State of Maine's Beaches in 2017

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Cover photo of Goose Rocks Beach profiling team, May 14, 2016
by William Van Benthuysen, Kennebunkport, Maine.

Acknowledgments

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Background

The 2017 State of Maine's Beaches Report is the 7th report in the series coinciding with the biennial Beaches Conference. This report summarizes observed changes of Maine beaches that are monitored as part of the State of Maine Beach Profiling Project (SMBPP; Maine Sea Grant, 2017) and the Maine Beach Mapping Program (MBMAP).

The SMBPP uses trained volunteers to collect monthly beach profiles that start at a benchmark (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). The data are entered by volunteers into an online database where it can be viewed, graphed, and downloaded by others (Maine Shore Stewards, 2015). SMBPP is funded and managed by the Maine Geological Survey (MGS), University of Maine, Maine Sea Grant, and Maine Coastal Program. For the 2017 report, there are ten participating beaches in the SMBPP, as shown in Figure 1.

As part of MBMAP, MGS scientists collect shore-parallel data along the seaward extent of dominant dune vegetation along the larger beach systems in southern and mid-coast Maine. Data are collected using a Real Time Kinematic Global Positioning System (RTK-GPS) on an annual basis, and are compiled in GIS by the MGS. MBMAP beaches are shown in Figure 1.

This report will focus on documenting changes at SMBPP and MBMAP beaches since 2010. Previous editions of this report (2011 and 2013), in addition to more recent studies (see *Setting the Stage: Sea Level Changes and Storms*) found that the winter of 2010 was especially erosive due to storms and higher than normal sea levels. Thus, this report will inspect subsequent changes at beaches from 2010 through summer 2016, and winter 2017, from available data.

Spatial and Temporal Extent of Beach Profile Data

Along each collected beach profile, topographic (elevation) points are collected at about 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 (Emery, 1961). Points are recorded in reference to the starting point, with negative values being below the starting point, and positive values above. For this year's report, the starting points were surveyed in using GPS so that their elevations are referenced to standard vertical datum. This allows for comparison between elevations recorded by beach profiles with elevations recorded with a GPS or LiDAR. All profile elevations are thus referenced to centimeters, North American Vertical Datum (NAVD).

This report builds on the 2015 report, which reported on beach recovery between 2010 and winter 2015, by including additional changes in the "winter" and "summer" beach shapes from 2015, 2016, and winter of 2017. Summer beach shapes are typically fully developed by August or September, after a season of gentle waves and sand accretion. Because we have not reached summer shapes for 2017, that data is not being included. 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. Beach profiles used for this analysis are shown in Table 1.

The following color scheme is used to represent beach profile data: **2010 (lavender), 2011 (light blue), 2012 (green), 2013 (pink), 2014 (red), 2015 (orange), 2016 (dark blue), and 2017 (dark red)**. Note that only "winter" beach profile data was collected for 2017; no data has yet been collected for summer 2017, so this data is not included. Note that to give the reader a reference point for profile heights, the approximate Mean Higher High Water (MHHW, referenced to NAVD) was added to each profile (dashed light blue line).

Spatial and Temporal Extent of MBMAP Data

The 2015 report included horizontal positions of the surveyed **vegetation line** from 2010 to 2014. This report will include additional shoreline positions from 2015 and 2016, as data is available. MBMAP shorelines follow the color scheme used for the beach profile, and only extend through 2016. The **linear regression rate (LRR),** or the shoreline change rate computed using a linear regression fit between available data, was calculated using a GIS tool developed by the Maine Geological Survey based on methodology from the United States Geological Survey (USGS, Thieler et al., 2008). MBMAP data used for this report is also shown in Table 1.

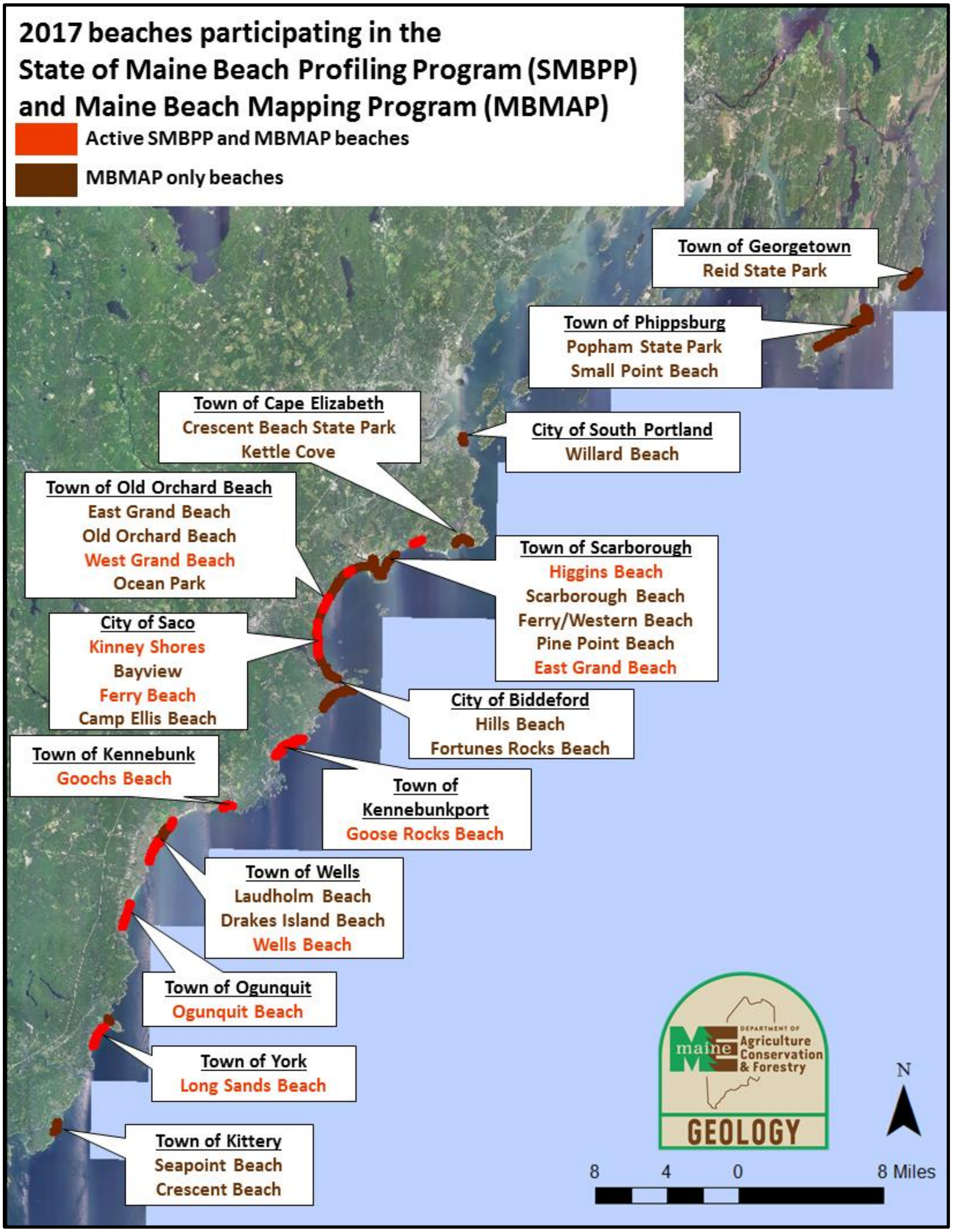

Figure 1. Beaches participating in the SMBPP and MBMAP.

Beach	Municipality	State of Maine Beach Profiling Datasets															Maine Beach Mapping Program Datasets						
		Winter								Summer													
		2010	2011	2012	2013	2014	2015	2016	2017	2010	2011	2012	2013	2014	2015	2016	2010	2011	2012	2013	2014	2015	2016
Crescent	Kittery	Not part of SMBPP															-	8/12	8/29	12/13	9/18	-	9/2
Seapoint	Kittery	Not part of SMBPP															-	8/12	8/29	12/13	9/18	-	9/2
Long Sands	York	4/25	4/15	4/15	4/6	4/19	4/12	4/15	4/9	8/15	8/5	8/24	8/23	8/15	8/7*	8/5*	8/4	8/3	8/27	12/12	8/8	-	7/13
Ogunquit	Ogunquit	4/23	4/16	7/28*	5/3	5/3	5/15*	4/15	4/9	9/12	8/7	9/15	9/12	9/12	8/4*	9/9*	6/15	6/23	6/27	9/24	7/14	8/10	6/29
Wells	Wells	4/24*	3/27*	4/14*	4/6	1/25*	4/11*	2/20*	4/8*	7/16*	7/9*	8/26	9/14*	9/13*	8/8*	8/6*	6/21	7/28	8/14	-	7/21	8/6	6/27
Drakes Island	Wells	Not part of SMBPP															6/18	7/27	8/8	10/24	7/18	8/18	6/23
Laudholm	Wells	Not part of SMBPP															6/18	7/27	8/8	10/24	7/18	8/26	6/23
Goochs	Kennebunk	4/25	4/15	4/24	4/5	4/19	4/11*	4/16	4/7	8/13	8/6	8/25	8/23	8/30	8/7	8/5	7/2	7/11	7/13	-	7/22	8/18	6/18
Goose Rocks	Kennebunkport	4/24*	4/15*	4/12	4/6	4/19	3/16*	4/16	4/8	8/14	8/6	8/26*	8/24	8/16	8/8	8/6	6/22	7/7	7/11	10/28	7/22	8/13	6/22
Fortunes Rocks	Biddeford	Not part of SMBPP															6/11	6/28	6/26	8/6	7/17	8/24	6/17
Hills	Biddeford	Not part of SMBPP															6/23	7/1	7/2	7/24	7/15	8/24	6/20
Camp Ellis	Saco	Not part of SMBPP															5/26	6/17	6/5*	6/19	7/1	7/23	6/6
Ferry Beach	Saco	4/23*	4/15	5/7	4/5	4/16	1/16	6/24	4/5	9/10*	9/23*	9/13*	9/16*	10/8*	10/27	9/13	5/26	6/17	6/5*	6/19	7/1	7/23	6/6
Bayview	Saco	Not part of SMBPP															5/26	6/17	6/5*	6/19	7/1	7/23	6/6
Kinney Shores	Saco	3/8	2/25	3/7	3/16*	7/21*	4/14	6/24	-	9/10	9/26	7/30	9/15	9/18	6/24	9/6	5/26	6/17	6/5*	6/19	7/1	7/23	6/6
Ocean Park	Old Orchard	Not part of SMBPP															6/2	6/27	6/16	7/16	7/10	7/27	6/14
West Grand	Old Orchard	-	-	-	6/12	-	5/14	4/5	4/14*	-	-	-	10/15	10/3	7/6*	9/22	6/2	6/27	6/16	7/16	7/10	7/27	6/14
East Grand	Old Orchard	4/21	3/30	4/12*	-	4/20*	4/12*	3/20*	4/9	8/18	8/23	-	9/15	8/24	9/27	9/10	5/27	6/20	6/11	6/20	7/3*	7/27	6/14
Pine Point	Scarborough	Not part of SMBPP															5/27	6/20	6/11	6/20	7/3*	7/27	6/14
Western/Ferry	Scarborough	Not part of SMBPP															6/4	6/3	5/15	5/30	6/24	7/21	6/3
Scarborough	Scarborough	4/24*	4/22	4/11	4/30	12/27*	-	-	-	8/21	8/10	8/31*	8/31	-	-	-	-	6/8	6/8*	6/13	6/27	7/22	6/6
Higgins	Scarborough	4/23	4/14	4/10	4/5	4/21	4/12	-	-	8/17	8/29*	8/27	8/23	8/15	-	-	6/4	6/6	5/25	6/3	6/24	8/28	6/7
Crescent	Cape Elizabeth	Not part of SMBPP															6/4	6/6	6/1	6/10	6/27	8/3	6/7
Kettle Cove	Cape Elizabeth	Not part of SMBPP															6/4	6/6	6/1	6/10	6/27	8/3	6/7
Willard	South Portland	Not part of SMBPP															6/11	6/7	6/6	6/6	7/2	8/3	6/6
Small Point	Phippsburg	Not part of SMBPP															-	9/14	9/18	-	9/15	8/14	9/7
Popham	Phippsburg	Not part of SMBPP															6/30	7/21	8/3*	12/11	9/14	8/14	9/7
Reid	Georgetown	Not part of SMBPP															7/19	7/13	7/23	-	7/24	8/17	7/14

Legend

(dark brown)	Beach surveyed only as part of MBMAP
(light red)	Beach surveyed as part of MBMAP and SMBPP
-	No data available
*	More than one date used in analysis

Table 1. Volunteer beach profiling dates used for winter and summer profile analyses along with the dates of MBMAP shoreline surveys since 2010.

Setting the Stage: Sea Level Changes and Storms

Sea Level along the Maine Coast

Over the past century, sea level at the Portland tide gauge has risen at a rate of approximately 1.9 mm/year, or about 7.3 inches per century (Figure 2). This has generally matched long-term global ocean trends over the past 100 years (U.S. National Climate Assessment, 2014). However, over the last twenty years, global sea level rise rates have almost doubled to around 3.4 mm/year (University of Colorado, 2017). Data from Portland has also shown an increase from 1993-2016 when compared with the long-term trend, up to about 3.1 mm/year (Figure 2). Some of the highest annual mean sea levels *ever recorded* at Portland occurred between 2009 and 2016, with 2010 having the highest recorded value over the 104 year period. To put this into context, 7 out of the 10 highest annualized sea level recordings occurred during this time period, with 2016 ranking 12th out of 104 years of data.

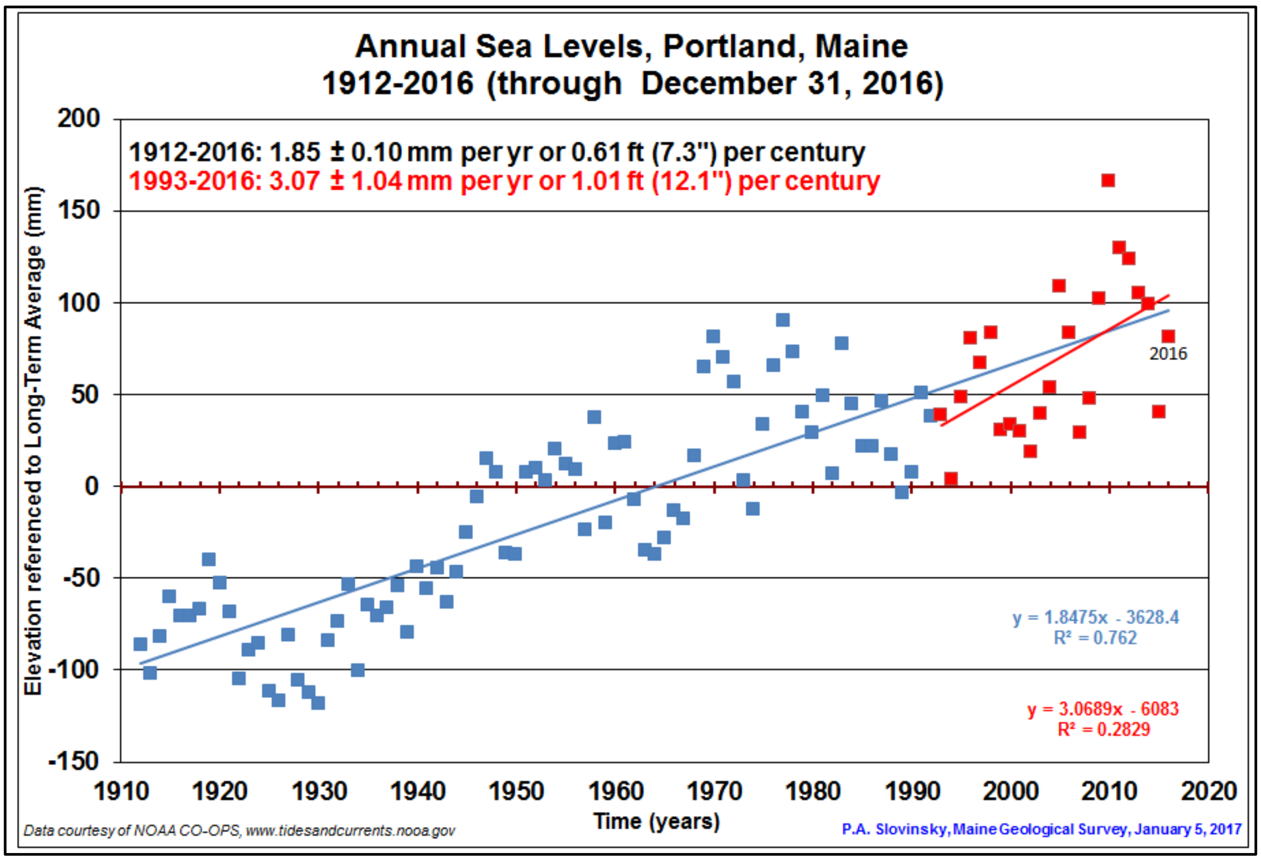

Figure 2. Annual sea level rise data for Portland, ME from 1912 through 2016. Data is referenced to the long-term average, which is the average of annual sea levels from 1912-2016.

Abrupt Sea Level Rise of 2009-2010

Sea level in Portland, Maine reached an all-time monthly high in January and February 2010. The record was set in January with the monthly mean level 9 inches (23 cm) above the 1912-2016 monthly mean at the Portland tide gauge. Since that time, levels have been gradually falling over the last 7 years (Figure 3). The lowest level from 2010 to 2017 was March 2015 which was -2 inches (-5 cm) below the 104-year mean sea level. For perspective on this "falling sea level," the average sea level for 2010-2016 was still 4 inches (10.7 mm) above the 1912-2016 average and 7 inches (19 mm) above what it was in 1912.

In the course of a single year, winter sea level tends to be lower than in the summer. The exception to this pattern was in 2010 when the East Coast sea level anomaly (Goddard et al., 2015; Slovinsky et al., 2015; Yin and Goddard, 2013) pushed the winter low level to the extreme high. In this report, all but 2010 had the late summer profiles measuring the beach at higher sea level than in the spring (Figure 3). Higher sea levels are more critical to beach erosion in the winter when the waves are typically larger due to stronger storms.

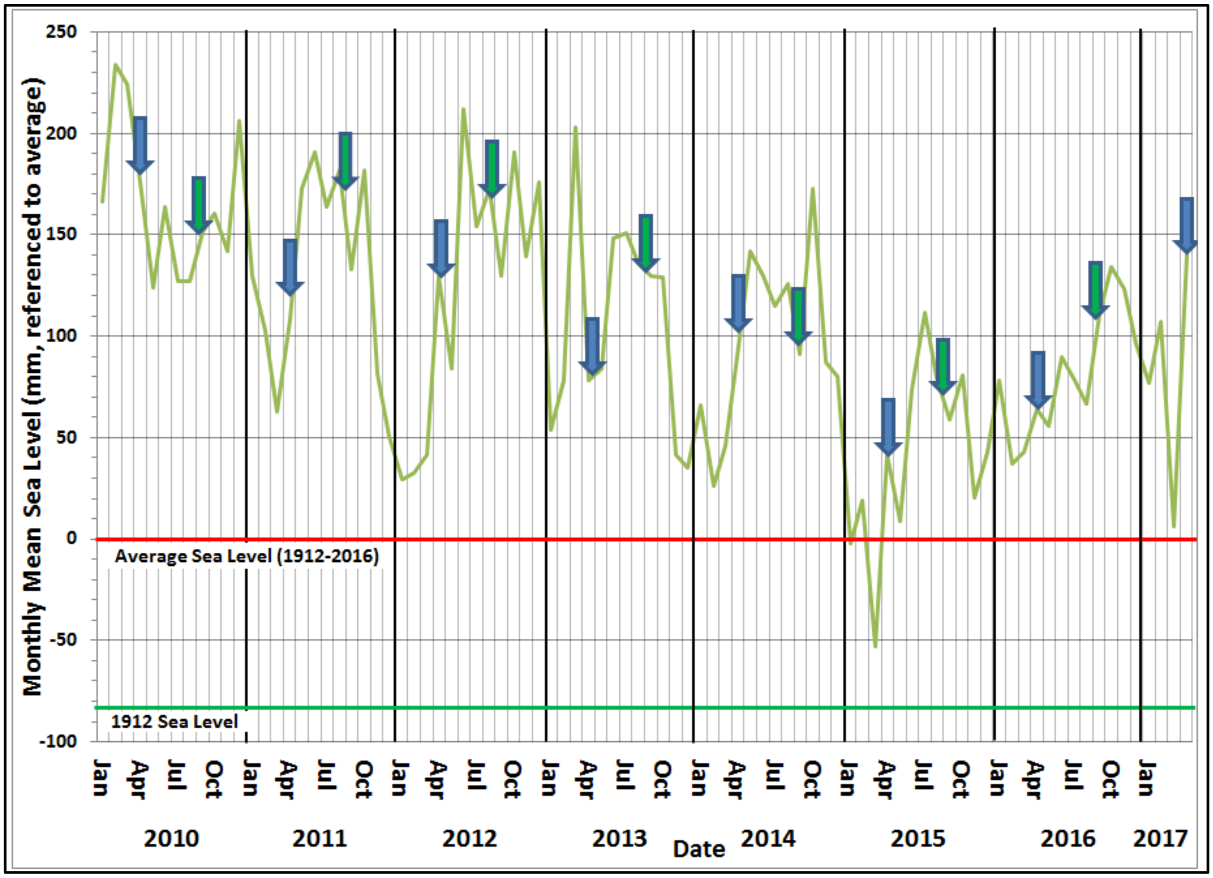

Figure 3. Monthly mean sea levels for Portland, ME from January 2010 through April 2017. Data is referenced to the long-term average, which is the average sea level from 1912-2016. Data from NOAA CO-OPs.

In winter 2010, sea levels were elevated due to a slowdown in the Gulf Stream, combined with a weather pattern that allowed northeasters to track up the Gulf of Maine coastline, resulted in some of the worst erosion seen. This was documented in the 2011 and 2013 State of Maine's Beaches reports (Slovinsky and Dickson, 2011; Slovinsky and Dickson, 2013). Figure 3 also shows sea level trends in relation to the seasonal beach profiling dates (mostly April for winter, August or September for summer) that were analyzed for these previous reports.

Wave Climate 2010-2017

Waves affect beaches all year. Winter storm waves are powerful and erode beaches quickly while smaller, but more frequent, summer waves lead to beach growth or sand accretion. We focus on some of the major storm events since interannual variability in storms tends to have a lasting impact on the summer beach profile. In prior reports we examined the variability of beach elevations from winter to summer, and significant events that affected the return of sand for more than a year. Two such examples were the 2007 Patriots' Day Storm and the 2009-2010 East Coast sea-level rise anomaly. Beach sand budgets are also affected by beach nourishment that adds sand to either the upper beach profile or to the nearshore where sand is reworked by waves. The severity of winter storms that produce big surf with nearshore wave heights in excess of 20 feet is the one factor that most directly affects beach conditions, both immediately and on time scales of months to over a year.

Wave History from 2010-2013

The wave climate from January 2010 through mid-May 2015 was described in Slovinsky et al. (2015) in greater detail. Monthly waves exhibited a common seasonality with waves frequently exceeding 15 feet in the winter months and backing down to 5 feet in the summer (Figure 4). Looking back to the period from 2010 to 2013, the biggest waves in the last 6 years occurred February 21, 2010 over 31 feet in height (Figure 5). March 14, 2010 also had large waves up to 26 feet. Calm wave conditions followed until the fall of 2010. The winter of 2010-2011 had the largest waves on December 26 of 25 feet. The remainder of winter storm waves were lower, with two notable 21-foot peaks on January 9 and April 10, 2011.

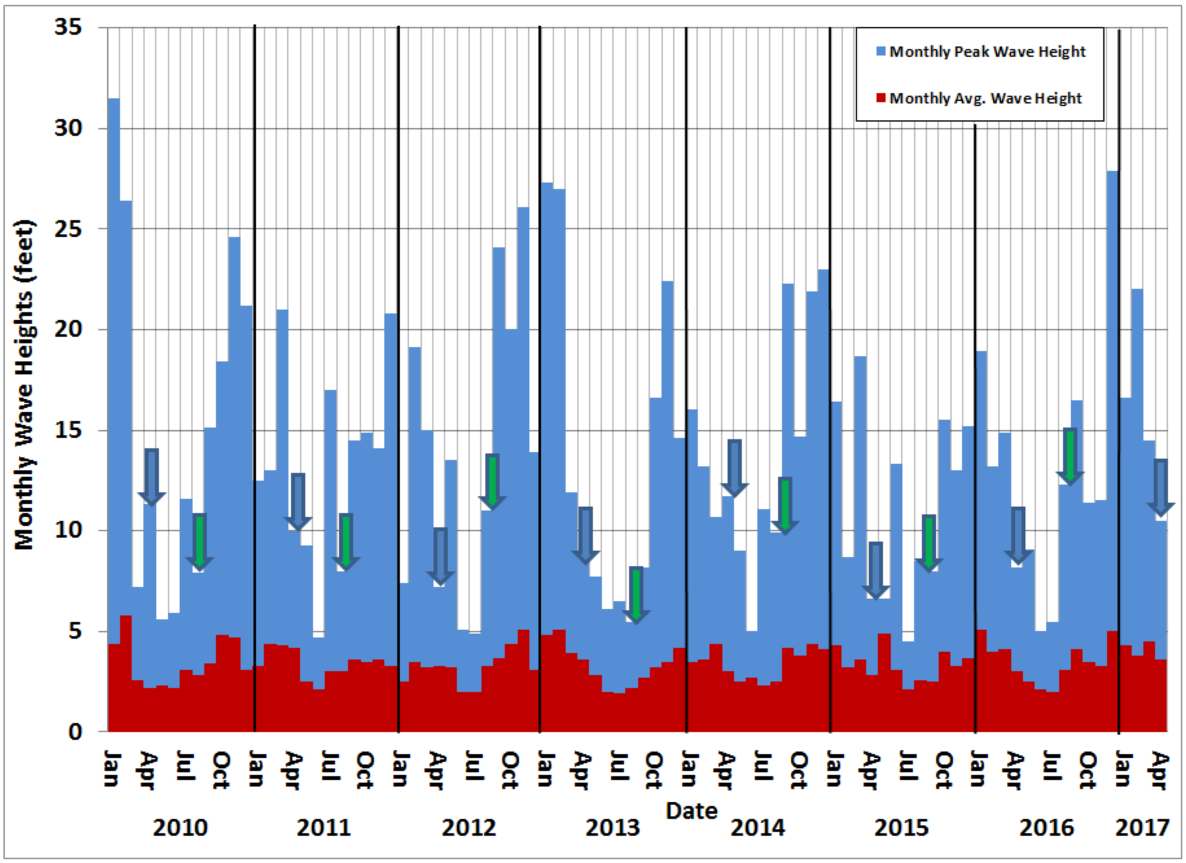

Figure 4. Monthly peak and monthly average wave heights, in feet, for January 2010 through April 2017 for the Western Maine Shelf Buoy (B01). Data from NERACOOS.

The winter of 2011-2012 was relatively mild compared to the winter of 2012-2013 (Figure 5). January 8, 2012 was the winter's largest wave event that reached 21 feet. Three lesser storms passed through ending the storm season in early June 2012. On December 23, 2012 waves reached 26 feet, topping the 25-foot level for the first time since March 2010. February 3, 2013 waves peaked at 27 feet and a month later on March 3, waves rose to 27 feet. So the winter of 2012-2013 had larger wave action than either of the two preceding winters.

Wave History from 2014-2017

From January 2014 through April 2017, the winter wave climate varied considerably from year to year. The record-setting wave event was from a storm that produced waves of 28 feet at the Western Maine Shelf Buoy (B01) on

January 23, 2017 (Figure 6). No other storms from January 2015 to May 2017 produced waves over 25 feet high. The previous high wave event was from 31-foot waves back on February 21, 2010, some 7 years earlier.

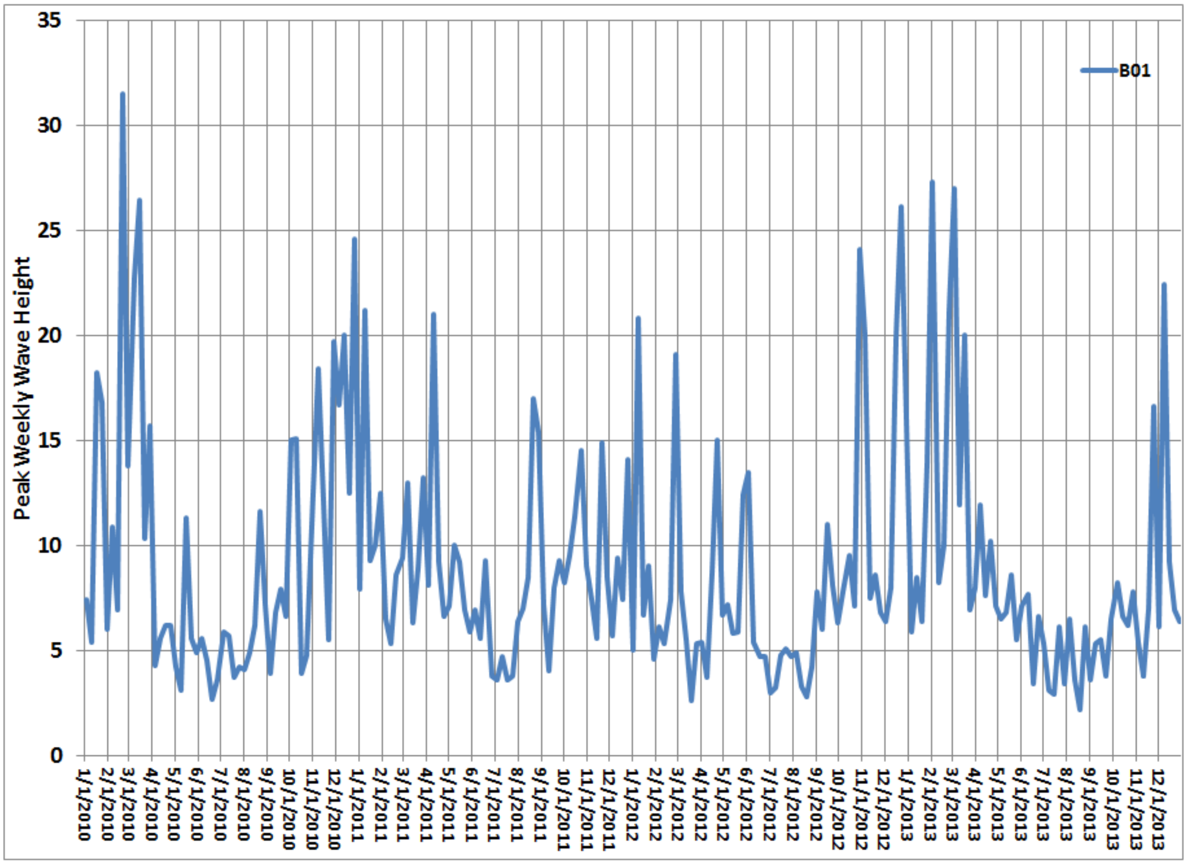

Figure 5. Peak weekly wave height data, in feet, for January 2010 to December 2013 for Western Maine Shelf Buoy (B01). Data from NERACOOS.

Other large wave events peaking over 20 feet occurred only 4 times: October 19, 2014, December 7, 2014, January 26, 2015, and March 13, 2017. Ten other events in that time period had waves in the 15-20 foot range. While the winter of 2015-2016 did not have any wave events over 20 feet, there were moderate waves and surf continually at the beaches in January and February 2016 (Figure 6). Starting October 19, 2014, a classic fall northeaster produced a 1.5-foot surge that generated an 11.3-foot storm tide. This event produced 22-foot waves to start the 2014-2015 storm season.

On December 7, 2014, an East Coast low stalled near Boston generating 22-foot waves near the southern Maine beaches. The peak storm tide was 11 feet as the 993 mb low became retrograde and moved ashore. In the past, this type of stalling and retrograde (westerly-tracking) low was responsible for considerable damage in the Blizzard of February 1978 and Perfect Storm on Halloween 1991. Unlike these historic and damaging storms, this storm tide was a foot below flood level and caused less damage. The third storm with waves in excess of 20 feet occurred on January 26, 2015. Blizzard Juno resulted in a 12.2-foot storm tide in Portland on the 27th. Because the tide was low at the peak surge, beaches escaped a 13.5-foot storm tide that could have resulted from a significant 3.4-foot storm surge. Waves from this 975 mb low were 23 feet when buoy B01 stopped recording (Slovinsky et al., 2015).

February 19, 2015 had a storm tide of 12.3 feet produced from a 0.8-foot surge on an 11.5-foot perigean tide. From the 17th to the 19th tides ran above predicted with a surge of around 1 foot.

Winter Storms of 2015-2016

This winter season was notable because of the lack of storms that produced waves in excess of 20 feet (Figure 6). The northern hemisphere winter was influenced by a strong El Nino that affected the storm tracks across the United States and thus storms in Maine. October 6, 2015 Hurricane Joaquin passed offshore in the Atlantic Ocean. Swells of 7 feet and the lack of storm surge resulted in minimal high water at the beaches.

