleration in the rate of sea level rise over the last 18 years to around 3.1 mm/year (Figure 98). Based on yearly sea level data from 1993 through 2009, Maine had not yet seen this acceleration, and was trending near 1.9 mm/year.

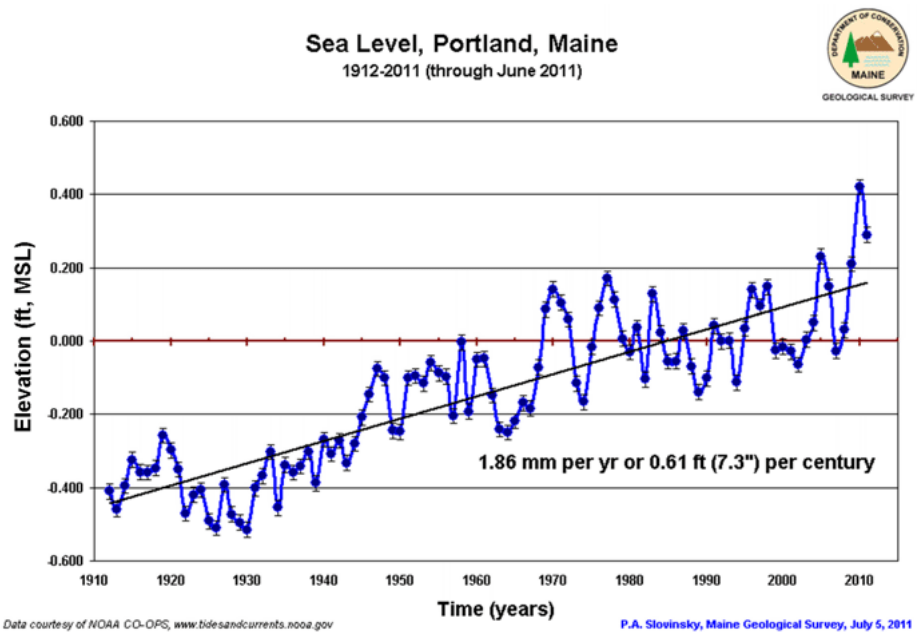

Figure 97. Yearly averaged sea level trends for the Portland tide gauge from 1912 through June 2011. Data courtesy of NOAA NOS CO-OPS.

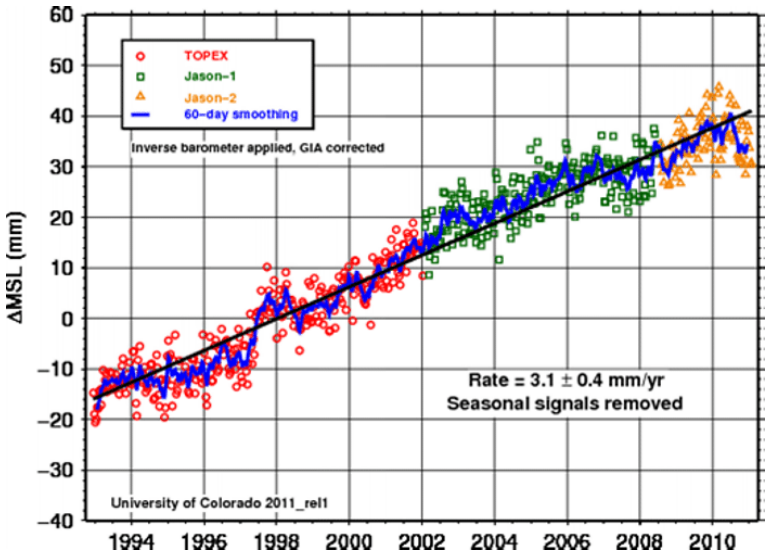

Figure 98. Global ocean sea level change rates from 1993 to 2011 based on satellite altimetry measurements. Data courtesy of University of Colorado Sea Level Research Group.

However, taking into account newer data from 2010 and 2011, it is clear that the Portland tide gauge recorded higher water levels in 2010 than in any of the previous years (Figure 99). Over this 18 year period, Portland's averaged annual sea level rise rate increased to almost 4.2 mm/year (or around 1.4 feet per century), over double the historic trend over the past 100 years.

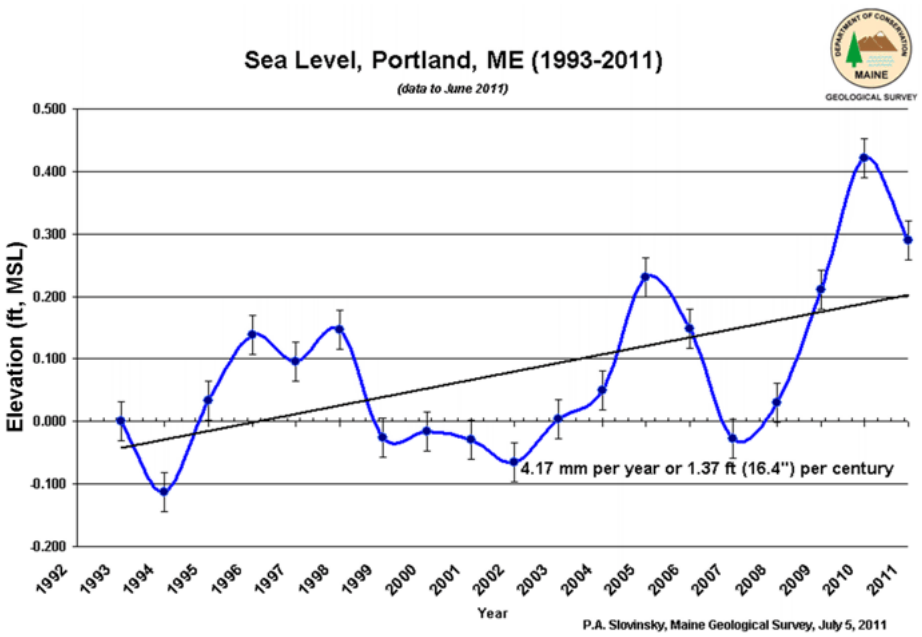

Figure 99. Yearly averaged sea level trends for the Portland tide gauge from 1993 through June 2011. Data courtesy of NOAA NOS CO-OPS.

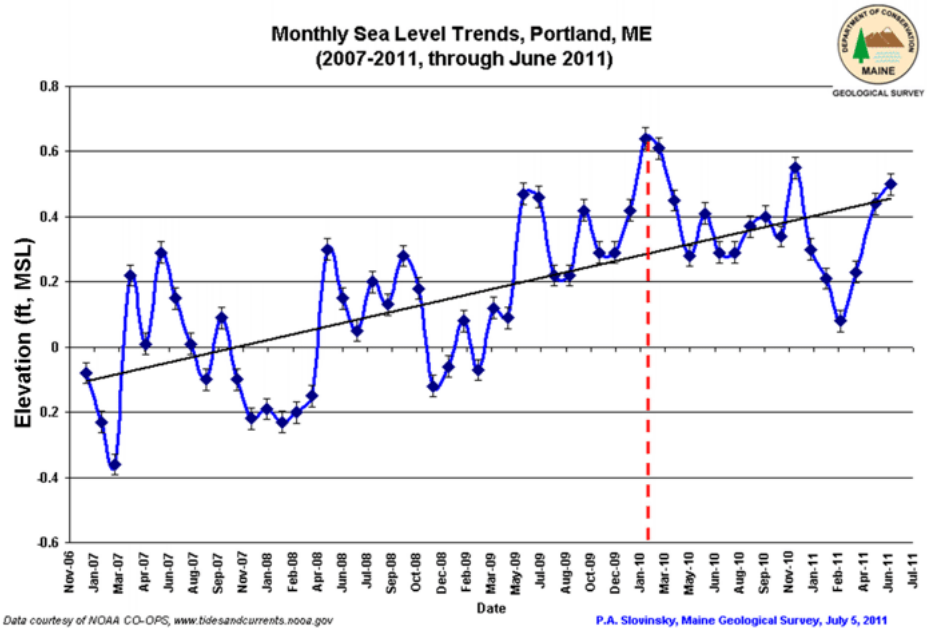

Figure 100. Monthly sea level trends for the Portland tide gauge from January 2007 through June 2011. Data courtesy of NOAA NOS CO-OPS.

Looking even closer at this sea level data on a monthly basis since January 2007 through June 2011 (Figure 100), one can see that the highest sea level measurements over this time period corresponded with the February and March 2010 storms. It is clear that this was the highest average monthly water level recorded in the past 100 years. It is also noteworthy that previous winters (2007, 2008, and 2009) had monthly sea levels below the trend of the linear regression. So the winter sea level of 2010 was on the order of 0.6 to 0.9 meters (2 to 3 feet) above that in the previous three winters. The winter of 2011 saw monthly sea levels fall to below the regression line. The higher sea levels from December 2009 through March 2010 most likely exacerbated beach erosion caused by the February and March 2010 storm events.

It is certain that the high surge from the February storm helped elevate the sea levels that are graphed, but we cannot conclude that was the only cause at this time without an analysis of residuals of tidal anomalies down to the day-to-day level. During June-July of 2009, there was also a period of relatively high sea levels (Figure 100) that was documented along the east coast, including Maine (Sweet and others, 2009). However, this period of anomalously high tides coincided with low wave heights and fewer storms, so had little impact on Maine beach erosion.

Seawalls and Natural Dunes

Profiles adjacent to seawalls generally show a more concave up shape, and undergo less overall profile change, in general, from season to season, than profiles at natural dunes. This is evident by looking at berm formation at areas like Goochs Beach, which is backed by seawalls, and areas like Scarborough Beach, which has a natural frontal dune ridge.

We investigated the average scores for summer and winter profiles at locations that start at a seawall, versus starting at a natural dune. Interestingly, both scored about the same. However, there was one important distinction. Using winter profiles only, those that profiles located adjacent to a seawall had a slightly higher average score (a 77, C+) than those profiles located at a natural starting point (average score of 76, C). Conversely, for summer beach profiles, the reverse was the case; the natural beach profiles had a slightly higher average score (77), as opposed to the profiles starting at a seawall (76).

These summer vs. winter values are so close that it is difficult to draw a strong conclusion. Intuitively however, this result makes some sense, although we would expect a slightly larger difference in the scores. That is, in winter, when profiles erode, the beaches with seawalls have less sediment available in the profile to begin with (thus the concave shape), and thus undergo slightly less change in response to winter storms, thus scoring higher. The natural profiles, which typically have more sand, undergo more erosion (including frontal dune erosion) in the winter months, thus scoring lower. Conversely, in the summer, the natural profiles typically see more sand return to form a better defined summer berm, indicating recovery, while beaches "stabilized" with seawalls only see a slight return since they don't undergo as much change.

Conclusion

The State of Maine Beach Profiling Project, with its volunteer beach monitors, is vital to better understanding the monthly, seasonal, and yearly patterns of beach change. The data provided by the program is helping us understand the impacts of larger storm events, such as the Patriots' Day Storm of 2007 and the winter 2010 February and March storms. The data are helping us better understand when profiles encounter their lowest erosional surface (e.g., HI01 at Higgins Beach in the spring 2010 profile), and how the beach can recover relatively well.

The Maine Geological Survey, which conducts annual and sometimes biannual shoreline surveys on its own, does not have the personnel or funding to support monthly beach profiling efforts. However, with the availability of the profiling data from the efforts of the volunteers and funded from local sources, we are able to utilize data that would simply not exist if not for the program. These data are extremely important in understanding the impacts of, and documenting the recovery from, large storm events, and seeing how Maine's beaches are changing from year-to-year.

Analysis of the most recent profile data has shown that:

- The majority of southern Maine's beaches showed initial, good, recovery from the Patriots' Day Storm, many within one year, by 2008.
- The winter and summer of 2008, to date, appear to be the profiles that show the most sediment on the beach.
- Since 2008, many profiles have started to slowly erode, especially at the location of the summer berm.
- Many beaches underwent erosion from the winter 2010 storms to elevations at or below the Patriots' Day Storm level. Some beaches appear to have reached a historic ravinement (erosional) surface (peat deposit or other subsurface geology).
- In many locations, profiles have recovered well from this event. In others, profiles are still recovering, or continue to erode.
- Compared with 2009, many beaches are more eroded, and thus have lower scores than the 2009 assessment.
- Together, based on summer and winter data through 2011, the beaches have overall mean value of a **Cautionary C** rating.