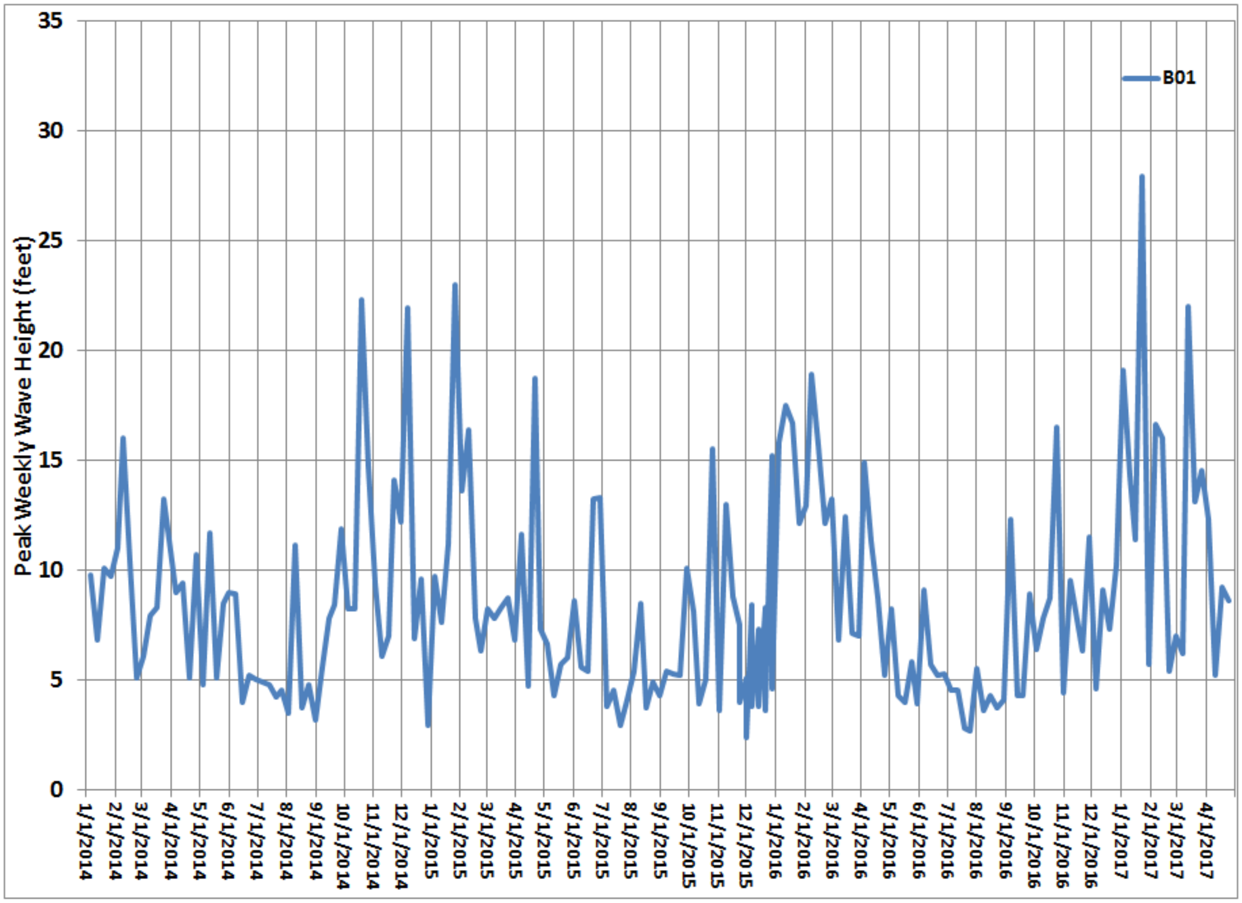

Figure 6. Peak weekly wave height data, in feet, for January 2014 to April 2017 for Western Maine Shelf Buoy (B01). Data from NERACOOS.

The predicted 11.8-foot Highest Annual Tide (HAT) of 2015 occurred just after midnight on October 28th but was reduced to 11.3 feet from a coastal set-down (lowering). A cold front generated a gale on the 29th and produced a 1.3-foot storm surge at low tide and a storm tide of just over 11.7 feet soon after midnight on the 30th. Minor coastal flooding and splashover from 14-foot waves was documented by John Canon of the National Weather Service, York County emergency manager Roby Fecteau, and John White, the beach profiling team leader at Goochs Beach.

No storms in November 2015 produced high water levels over the 12-foot level of the highest astronomical tide. A surge of 1 foot on November 11 pushed tides to 10.8 feet for the highest surge during a storm. In December, a storm tide of 11.4 feet occurred from a 0.3-foot surge on the 24th. So no fall 2015 conditions saw coastal flooding other than the October splashover described above.

January 10, 2016 a rapidly-intensifying low produced a southeaster with a surge of 2 feet at low tide and a storm tide of 11.6 feet from a 1.2-foot surge. Only one high tide water level exceeded 11 feet and waves briefly peaked at 17 feet.

February 8-9, 2016 winter storm Mars resulted in two storm tides over 12 feet. On the 8th the storm tide reached 12.4 feet from a surge of 1.7 feet. On the 9th the storm tide of 12.5 feet resulted from a 1.6-foot surge. This storm formed from an unusual convergence of 3 lows from the Great Lakes, Virginia, and the open Atlantic Ocean. With waves up to 19 feet, this was the biggest storm event of the 2015-2016 winter.

The second half of February and all of March were relatively quiet and water levels rarely exceeded 10 feet. Storms moved quickly west-to-east as clippers and bigger storms formed farther off the U.S. East Coast.

April 7, 2016 a clipper crossed the upper Midwest and passed offshore of New Jersey. This storm track produced 15-foot waves at B01 and resulted in a 12.7-foot storm tide from a 1.4-foot surge late on the 7th. This flooding was facilitated by a high astronomical tide of 11.3 feet. Beach profiling in Saco and NWS analysis documented beach changes from wave impact and splashover along Surf Street. This was the last significant storm of a winter dominated by milder conditions and El Nino. By the following winter ENSO conditions were neutral and, as described below, winter storms were more intense.
June 6, 2016 Tropical Storm Colin was over the coastal Carolinas and headed up the East Coast. This storm coincided with a period of perigean (king) tides. On June 6th waves peaked at 9 feet and a 0.8-foot surge produced a storm tide of 12.6 feet just after midnight. A storm tide then next night reached 12.1 feet from a 0.6-foot surge. Around 2 a.m. on the 8th, a third storm tide reached 12.0 feet from a 0.9-foot surge. Waves on the 7th and 8th had dropped to 3 feet so splashover was limited.

Winter Storms of 2016-2017

Tropical Storm Hermine on September 6, 2017 produced 12-foot waves but no significant storm surge so tides only reached the 10-foot level as the low became a post-tropical gale and became retrograde to the south in the New York Bight (south of Long Island). Hurricane Matthew had only a minor impact on Maine. On October 10, 2016 waves reached 8 feet (B01) and 5 feet (buoy 44007) while tides were neap and around 9 feet without a storm surge.

October 27, 2016 two low pressure centers combined to produce a fall gale in the Gulf of Maine. On the 28th, a brief storm surge of 1.3 feet produced a storm tide of 11 feet during a single high tide. Waves peaked around 16 feet on the 28th but remained over 8 feet through the next day. November and December were relatively quiet without large storms.

On January 3, 2017 a gale formed in the Gulf of Maine, tracked north, and produced inland freezing rain. This locally-formed 991 mb low produced 19-foot waves on the 4th but subsided rather quickly. This storm produced a 1.9-foot surge at low tide. A 1.6-foot surge at a neap high tide resulted in a storm tide of only 10.8 feet at the Portland tide gauge.

January 24, 2017 northeasterly 990 mb gale passed east of Cape Cod and across the Gulf of Maine into Nova Scotia. This storm produced the biggest waves of the 2016-2017 winter season with 28-foot waves offshore of the southern Maine beaches (B01) and 20-foot waves in outer Casco Bay (buoy 44007). For six days, starting January 20th, and ahead of the storm, tides ran above normal. A 2-foot surge lasted about 8 hours and included a high tide. However, a neap tide condition kept the storm tide to only 11 feet, a foot below flood level. Had this storm occurred with a spring tide with heights of 11 to 12 feet, even a 2-foot surge (making a 13-14 foot storm tide) and the large surf would have produced much more serious beach and dune erosion.

February 13, 2017 a 980 mb low formed off Cape Cod and warnings of hurricane-force wind was issued by NOAA. A storm tide reached 11.5 feet on the 13th. Waves reached 16 feet at B01. This event was in a stormy period that started with a southeast gale on the 7th, an offshore northeaster on the 9th, and was followed by a southeaster on the 15th. From the 11th through the 16th ten tides ran above normal resulting in elevations from 10-11 feet MLLW. On the 16th the storm tide peaked at 11.2 feet MLLW from a 2-foot storm surge and waves were only 10 feet. Despite this storminess, not one storm tide reached flood stage.

March 13, 2017, a winter storm developed off the Carolinas and tracked north into Maine. This storm, named Stella in the media, produced 22-foot waves at BO1 and offshore waves may have reached 30 feet from a 977 mb low at buoy 44007 off Portland. There were near-hurricane force winds offshore. A storm surge of 2.5 feet was recorded in Portland Harbor and coincided with low tide. The highest storm tide reached 11 feet MLLW, one foot below splashover because the storm surge had dropped to about 1 foot by the time of high tide. Had the peak of the storm arrived about 6 hours later, dunes would have seen more extreme erosion.

Summary of Storm Seasons 2015-2017

The most notable contrast is in storms over the last two winters can be seen in the number and intensity of storms. The winter of 2015-2016 was comparatively less stormy with lower wave heights and storm tides that resulted in less surf and flooding in the dunes. That winter there was ample surf in the 10 to 15-foot range but no storm waves rose above 20 feet. Minor coastal flooding and splashover were aided a few times by astronomically high tides that combined with minor storm surges as seen April 7, 2016.

The winter of 2016-2017 had more large storms and even had one time when waves were up to 28 feet on January 24th. This was a more typical storm season and similar to the winters of 2012-2013 and 2014-2015. Despite larger waves this winter than the previous one, many storms arrived on neap tides (relatively low high tides) so storm surges did not often result in significant coastal flooding. Some of the largest surges occurred near the time of low tide also minimizing the storm’s impact on the dunes.

In retrospect, the strong El Nino conditions across the northern hemisphere in the winter of 2015-2016 appear to have reduced the intensity of storms in the Gulf of Maine for a year. That winter, wave heights and storm surges were unable to rise frequently above the beach profile and reach the frontal dune. The maximum wave height in the winter of 2015-2016 was about 10 feet lower than that in the following 2016-2017 storm season that had a peak of 28 feet offshore of the southern Maine beaches.

Review of Beach Responses from Analysis of SMBPP and MBMAP Data

This portion of the report will review beach changes from 2010 to 2017 using analysis of available MBMAP and SMBPP datasets. The analysis starts with the southern-most monitored beach (Crescent Beach in Kittery), and progresses north, ending with Reid State Park beaches in Georgetown.

As needed for each beach, a figure will be shown orienting the reader to the shape of the beach, and the location of SMBPP and MBMAP data. If no SMBPP data exists, only MBMAP data will be shown. To the maximum extent practical, figures for each beach have been created and rotated so that water appears on the bottom of each image. A north arrow is included in each figure to properly orient the map.

If SMBPP data exists, we will review profile changes using the winter 2010 beach profile shapes as a starting point for comparison with subsequent years from roughly the same months, through April or May 2017. Review of the "winter" beach profile shapes will allow us to detail whether or not the beaches have recovered from the significantly erosive 2010 winter season. We will also review profile changes and recovery from 2010 through the summer of 2016 for the "summer beach" profiles. This will include, as data is available, profile data from July, August, or September of each year.

Each profile is assigned a "grade," based on the amount of erosion, stability, or growth, exhibited by both summer and winter beach profile shapes. 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 2.

Grade	Numerical Score	SMBPP Score Description	MBMAP Score Description
A	95	**Excellent** (profile shows excellent recovery since 2010 with continued accretion and growth)	**Extremely Accretive (+), Very Highly Accretive, Highly Accretive (-)** 10 ft/yr>=LRR>3ft/yr
B	85	**Very Good** (profile shows very good recovery since 2010 with growth and stability)	**Very Accretive (+), Accretive, Somewhat Accretive (-)** 3ft/yr>=LRR>1ft/yr
C	75	**Satisfactory but Cautionary** (profile shows some growth or stability, but may have one or two years of erosion since 2010)	**Slightly Accretive (+), Relatively Stable, or Slightly Erosive (-)** 1 ft/yr>=LRR>=-1 ft/yr
D	65	**Very Cautionary** (profile shows lots of signs of instability since 2010 , including numerous years of erosion or massive erosion for a short period of time)	**Somewhat Erosive (+), Erosive, Very Erosive (-)** -1 ft/yr>LRR>=-3ft/yr
F	55	**Fail** (profile shows no recovery since 2010, with extensive, continued erosion)	**Extremely Erosive (-), Very Highly Erosive, Highly Erosive (+)** -10 ft/yr>LRR>-3ft/yr
Note: scores can have a + or - which will add or subtract 3 points			
LRR = Linear Regression Shoreline Change Rate			

Table 2. Scoring method used for the SMBPP and MBMAP datasets.

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 satisfactory (yet potentially cautionary) stability or recovery, and a D and F to be an unsatisfactory outcome for the beach recovery, signifying an ongoing erosion or instability problem.

For MBMAP data, calculated linear regression rates (LRR, in feet per year) were completed at 10 meter transect intervals along each beach. The LRR calculation requires a minimum of three surveyed shoreline positions. Each beach surveyed as part of MBMAP will be reviewed in terms of the alongshore trends at each beach using the descriptive rankings below, and in terms of the overall mean value calculated for each beach (Table 2). These mean values are used to help establish a grading system based on MBMAP data. *It is important to note that using a mean calculation for an entire beach is not necessarily representative of the beach's stability along the entire beach*. For example, a beach that is eroding along one stretch and accreting along another may have a mean value that indicates little change (a stable beach) despite distinct shifts in shoreline change patterns. Thus, we will describe these shifts in shoreline change trends in each MBMAP section. For each "section" of beach (and for the entire beach), the mean shoreline change rate will be provided along with the standard deviation (symbolized by **σ**). Standard deviation describes the variation of data around the mean value, with a low standard deviation value indicating little variability from the mean value.

Crescent Beach, Kittery

Crescent Beach is not part of the SMBPP.

Crescent Beach MBMAP Score = **Somewhat Accretive (B-)**

Crescent Beach is a small pocket beach on the south side of a headland that separates Crescent from Seapoint Beach to the north. It consists of a narrow, cobble beach and dune, only a portion of which is vegetated. For this reason, only a small portion of the beach has been surveyed (Figure 7). Based on available data, the central portion of the beach (transects 1-13) was stable to accretive, while the remainder of the beach to the east was stable.

Overall, **Crescent Beach** was **somewhat accretive** with a mean shoreline change rate of **+1.2 ft/yr (σ =1.6)**.

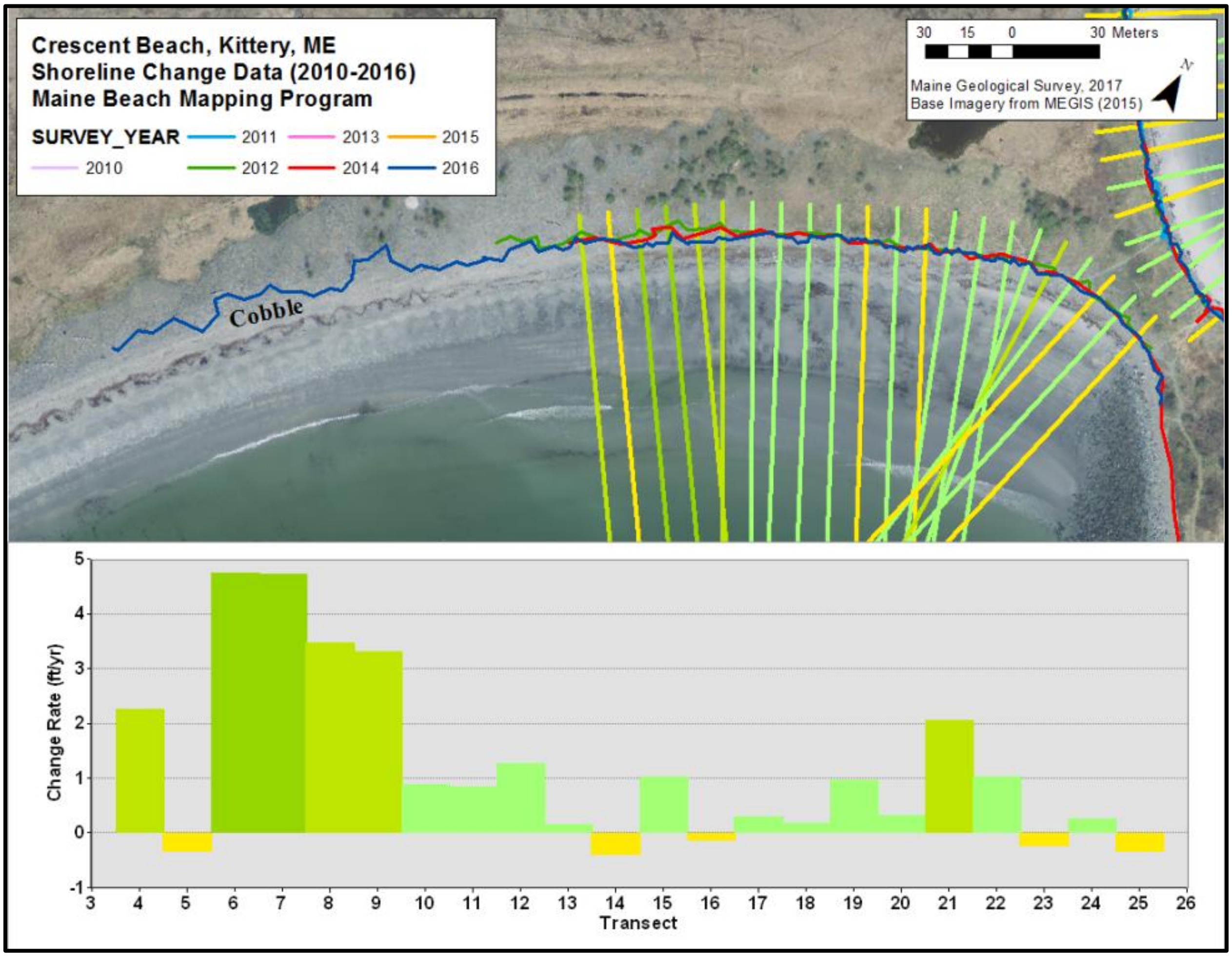

Figure 7. Shoreline change data (2010-2016) for Crescent Beach, Kittery, ME.

Seapoint Beach, Kittery

Seapoint Beach is not part of the SMBPP.

Seapoint Beach MBMAP Score = **Stable (C)**

Seapoint Beach is a small pocket beach on the northeast side of a headland that separates Seapoint from Crescent Beach to the south. It consists of a sandy beach with a small dune system, which is vegetated along its entirety (Figure 8). Based on available data, the majority of the beach was slightly erosive. There was a small pocket of dune growth just north of the access path (transects 63-73), otherwise the **beach was stable**, with a mean shoreline change rate of **-0.3 ft/yr (σ = 0.8 ft)**.

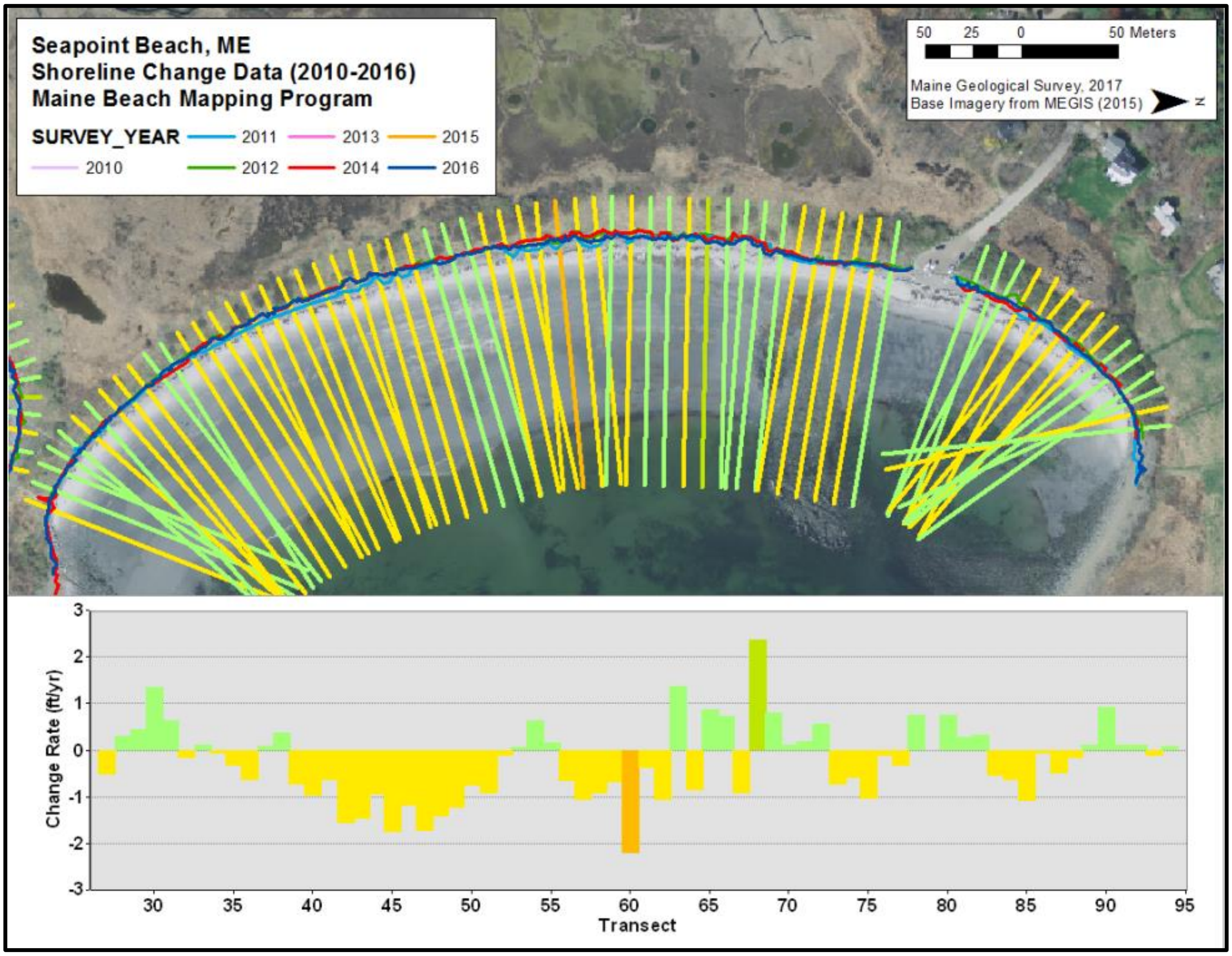

Figure 8. Shoreline change data (2010-2016) for Seapoint Beach, Kittery, ME.

Long Sands Beach, York

Profile LS01 is located in the northern half of the beach, while LS03 is located at a natural cobble dune and beach area south of the promintory (Figure 9). Figures 10 to 13 show winter and summer shapes for LS01 and LS03.

Figure 9. Location of beach profiles along Long Sands Beach, York, ME.

Winter LS01 = C- (72). The profile is mostly concave in winter. 2010 was the most erosive year. LS01 accreted in 2011 and 2012, with 2012 having the highest berm. By 2013, it eroded to the 2010 shape. It recovered in 2014 and in 2015 and reached near the 2012 shape, except for loss of the berm. In 2016, the profile eroded back to near 2010 and 2013 levels, and remained the same in 2017. LS01 had its best shapes in 2012 and 2015, and its worst in 2010, 2013, 2016, and 2017. The MHHW line moved approximately 20 meters landward since 2015.

Summer LS01 = C (75). The profile showed some berm development in summer. Similar to the winter profile, 2012was the highest, and had the best defined berm. 2013 saw the worst erosion, to below 2010 levels. 2014 showed recovery, but not to 2012 levels. In 2015, the profile lowered. In 2016, a berm developed and the profile remained stable. Overall, the profile showed positive recovery since a low in 2013but loss in comparison with the 2012 high. The profile had its best shape in 2012 and worst shape in 2013, and has been somewhat stable the past few years. In 2013, the MMHW line moved approximately 20 meters landward since 2012, but recovered in 2014, then eroded about 10 m in 2015. It was stable in 2016.

Winter LS03 = B- (82). The profile showed variable cobble berm formation in the winter months. 2010 showed a steep, erosive profile. LS03 grew in in 2012 seaward of 30 m. The berm eroded in 2013 and 2014 saw recovery but loss of sand on lower portions. 2015 showed gain at the dune but berm loss. 2016 showed dune growth, while 2017 showed relative profile stability. 2010 and 2013 were the worst years, and 2016 and 2017 the best years. The MMHW grew seaward slightly in the past few years.

Summer LS03 = B (85). Compared with winter, the summer profile is smoother with more consistent shape in the berm. The profile remained stable in 2011, 2012, and 2013. It grew seaward at the 20 m mark in 2014, and although this berm was lost in 2015, it returned in 2016. The MHHW moved seaward in 2014, and has been markedly stable. 2010 and 2013 were the worst years, and 2014 and 2016 the best years. LS03 maintained better shape than LS01, likely due to its location at a cobble area with a natural dune.

Overall Long Sands Beach Grade: B- (81). LS03 performed better than LS01; this may be due to the fact that LS03 is in a natural, cobble dune area. Cobble beaches tend to be more stable than sandy beaches. Also, LS03 is a bit more sheltered from nor'easters than LS01.

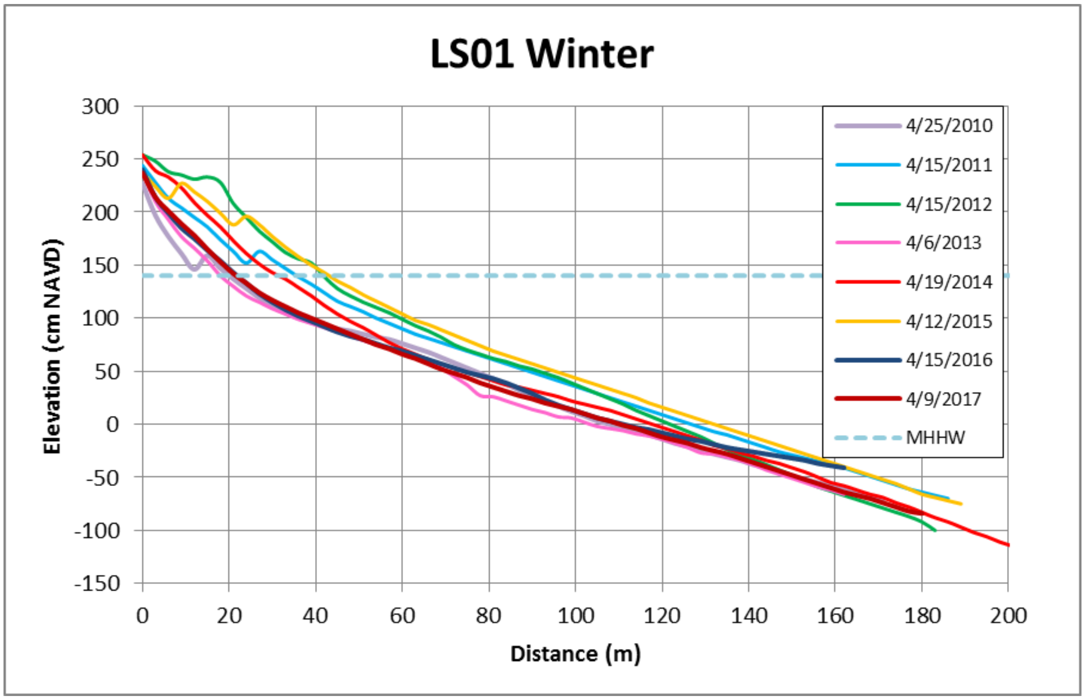

Figure 10. Winter beach profiles at LS01, Long Sands Beach, York, ME.

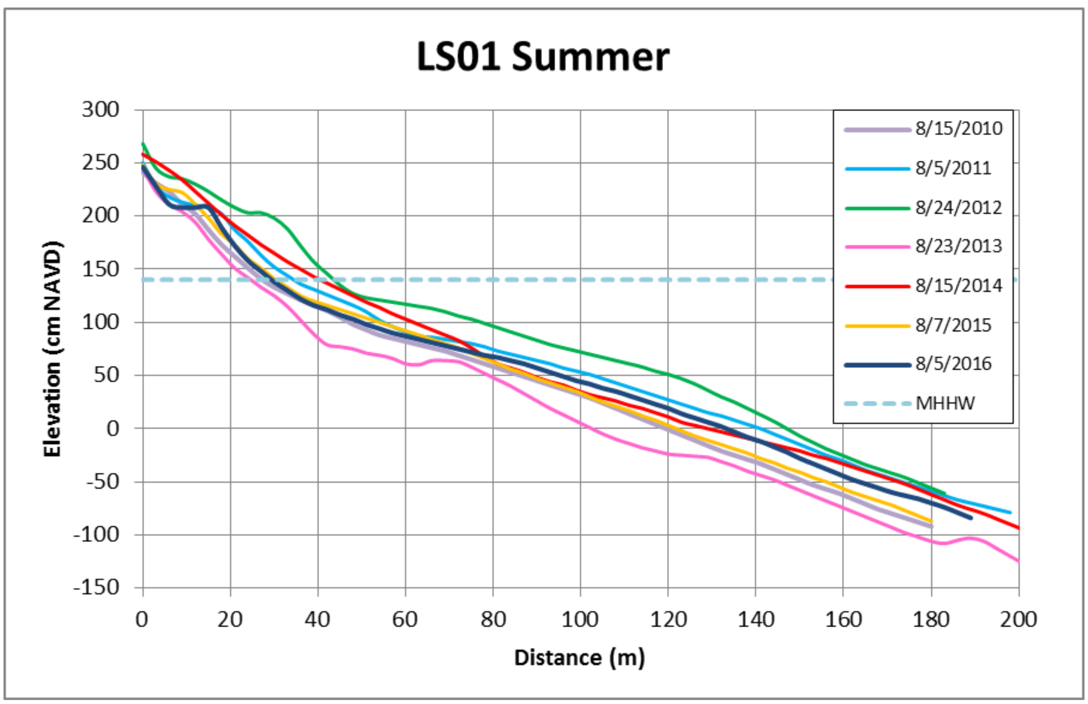

Figure 11. Summer beach profiles at LS01, Long Sands Beach, York, ME.

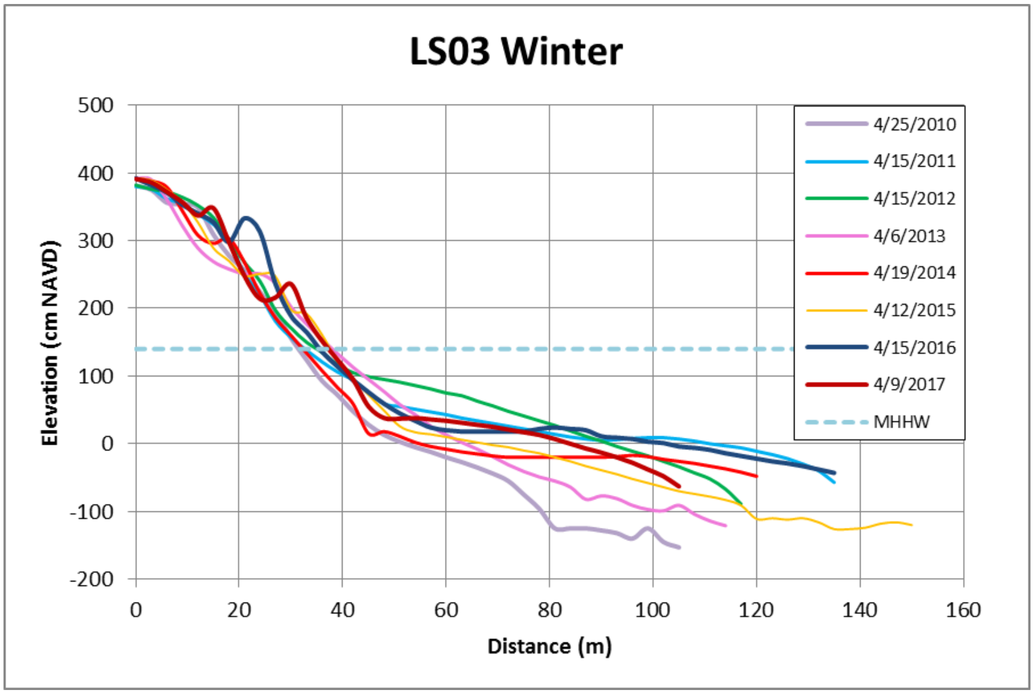

Figure 12. Winter beach profiles at LS03, Long Sands Beach, York, ME.