Comparison of summer (August) 2011 profile data will help determine if many of the beaches that underwent erosion through the summer of 2009 and 2010 continued to recede. The Maine Geological Survey plans to amend this online report to include analysis of summer trends at the end of this summer or in early fall. In the meantime, continued monthly profiling over the next few years will also help determine the status of Maine's beaches as we move into the future. We also highly recommend that beach profiling be restarted and spread out at some profile locations (e.g., Ogunquit Beach), and that some additional profiles be added in other locations (e.g., the central portion of Wells Beach).

In addition, in order to supplement the 2011 State of Maine's Beaches report, MGS will be incorporating the results of its Maine Beach Mapping Program (MBMAP). This program, which began in earnest in 2007, conducts annual surveys of several shore parallel beach features, including the wrack line or high water mark (after the last high tide) and the seaward edge of the dune vegetation line, at the majority of southern Maine's beaches. This data is captured in the field using a highly precise Real Time Kinematic Global Positioning System (RTKGPS), which is capable of horizontal and vertical accuracies of several centimeters. This data, part of which was shared during the 2011 Maine Beaches Conference concurrent session, will help supplement data collected by profiling volunteers, and will help us better quantify the shoreline changes observed over the past few years. Data collection as part of MBMAP for this year should be completed by August 2011. A subsequent report detailing observed changes through the summer of 2011 will be provided in online format by early fall 2011.

This kind of combined data - especially when collected over a long period of time - is important for future decision-making processes that incorporate different aspects of beach management, including identification of stable, eroding, or accreting shorelines, potential beach nourishment projects, dune restoration or construction projects, dune grass management, and where to best spend public (or private) funds in order to get the greatest benefit.

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Appendix A: Setting the Stage for a Course Change at Popham Beach, Phippsburg

Popham Beach in Phippsburg, Maine has changed dramatically in the last two decades. As regular visitors to the beach have observed, the beach and dunes are different from one year to the next. In 1990 the beach was backed by an enormous dune field and visitors walked long paths to reach the shoreline. Even in 2005 there were large dunes in the area of Center Beach (Figure A1). By 2010 the shoreline was hundreds of feet closer to the parking lot and encroaching on a new bath house. In addition, the last few years have seen hundreds of large pitch pine trees topple onto the beach as a result of erosion driven by the Morse River cutting a long and sinuous path in an easterly direction into the state park before turning south to reach the ocean. In the last week of February and first week of March 2010, the Morse River dramatically changed its direction and cut a more direct course to the sea. As a result, the worst erosion cycle Popham Beach State Park has ever experienced has come to an end and the next several years should see beach and dune building as a period of accretion begins. This chapter chronicles the dramatic changes at Popham Beach State Park over the last few years.

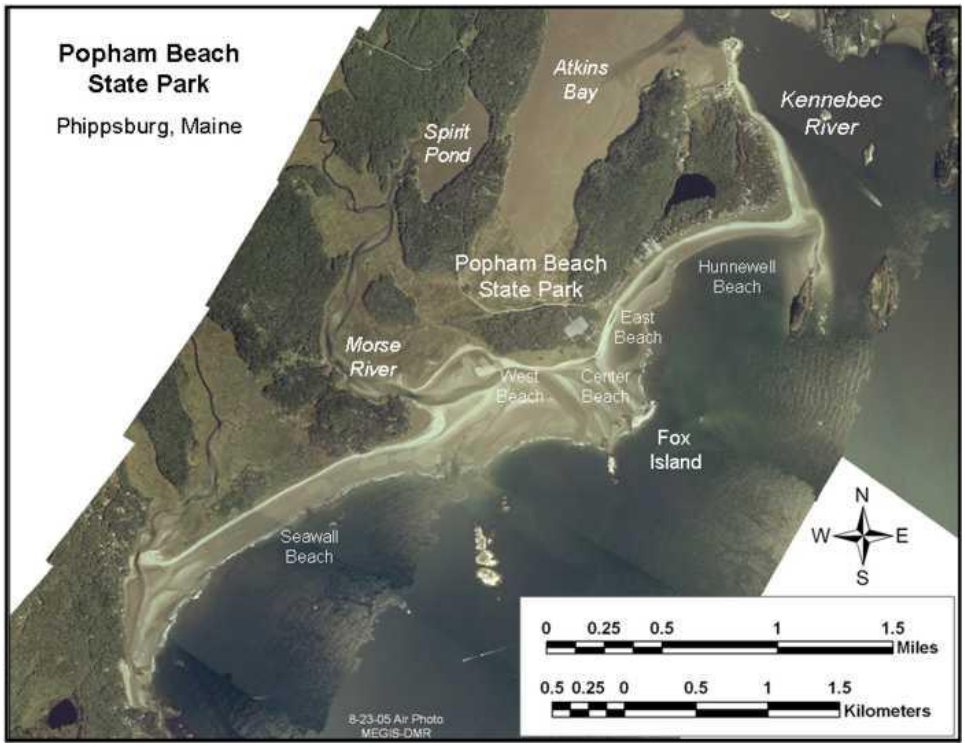

Figure A1. Location map of Popham Beach State Park, adjacent beaches, and water bodies. Note the background air photo was taken in 2005 and shows a large vegetated dune field near Center Beach. The sand bar from the park out to Fox Islands is called a tombolo by geologists. Photographs courtesy of the Maine Department of Marine Resources and Maine Office of GIS.

April 2009 - An Overwash Channel Forms

On April 7, 2009 Bates College geology professor Mike Retelle and his students were at Seawall Beach to measure the sand bar that is seaward (south) of the Morse River's tidal inlet. This sand bar, also called a beach spit by geologists, had grown and extended eastward across the mouth of the Morse River for several years. Their field survey was just after a storm on April 6 that came during a period of high tides and coastal flooding to a level of over 11 feet above Mean Lower Low Water (MLLW) for two sequential high tides recorded at the Portland tide gauge (Dickson, 2007; Dickson, 2009 - Figure 12). During their survey, the Bates College team found evidence of storm washover and downward erosion of the sand bar (Dickson, 2009 - Figure 13, Figure 14, Figure 15). This was the first sign that an avulsion, or course change, might occur in the Morse River.