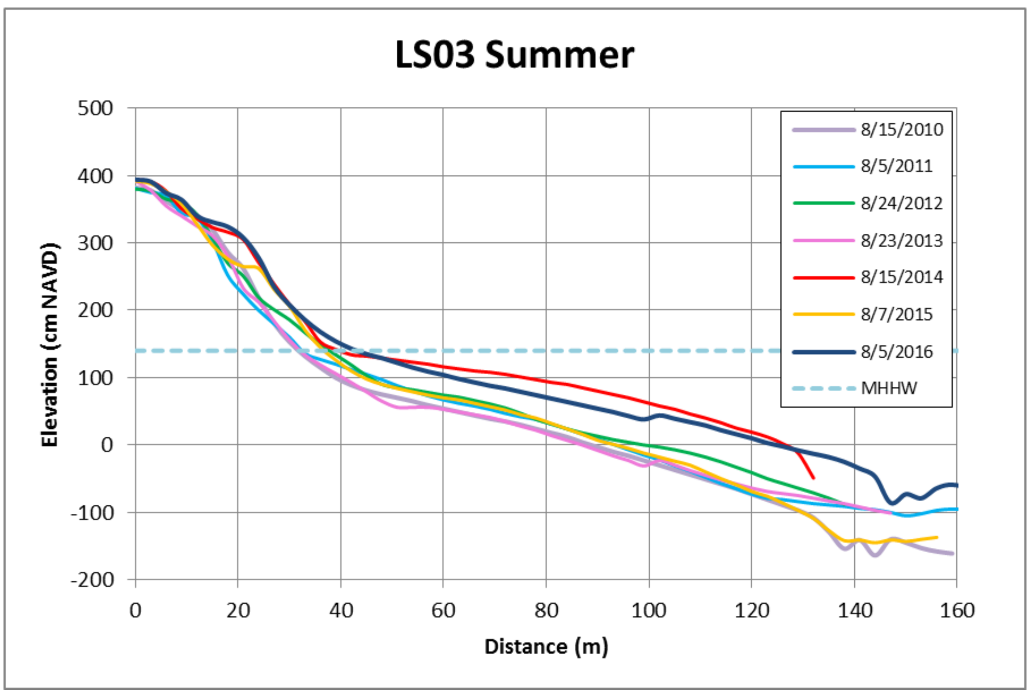

Figure 13. Summer beach profiles at LS03, Long Sands Beach, York, ME.

Long Sands Beach MBMAP Score = **Slightly Accretive (C+)**

Only an extremely small section of Long Sands Beach (where profile LS03 is located) is comprised of vegetated cobble dune; the rest of the beach is seawall with no dune whatsoever. Thus, MBMAP analysis only includes this small area (Figure 14).

The dune here was **slightly accretive,** with a mean shoreline change rate of **+1.0 ft/yr (σ = 0.8 ft)**. Some minor erosion is concentrated closest to the seawall to the north. The stability to slight growth along the dune is well reflected in the profile scores at LS03.

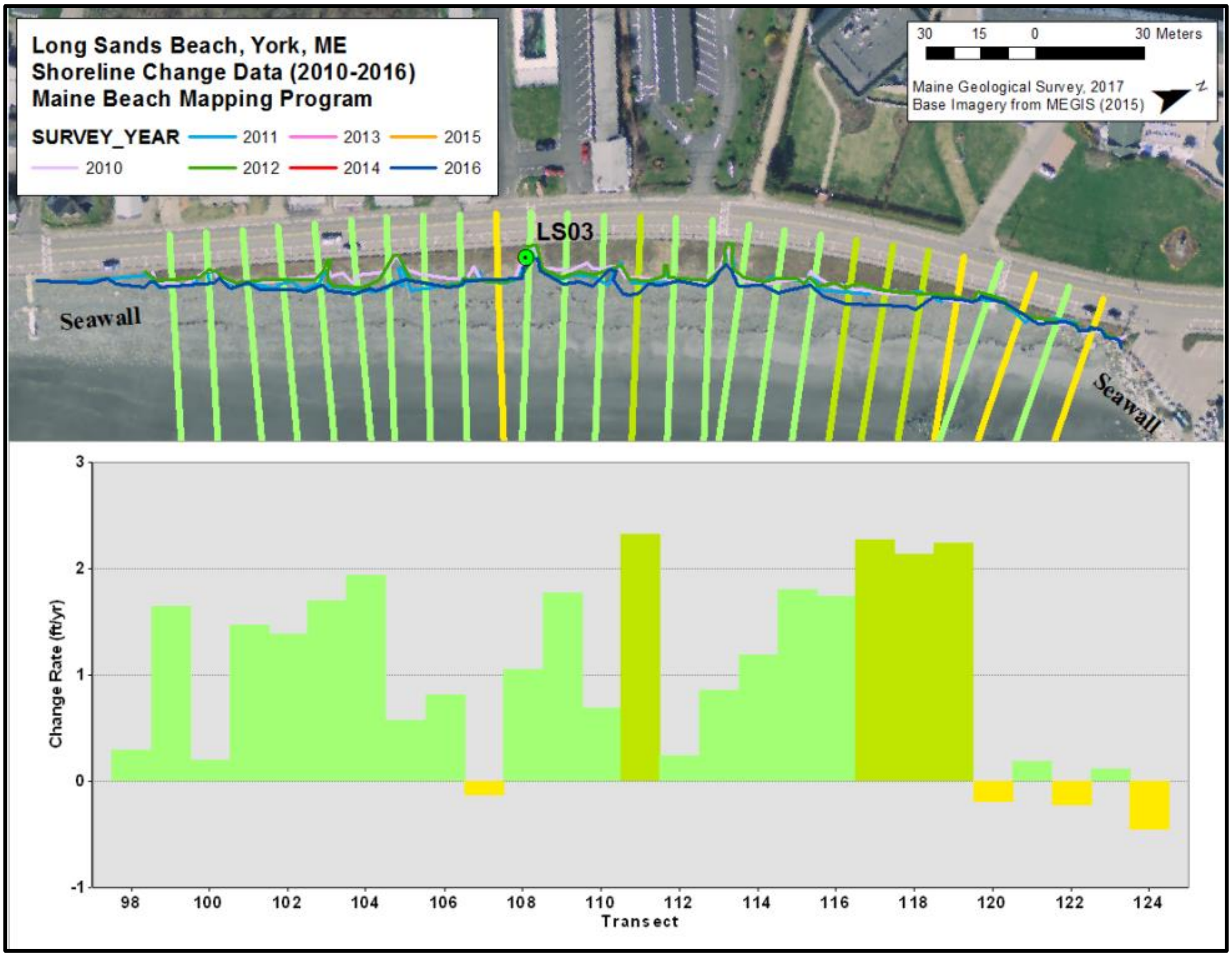

Figure 14. Shoreline change data (2010-2016) for Long Sands Beach, York, ME.

Ogunquit Beach, Ogunquit

Profiles OG02 and OG07 were available for analysis (Figure 15); OG02 is located near the treatment plant at the northern end of the beach, and OG07 is located at the seawall at the Norseman hotel. Figures 16 to 19 show seasonal changes at the profiles.

Figure 15. Location of beach profiles along Ogunquit Beach, Ogunquit, ME.

Winter OG02 = C+ (78). In 2010, the profile had a well-defined berm, but had the lowest elevations of all years. In 2011 and into 2012, the dune built higher, and OG02 accreted at the berm, and along the entire profile. In 2013, the berm was lost and the dune retreated landward, indicating erosion. In 2014, the dune lost elevation and the berm was eroded. In 2015, OG02 was stable at the dune and the berm and appeared relatively stable. It eroded in 2016, especially at the dune, but showed good recovery in 2017, regaining dune elevations to 2011 levels (but losing elevation in the profile seaward of the 80 m mark). The MHHW appeared to be relatively stable throughout. The worst year appeared to be 2013, and the best 2012 and 2017.

Summer OG02 = C+ (78). The summer profile showed better berm development than the winter. The berm seemed to be most prominent between elevations of 200-300 cm. From 2010 to 2011, OG02 was stable at the dune, gained slightly (but moved landward) at the berm, and gained sand offshore of 60 m. In 2012, the dune built farther seaward, and the berm built seaward at about 45 m. By 2013, the entire profile, including the dune and berm, gained in elevation, indicating accretion. However, by 2014, the dune had eroded substantially, and the berm flattened. In 2014, the entire beach eroded, but recovered well in 2015. The dune eroded in 2016. The MHHW moved seaward since 2010 and 2011, and has been in a relatively stable location.

Winter OG07 = B+ (88). Only winter data from 2015, 2016, and 2017 was available for comparison. Each year, the profile accreted at the wall, indicating the beach has been growing since 2015. The MHHW line stayed markedly stable.

Summer OG07 = C (75). Summer data included 2012, 2015 and 2016. 2012 and 2015 had relatively flat beach shapes, while 2016 had a berm. The profile was stable from 2015 to 2016. The MHHW receded slightly since 2012.

Overall Ogunquit Beach Grade: B- (81). Ogunquit beach profiles showed good stability to growth after dune losses in 2016 (for the winter profiles). OG07 performed slightly better than OG02.

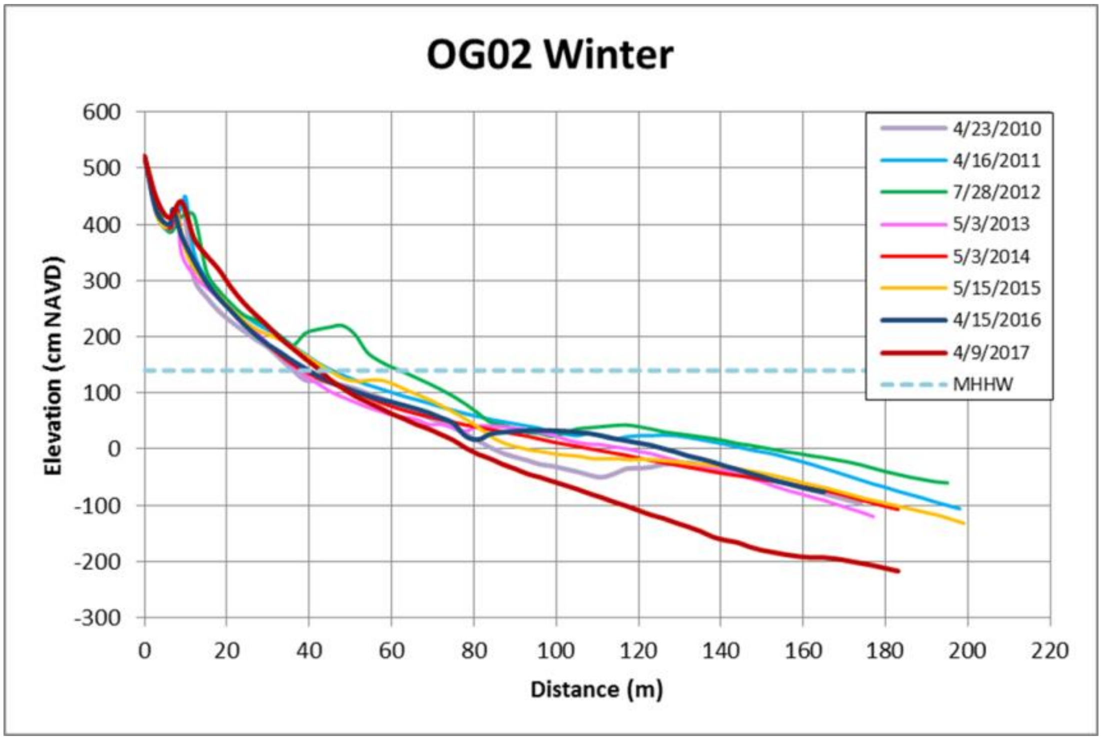

Figure 16. Winter beach profiles at OG02, Ogunquit Beach, Ogunquit, ME.

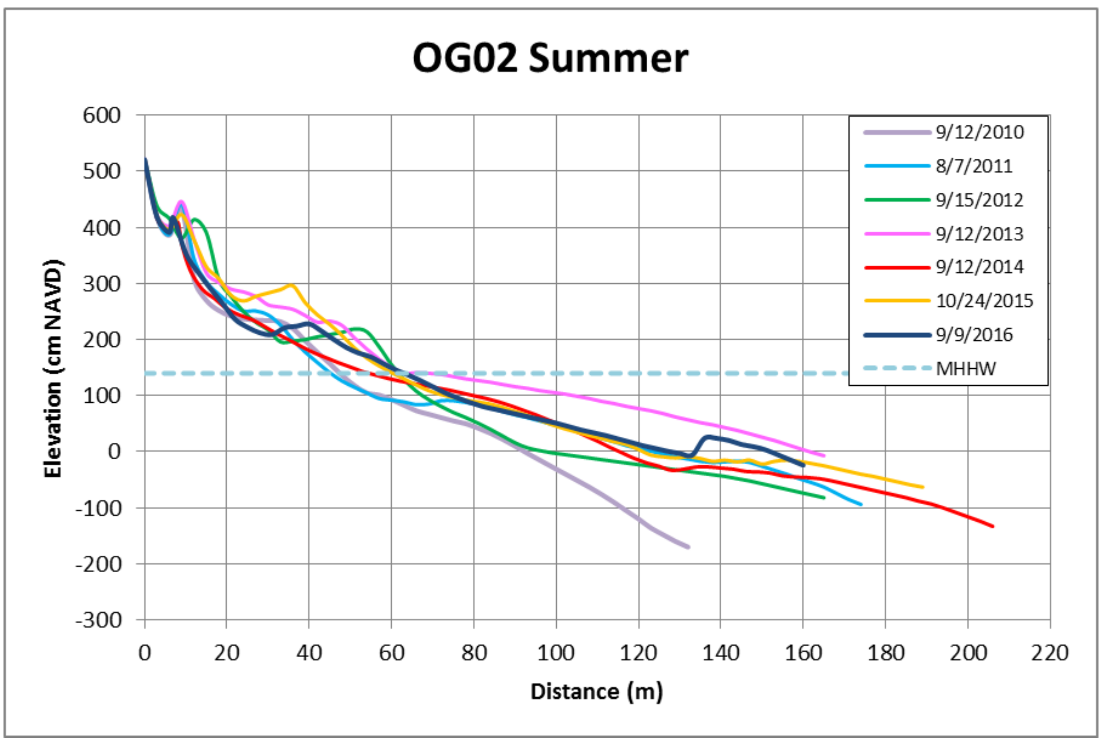

Figure 17. Summer beach profiles at OG02, Ogunquit Beach, Ogunquit, ME.

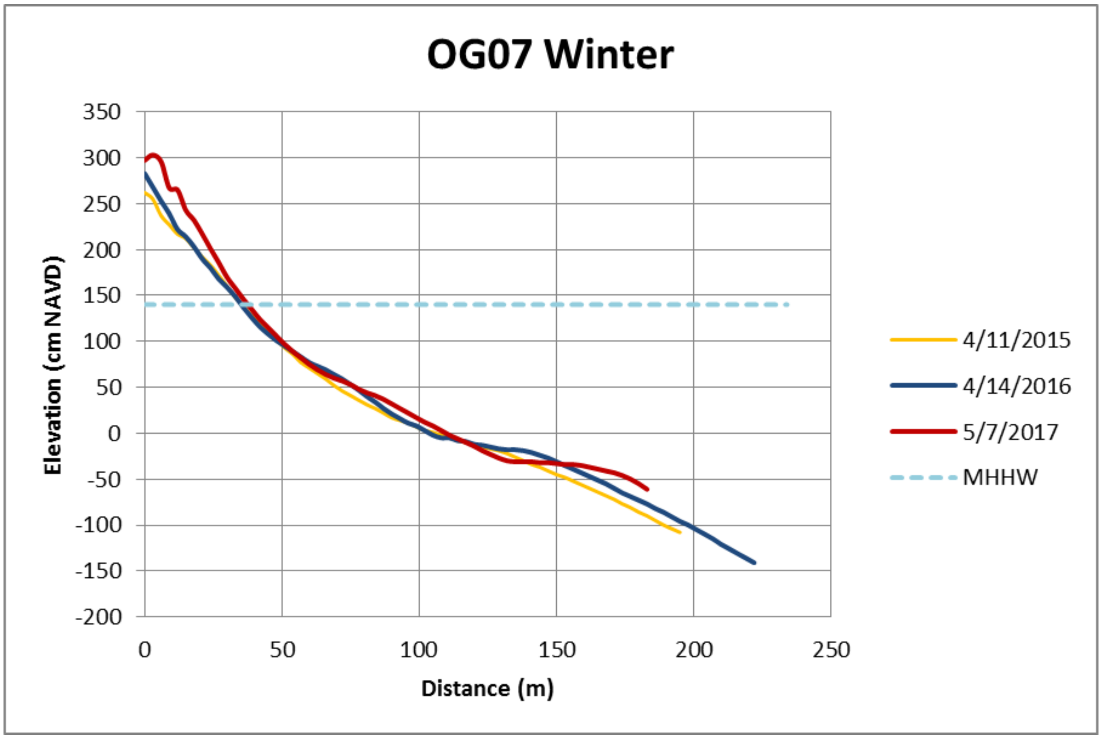

Figure 18. Winter beach profiles at OG07, Ogunquit Beach, Ogunquit, ME.

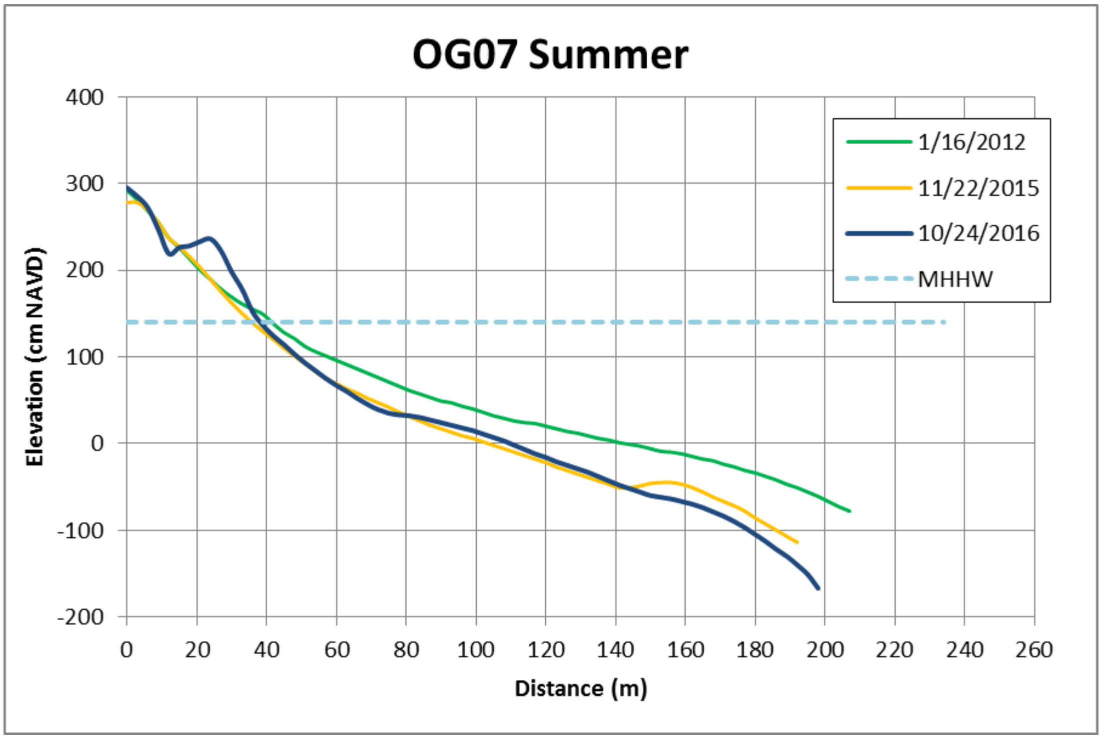

Figure 19. Summer beach profiles at OG07, Ogunquit Beach, Ogunquit, ME.

Ogunquit Beach MBMAP Score = **Slightly Accretive (C+)**
South = Stable (C)
Central = Highly accretive (A-)
North = Slightly accretive (C+)

Ogunquit Beach was broken into three distinct sections of beach based on shoreline change trends: south, central, and north (Figure 20).

Along the **south section** (transects 141-225) the dunes were **stable** with a mean shoreline change rate of **0.0 ft/yr (σ=0.7)**. This section has pockets of erosion and accretion. Profile OG07 is located in this section, adjacent to the Norseman Hotel.

The **central section** (transects 226-275) was **highly accretive** with a mean shoreline change rate of **+3.1 ft/yr (σ=1.4)** – this is the portion of the beach managed as a "natural area" by the Town.

The **north section** (transects 273-329) of the beach was **slightly accretive** with a mean shoreline change rate of **+0.5 ft/yr (σ=0.8)**. OG02 is located in this section.

Overall, **Ogunquit Beach** was **slightly accretive** with a mean shoreline change rate of **+0.9 ft/yr (σ=1.6)**. Note that this mean value is heavily influenced by the positive central portion of the beach.

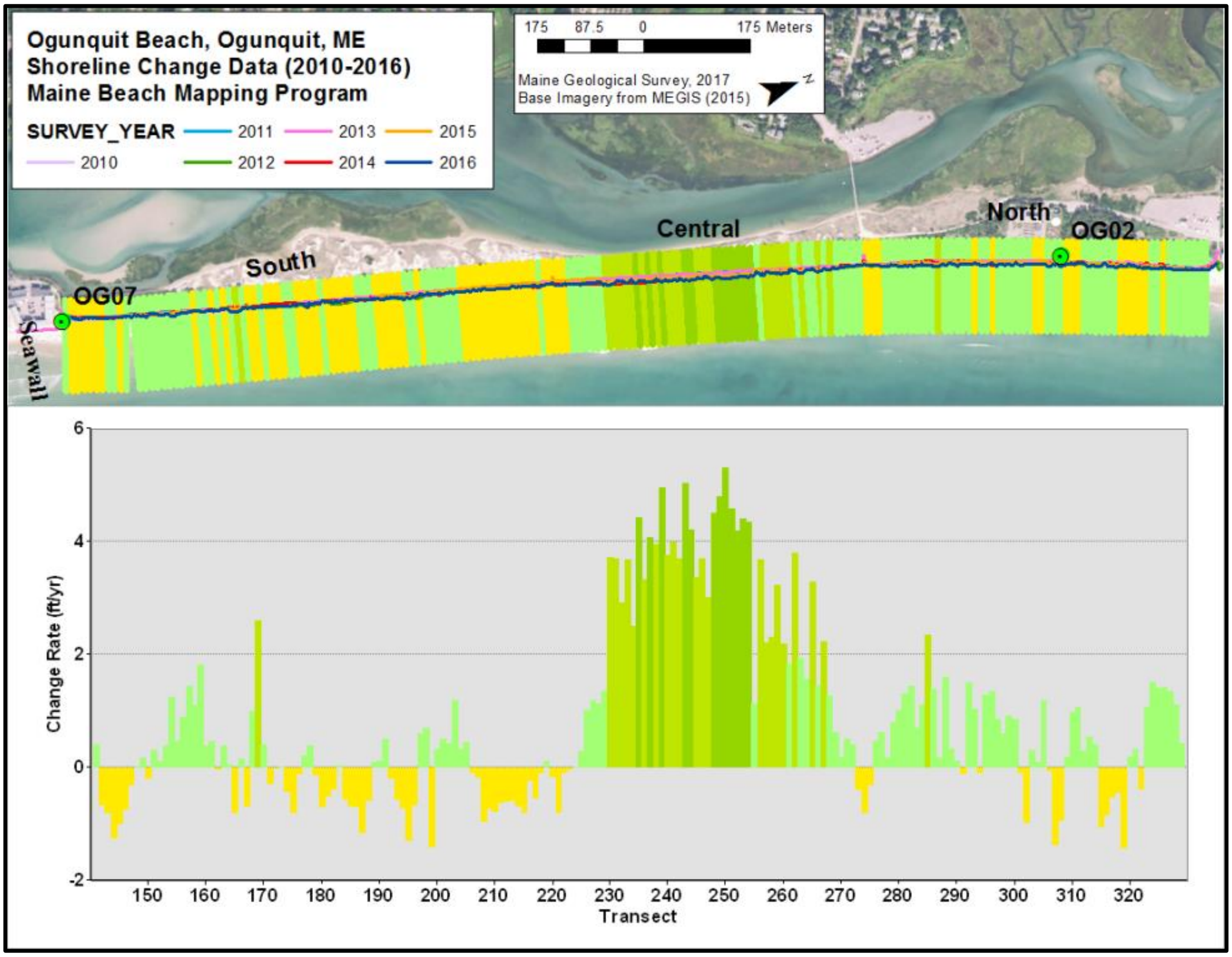

Figure 20. Shoreline change data (2010-2016) for Ogunquit Beach, Ogunquit, ME.

Wells Beach, Wells

Four profiles (WE00, WE02-WE04, Figure 21) were available for analysis. WE00 is just south of Casino Point; WE02 is just north of Casino Point; WE03 is just south of the Webhannet River; and WE04 is directly adjacent to the south jetty of the Webhannet River. Figures 22 to 29 document seasonal changes.

Figure 21. Location of beach profiles along Wells Beach, Wells, ME.

Winter WE00 = C (75). This profile, adjacent to a seawall, has sand levels that start consistently about 50 cm below the MHHW. The 2010 profile was steep with a flat beach that likely represented the historical geologic surface. It recovered well in 2011 and reached a peak shape in 2012, gaining about 100 cm in elevation over 2010. However, it eroded in 2013 to almost 2010 levels. It recovered well in 2014, almost to 2012 levels, but then eroded in 2015 and 2016. 2016 was the lowest profile shape – even below 2010 levels. It recovered slightly in winter 2017. 2016 was the most erosive and 2012 the best profile shape.

Summer WE00 = B- (82). In summer, the sand levels generally have stayed near the winter starting point, except for the last few summers. The 2010 profile had a defined berm, and convex shape. In 2011, it eroded and was more concave, with no berm. In 2012, it gained at its berm (out to about 30 m), but eroded below 2011 elevations. The berm grew slightly in 2013, but the profile steepened. In summer 2014, WE00 attained its most sediment rich shape. 2015 was similar in shape, with some sand building up against the wall. 2016 saw the most sand on the upper part of the profile (up to the MHHW). Summer 2016 was the best profile shape, indicating that although winter 2016 was its worst shape, it can recover by the next summer. The profile built over the last 2 summers.

Winter WE02 = D (65). Since 2010, WE02 has been eroding overall. In 2010, WE02 had a large well developed berm. In 2011, the berm disappeared, and WE02 lost elevation at the dune and berm but was similar to 2010 from 35 m seaward. In 2012, WE02 steepened out to about 40 m, and then flattened to near the 2010 shape. By 2013, it lost sand at the dune/wall edge, gained in the berm area (remained below 2010), and steepened dramatically at around 40 m indicating large amounts of scour. The 2014 profile returned to the 2012 shape. The 2015 profile steepened near the profile pin, yet maintained a similar shape to 2014. 2016 had a similar shape, yet in 2017, the profile eroded further. The MHHW has moved about 18 meters landward since 2010.

Summer WE02 = D (65). Sand elevations at the starting point do not increase much in summer. 2010 had a berm and steep slope to a deep trough near 70 m – this shape looked similar to the winter 2013 shape, likely eroded to the historical erosion surface. By 2011, it recovered along its end (seaward of 20 m), but lost berm elevation. In 2012, it gained elevation at the berm and offshore, but formed a deep trough near 30 m. By 2013, it lost elevation in the berm, and flattened dramatically. The 2014 shape was most erosive, with a steep profile below 2010 and 2013. In 2015, the profile recovered to its best shape. In 2016, it eroded, but stayed above 2014 levels. The profile has steepened over the years. The MHHW, though variable through the years, was stable between 2010 and 2016.

Winter WE03 = B- (82). From 2010 to 2013, the profile eroded – its most erosive shape was in 2013. No data was available in winter 2014. Since then, it has grown seaward consistently in 2015, 2016, to its best shape in 2017, with a well-developed dune. Aside from 2013 (the most erosive year), the MHHW line has been stable.

Summer WE03 = C+ (78). The summer shape of WE03 has been quite variable due to the influence of swash bars. 2011 was the most eroded profile, with recovery in 2012. Although there is bar variability, the profile has been stable to slightly growing, with 2016 having the best dune shape. Since 2010, the MHHW moved landward, but the profile gained elevation above the MHHW.

Winter WE04 = C+ (78). November 2010 had a high, well defined frontal dune that sloped to a small berm near 10 m, with a gradual slope offshore. In 2011, the frontal dune lowered, the berm disappeared, and the profile steepened. 2012 showed recovery, with the dune maintaining its position, a return of the berm, and the highest elevations along the profile. Winter 2013 showed significant dune loss and landward movement, in addition to profile steepening, and berm loss. There was no data from 2014. In 2015, the dune built slightly seaward, and the profile achieved some of its highest elevations seaward of 50 m. 2016 showed dune growth, while 2017 showed slight dune erosion and landward movement. The MHHW has been markedly stable, aside from erosion in 2011 and 2013.

Summer WE04 = C (75). The summer profile showed clear berm development. The November 2010 profile showed a well-defined dune ridge, small berm, and gradual slope offshore. In 2011, the dune moved slightly landward. This trend continued into 2012, with dune landward movement (but growth), and a well-defined berm and sand rich nearshore. 2013 had the most erosive profile, with loss of the dune and a deep trough at about 40 m offshore. The 2014 profile showed some recovery, and this continued into 2015, which was one of the best profile shapes, with lots of sand above the MHHW and a well-defined berm. 2016 had dune growth, but loss along the profile, especially at the berm. The MHHW position was highly variable over the years, but since 2010, has eroded slightly.

Overall Wells Beach Grade = C (75). Profiles along Wells Beach were generally stable to slightly accretive since 2010. The worst scoring profile was WE02

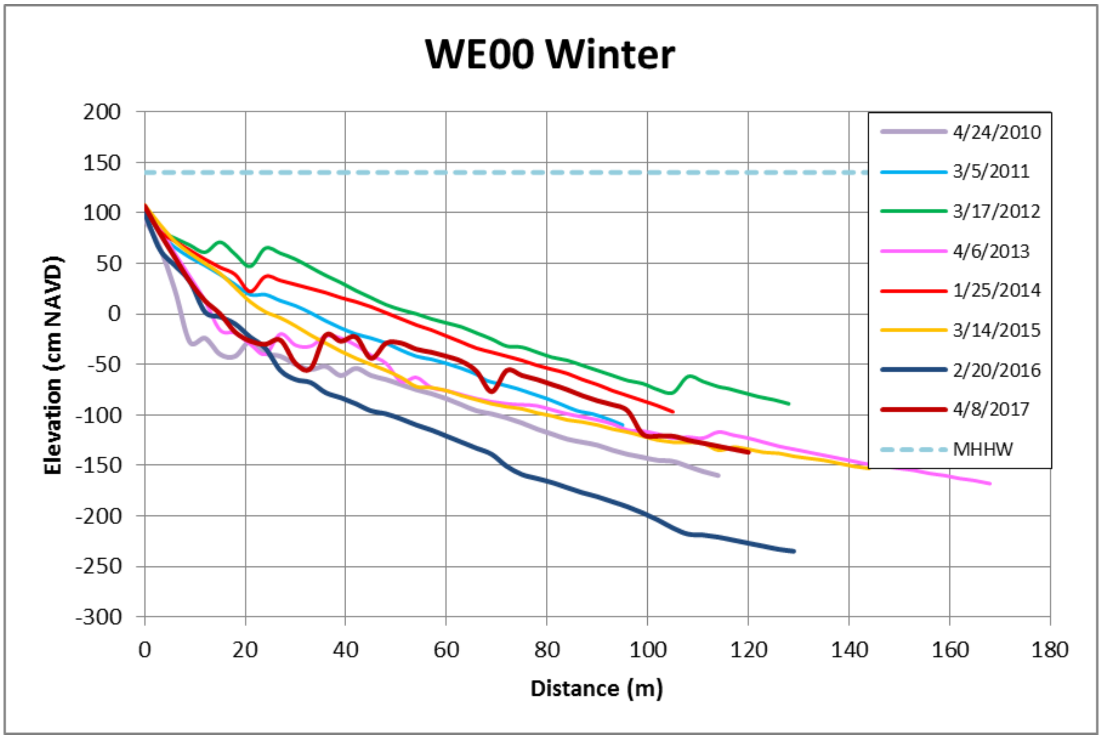

Figure 22. Winter beach profiles at WE00, Wells Beach, Wells, ME.

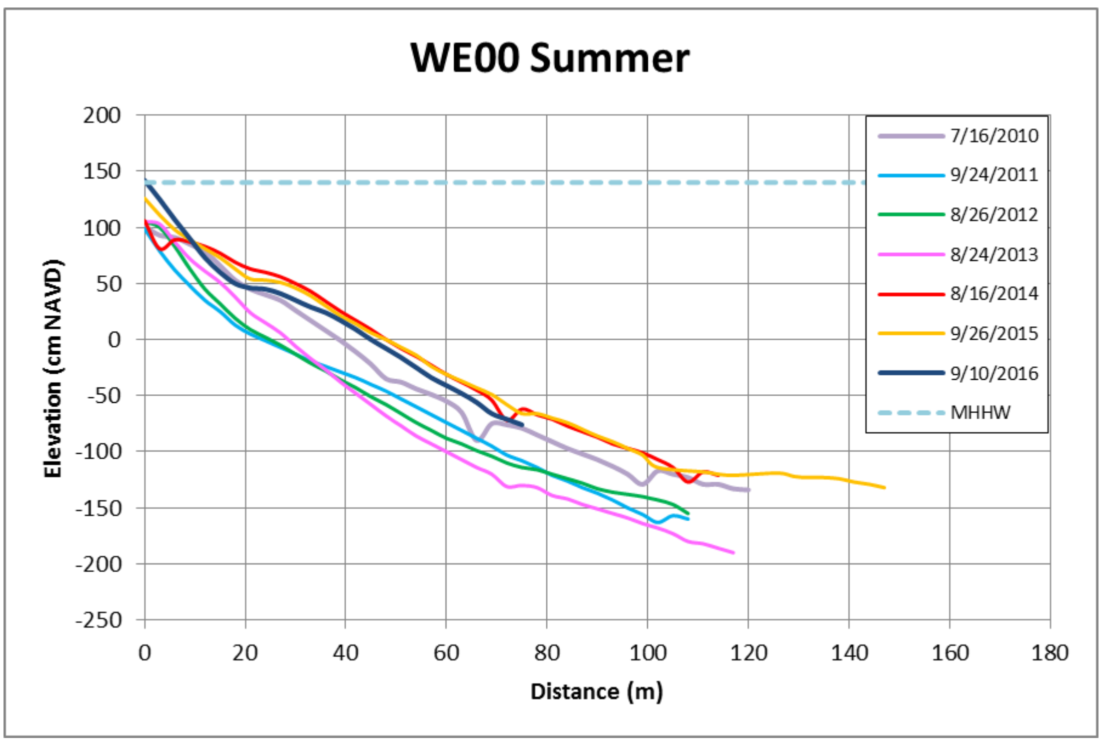

Figure 23. Summer beach profiles at WE00, Wells Beach, Wells, ME.

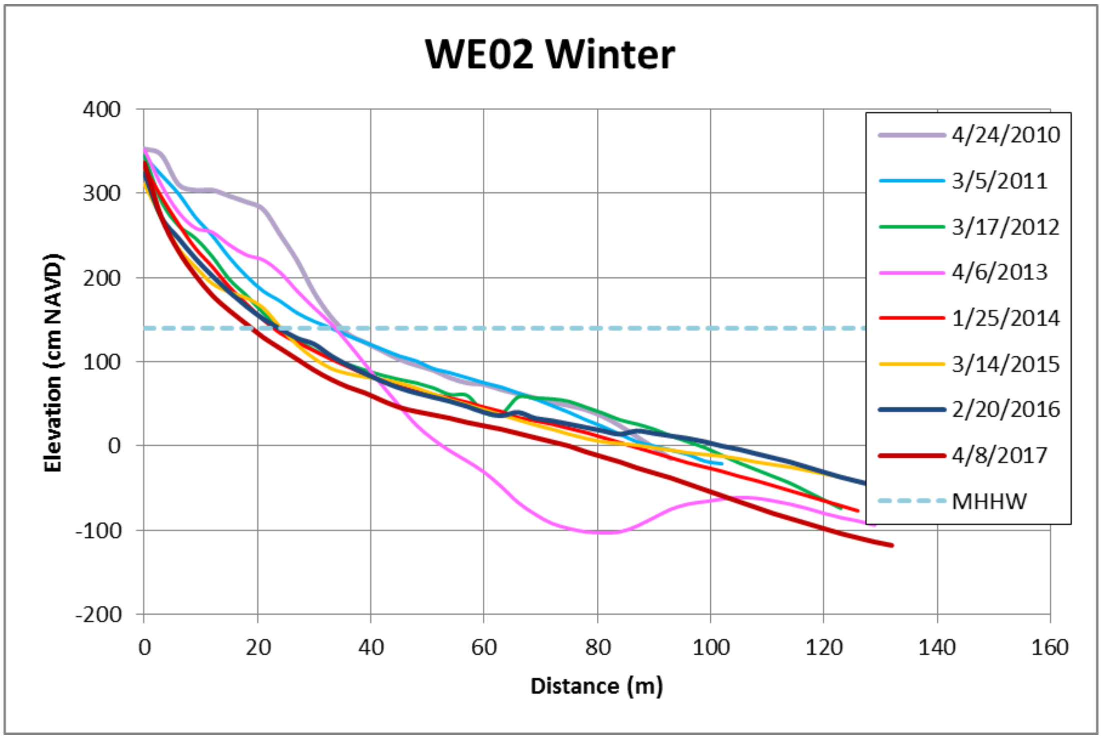

Figure 24. Winter beach profiles at WE02, Wells Beach, Wells, ME.

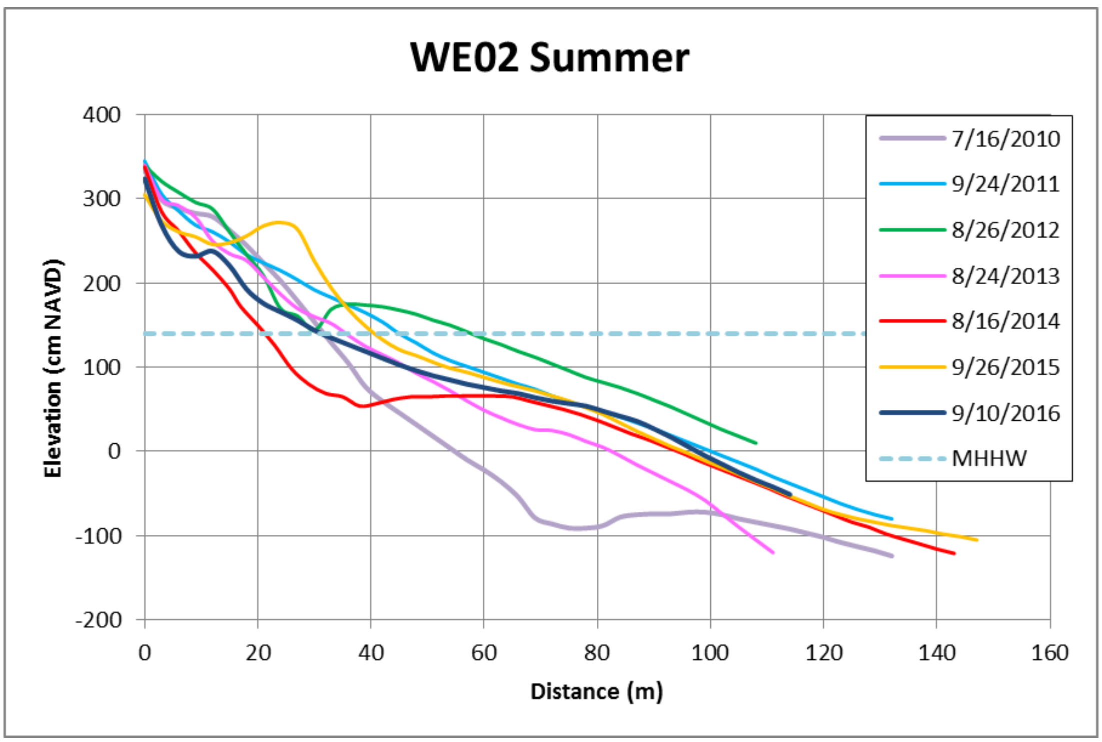

Figure 25. Summer beach profiles at WE02, Wells Beach, Wells, ME.

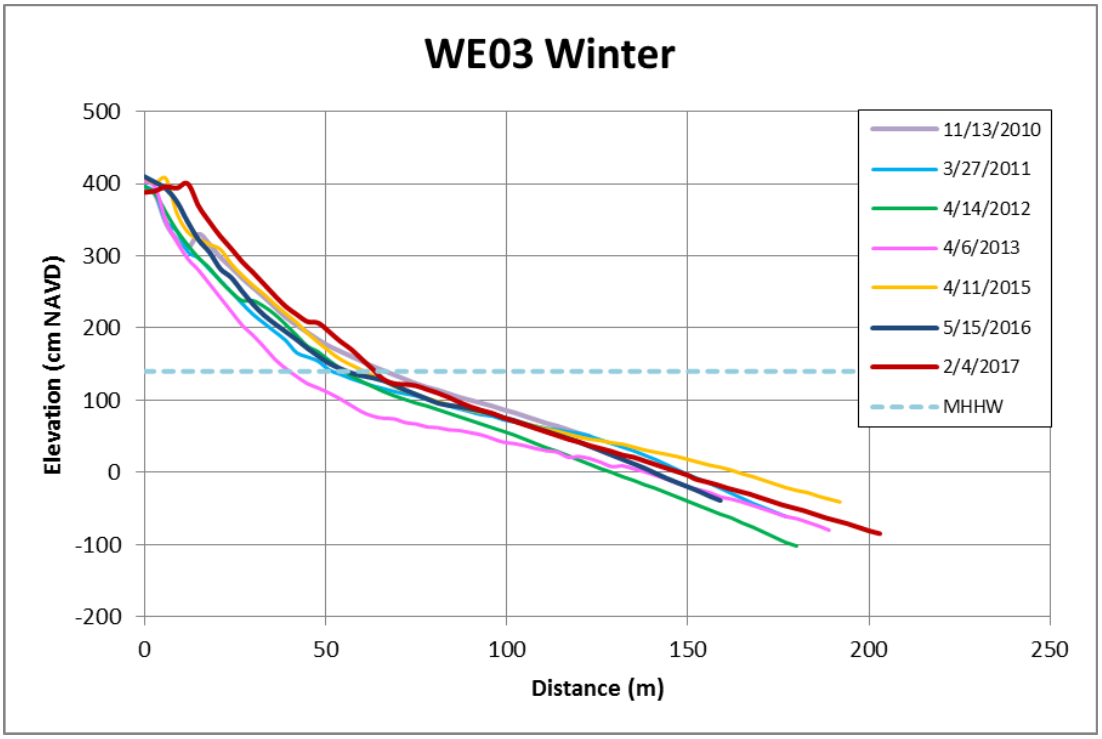

Figure 26. Winter beach profiles at WE03, Wells Beach, Wells, ME.

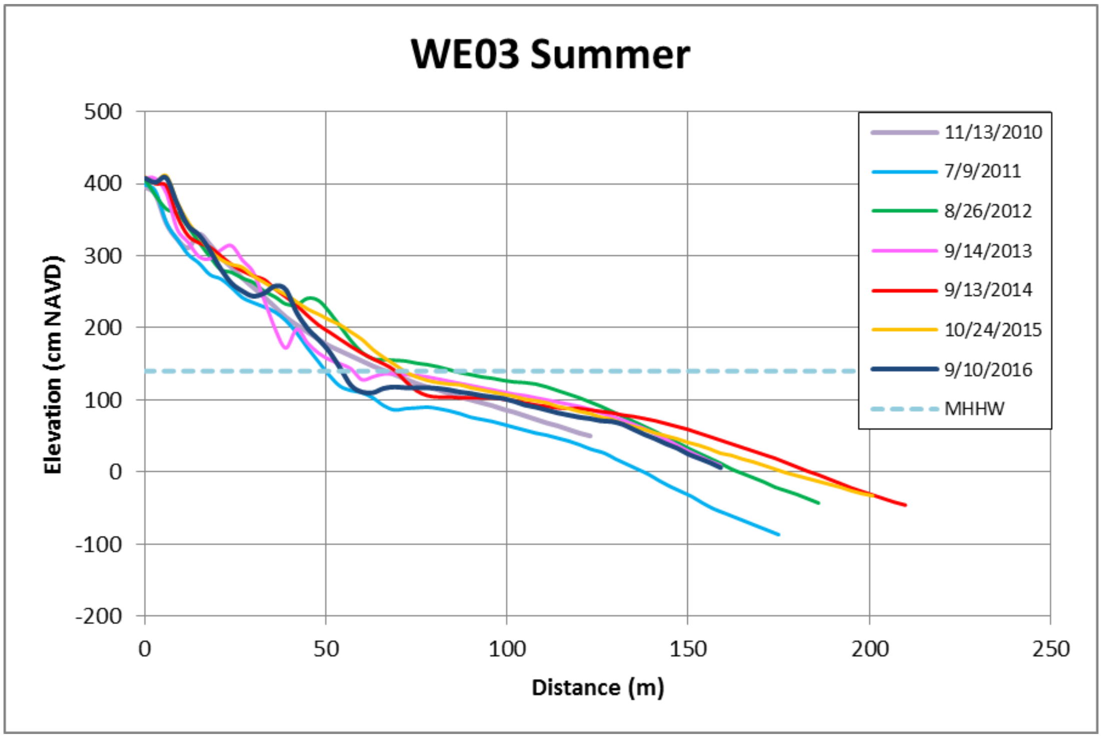

Figure 27. Summer beach profiles at WE03, Wells Beach, Wells, ME.

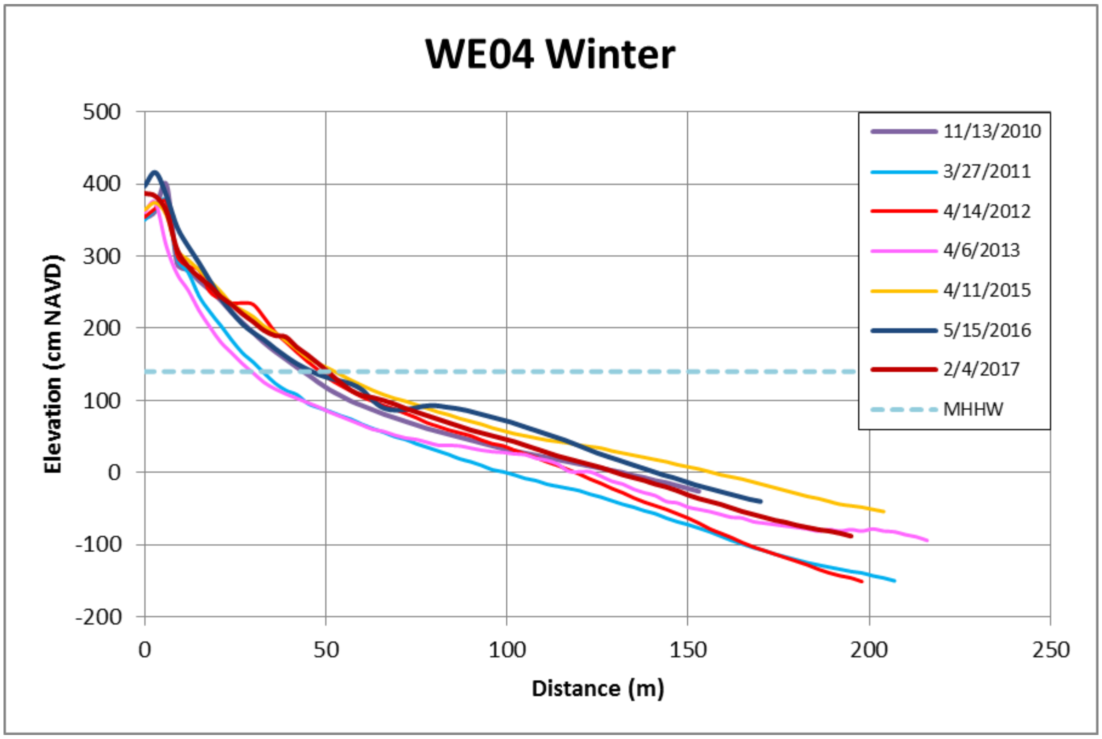

Figure 28. Winter beach profiles at WE04, Wells Beach, Wells, ME.

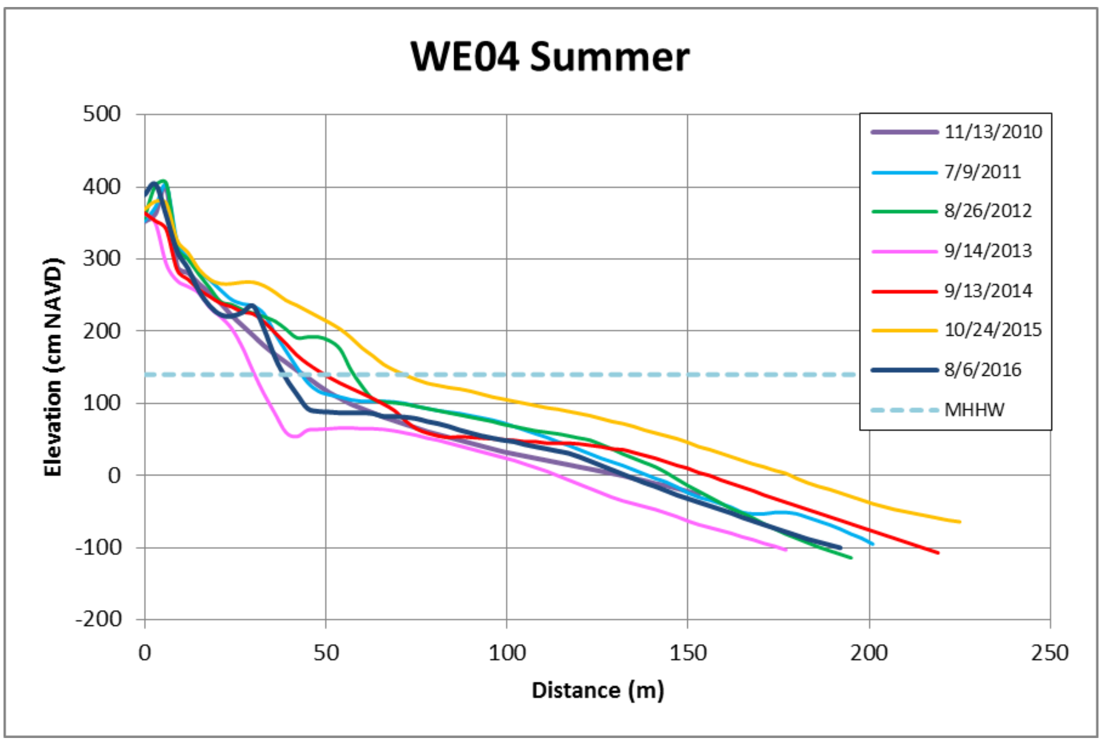

Figure 29. Summer beach profiles at WE04, Wells Beach, Wells, ME.

Wells Beach MBMAP Score = **Slightly accretive (C+)**
South = Slightly accretive (C+)
Central = Stable (C)
North = Somewhat accretive (B-)

Wells Beach was divided into three distinct sections: south, central, and north (Figure 30).

The **south section** (transects 330-425) was **slightly accretive** with a mean shoreline change rate of **+0.7 ft/yr (σ=2.4)**.

The **central section** (transects 446-466) was **stable**, with a mean shoreline change rate of **+0.5 ft/yr (σ=3.8)**, with several pockets of erosion.

The **north section** (transects 467-489) was **somewhat accretive** with a mean shoreline change rate of **+1.2 ft/yr (σ=1.8)**. The dune in this northern section, nearest the jetty, grew the most.

Overall, **Wells Beach** was **slightly accretive** with a mean shoreline change rate of **+0.7 ft/yr (σ=2.4)**.

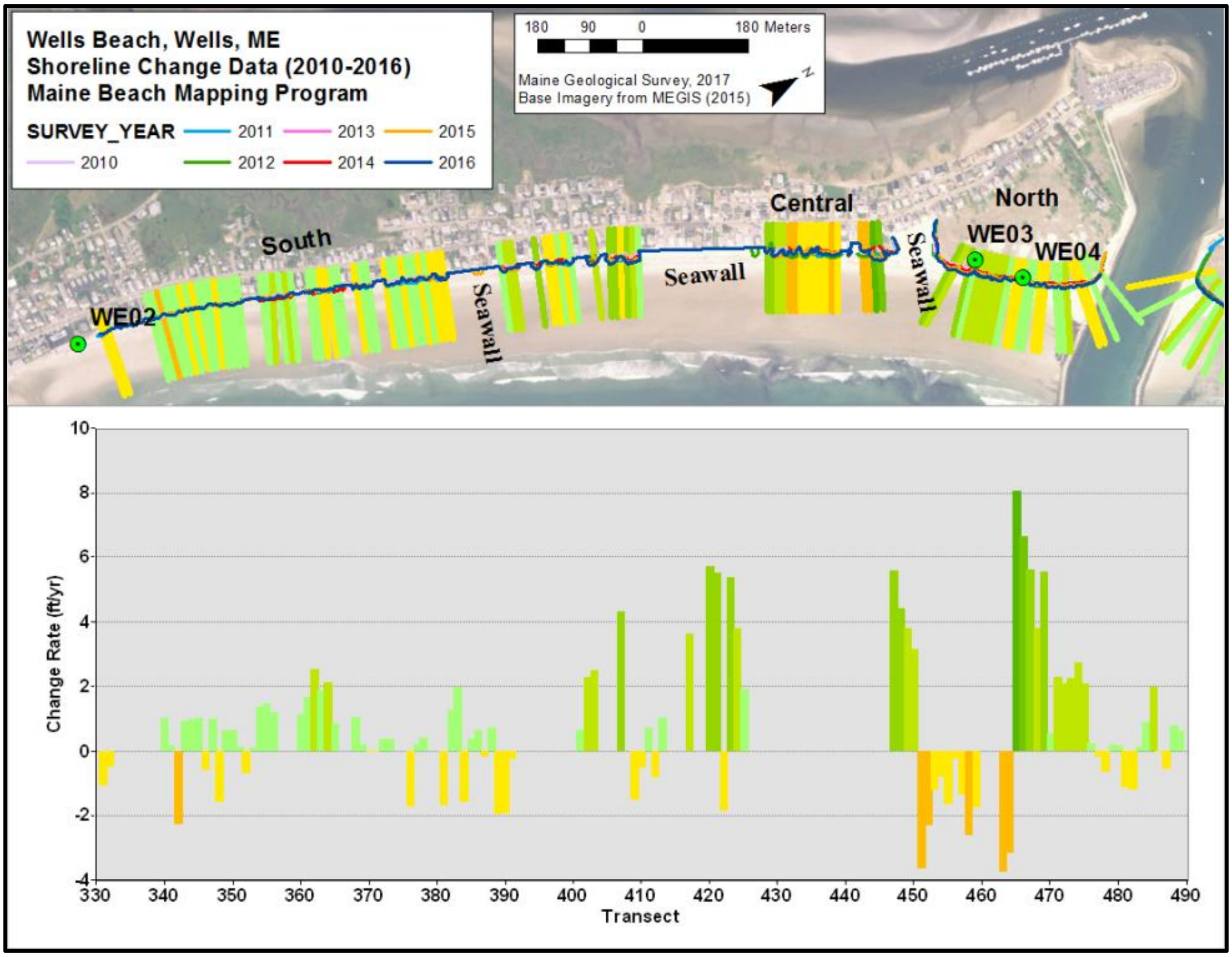

Figure 30. Shoreline change data (2010-2016) for Wells Beach, Wells, ME.

Drakes Island Beach, Wells

Drakes Island Beach is not part of the SMBPP.

Drakes Island Beach MBMAP Score = **Slightly accretive (C+)**
South = Somewhat accretive (B-)
Central = Slightly erosive (C-)
North = Somewhat accretive (B-)

Drakes Island Beach is just north of the Webhannet River, between Wells and Laudholm Beach. The beach was divided into three different sections based on shoreline change trends: south, central, and north (Figure 31).

The **south section** (transects 490-499) nearest the jetty, was **somewhat accretive** with a mean shoreline change rate of **+1.2 ft/yr (σ=0.8)**.

The **central section** (transects 500-514) was **slightly erosive** with a mean shoreline change rate of **-0.7 ft/yr (σ=0.6)**.

The **north section** (transects 515-528) was **somewhat accretive** with a mean shoreline change rate of +1.5 ft/yr **(σ=0.9)**.

Overall, **Drakes Island Beach** was **slightly accretive** with a mean shoreline change rate of **+0.6 ft/yr (σ=1.3)**.

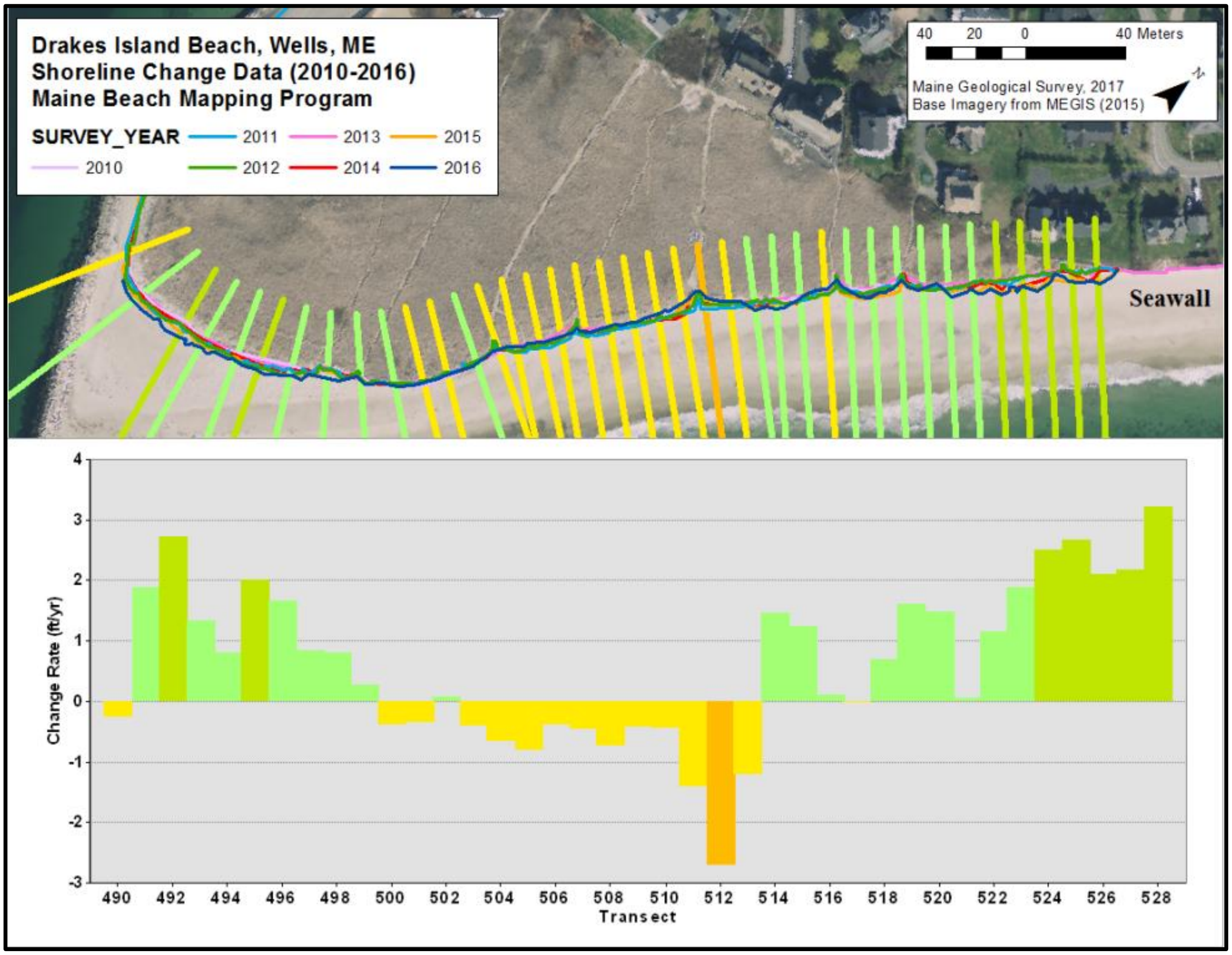

Figure 31. Shoreline change data (2010-2016) for Drakes Island Beach, Wells, ME.

Laudholm Beach, Wells

No SMBPP profiles are currently monitored at Laudholm Beach.

Laudholm Beach MBMAP Score = **Very erosive (D-)**
Beach = Stable to slightly erosive (C-)
Spit = Highly erosive (F+)

The Laudholm Beach shoreline was divided into two different sections based on shoreline change trends: beach and spit (Figure 32).

The **beach** section (transects 529-551) was **stable to slightly erosive** with a mean shoreline change rate of **-0.3 ft/yr (σ=0.8)**.

Along the **spit** section of the shoreline (transects 552-592), the shoreline became **highly erosive** with a mean shoreline change rate of **-3.9 ft/yr (σ=2.5)**. Some of the worst erosion was nearest the river (up to -10 ft/yr).

Overall, the dunes along **Laudholm Beach** was **very erosive** with a mean shoreline change rate of **-2.6 ft/yr (σ=2.7)**.

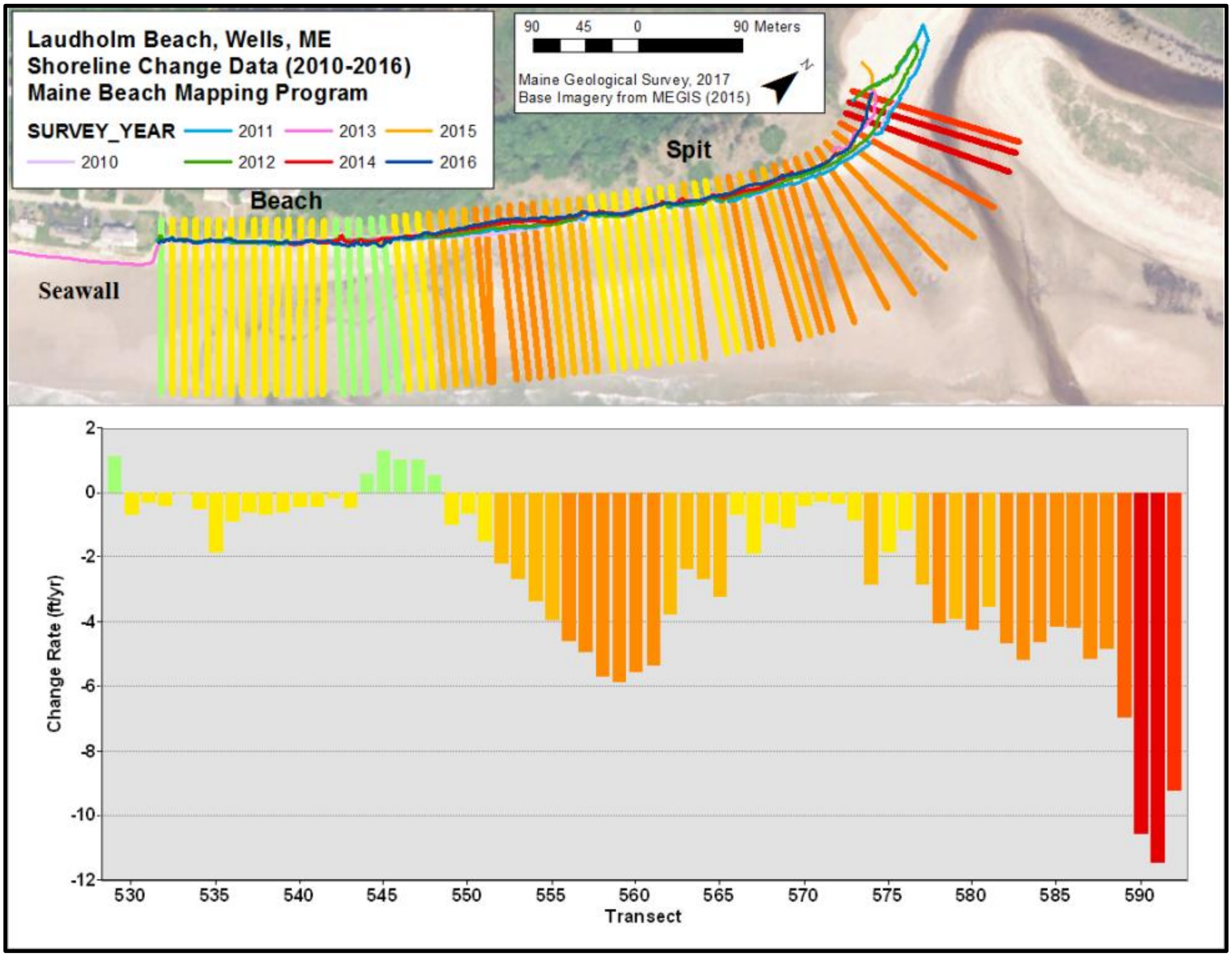

Figure 32. Shoreline change data (2010-2016) for Laudholm Beach, Wells, ME.

Goochs Beach, Kennebunk

Four profiles (GO01 to GO04, Figure 33) were available for analysis. All are located in the seawall at the beach. GO01 is at the western end of the beach, while GO02 is centrally located. GO03 is the easternmost profile, and GO04 is located at the southeastern end of Middle Beach. Figures 34-41 show seasonal changes.

Figure 33. Location of beach profiles along Goochs Beach, Kennebunk, ME.

Winter GO01 = D (65). The profile is in a seawall, just above the MHHW. The profile eroded slightly from 2010 to 2012, and then severely eroded in 2013 – this was the most erosive profile in the nearshore. By 2014, the profile lowered more at the wall but recovered well seaward of 10 m. In 2015, a small berm appeared at the wall (likely due to freezing of the beach), but the profile lowered and steepened back to 2010 elevations. In 2016, the sand at the wall lowered slightly, and in 2017, the profile flattened dramatically, losing almost a meter in elevation at the wall, well below the MHHW. This was the worst profile in terms of the elevation of sand against the wall. The profile eroded since 2010.

Summer GO01 = C (75). Generally, summer profiles are flatter, with more sand along the profile than winter. 2010 had a slightly convex shape. By 2011, GO01 gained elevation at the berm. By 2012, it gained sand within about 40 m of the wall. In 2013, GO01 dramatically eroded by about 50 cm. In 2014, it recovered well, with a starting point near 2010, an evident berm, and the highest sand elevations along the profile seaward of 20 m. 2015 and 2016 had very similar shapes, indicating stability. 2013 was the most erosive year.