That particular storm had a combined tide and storm surge 2 feet above mean high water. That water level is not exceptional among annual winter storms on the Maine coast and it is possible that similar episodes of erosion occurred in prior winter storms in 2009. To put this storm in perspective, storm surges of 3 to 4 feet are possible adding to the normal elevation of the tides (Dickson, 2007). The 2007 Patriots' Day Storm had a surge of up to 2.5 feet over 7 high tides during a period of astronomically high tides (Slovinsky, 2007; Slovinsky and Dickson, 2009) and resulted in sand deposition into Popham Beach's dunes (Dickson, 2008 - Figure 7). The early April 2009 storm had rather common storm wave characteristics with wave heights of 10 feet with a dominant period of 8 seconds at the Casco Bay buoy (NDBC, 2011). It was concluded that it may take a larger storm event and continued seaward erosion into the spit by the Morse River channel to result in a lasting breach (Dickson, 2009).

November 2009 - The Forest Falls

By the fall of 2009, the Morse River had cut deeply into Popham Beach State Park causing erosion that removed primary frontal dunes and carved into back dunes to fell mature trees from a pitch pine (Pinus rigida) maritime forest (Dickson, 2010 - Figure 12, Figure 16). The climax forest here is the largest, most northern such stand of trees in the Gulf of Maine (Nelson and Fink, 1980). Based on the presence of a mapped forest on an 1879 nautical chart (Survey of the Coast, From Seguin I. to Cape Elizabeth, Maine, scale 1:80,000, Maine State Archives), the forest and possibly these trees may be as much as 100 years old. This 2009 shoreline may be the farthest inland the Morse River has meandered since the mid-1800s or earlier.

An aerial reconnaissance flight on November 10, 2009 by John Picher of the Department of Conservation showed a thin neck in the Seawall Beach spit at the outside (erosional) bend of the Morse River channel (Dickson, 2010 - Figure 17). The overwash channel was visually estimated to be 10 to 11 feet above MLLW and perhaps 200 feet wide (Dickson, 2010 - Figure 18). The presence of the narrow spit neck and the overwash channel led the Maine Geological Survey to predict a river course change, or avulsion, at that location sometime in the near future.

Near the western bath house at Popham Beach State Park, the river bank along West Beach eroded landward at a rate of 10 to 15 feet a week in November 2009 (Figure A2). Erosion was most rapid during storms but the ebb and flood currents in the Morse River most likely led to additional sand being swept away between storms along the outer bend in the river (Dickson, 2010 - Figure 15). The Department of Conservation considered and implemented a plan to slow erosion that included moving fallen trees downstream to the vicinity of the bath house. The goal was to emulate the natural process observed along the river bank nearby where fallen trees were slowing the flow, resulting in a wider beach, and reducing bank erosion and forest loss (Dickson, 2010).

Figure A2. A November 11, 2009 view of the edge of the Popham dunes and forest along West Beach. Pitch pine trees were actively being undercut by Morse River erosion and wave action and falling on West Beach. MGS file photo by S. M. Dickson.

December 2009 - The Beach Moves in on the Bath House

Storms continued to erode Popham Beach State Park in December. A prolonged series of strong fall and winter storms allowed the Morse River to become repeatedly elevated and sweep away large amounts of sand in a matter of hours from the edge of the forest at the state park (Figure A3 and Figure A4). A storm on December 12 elevated the tide with a 1.5-foot storm surge and resulted in minor coastal flooding over the 12-foot level. Offshore waves in this storm were 12 feet high. Surf broke on sand shoals offshore of Popham Beach State Park and moved ashore as smaller waves that still managed to erode the forested dunes and cause flooding in low areas (Dickson, 2010 - Figure 9, Figure 10, Figure 11).

Figure A3. A December 3, 2009 southeaster sent large irregular surf directly to the edge of the Popham dunes and forest at high tide. Fortunately some of the surf broke offshore on sand bars and reduced the energy in the waves reaching the dunes. MGS file photo by S. M. Dickson.

Figure A4. A December 3, 2009 southeaster sent large irregular surf directly to the edge of the Popham dunes and forest at high tide. As waves scoured the toe of the sand bluff, alongshore currents driven by the Morse River removed sand from the beach. MGS file photo by S. M. Dickson.

There was a general, but undocumented, consensus from eye witnesses that erosion was reduced by the trees temporarily bundled with ropes in front of the bath house - just 75 feet from the building (Figure A5; Dickson, 2010 - Figure 14).

Figure A5. Each big storm moved the ocean 15 feet closer to the bath house. Only 75 feet of ground remained between the erosional scarp and the bath house. The vertical cut down to the beach is 5-10 feet below the grade the bath house sits on. Ropes tied fallen trees together and then were secured to living trees to hold them in place. MGS file photo by S. M. Dickson, February 17, 2010.

February 2010 - Setup for a Breach

With only a month left in the winter storm season, conditions were set up for a major storm in the Gulf of Maine the last week of February. Predicted tides would be some of the highest in a year. A storm centered over Connecticut developed a low barometric pressure of 972 millibars that created strong onshore winds along the Maine coast. On February 25, storm tides ran higher than normal as a result of the wind-driven surge. From February 25 to 26 waves at the Portland buoy were 15 to 28 feet (Figure A6). These extreme waves were only 2 to 3 feet below the historic October 1991 Perfect Storm and the April 2007 Patriots' Day Storm.

Figure A6. Waves at the Casco Bay buoy (No. 44007) off Portland recorded waves as high as 28 feet during the onset of a large storm on February 25-26, 2010. Waves, and thus surf at Popham Beach remained elevated into March. Significant wave height is the average of the one-third highest waves recorded over a period of 20 minutes. Image courtesy of the National Data Buoy Center at the National Oceanic and Atmospheric Administration.

On February 27, after the peak waves of the storm passed, the Maine Geological Survey determined that only a shallow and wide overwash channel had formed on the Seawall Beach spit (Figure A7, and Figure A8). It was clear that the storm did not open a permanent new channel that the Morse River could pass through at all stages of the tidal cycle. An Emery Method beach profile survey on February 27 across the channel and parallel to the beach showed a broad lowering of the spit relative to surrounding areas (Figure A9 and Figure A10). The cut in the spit was about 300 feet wide at the spring high tide level and about 200 feet across at the mean high tide level. So elevated storm tides were able let the Morse River flood and ebb on a more direct path to the sea. After the water level fell below a normal high tide elevation, the river still was confined to its old path along Popham Beach State Park. At this point, it remained uncertain if additional surf would (a) deposit more sand in the overwash channel and seal it up or if (b) overtopping by waves and tides would keep this section of the beach spit low and allow for more downward erosion. These competing coastal processes were quite dependent on the nature of waves coming ashore, the strength of tidal currents, and water levels from both tides and storms.