Winter GO02 = D- (62). In 2010, GO02 was steep and concave, flattening out at 20 m. In 2011, it lowered at the wall, but gained elsewhere. In 2012, the sand at the wall dropped, but the berm grew. In 2013, it gained sand at the wall out to 25 m, but lost elevation seaward by about 1 m below 2010 elevations, likely exposing peat surfaces. In 2014, sand increased at the wall, and GO02 gained sand back to near 2011 levels. In 2015, GO02 lowered near the wall to 2011 levels, but gained a large volume of sand at 20 m seaward, raising the beach by 50 to 75 cm. It lost significant elevation against the wall and in the nearshore in 2016, and 2017 was the worst profile in terms of elevation at the wall, losing about 50 cm. The MHHW eroded about 8 meters between 2010 and 2017.

Summer GO02 = D (65). In 2010, GO02 had a starting elevation of 300 cm and a steep slope that flattened at 20 m. By 2011, it lost 50 cm at its starting point, and eroded along its entire length. In 2012, it flattened more.

Seaward of 30 m, it had the same shape as 2010. In 2013, it eroded deeper to a historic erosion surface, but gained elevation at the wall to its highest level. In 2014, it lost elevation at the wall (back to 2011), but gained slightly offshore. In 2015, it was stable at the wall, but lost elevation offshore. In 2016, it lowered at the wall but remained somewhat stable offshore. For this profile, 10 m is an inflection point where sand is exchanged from the berm to the beach. Since 2010, the profile lost sand at the wall, and the MHHW moved slightly landward.

Winter GO03 = C (75). Winter profiles at GO03 show little overall changes, and are relatively steep and featureless. The greatest variability is in the starting sand elevation at the wall. In 2010, this was highest, with loss in 2011. In 2012, the profile had the highest berm at 30-40 m. In 2013, it gained slightly at the wall, but deepened seaward of 40 m. In 2014, it gained slightly at the wall, but lowered again in 2015. 2016 was the most erosive profile, with loss of sand at the wall and in the nearshore. There was some recovery in 2017, but not at the starting elevation. In general, GO03 is relatively stable and shows little overall vertical movement. The MHHW between 2010 and 2017 eroded slightly landward.

Summer GO03 = C (75). The summer GO03 profile does not change much, and is markedly stable, with only slight berm changes from year-to-year. The profile underwent little changes from 2010 to 2013. The 2014 profile was the highest – potentially a result of nearshore dredged material placement in March 2014. The profile lowered slightly in 2015 and 2016, but remained relatively stable.

Winter GO04 = C- (72). GO04 was flat, with a slight berm around 18 m in 2010. In 2011, it gained at the wall, and formed a well-defined berm at 10 m. The berm moved up the profile in 2012, but lost around 50 cm of elevation at the seawall and slightly steepened offshore. The berm maintained its position in 2013, but lost elevation at the wall. 2014 saw significant growth adjacent to the wall and at the berm. In 2015, the berm lowered. This continued in 2016, and in 2017, the profile flattened, with no berm at all. The MHHW line moved about 3 meters inland from 2010 to 2017. The profile clearly eroded in 2017.

Summer GO04 = C (75). 2010 had a starting point of -35 cm, and a well-defined berm. In 2011, it lost sand at the wall, and the berm migrated landward. By 2012, the profile's starting point moved back up to 2010 levels, but a trough feature formed landward of the berm (at the 4 m mark). 2013 and 2014 saw berm growth, with a high in 2014. This eroded in 2015, and recovered to a near "average" shape in summer 2016. The profile has been relatively stable since 2010, especially seaward of the 8 m mark; most of the variability is in the summer berm.

Overall Goochs Beach Grade = C- (71). Goochs beach profiles underwent erosion, especially in 2016 and 2017. It seems that GO01 and GO02 performed worse than GO03 and GO04. GO03 may have been positively influenced by nourishment

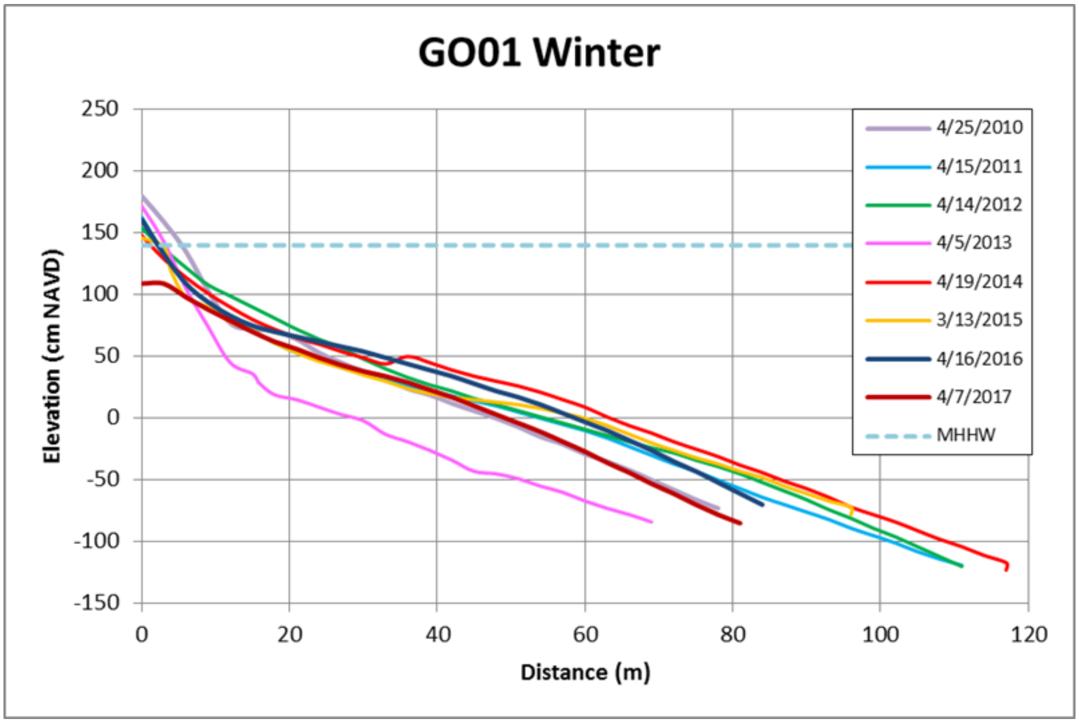

Figure 34. Winter beach profiles at GO01, Goochs Beach, Kennebunk, ME.

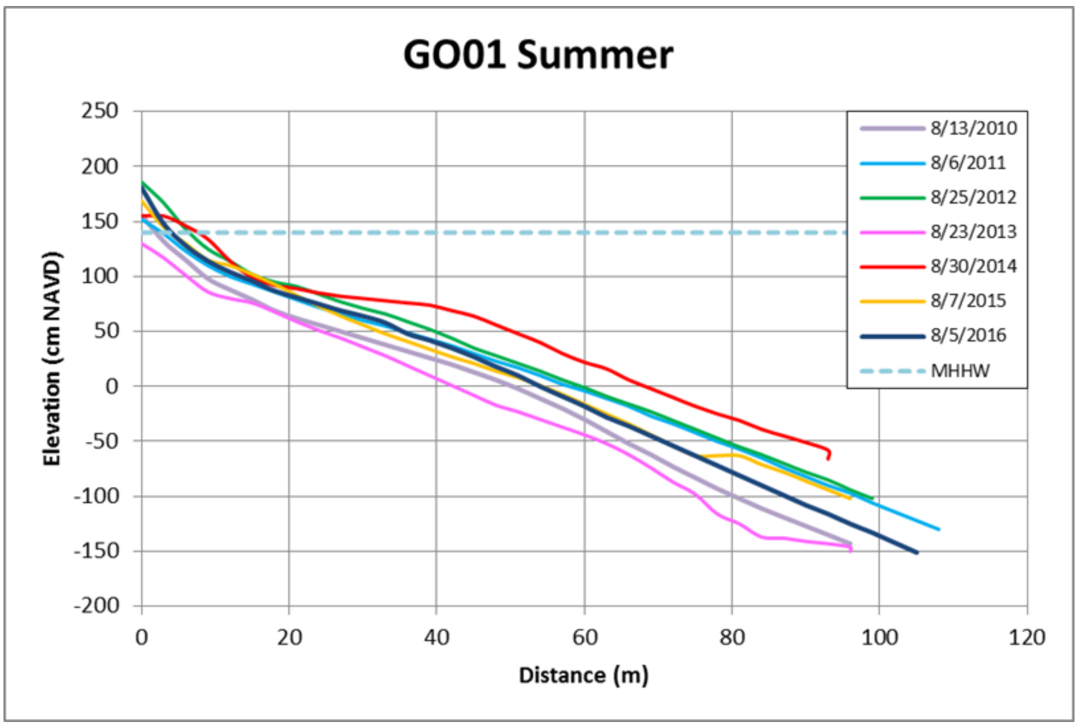

Figure 35. Summer beach profiles at GO01, Goochs Beach, Kennebunk, ME.

Figure 36. Winter beach profiles at GO02, Goochs Beach, Kennebunk, ME.

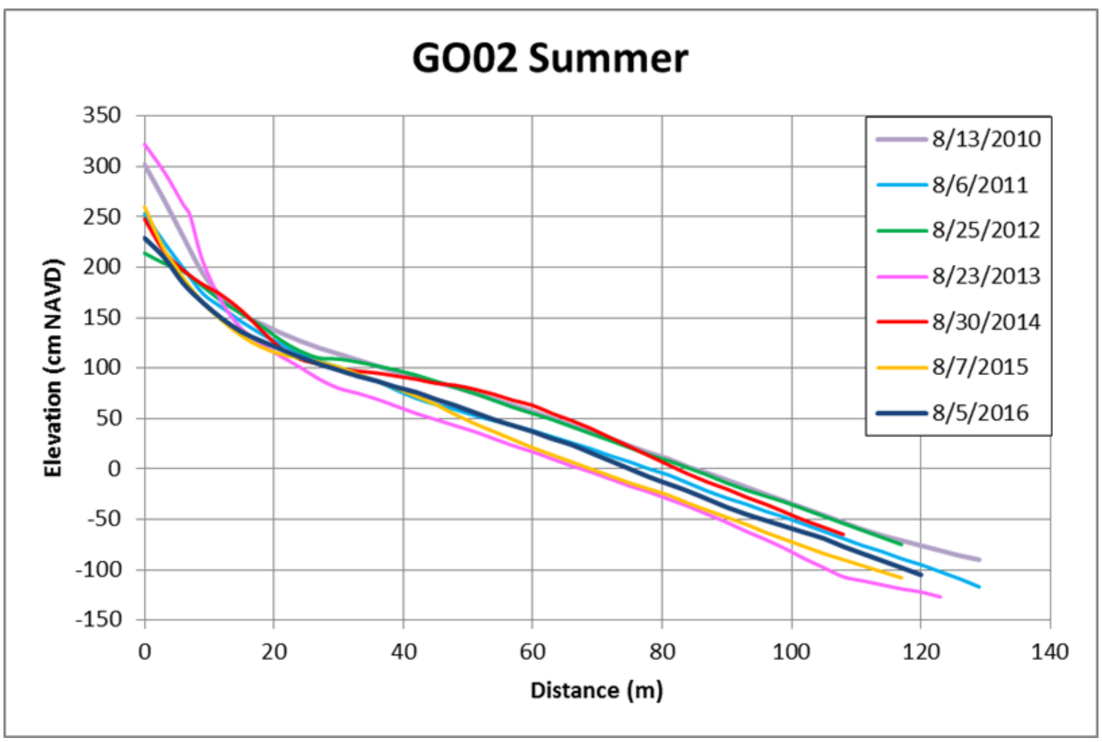

Figure 37. Summer beach profiles at GO02, Goochs Beach, Kennebunk, ME.

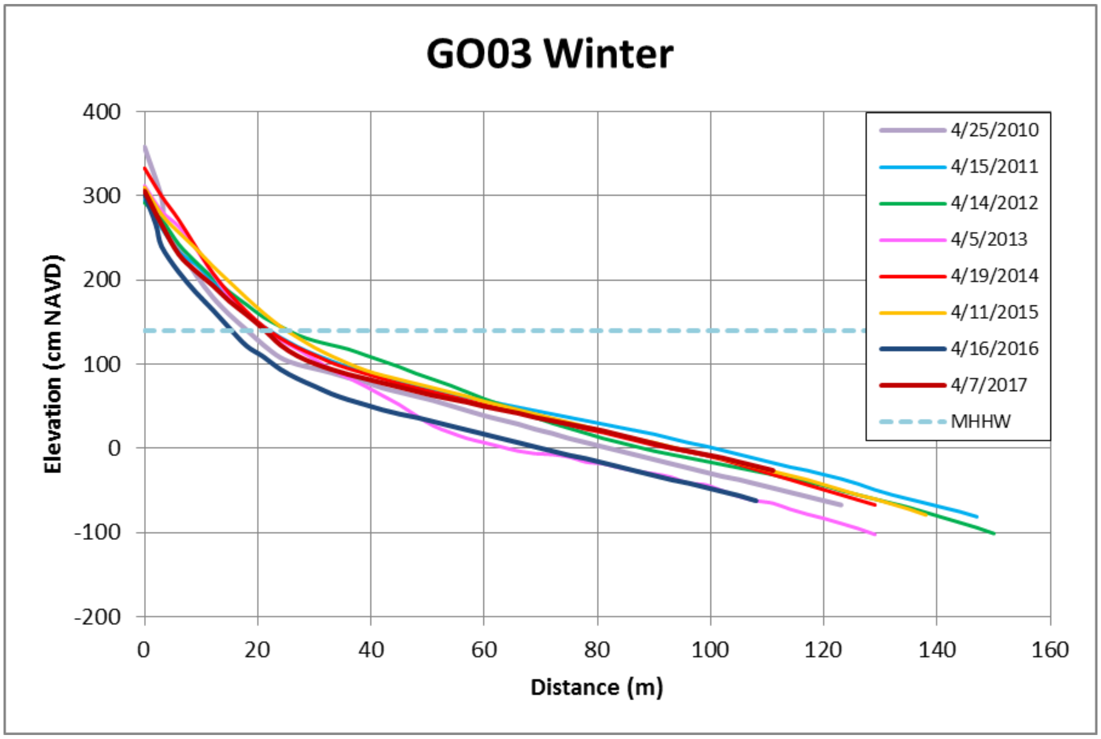

Figure 38. Winter beach profiles at GO03, Goochs Beach, Kennebunk, ME.

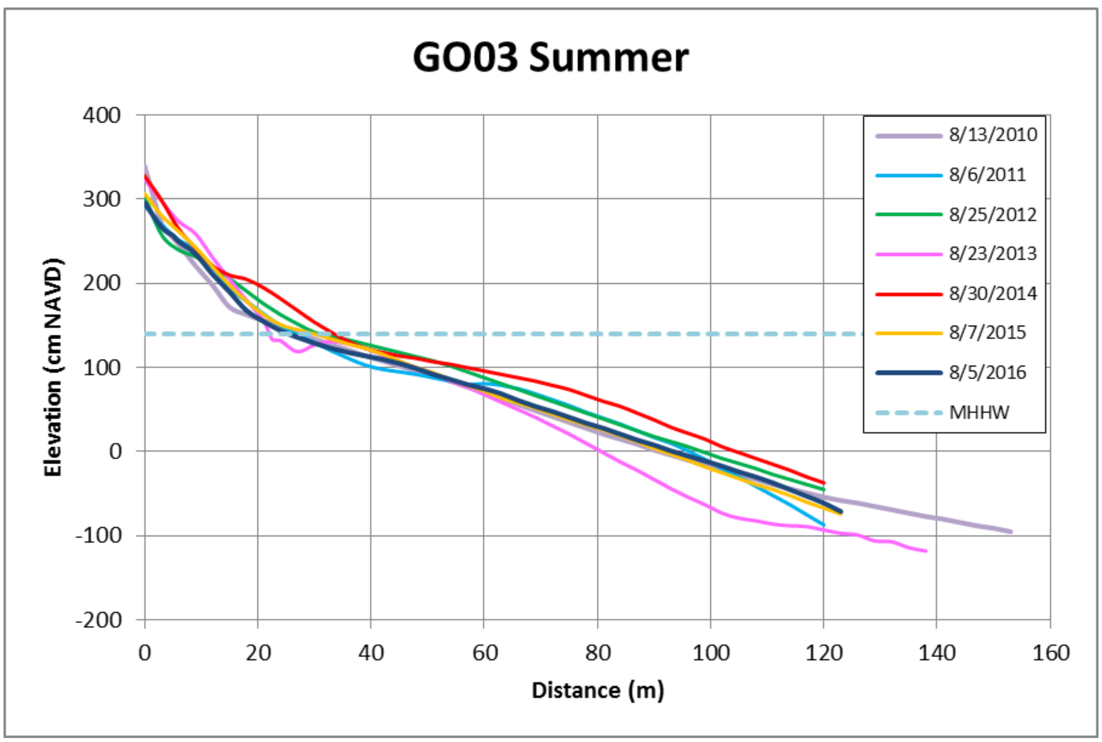

Figure 39. Summer beach profiles at GO03, Goochs Beach, Kennebunk, ME.

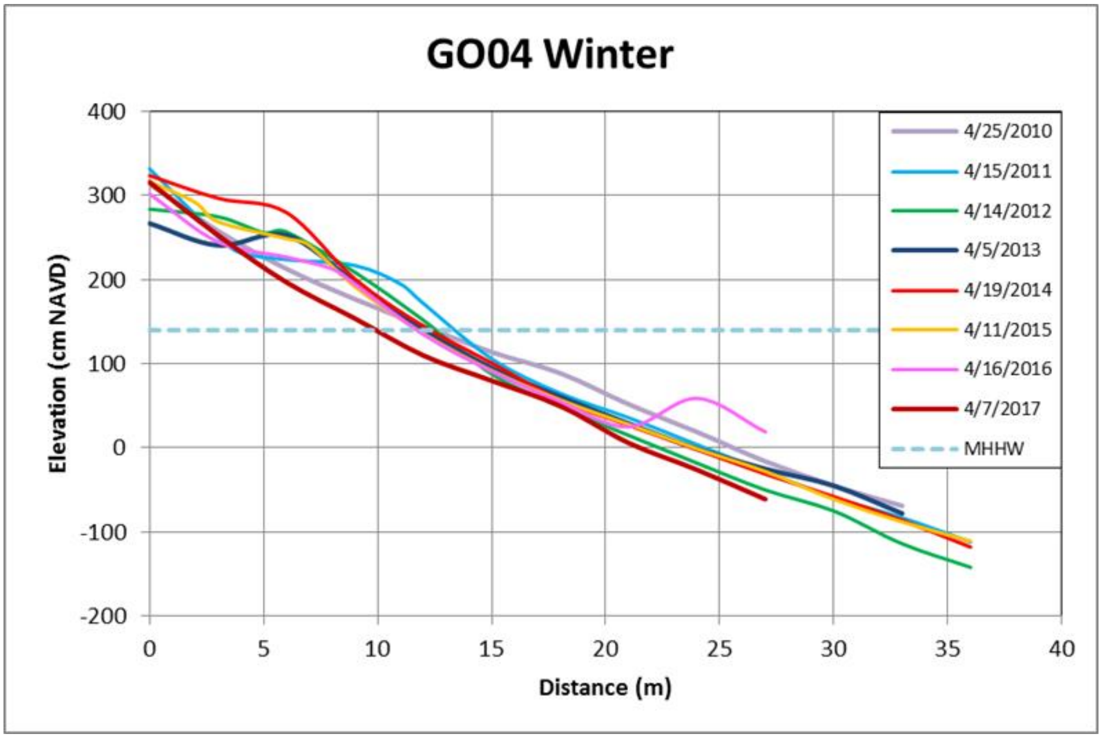

Figure 40. Winter beach profiles at GO04, Goochs Beach, Kennebunk, ME.

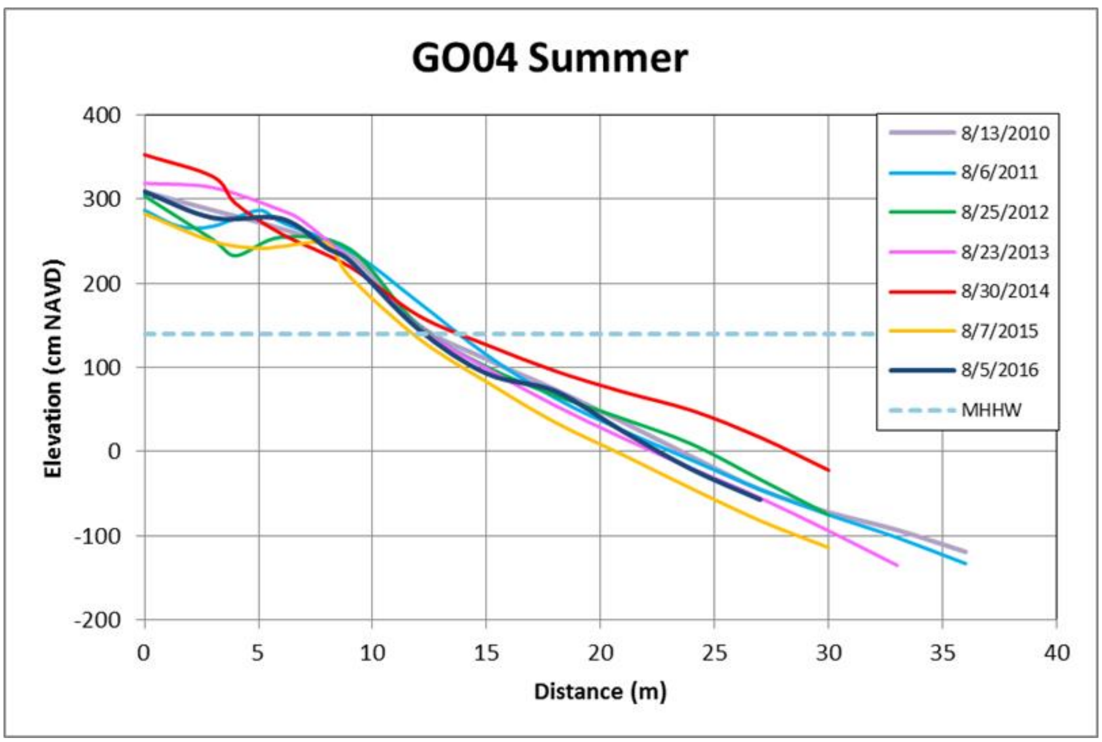

Figure 41. Summer beach profiles at GO04, Goochs Beach, Kennebunk, ME.

Goochs Beach MBMAP Score = **Slightly erosive (C-)**

Only a small section of vegetated shoreline exists adjacent to the seawall at the Kennebunk River (Figure 42). The remainder of Goochs Beach has a seawall with no measureable vegetation. There is a distinct section of erosive to very erosive (-3 ft/yr) shoreline adjacent to the jetty at the Kennebunk River (transects 601-604). The rest of the beach is stable.

Overall, **Goochs Beach** was **slightly erosive** with a mean shoreline change rate of **-0.8 ft/yr (σ=1.6)**.

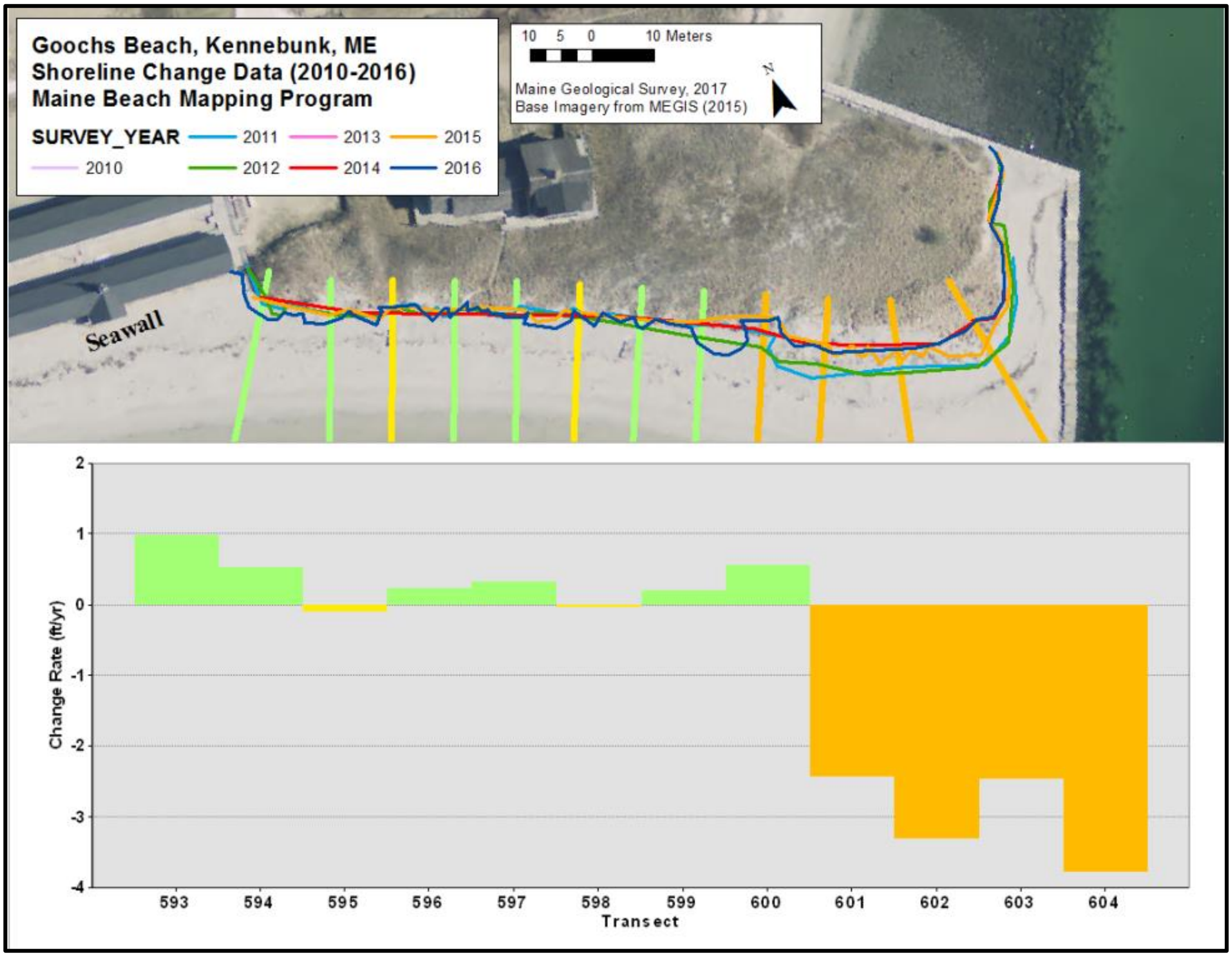

Figure 42. Shoreline change data (2010-2016) for Goochs Beach, Kennebunk, ME.

Goose Rocks Beach, Kennebunkport

Four beach profiles (GR01 to GR04, Figure 43) were available for analysis. GR01 is at the south end of the beach, nearest of the profiles to the Batson River. GR02 is in a small cell in the central portion of the beach. GR03 is in a cove at the north third of the beach GR04 is adjacent to the Little River. Figures 44 to 51 show seasonal changes.

Figure 43. Location of beach profiles along Goose Rocks Beach, Kennebunkport, ME.

Winter GR01 = B (85). GR01, although nearest to the Baston River of all the profiles, was stable to accretive, with growing dunes and a highly variable nearshore. From 2010-2011, the profile gained in elevation. In 2012, the dune grew, but the fore-shore steepened. In 2013,the dune grew more, but the beach lost sand and steepened, but bars were visible on the low tide terrace. In 2014, the dune was stable, but the berm was lost. In 2015, the berm was well developed and the profile had additional swash bars. In 2016, the dune built seaward; otherwise the profile stayed about the same. In 2017, the profile continued seaward growth, resulting in the best profile. The dune grew consistently seaward since 2010.

Summer GR01 = B (85). Similar to winter trends, the dune grew seaward and increased in height from 2010 to 2016, and showed a highly variable nearshore. In 2010, GR01 had a low dune, defined berm, and steep slope to a flat low-tide terrace. In 2011, it gained sand at the berm and dune. In 2012, it gained sand at the dune, lost at the berm, and was similar to 2010 offshore. 2013 had berm erosion, resulting in the steepest profile. In 2014, the dune was stable, the profile still steep, but had sand near the base of the berm. 2015 showed lowering of the beach, but dune growth. 2016 showed more dune growth and a relatively stable nearshore. The MHHW was stable.

Winter GR02 = B (85). From 2010 to 2011, GR02 gained at the berm but steepened seaward of 30 m. In 2012 it had more berm growth, but steepened and formed a trough at 35 m. The profile eroded severely in 2013 (below the 2010 shape) – this was the worst profile. By 2014, it gained sand back at the upper 50 m of the profile, and was stable seaward. In 2015, it gained near the dune, but lost sand along the rest of the profile (below 2010 levels). 2016 showed good recovery, with the highest starting point elevation and a well-defined berm. The profile was stable in 2017. The MHHW line remained about the same from 2010 to 2017.

Summer GR02 = B- (82). GR02 showed nice berm development during the summer. In 2010, the profile had a trough landward of a berm. By 2011, it gained sand while the berm moved seaward and flattened. By 2012, it gained dune elevation and the berm returned to about the 2010 shape. By 2013, the profile eroded back to the 2010 shape, with a defined trough near 15 m. In 2014, it recovered near the dune and the trough filled, but the berm was lost. In 2015, the profile returned to 2011 levels. In 2016, it grew at the berm and the dune to the best profile shape. The MHHW grew seaward about 5 m from 2010 to 2016.

Winter GR03 = B- (82). From 2010 to 2011 it changed very little with slight gains at its upper end. By 2012, it gained a large berm at the 50 m mark. The 2013 profile lost sand at the dune and berm (lower than 2010), and was about equal to 2010. In 2014, GR03 gained sand, especially at the berm and in the offshore. In2015, it eroded slightly, but built at the dune. 2016 and 2017 both showed a stable profile. The MHHW line moved slightly seaward from 2010 to 2017.

Summer GR03 = C (75). 2010 was by far the most erosive profile shape. By 2011, it gained substantial elevation (about 50 cm over 2010 elevations) at the 40 m mark and swash bars formed around 110 m and 210 m. In 2012, the profile gained nearest the dune, but lowered elsewhere. 2013 had a steep dune and beach shape, which recovered in 2014 to some of the highest elevations. This slightly eroded in 2015, and was eroded (to near 2010 levels at the MHHW mark) in 2016, yet maintained a berm near the 20 m mark.

Winter GR04 = C (75). Note that the starting pin for GR04 was moved several times, so it is difficult to compare profiles collected from different starting points. Profiles from 2010 to 2013 were removed – thus, 2014 is the first profile for analysis. 2014 was steep, with no berm. A dune and berm formed in 2015, but in 2016, was lost and the profile returned to near 2014 shape. In 2017, the profile built seaward, but never reached 2015 levels. From 2014-2017, the MHHW line moved seaward about 10 m.

Summer GR04. Note that beach profile data at GR04 appears to be too variable to be accurately recorded. If it is accurate, then the profile has undergone *significant erosion from 2014 to 2016*. This does not correlate with winter trends, nor MBMAP data (see below); thus, we will not include a score for GR04 summer.

Overall Goose Rocks Beach Grade = 81 (B-). Profiles at Goose Rocks showed general stability and growth, especially of the dunes.

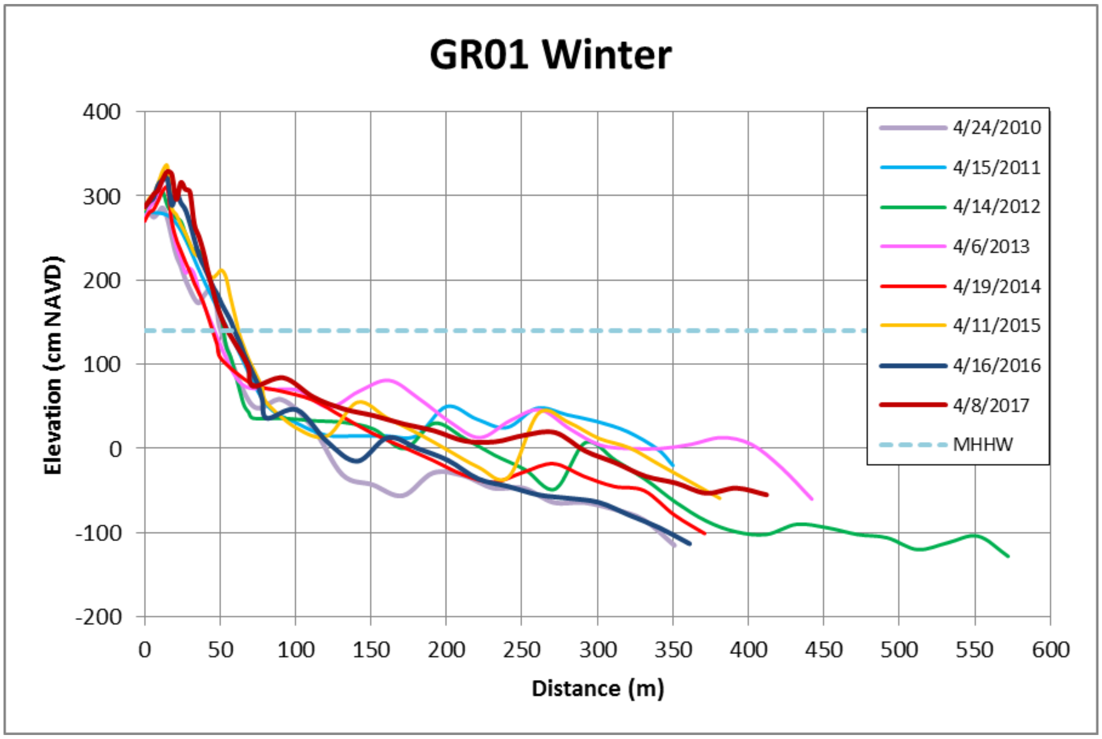

Figure 44. Winter beach profiles at GR01, Goose Rocks Beach, Kennebunkport, ME.

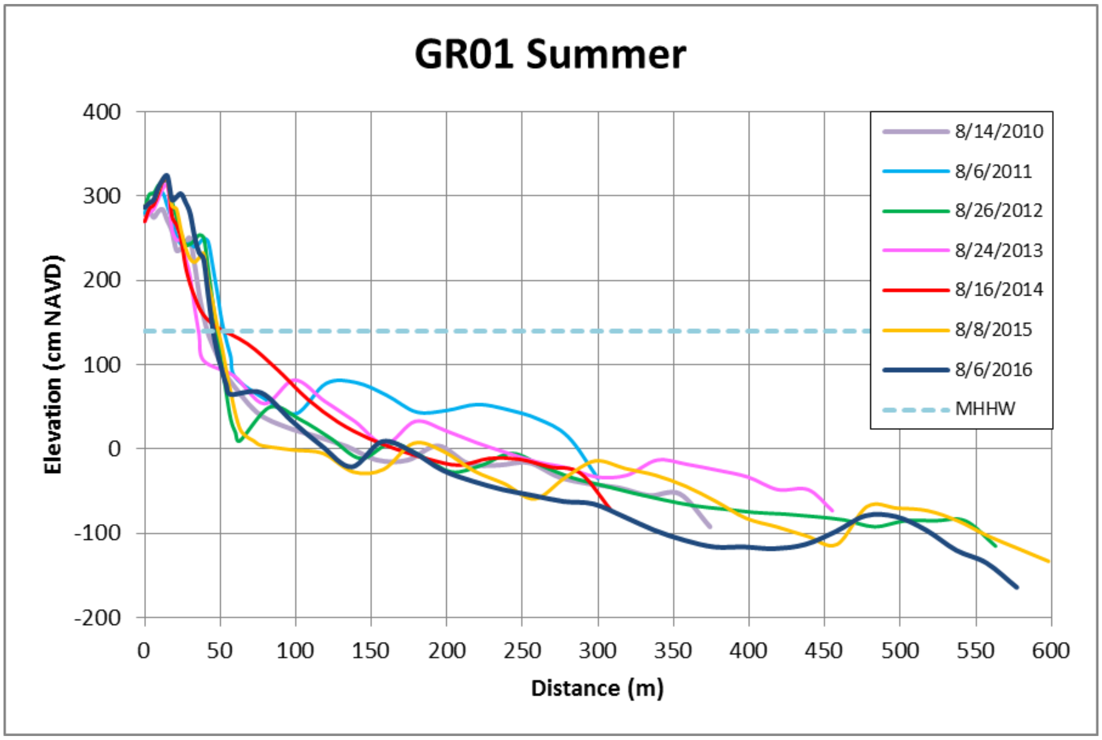

Figure 45. Summer beach profiles at GR01, Goose Rocks Beach, Kennebunkport, ME.

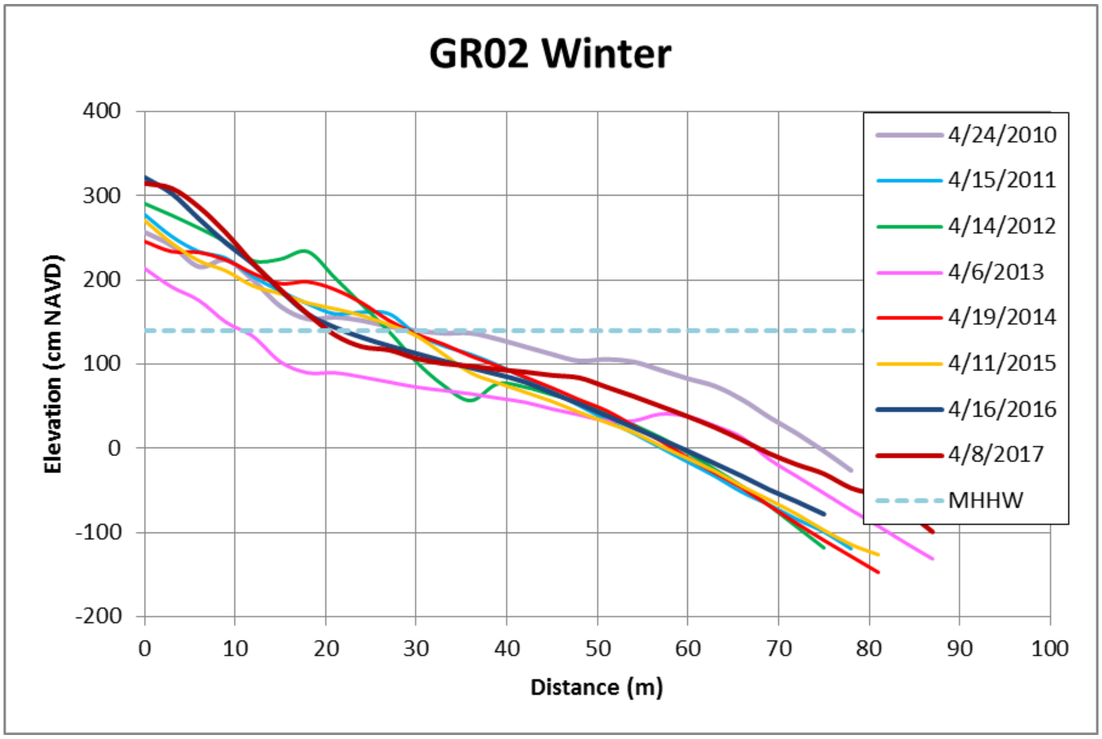

Figure 46. Winter beach profiles at GR02, Goose Rocks Beach, Kennebunkport, ME.

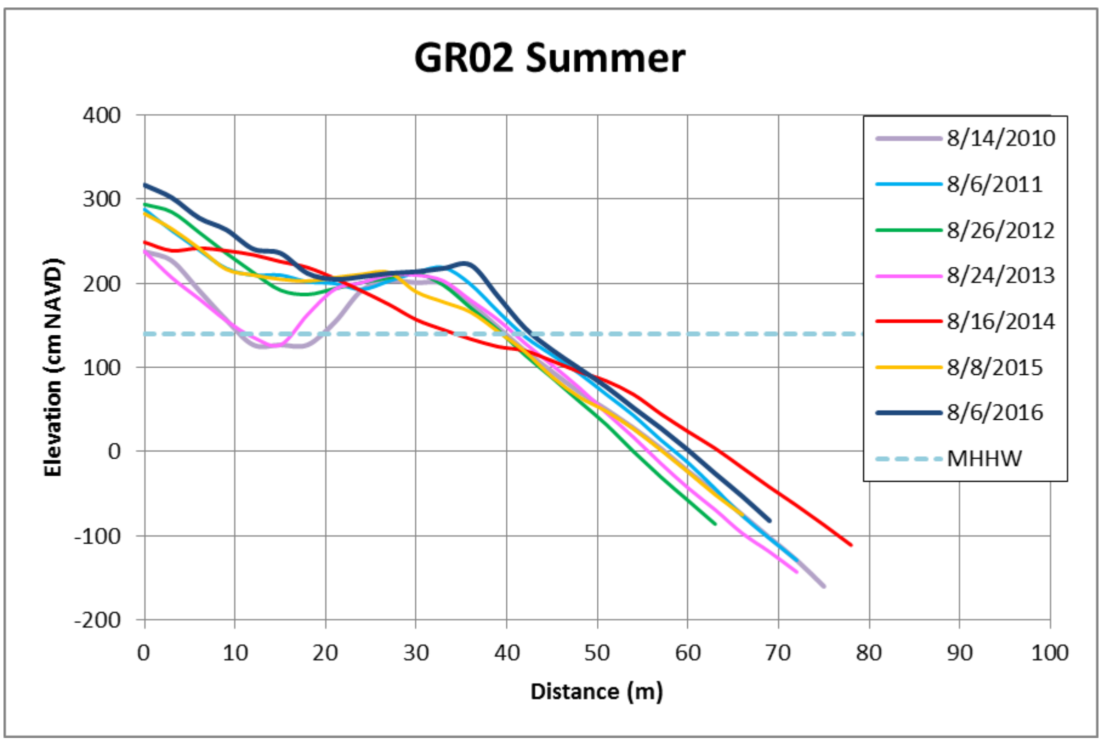

Figure 47. Summer beach profiles at GR02, Goose Rocks Beach, Kennebunkport, ME.

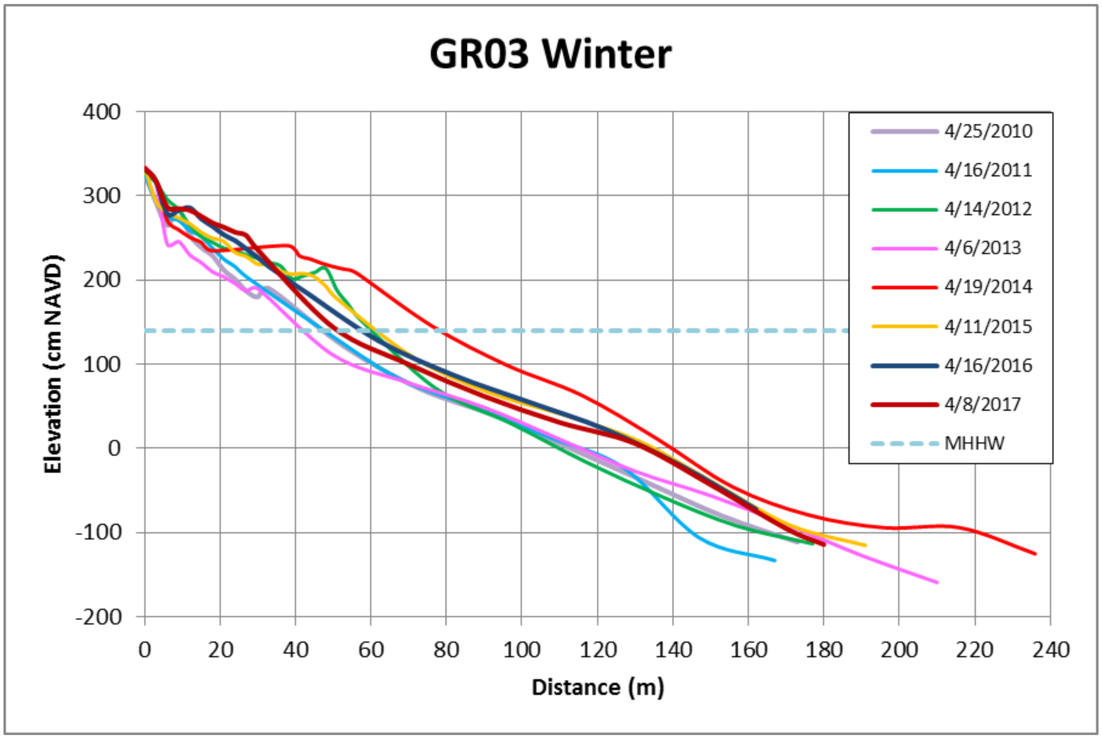

Figure 48. Winter beach profiles at GR03, Goose Rocks Beach, Kennebunkport, ME.

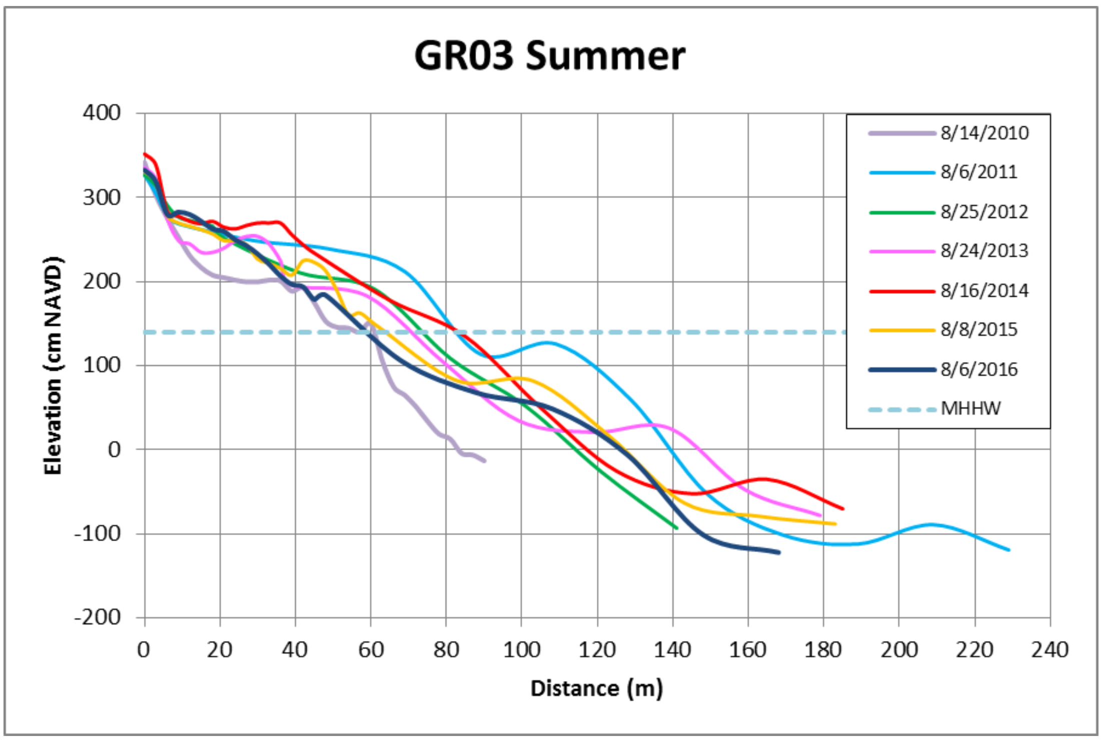

Figure 49. Summer beach profiles at GR03, Goose Rocks Beach, Kennebunkport, ME.

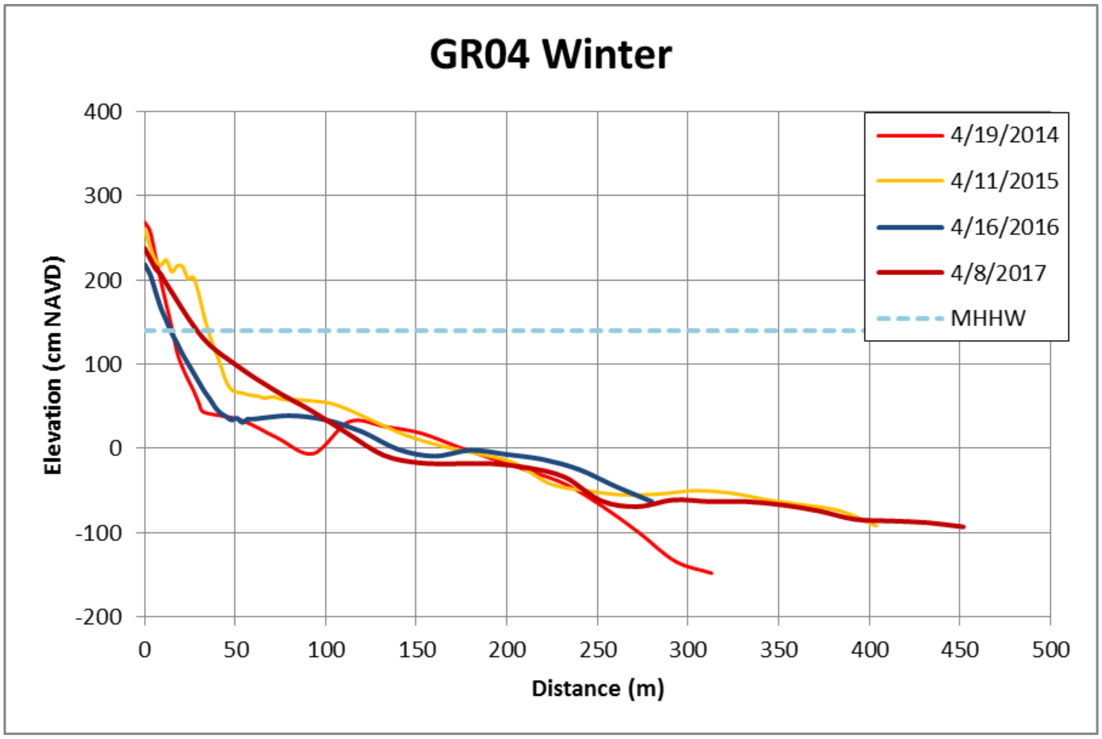

Figure 50. Winter beach profiles at GR04, Goose Rocks Beach, Kennebunkport, ME.

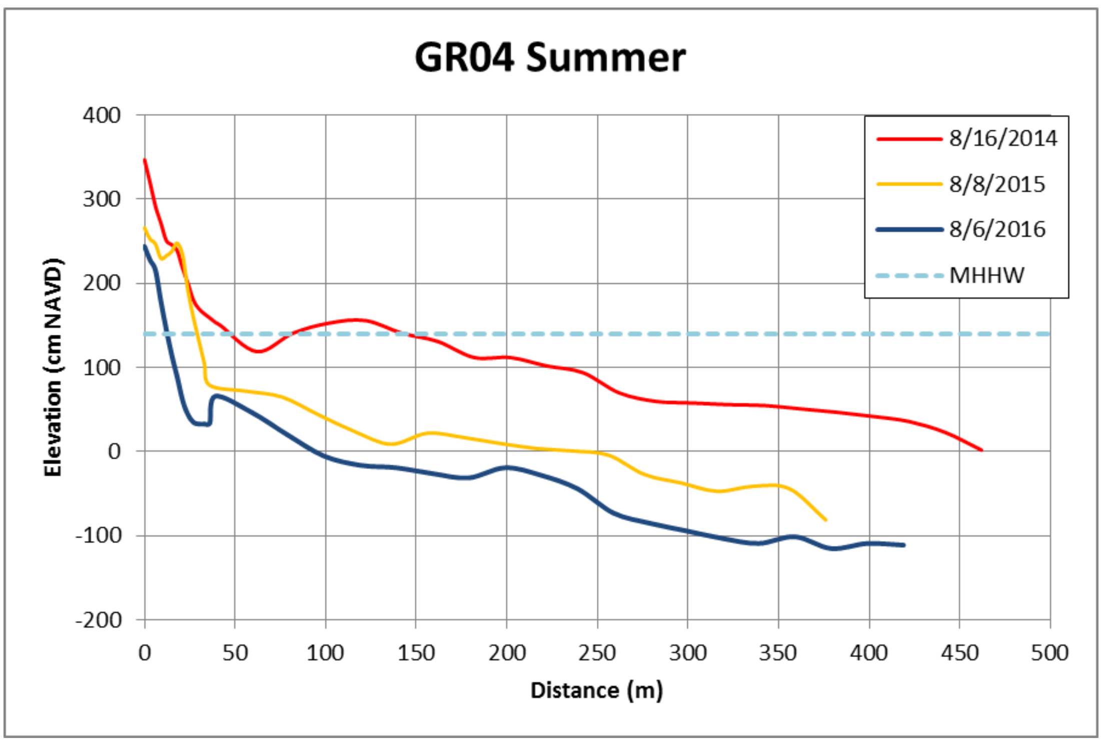

Figure 51. Summer beach profiles at GR04, Goose Rocks Beach, Kennebunkport, ME.

Goose Rocks MBMAP Score = **Accretive (B)**
Batson River = Extremely erosive (F-)
West = Very highly accretive (A)
Central = Slightly accretive (C+)
East = Very highly accretive (A)
Little River = Very highly accretive (A)

Goose Rocks Beach stretches from the Batson River in the west to the Little River in the east, with several tombolos. The rivers and tombolos greatly influence the shoreline change rates along the dunes. Goose Rocks Beach has several stretches of seawalls where no vegetation line data could be collected, as labeled below. The shoreline along Goose Rocks Beach was classified into several different sections based on shoreline change trends (from west to east): Batson River, West, Central, East, and Little River (Figure 52).

Nearest to the **Batson River** (transects 605-622), the dunes were **extremely erosive** with a mean shoreline change rate of **-18 ft/yr (σ=7.7).** This section included stretches of shoreline where the dunes have eroded at -30 ft/yr, some of the highest in the state.

In the **west section** (transects 623-682) where GR01 is located, the dunes were **very highly accretive** with a mean shoreline change rate of **+ 4.8 ft/yr (σ=4.6)**. This section included areas where dunes have grown at rates of +10 to +15 ft/yr.

In the **central section** (transects 683-791), where GR02 is located, the shoreline was **slightly accretive** with a mean shoreline change rate of **+0.8 ft/yr (σ=1.8)**, with a few pockets of slight erosion.

In the **east section** (transects 792-873), where GR03 is located, the shoreline was **very highly accretive** with a mean shoreline change rate of **+5.2 ft/yr (σ=2.5)**, with pockets of accretion exceeding +10 ft/yr.

Finally, **along the Little River** (transects 883-906), where GR04 is located, the shoreline was **very highly accretive** with a mean shoreline change rate of **+4.3 ft/yr (σ=1.9)**.

Overall, **Goose Rocks Beach** was **accretive** with a mean rate of **+2.0 ft/yr (σ=6.6).** Note that the extremely erosive shoreline along the Batson River has a significant impact on this mean rate; without it, the mean shoreline rate would be double that, making the shoreline highly accretive.

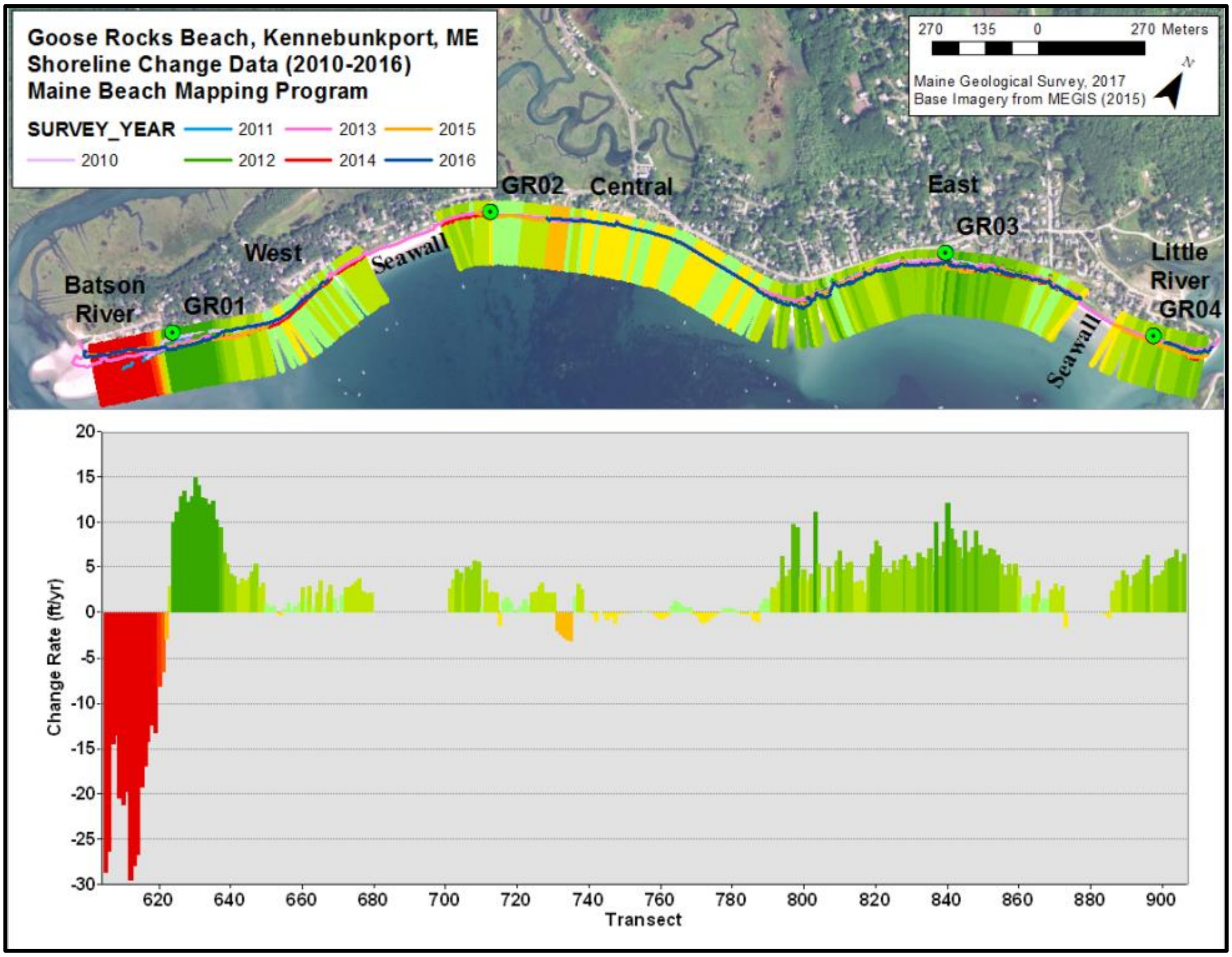

Figure 52. Shoreline change data (2010-2016) for Goose Rocks Beach, Kennebunkport, ME.

Fortunes Rocks Beach, Biddeford

Fortunes Rocks Beach is not part of the SMBPP.

Fortunes Rocks Beach MBMAP Score = **Accretive (B)**
West = Very accretive (B+)
East = Accretive (B)

Fortunes Rocks Beach is a large pocket beach bound by a headland to the south and Biddeford Pool to the north. Several sections of the beach are continuously seawalled, especially in the southwest and central portion of the beach (Figure 53). Fortunes Rocks Beach was divided into two distinct sections –west and east – which are divided by a long stretch of seawalls.

The dunes in the **west section** (transects 907-989) were **very accretive** with a mean shoreline change rate of **+2.5 ft/yr (σ=1.6)**, with pockets of accretion up to +6 ft/yr.

The dunes in the **east section** (transects 1092-1170) were **accretive** with a mean shoreline change rate of **+2.0 ft/yr (σ=1.3).**

Overall, **Fortunes Rocks Beach** was **accretive** with a mean shoreline change rate of **+2.3 ft/yr (σ=1.5)**.

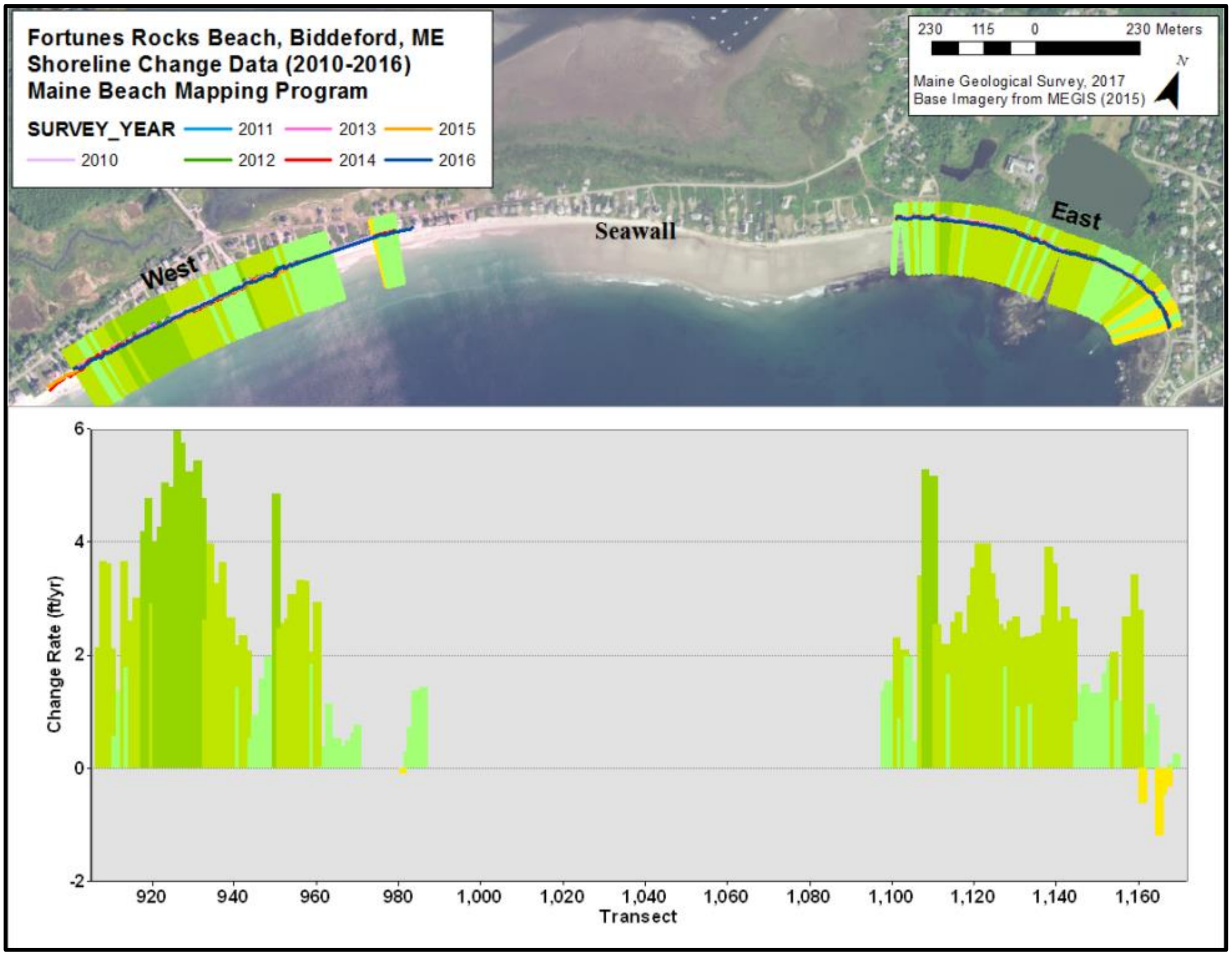

Figure 53. Shoreline change data (2010-2016) for Fortunes Rocks Beach, Biddeford, ME.

Hills Beach, Biddeford

Hills Beach is not part of the SMBPP.

Hills Beach MBMAP Score = **Somewhat accretive (B-)**
South = Accretive (B)
Central = Erosive (D)
North = Very accretive (B+)

Hills Beach is a small pocket beach on the south side of the Saco River. It is bound to the north by the southern jetty of the river, and to the southeast by Biddeford Pool. A central portion of the beach has contiguous seawalls, and has no vegetation to measure as part of MBMAP (Figure 54). Shoreline changes indicate that the shoreline can be classified into distinct sections: south, central, and north.

The **south section** (transects 1171-1205) was **accretive** with a mean shoreline change rate of **+2.3 ft/yr (σ=2.8)**.

The **central section** (transects 1215-1244) was **erosive** with a mean shoreline change rate of **-1.8 ft/yr (σ=1.5)**. The central section is separated from the north section by a long stretch of contiguous seawalls.

The **north section** (transects 1283-1338) is nearest to the southern jetty of the Saco River, and was **very accretive** with a mean shoreline change rate of **+2.5 ft/yr (σ=1.8)**.

Overall, **Hills Beach** was **somewhat accretive** with a mean shoreline change rate of **+1.3 ft/yr (σ=2.7)**.

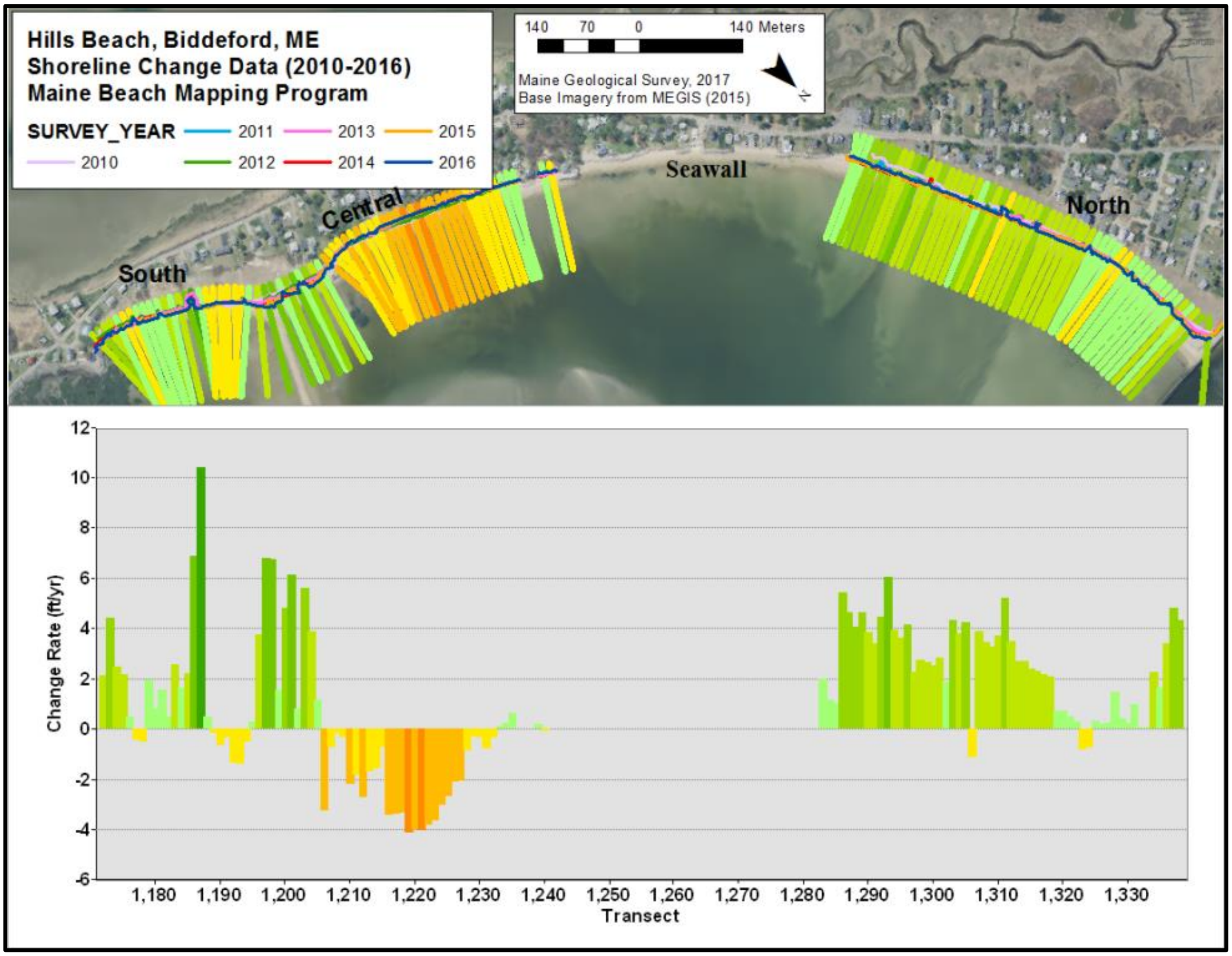

Figure 54. Shoreline change data (2010-2016) for Hills Beach, Biddeford, ME.