Figure A7. A view on February 27, 2010 from the Seawall Beach spit looking north toward West Beach at Popham Beach State Park. The washover channel (right) still holds water but is only a foot deep and well above the depth of the Morse River channel in the background. MGS file photo by S. M. Dickson.

Figure A8. A view on February 27, 2010 on the Seawall Beach spit looking west toward Seawall Beach and across the incipient new channel of the Morse River (darker beach below the stranded tree). Emery Beach Profiling rods and tape measure in the foreground are at the eastern terminus of an elevation survey started at the dune in the background. The survey was conducted to check the new channel's width and depth. MGS file photo by S. M. Dickson.

Figure A9. The Emery Beach Profile across the channel spanned the shallow channel that would become the new Morse River channel in about a week. Elevations are recorded in centimeters from the higher of two poles and a line with the horizon. February 27, 2010 MGS file photo by S. M. Dickson.

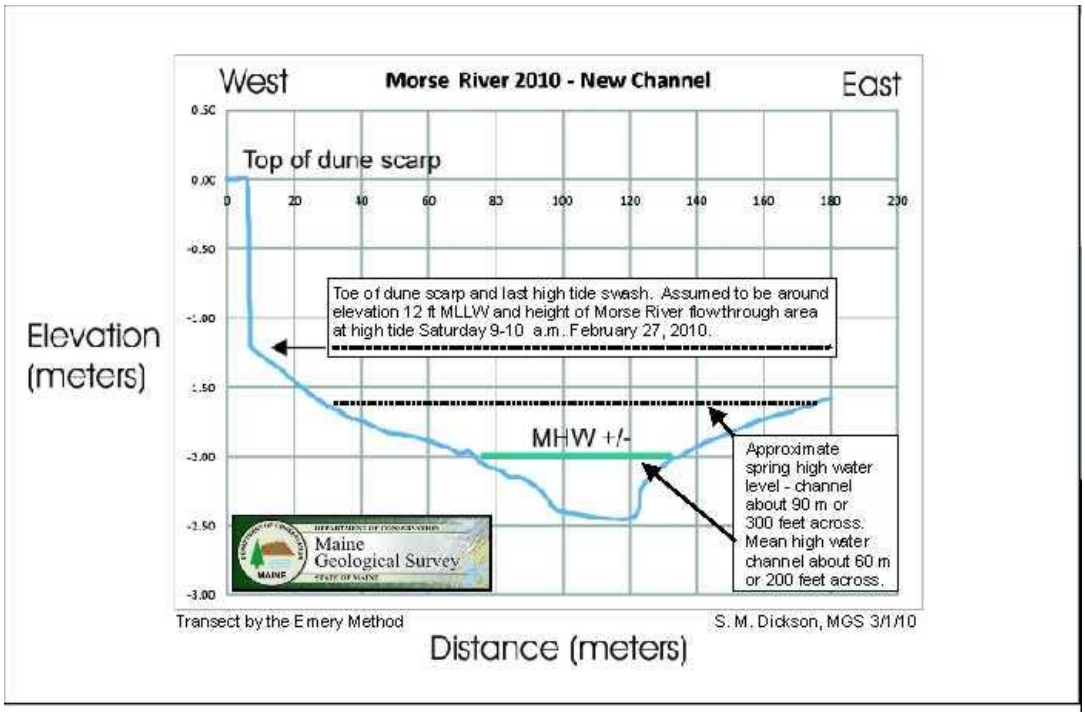

Figure A10. A graph showing a transect across the overwash channel on the Seawall Beach spit. The transect runs parallel to the beach and is about 180 meters (590 feet) long from west to east across the most shallow portion of the channel. The vertical exaggeration (about 40 times V:H) helps to show the shape of the channel cross-section. Graphic by S. M. Dickson, MGS.

A unique set of meteorological and oceanographic conditions followed the February 26 storm. There were 7 days of high "spring" tides that allowed the river to ebb and flood across the sand spit. For a period of 9 days, from February 24 through March 4, there was also coastal flooding from a persistent storm surge of 1 to 2 feet. These conditions resulted in 15 extra high tides (Figure A11). With each exceptionally high tide, more water was able to flow up the Morse River, enter the back-barrier salt marshes, and elevate Spirit Pond (Figure A1). This increased volume of water needed to exit over a fixed number of hours on a falling tide, so tidal currents were stronger than normal. Faster flood and ebb currents are capable of moving more sand off the top of the spit, and deposit it either into the deeper Morse River or offshore into the surf zone. During this period of stronger tidal flow, moderate waves, in the 5-foot range, continued to create surf, wave action, and turbulent flow across the spit around the time of high tide.