Ferry Beach, Saco

Four beach profiles (FE01 to FE04) were available for analysis. Figure 55 shows that that they are located from north to south along a stretch of Ferry Beach near the Ferry Beach Ecology School (the figure also shows Kinney Shores profile locations). Note that some of the profiles have different starting points (front or back stakes), as discussed below. Figures 56 to 63 show seasonal changes at the profiles.

Figure 55. Location of beach profiles along Ferry Beach and Kinney Shores, Saco, ME.

Winter FE01 = F (55). Data from 2010 to 2013 was collected at a front stake, while data 2014 to 2017 was collected from a back stake. *All data was shifted to the back stake starting point*. From 2010 to 2011, FE01 built a dune and developed a berm, but steepened. In 2012, the dune was eroded and the profile flattened. The profile eroded further in 2013 and the starting point lost. In 2014, the profile shifted landward, indicating extensive erosion. 2016 showed stability of the dune, and some recovery landward of 25 m from the pin. 2017 showed additional loss, to the most erosive profile. The MHHW, since 2010, moved around 10 m landward.

Summer FE01 = C- (72). Data from 2010 to 2012 was collected at a front stake, while data from 2013 to 2016, a back stake. From 2010 to 2012, the dune and berm flattened and consistently eroded landward. From 2012 to 2013, the entire frontal dune eroded, losing about 50 cm in elevation, and about 5 m horizontally. From 2013 to 2014, there was slight seaward growth of the dune and berm, which remained stable in 2015. The dune and berm grew seaward slightly in 2016. However, since 2010, the MHHW moved landward about 10 m. The profile eroded dramatically from 2010 to 2013, then showed some stability to growth over the past few summers.

Winter FE02 = D+ (68). FE02 was also shifted so that all data started from the back stake. In 2011, the dune receded slightly, but the berm and lower portion built seaward. It returned to a very similar shape to 2010 in 2012, except for the dune showing more recession. In 2013, the frontal dune crest was lost and profiling began at the back stake, but the berm built seaward. In 2014 there was additional loss of the dune but slight seaward growth of the berm. In 2015, the profile was back to near 2012 shape, but had no frontal dune crest. In 2016 the berm further eroded, and the dune gained elevation. By 2017, the dune grew in elevation slightly, but the nearshore eroded further. Since 2010, the MHHW line moved about 5 m landward.

Summer FE02 = C (75). The 2010 profile was extremely steep and erosive, with no berm. In 2011, FE02 had good recovery of the berm but erosion of the dune. In 2012, FE02 remained relatively unchanged. By 2013 (profiling at the back stake), the rest of the dune was lost, but the profile gained slightly at the berm. In 2014, the dune lowered slightly, and the berm was lost. In 2015, the dune grew in elevation, and a well-developed berm was present. The berm eroded in 2016, but the dune continued to grow. The MHHW line moved seaward by about 6 m since 2010.

Winter FE03 = C- (72). Profiles were offset to a back stake as the front stake was lost after April 2013. Note that the 2010 profile used a July date because the starting pin was lost in May. From 2010 to 2011, the dune eroded landward but the rest of the profile was relatively stable. 2012 saw more dune recession and slight landward migration. In 2013, the dune grew landward (likely caused by overwash) and an otherwise stable profile shape. The profile was markedly stable in 2014 and 2015. In 2016, the dune grew, but the nearshore eroded. This trend continued in 2017. The MHHW moved about 5 m landward since 2010.

Summer FE03 = C- (72). During summer FE03 showed steady landward movement of the dune from 2010 to 2013, but slight seaward migration of the lower part of the berm. This indicates the profile was flattening out and eroding. However, in 2014, the profile clearly built seaward at the dune and across the berm. It eroded slightly in 2015, and was stable in 2016 except for some loss in the nearshore.

Winter FE04 = D (65). From 2010 to 2012, FE04 was stable at the dune, but lost the berm present in 2010. By 2013, the dune eroded, but a berm reappeared, similar to but slightly higher than the 2010 shape. In 2014, the dune eroded further inland, but a better defined berm appeared. By 2015, the dune and berm had both eroded, leaving a steep, concave, featureless profile. In 2016 and 2017, the dune and beach eroded. Since 2010, the MHHW line moved about 10 m landward.

Summer FE04 = F (55). 2010 had the profile with the most sand and elevation. The entire profile eroded inland from 2010 to 2012. In 2013, the dune eroded further, but a small berm appeared. Consistent erosion continued in the subsequent years. The MHHW line moved about 8 m landward since 2010.

Overall Ferry Beach Grade = D+ (67). In general, the profiles at Ferry Beach continued to erode; FE03 performed best.

MBMAP Results for Ferry Beach, Saco will be discussed in the context of the entire Saco shoreline in the section after Kinney Shores.

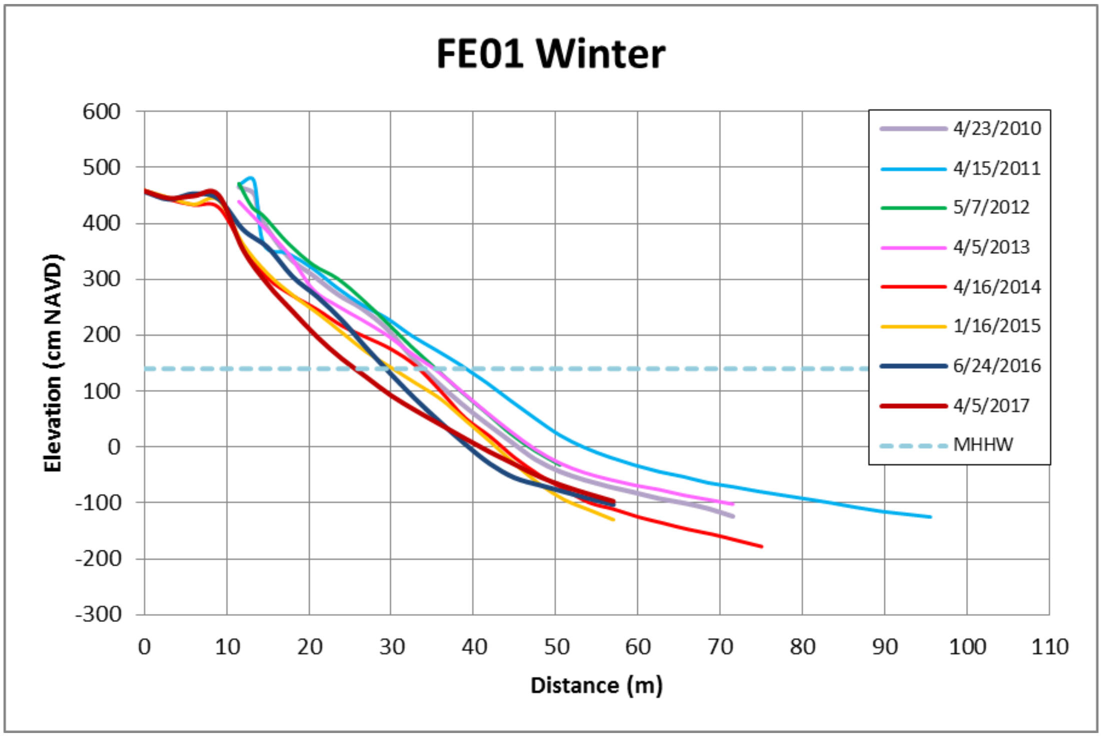

Figure 56. Winter beach profiles at FE01, Ferry Beach, Saco, ME. Note movement of starting point between 2013 and 2014.

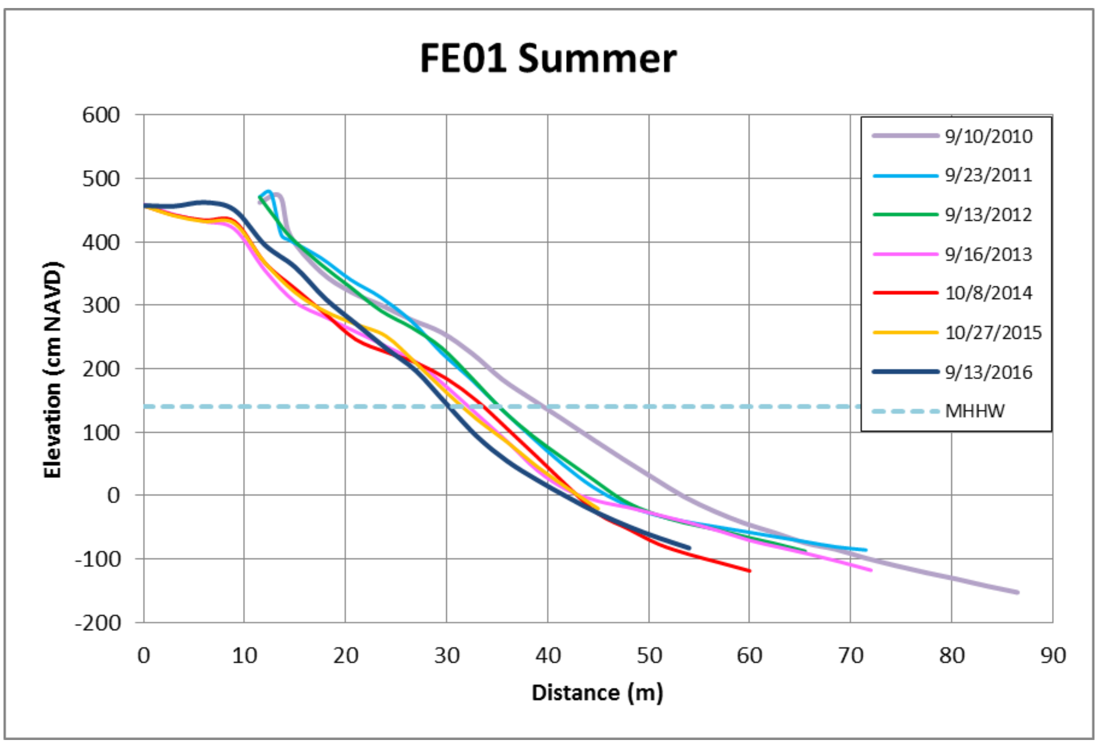

Figure 57. Summer beach profiles at FE01, Ferry Beach, Saco, ME. Note movement of starting point between 2012 and 2013.

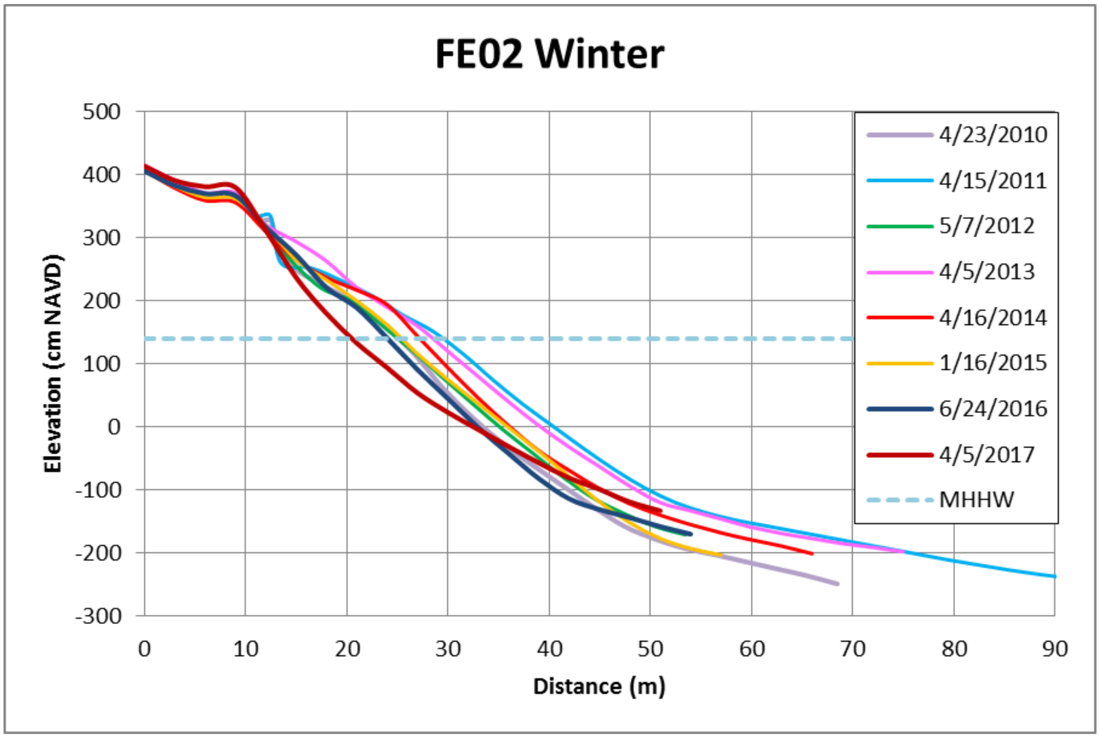

Figure 58. Winter beach profiles at FE02, Ferry Beach, Saco, ME. Note movement of starting point between 2013 and 2014.

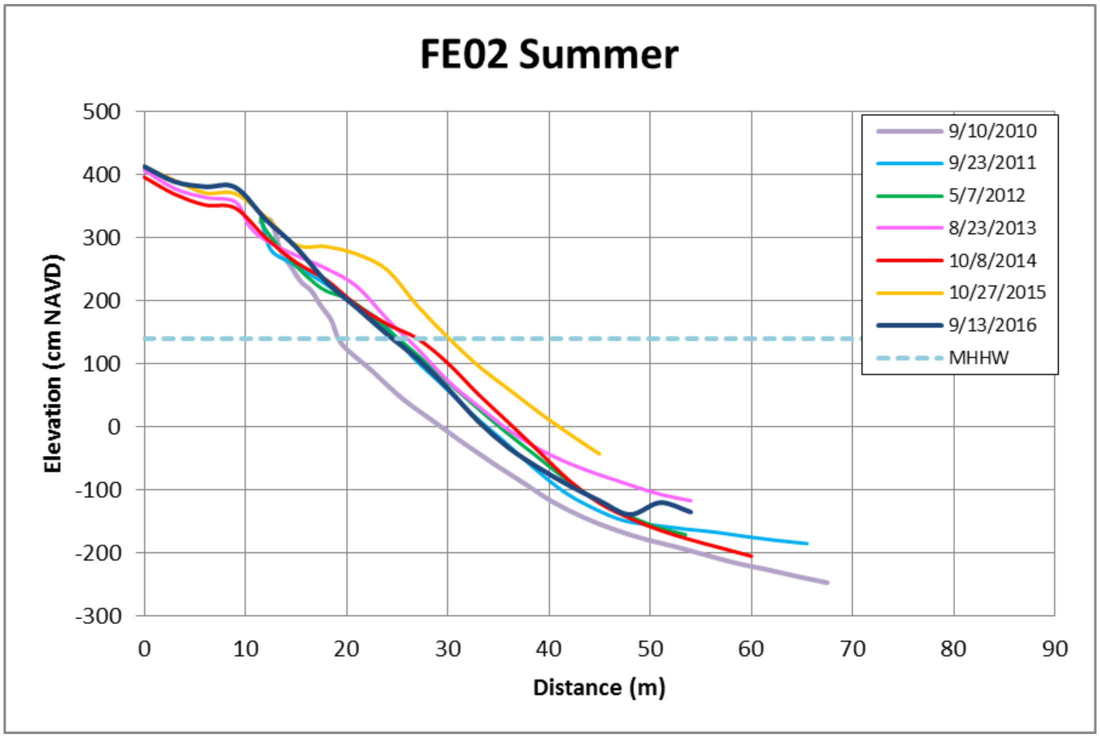

Figure 59. Summer beach profiles at FE02, Ferry Beach, Saco, ME. Note movement of starting point between 2012 and 2013.

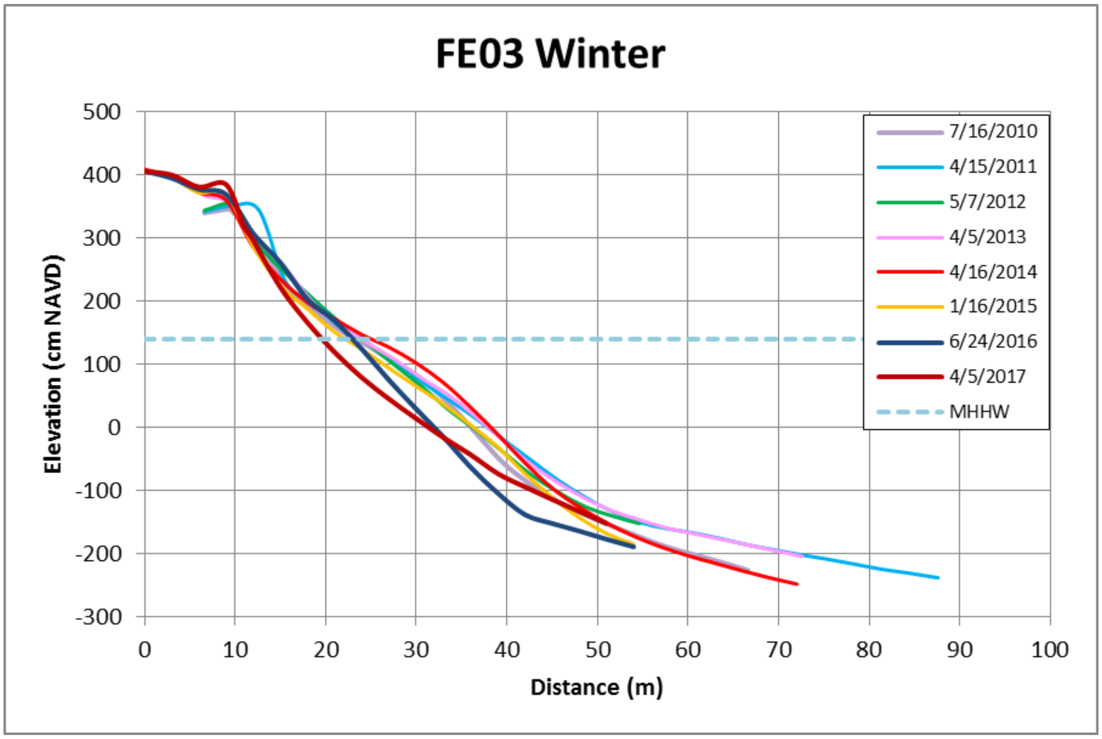

Figure 60. Winter beach profiles at FE03, Ferry Beach, Saco, ME. Note movement of starting point between 2012 and 2013.

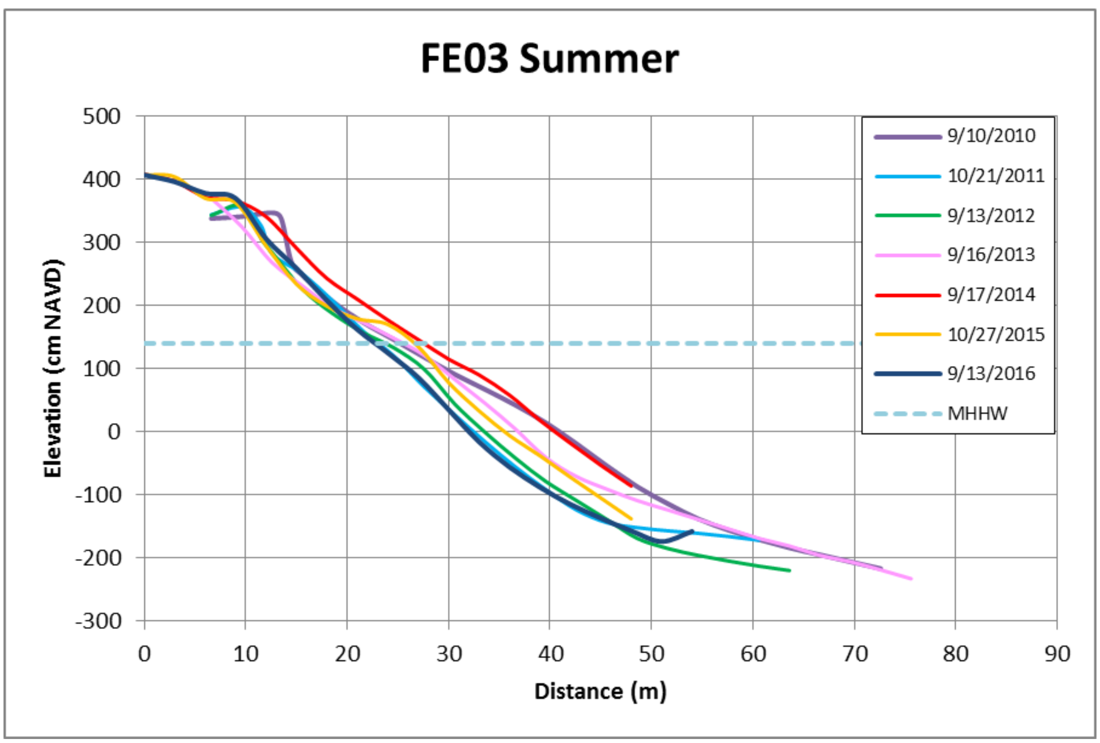

Figure 61. Summer beach profiles at FE03, Ferry Beach, Saco, ME. Note movement of starting point between 2012 and 2013.

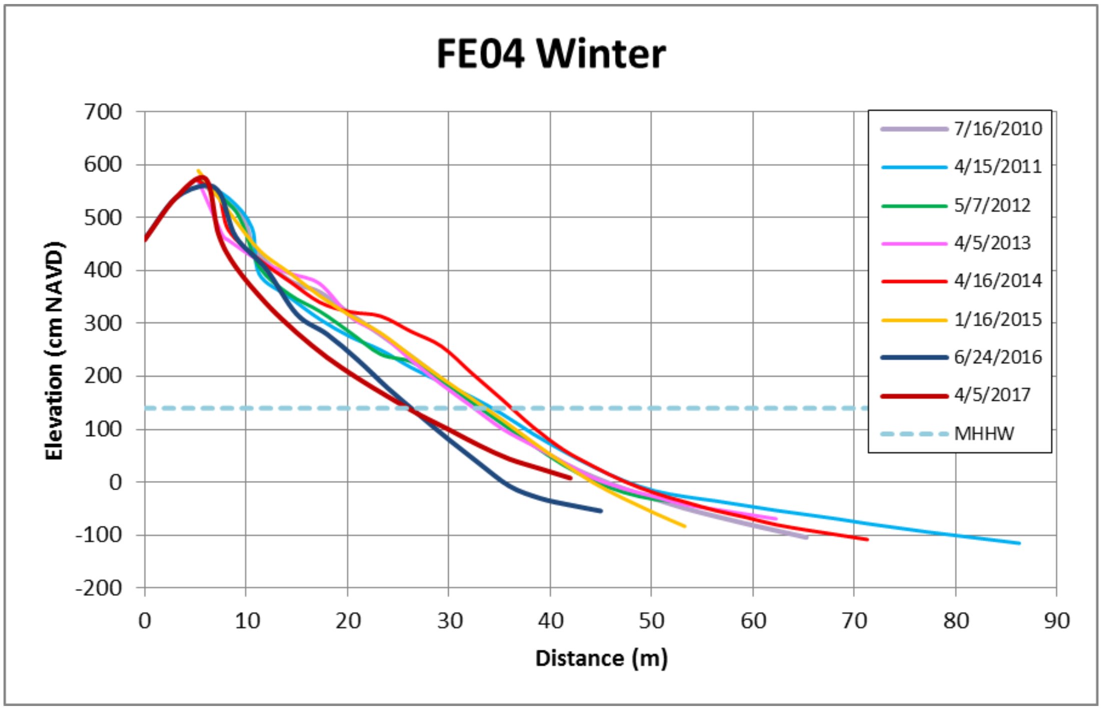

Figure 62. Winter beach profiles at FE04, Ferry Beach, Saco, ME. Note movement of starting point between 2015 and 2016.

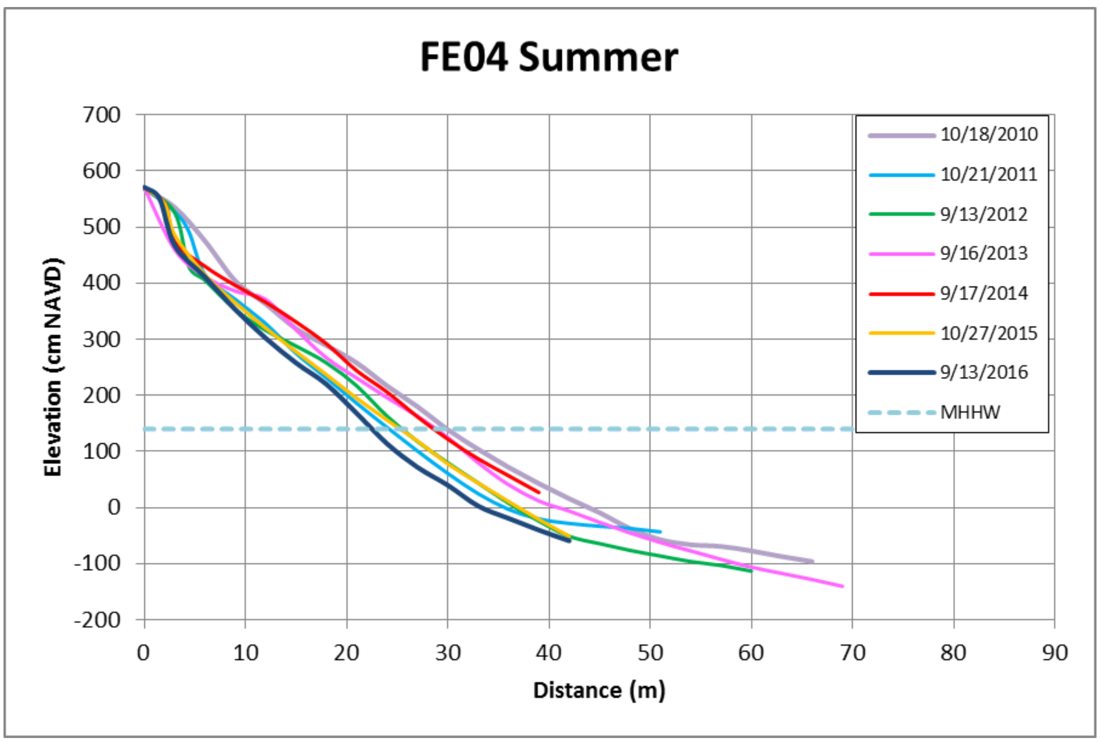

Figure 63. Summer beach profiles at FE04, Ferry Beach, Saco, ME.

Kinney Shores, Saco

One beach profile (KS02, shown on Figure 55) was available for analysis, though data collection stopped in 2016, so no 2017 data is available. Profiling at KS01 stopped in 2015, so it is not included. KS02 is located at the northern end of Kinney Shores. Figures 64 to 65 show seasonal changes at the profile.

Winter KS02 = **B- (82)**. From 2010 to 2011, the profile built at the dune, but steepened at the berm. In 2012, the profile built seaward, indicating accretion, especially at the berm. It lost sand at the dune and seaward of 40 m in 2013. By 2014, the dune built back, and the berm eroded. It was stable in 2015. In 2016, the dune built seaward, and the berm increased in elevation. The nearshore stayed about the same as 2014 and 2015. Note that 2016 data was from June. The profile has been stable, with a highly variable berm. It has been stable to growing since 2014, with lows in 2010 and 2011, and highs in 2016.

Summer KS02 = C (75). From 2010 to 2011, the profile gained sand slightly along its length. In 2012, it built a large berm. In 2013, the berm increased in elevation, and the profile gained sand near the pin. In 2014, the profile gained sand at its upper portions (landward of 20 m), but lost its berm and steepened in the foreshore. No data was collected in 2015. By 2016, the sand near the pin was lost, but the berm returned somewhat, though the steep foreshore remained. The MMHW moved slightly landward since 2010, but generally remained stable.

Kinney Shores Summary: KS02 showed stability and dune growth, but with a highly variable berm. **Overall Grade = C+ (79)**.

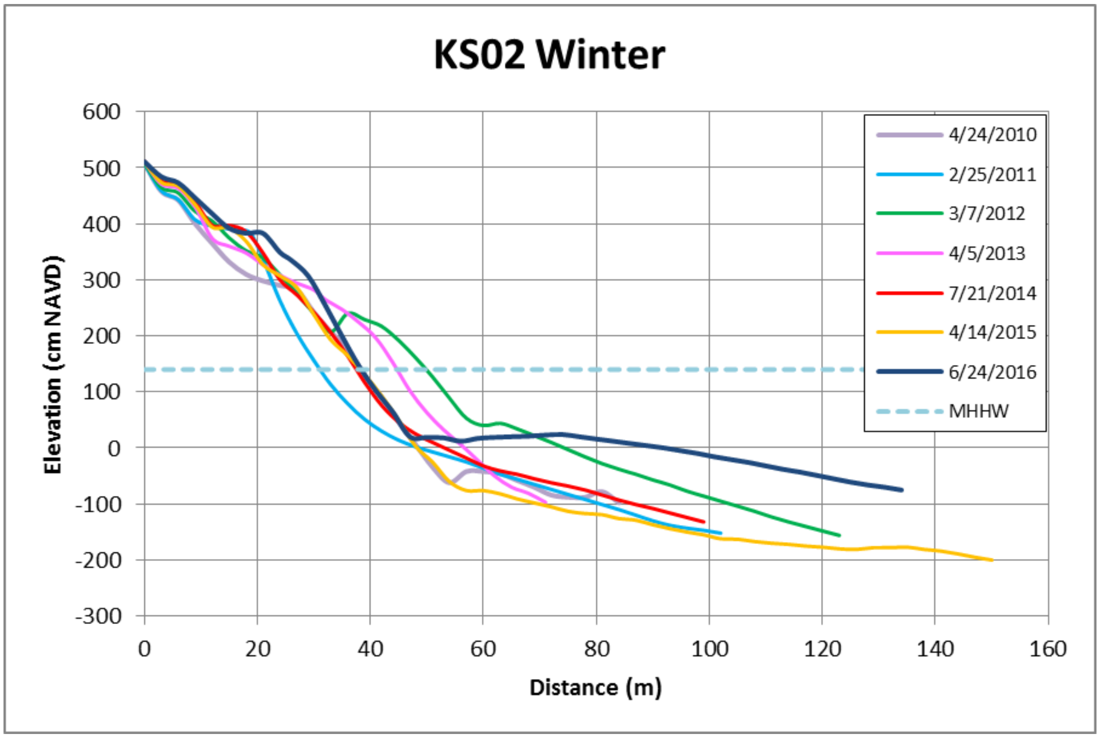

Figure 64. Winter beach profiles at KS02, Kinney Shores, Saco, ME.