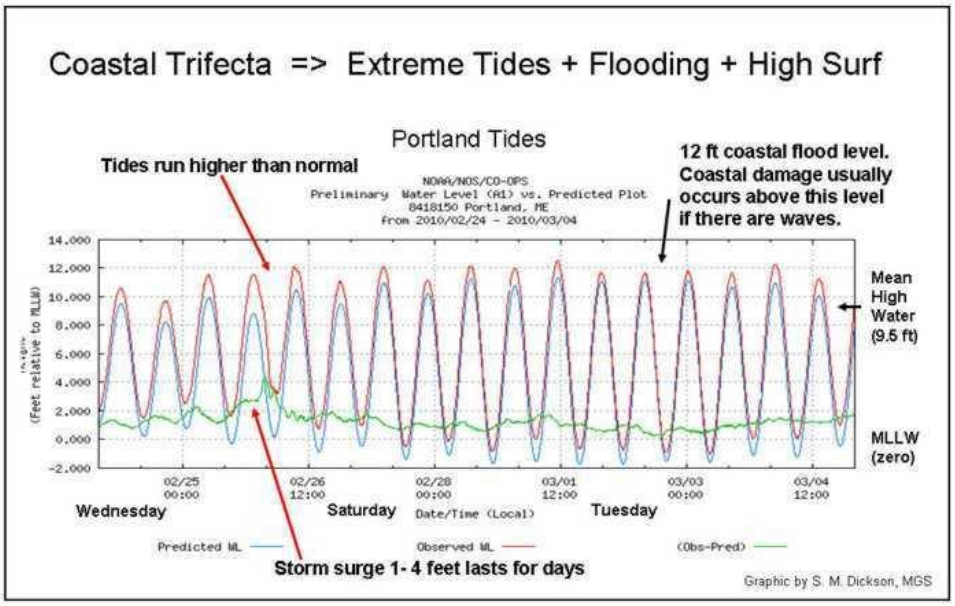

Figure A11. This graph shows the difference from the observed tide (red) and predicted tide (blue). The difference is the storm surge amount (green). Tides exceeded the 12-foot level 5 times in 4 days at the Portland Harbor tide gauge. Just before midnight on February 25, 2010, the Portland Tide Gauge recorded a 4.37 foot surge. Since 1912, the highest surge recorded in Portland (at high tide) was 4.6 feet on March 3, 1947. The Blizzard of February 7, 1978 had a 3.5 foot surge but it occurred during an extreme high tide and holds the highest record for water levels - 2 feet above this storm. Tides ran above normal for 9 days: February 24 - March 4, 2010. Data courtesy of the National Oceanic and Atmospheric Administration. Graphic by S. M. Dickson, MGS.

With each successive tidal cycle, we expect that more sand was removed from the spit and lowered its peak elevation in the overwash channel. Lowering would have led to even longer tidal flow in and out of the Morse River and thus more duration of erosion on the spit. Since a straight path to and from the sea is hydraulically more efficient, the Morse River would have preferentially flowed across the spit when it had the opportunity during this week.

March 2010 - Final Breach

By March 6, 2010 the 9 days of stormy weather were over. A reconnaissance survey by Laura Sewall, the Director of the Bates-Morse Mountain Conservation Area, documented active Morse River flow through the new channel. This was the same location that was progressively lowered by storms in the previous year and more deeply incised in late February and early March (Figure A12 and Figure A13). Once this new connection to the sea had been started, tidal ebbing and flooding of the Morse River rapidly led to additional channel deepening and widening. Sand was deposited into the old course of the Morse River resulting in shoaling that made the former channel hydraulically less efficient and helped to confine more flow in the new channel (Figure A14, Figure A15, and Figure A16).

Figure A12. A photo from March 6, 2010 of the new Morse River channel looking north toward West Beach. The rapid downward erosion of the channel results in a steep vertical cut into the sand spit (right) where large blocks of sand fall into the flowing channel. Bank erosion even exhumed a buried yellow lobster trap. Photo courtesy of L. Sewall, Bates-Morse Mountain Conservation Area.

Figure A13. A photo from March 6, 2010 of the new Morse River with waves helping to suspend sand and scour the channel deeper. In the background is surf breaking on Seawall Beach. Photo courtesy of L. Sewall, Bates-Morse Mountain Conservation Area.

Figure A14. The Seawall Beach spit (sand bar) was cut by the February 25-26 storm. Large tides and surf continued to lower the bar for a week - through March 5 and 6 - when deep erosion formed a new tidal channel with a straighter and more direct course for the Morse River to the sea. Note the stranded tree on the far bank of the channel is the same one in Figure A8. Photo taken March 10, 2010 courtesy of J. Picher, DOC. Annotation by S. M. Dickson, MGS.

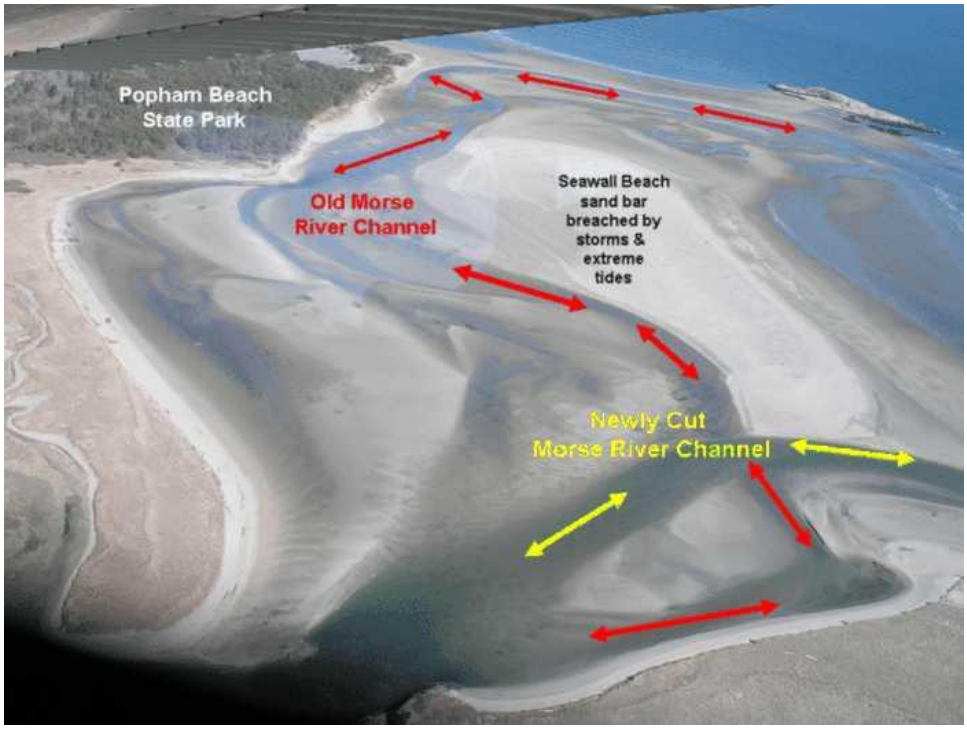

Figure A15. The Seawall Beach spit became a sand island as a result of the new Morse River channel. The shorter path to the sea (yellow arrows) is more efficient and becomes the dominant channel as the old Morse channel fills in with sand. Photo taken March 10, 2010 courtesy of J. Picher, DOC. Annotation by S. M. Dickson, MGS.

Figure A16. An aerial view from over Fox Island and its tombolo (sand bar in foreground leading to the state park dunes). The meandering course of the Old Morse River is marked by red triangles. The new channel is shown by green triangles. The newly formed sand island is in the center with Seawall Beach and Casco Bay in the background. Photo taken March 10, 2010 courtesy of J. Picher, DOC. Annotation by S. M. Dickson, MGS.

August 2010 - Closing the Old Morse River Channel

The breach resulted in the separation of the spit from Seawall Beach. This process led to the formation of a low-relief sand island that was surveyed by the Maine Geological Survey on March 27, 2010 (Figure A17). By August 20, 2010 the former channel of the Morse River was blocked by sand swept northward off the western end of the island to form a small spit platform upstream (Figure A18).

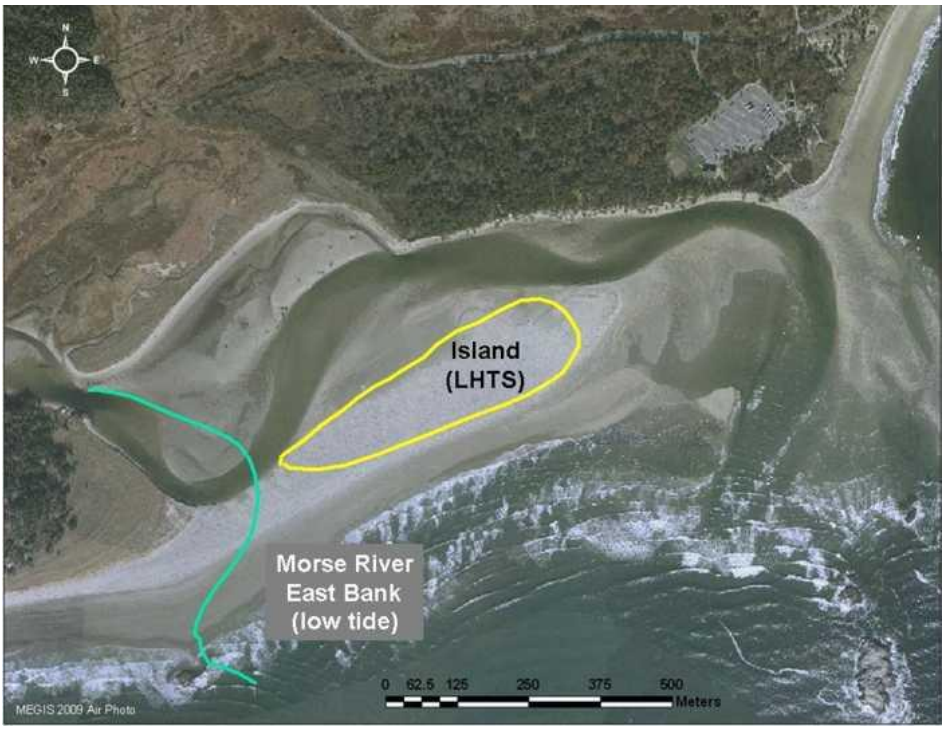

Figure A17. Comparison of the high water mark (last high tide swash line - LHTS) around the sand island (yellow) with the east bank of the Morse River (teal line) at low tide on March 27, 2010. A 2009 air photo shows the former path of the Morse River and fallen trees along West Beach at the state park (photo courtesy of the Maine Office of GIS). Shoreline positions were recorded with a hand-held Garmin 12Map GPS. Graphic by S. M. Dickson, MGS.

Figure A18. An aerial view of Popham Beach State Park and the sand island on August 20, 2010. In the foreground, sand has been transported off the island in a shoreward (left) direction and resulted in the infilling of the former Morse River channel. Photograph by J. Picher, DOC. Flight courtesy of the Maine Dept. of Marine Resources.

November 2010 - The Island Moves Landward

Through the summer and fall of 2010, sand continued to be reworked by waves and tides. From March through November 2010, the sand island migrated 500 to 700 feet east-northeast toward the state park while retaining its overall subaerial exposure. Concurrently, the Morse River's new channel began to migrate easterly (Figure A19). This pattern of channel movement is consistent with what it has done in the past (Goldschmidt and FitzGerald, 1991).

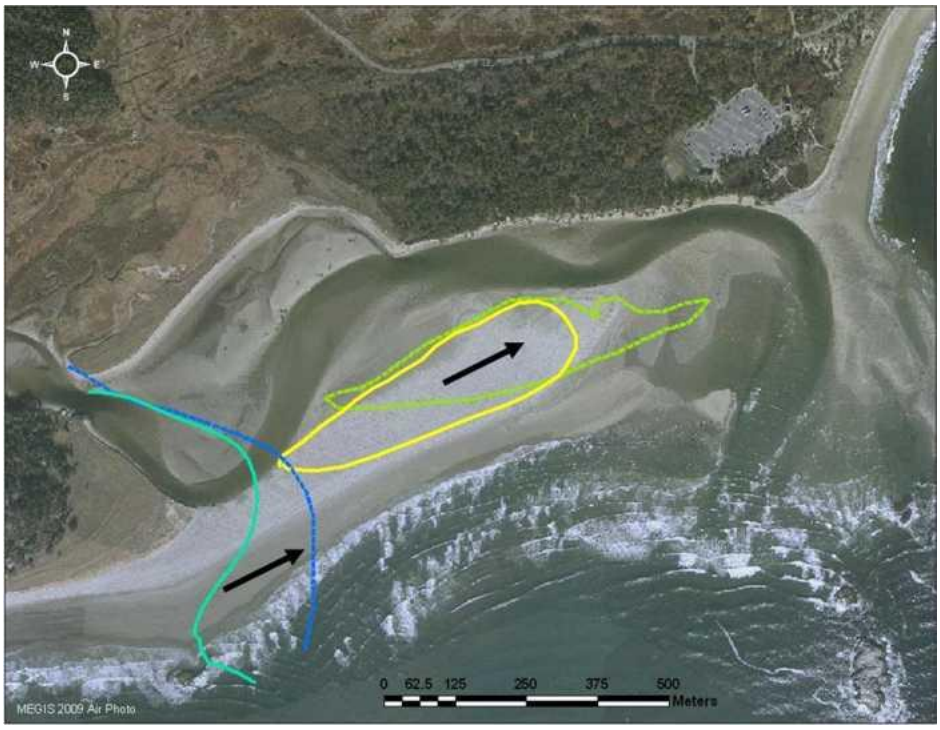

Figure A19. In 2010 the sand island migrated toward Popham Beach State Park. March 27 (yellow) and October 29 (green) high water lines show an east northeast movement. The Morse River's eastern bank at low tide also migrated easterly from March 27 (teal) to October 29 (blue). Shoreline positions were recorded with a hand-held Garmin 12Map GPS. Graphic by S. M. Dickson, MGS.

The dramatic change in shoreline positions is best seen by overlaying the 2010 island perimeter in relation to the dunes in a 2003 air photo (Figure A20). Remarkably, the landward edge (approximately the high tide line) of the island now overlaps the area where the seaward edge of the park dunes was back in 2003.

Figure A20. The October 29, 2010 island shoreline (LHTS, short dashed green line) is superimposed on a 2003 air photo. The fall 2010 island position slightly overlaps the 2003 dune field. The October dune/forest edge is shown in the upper dashed green line and the east bank of the Morse River is in the blue dashed line. Shoreline positions were recorded with a hand-held Garmin 12Map GPS. Photo courtesy of MEGIS/Delorme.

Shoreline Change at Popham Beach State Park

Historical shoreline change has been previously documented (FitzGerald and others, 2000; Nelson, 1979) as has the meandering of the Morse River (Goldschmidt and others, 1991). Nelson and Fink (1980, p. 110) described the shoreline at Popham Beach State Park as "...among the most unstable in Maine." FitzGerald and others (2000) estimated that the state park lost an average of 74,000 m3/yr from 1942-1953 and gained 15,000 m3/yr from 1953 to 1979. The last time the shoreline was close to the pitch pine forest was in 1953 (Dickson, 2008 - Figure 12).

Recent shoreline change along the dune edge shows the pattern of erosion at Popham Beach State Park that led to unprecedented dune and forest loss since 2005. It is clear that the Morse River began to encroach on the state park dune field before the 2007 Patriots' Day Storm and that a considerable area of open dunes were lost from 2005 to 2007. The pattern of erosional loss is consistent with easterly migration of the outer bend, or cut bank, of the Morse River (Dickson 2010 - Figure 7). From 2007 through January 2011 the erosion trend at the state park continued with a progressively easterly loss of dunes (Figure A21).

Figure A21. Shoreline change map at Popham Beach State Park from 2005 shown in the photo to 2011. From 2005 to 2007 as much as 500 feet of the open dune field at Center Beach was removed by erosion. Between 2007 and 2009 erosion moved eastward taking out additional dunes where the Fox Island tombolo connects to the beach. From 2009 to 2011 the area removed by erosion lessened slightly but the entire shoreline from West Beach to East Beach continued to erode. Real-time Kinematic GPS was used for the 2007 and 2009 shorelines by MGS summer interns J. Howard and L. Wurst. A Garmin 12Map GPS was used to measure the January 2010 shoreline. Air photo (8-23-05) courtesy of the Maine Office of GIS and Department of Marine Resources. Graphic by S. M. Dickson, MGS.

From 2007 to 2011, erosion took place on East Beach and severely compromised the height of the frontal dune, particularly on the eastern end. The lower dune ridge is now more susceptible to wave overtopping and additional sand deposition on the back slope of the frontal dune ridge (Figure A22). Based on shoreline positions from 1980 to present, the area of vegetated dunes at the state park is now about the lowest on record (Figure A23).

Figure A22. January 3, 2010 photo of low frontal dunes at the eastern end of East Beach. Storm waves and flooding have deposited sand and driftwood into the dunes. Erosion has removed some of the higher frontal dune ridge at this location so flooding is more able to reach farther inland. Photo by S. M. Dickson, MGS.

Figure A23. This map shows twenty years of shoreline change at Popham Beach State Park from 1991 to 2011 showing the maximum and minimum edge of the dunes. The largest dune area was present in 1991 and represents the most southerly extent of dunes at Center Beach in the last 30 years. From 1991 to 2003 (when the photo was taken) the Morse River removed dunes on the west side of the dune field but the center of the dune field remained stable. From 2003 to 2011 erosion by the Morse River progressed eastward (Figure A21). The smallest area of dunes since 1980 (not shown) occurred in 2011. The 1991 shoreline from an historical vertical photograph about 3 weeks after the Perfect Storm (October 31, 1991), shows an irregular dune edge. The 2011 shoreline was recorded using a hand-held Garmin 12Map GPS. Air photo (6-6-03) courtesy of the Maine Office of GIS. Graphic by S. M. Dickson, MGS.

Discussion

The last time the Morse River breached the sand bar was November 23, 1986 (Goldschmidt and others, 1991). Goldschmidt and others estimated that about 100,000 m3 of sand migrated onto Popham Beach State Park as a result of that course change in the river. Based on partial submergence of the sand bar in an air photograph taken about 18 months before the breach (May 9, 1985; Goldschmidt and others, Figure 3) the sand bar was significantly lower than it was in 2009 when tides could not routinely overtop it. The 1986 breach was followed by breaching of the Fox Island tombolo whereas in 2008, the tombolo was breached prior to channel avulsion (Dickson, 2008). It remains to be seen if the onshore migration of the island leads to another tombolo breach in the near future.

In the next few years the sand island should migrate ashore and weld onto Popham Beach State Park. As sand moves ashore, the intertidal beach will become much wider and the height of the tombolo to the Fox Islands should increase providing additional recreation space and protection for the remaining dunes at Center Beach. Based on past trends, the next several years should see additional dune building from wave and wind action. Once the upper dry beach, or berm, reaches an elevation above the spring high tides, American beach grass should colonize the area. Vegetation, if kept from excessive foot traffic, will trap additional sand and lead to further dune building. Given the large size of the island, the area of dunes built over the next decade may reach an equivalent area to those removed in the last decade - possibly completing a natural cycle that began about 20 years ago.

Conclusion

Popham Beach at the mouth of the Kennebec River is one of Maine's premier public beaches. The beach and dunes have been highly dynamic based on historical evidence. The geology of the system is complex and affected by bedrock islands that affect wave shoaling and by the ebb and flood of currents in the Kennebec and Morse Rivers. Geological evidence of impending spit breaching by the Morse River was observed for about a year. It took a

trifecta of large storm waves, coastal flooding, and extreme tides for an avulsion to abruptly alter the channel of the Morse River away from the state park and a new bath house. Erosion reached much farther inland than ever recorded in the last century, but conditions are favorable for the beach and dunes to return naturally in the next several years.

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