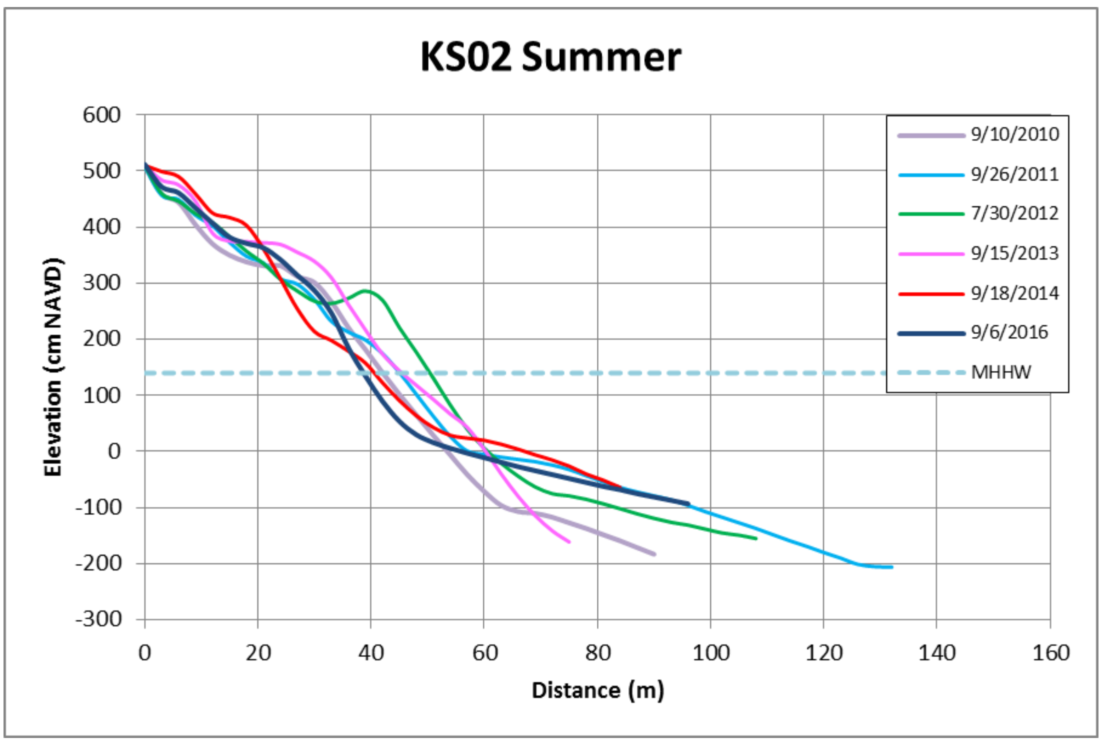

Figure 65. Summer beach profiles at KS02, Kinney Shores, Saco, ME.

Kinney Shores MBMAP Results

Results for the Kinney Shores MBMAP results will be presented in the next section in the context of the larger Saco beach shoreline.

Saco Beaches (Ferry Beach, Bayview, and Kinney Shores) MBMAP Score = **Stable to slightly erosive (C)**
Ferry Beach = Very erosive (D-)
Bayview = Somewhat accretive (B-)
Kinney Shores = Accretive (B)

MBMAP data is presented below for all of the Saco beaches, including Ferry Beach, Bayview and Kinney Shores (Figure 66). The shoreline was divided into three sections based on apparent trends:

Ferry Beach (transects 1339-1470), from the geotube at Camp Ellis north to the seawall at Bayview;
Bayview (transects 1488-1559), from the seawall north to just south of Outlook Avenue; and
Kinney Shores (transects 1560-1627), from just south of Outlook Avenue north to Goosefare Brook.

Along **Ferry Beach** the dunes were **very erosive** with a mean shoreline change rate of **-2.5 ft/yr (σ=2.0).** Pockets of dunes have eroded up to -4 to -6 ft/yr. Almost the entire section is erosive, aside from a small portion of dunes adjacent to the seawall in Bayview where dune restoration has occurred. Profiles FE01 to FE04 are located in this south section.

Along **Bayview** the dunes were **somewhat accretive** with a mean shoreline change rate of **+1.2 ft/yr (σ=1.2).** There is a small pocket of erosion (up to about -1 ft/yr from transects 1531-1540), otherwise the shoreline is accreting.

Kinney Shores the dunes were **accretive** with a mean shoreline change rate of **+1.7 ft/yr (σ=2.4).** Dunes in the Kinney Shores area accreted at up to +8 ft/yr. Profiles KS01 and KS02, which are no longer monitored, used to be in this stretch of shoreline.

Overall, the **Saco beaches** were **stable to slightly erosive** with a mean shoreline change rate of **-0.5 ft/yr (σ=2.8)**. This overall mean trend does not adequately describe the great difference in the trends as one progresses from Ferry Beach to Bayview and Kinney Shores. Clearly, the northern end of Saco beaches have been benefitting from erosion of the beaches and dunes in the southern end.

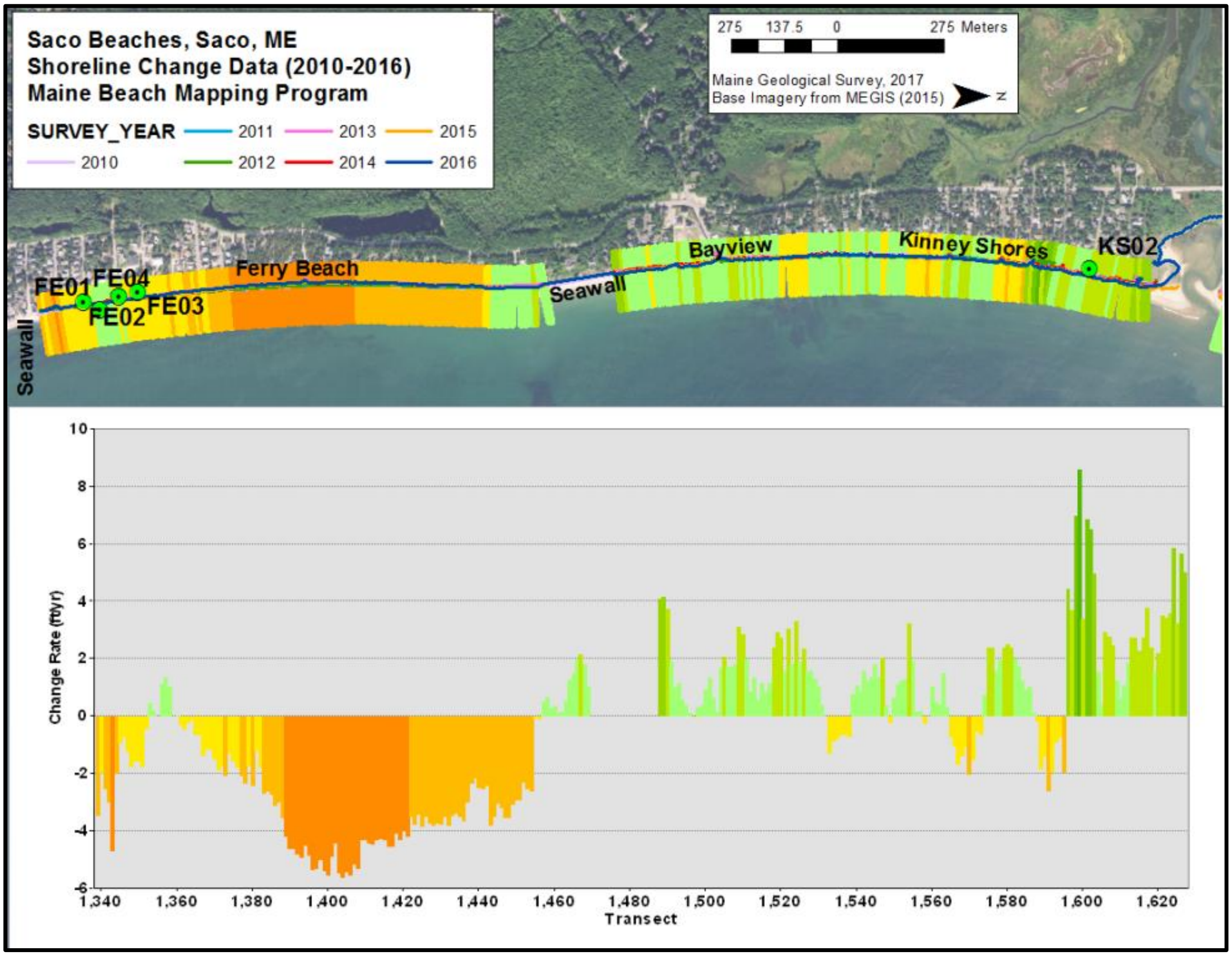

Figure 66. Shoreline change data (2010-2016) for Ferry Beach, Bayview, and Kinney Shores, Saco, ME.

West Grand Beach, Old Orchard Beach

West Grand Beach has three profiles (WG01, WG02 and WG03) surveyed starting in 2013. They are located centrally in the dunes between the pier and Goosefare Brook, with WG01 being the farthest north (Figure 67). See Figures 68 to 73.

Note: profiles from East Grand Beach are actually within Scarborough town boundaries and are discussed in the next section.

Figure 67. Location of beach profiles along West Grand Beach, Old Orchard Beach, ME.

Winter WG01 = B (85). The 2013 profile had a steep slope from the dune to a low, wide berm. There was no data in 2014. In 2015, the berm increased in elevation by about 80 cm, and moved inland. In 2016, the berm increased elevation more, and was stable. In 2017, it increased at the dune, at the berm, and remained markedly stable in the nearshore. The profile is stable to growing.

Summer WG01 = C+ (78). Profiles from 2013 to 2016 showed very little changes to the profile, with slight increases in the berm elevation. From 2013 to 2014, the MHHW line moved markedly inland (by about 10 m), but was stable in 2015 and grew slightly seaward in 2016.

Winter WG02 = C+ (78). Profiles from 2013 to 2017 (excluding 2014) showed a markedly stable berm and nearshore, especially from 2015-2017. The 2013 profile appears to be the most sand rich, but it was captured in June, which may explain this difference from the other profiles (collected in April and May).

Summer WG02 = C (75). Summer profiles from 2013 to 2016 showed a very stable berm, with little change. The seaward edge of the berm did recede slightly from 2013 to 2014, but retained its elevation. The berm was stable in 2015 and 2016. The MHHW moved about 10 m landward as a result of this recession.

Winter WG03 = B (85). From 2013 to 2015 (no data in 2014), the berm grew almost a full meter in elevation, and the MHHW moved seaward slightly. In 2016, the berm eroded at its seaward edge, but returned to its 2015 position in 2017. Since 2013, the profile was stable to accretive.

Summer WG03 = C (75). From 2013 to 2014, the berm grew in elevation and migrated seaward by about 5 m. This eroded back landward of the 2013 position in 2015, yet maintained its overall elevation. In 2016, the berm built slightly seaward, and maintained its elevation. From 2013 to 2016, the MHHW line moved inland about 10 m. Although the berm is maintaining its elevation and position the nearshore has migrated inland.

West Grand Beach Summary: Profiles along West Grand Beach have shown dune stability and growth and highly variable berms, which appear to be slowly eroding. All profiles were characterized by a very steep slope from the berm along the beach to the low-tide terrace. **Overall Grade: C+ (79)**.

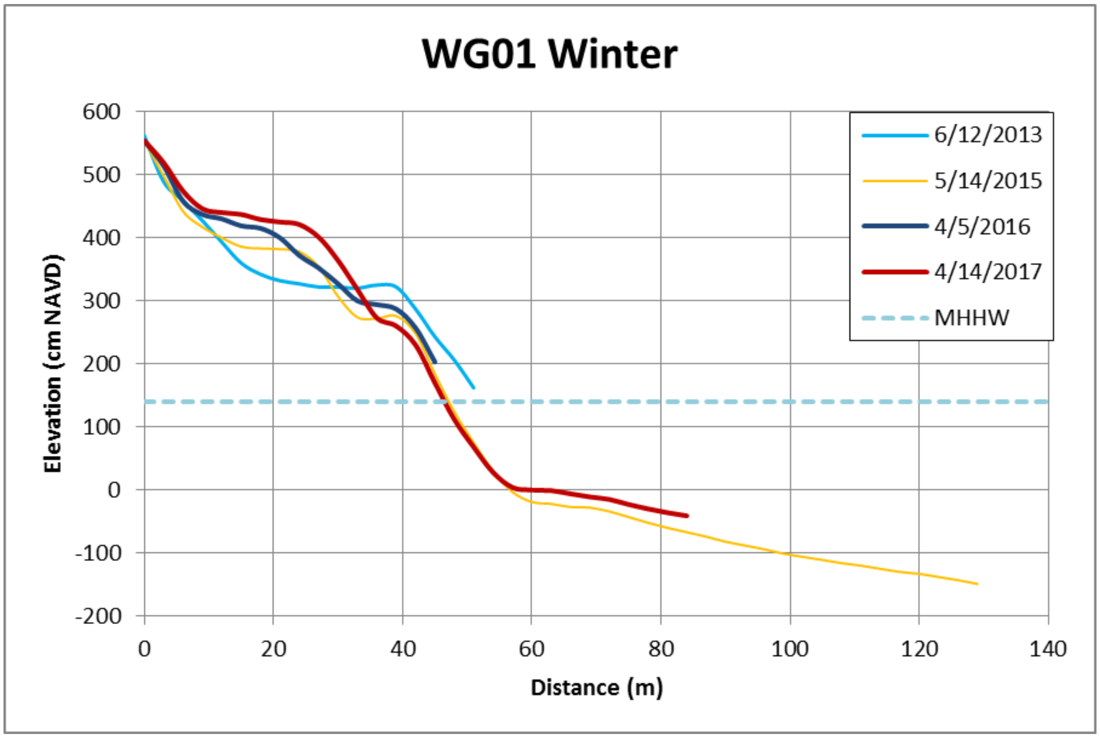

Figure 68. Winter beach profiles at WG01, West Grand Beach, Old Orchard Beach, ME.

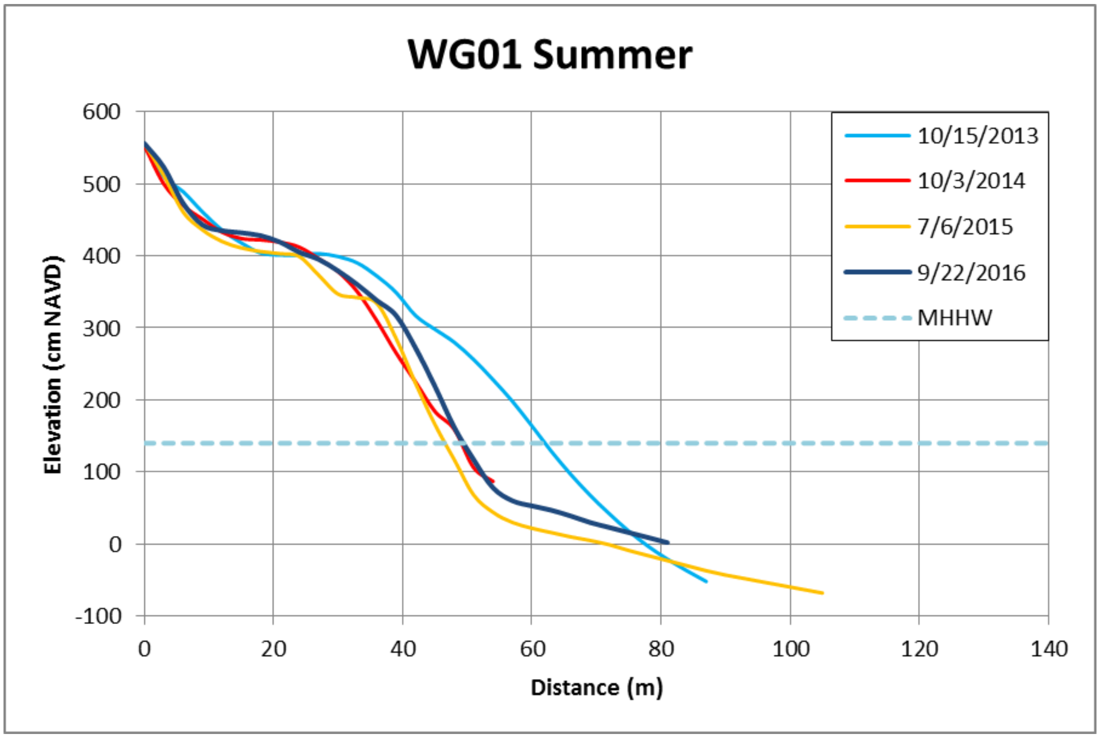

Figure 69. Summer beach profiles at WG01, West Grand Beach, Old Orchard Beach, ME.

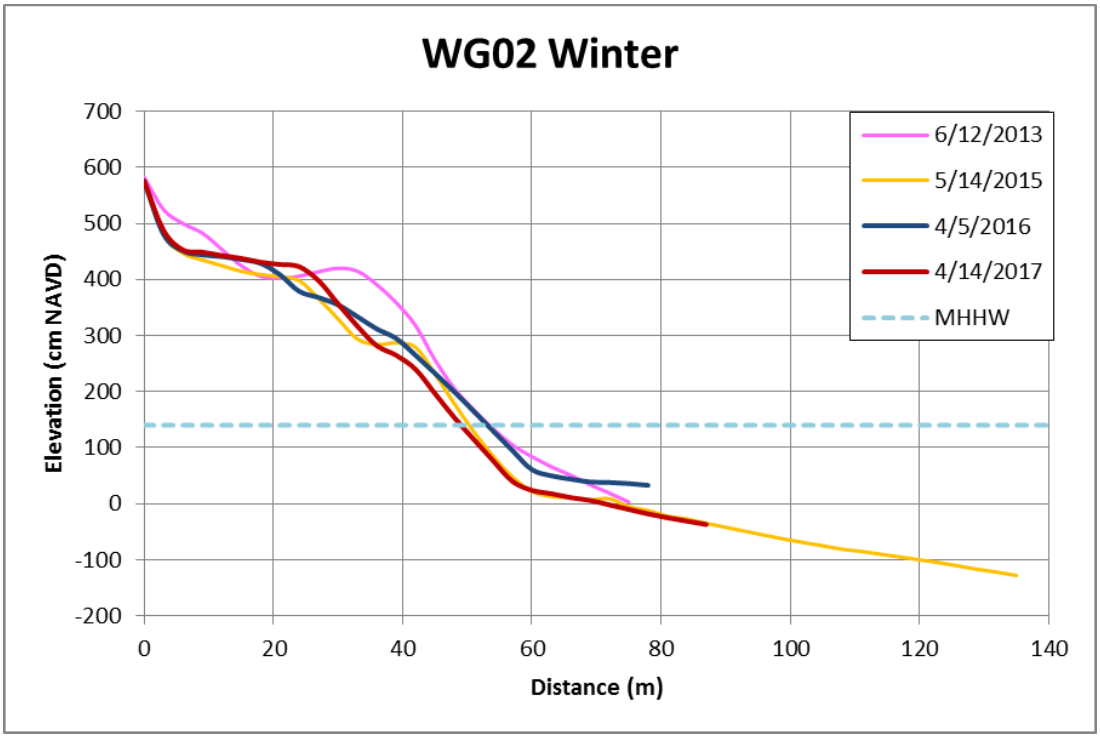

Figure 70. Winter beach profiles at WG02, West Grand Beach, Old Orchard Beach, ME.

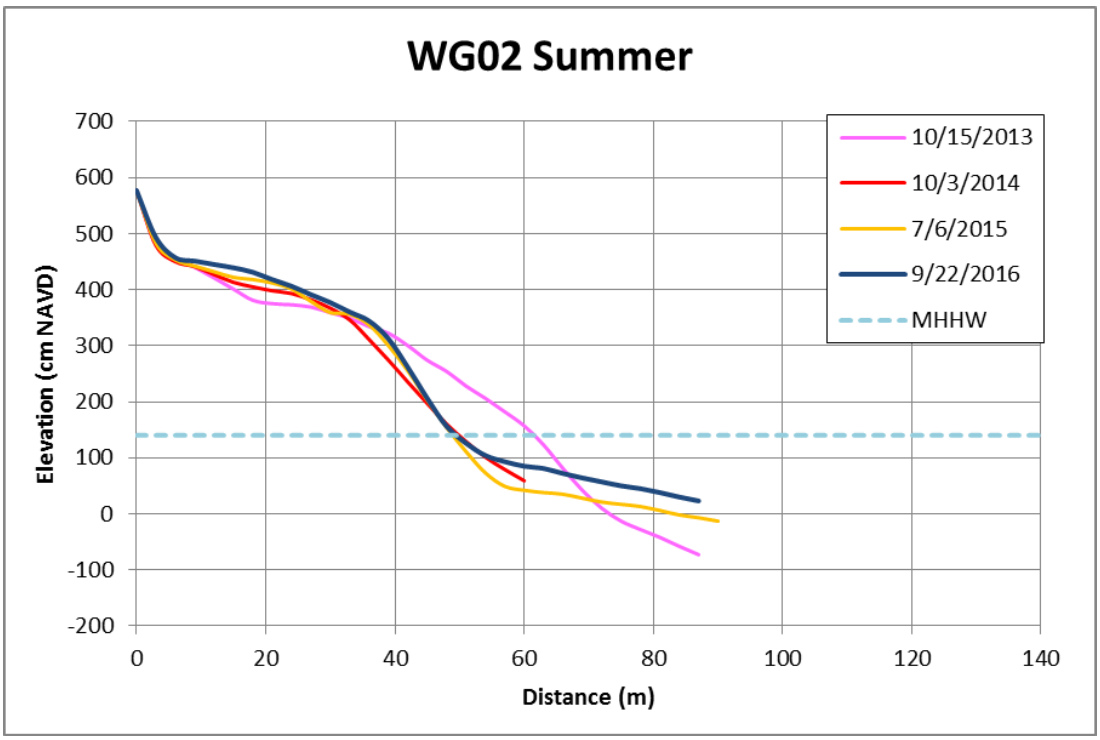

Figure 71. Summer beach profiles at WG02, West Grand Beach, Old Orchard Beach, ME.

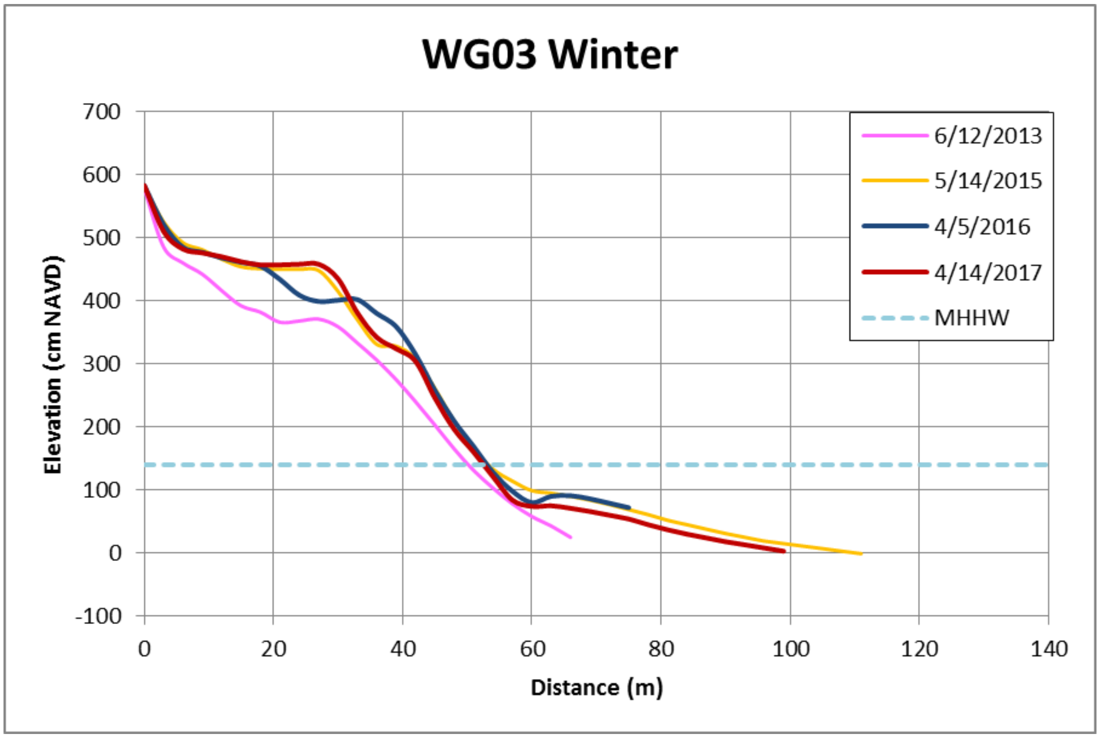

Figure 72. Winter beach profiles at WG03, West Grand Beach, Old Orchard Beach, ME.

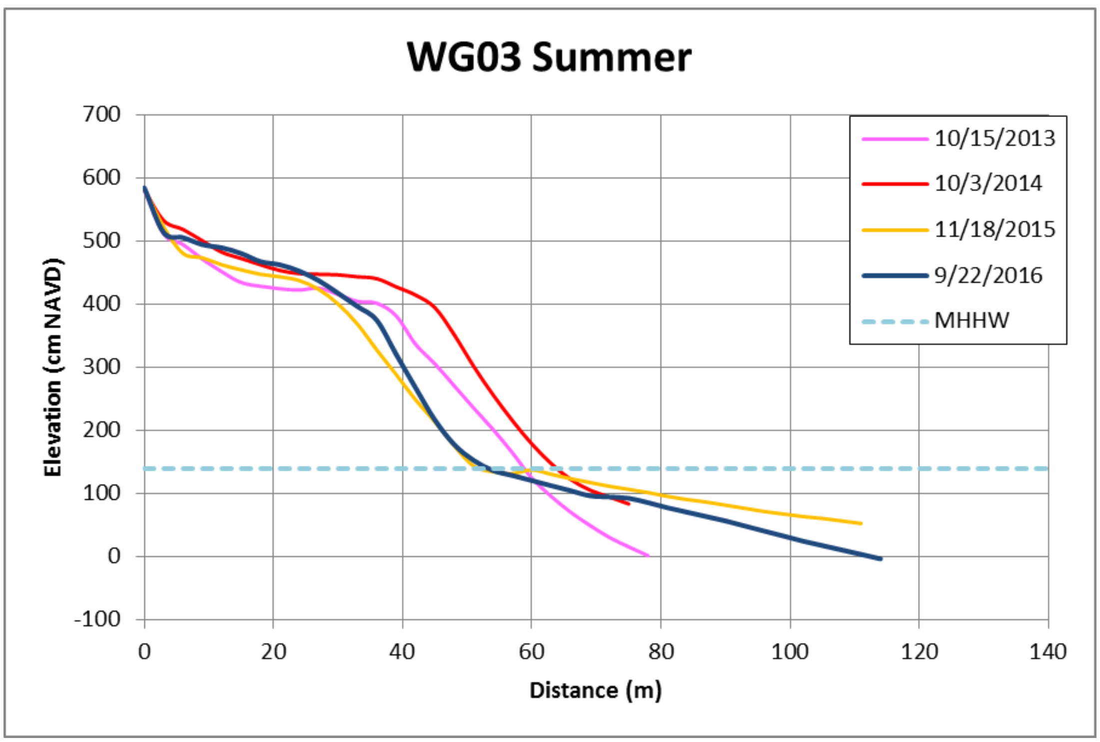

Figure 73. Summer beach profiles at WG03, West Grand Beach, Old Orchard Beach, ME.

Old Orchard Beach MBMAP Score = **Very Accretive (B+)**
Ocean Park = Accretive (B)
West Grand Beach = Slightly Accretive (C+)
East Grand Beach = Highly Accretive (A)

Old Orchard Beach is one of the largest beach systems in the state, stretching from Goosefare Brook in the south to the border with Pine Point, Scarborough in the north. The majority of the beach has vegetated dune except for a small portion in the northern end of the beach (Figure 74). From Goosefare Brook to The Pier is generally known as Ocean Park and West Grand Beach, while from The Pier north to near the Scarborough town line is known as East Grand Beach. The shoreline was divided into these three different sections based on shoreline change trends.

Along **Ocean Park** the (transects 1628-1736) the dunes were **accretive** with a mean shoreline change rate of **+1.6 ft/yr (σ=1.0).** The majority of the dunes were accreting, with slight erosion at the southern end of Ocean Park.

Along **West Grand Beach** (transects 1737-1852) the dunes were **slightly accretive** with a mean shoreline change rate of **+0.8 ft/yr (σ=1.0)**, with pockets of slight erosion and pockets of higher accretion. Erosion (up to -2.0 ft/yr) was concentrated along the central portion, from transects 1740-1780. Areas of higher accretion (up to over + 6 ft/yr) were within the dunes just south of the pier.

Along **East Grand Beach** (transects 1856-2047) the dunes were **highly accretive** with a mean shoreline change rate of **+4.1 ft/yr (σ=1.6)**. Dune accretion rates exceed 6 ft/yr along a stretch of the beach from transects 1960-1980. The dunes are all growing except for at the northern end of East Grand Beach, nearest the seawall.

Overall, the dunes along **Old Orchard Beach** beaches were **very accretive** with a mean shoreline change rate of **+2.5 ft/yr (σ=2.1)**.

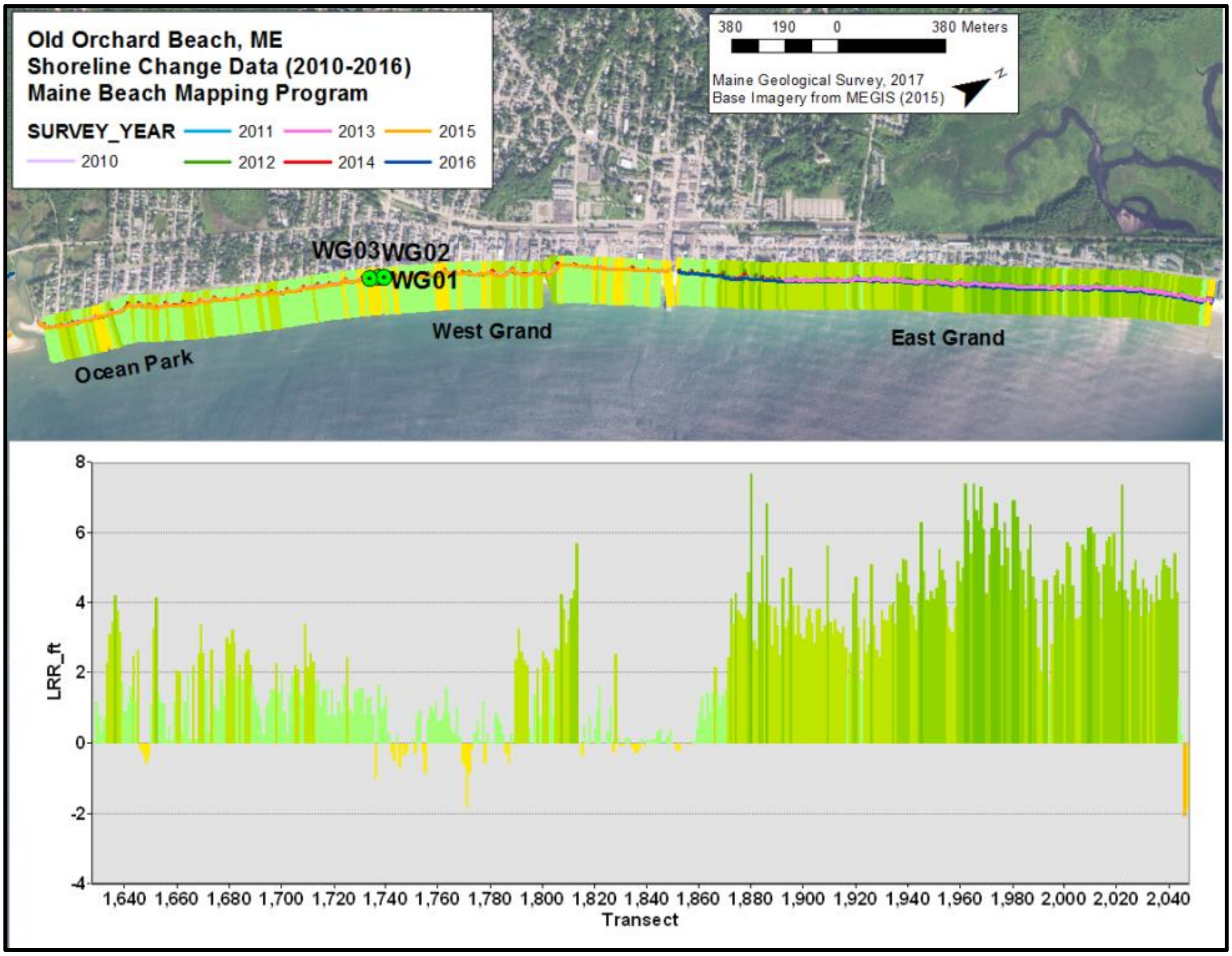

Figure 74. Shoreline change data (2010-2016) for Ocean Park, West Grand, and part of East Grand, Old Orchard Beach, ME.

East Grand Beach and Pine Point, Scarborough

Two profiles (EG01 and EG04, Figure 75) were available for analysis with data from 2010 to 2015; these profiles are actually located in Scarborough, not Old Orchard Beach, but are listed as being part of East Grand Beach. Figures 76 to 79 show seasonal changes.

Figure 75. Location of beach profiles along East Grand Beach, Scarborough, ME.

Winter EG01 = C (75). From 2010 to 2011, grew seaward at the dune and along the beach. By 2012, it eroded along the entire profile. No winter 2013 data was available. By 2014, the dune grew by 30 cm, and the berm and recovered from the 2012 shape, but not back to 2010 or 2011 levels. In 2015, the dune remained stable, and the berm moved slightly landward. In 2016, the dune moved slightly landward, and the berm receded slightly. The profile was stable in 2017. The MHHW moved about 15 m landward since 2010. The dune crest increased in elevation.

Summer EG01 = C (75). From 2010 to 2011, the summer profile showed growth at the dune, loss of the berm, and growth seaward of 60 m. No 2012 data existed. In 2013, the profile's dune continued to grow, the berm recovered slightly, but the profile deepened back to 2010 levels seaward of 60 m. By 2014, the dune grew slightly more, yet the berm was lost. Seaward of 60 m, the profile gained back to 2011 levels. Since 2014, the berm receded slightly, but the dune crest was markedly stable. The MHHW has not moved.

Winter EG04 = C+ (78). From 2010 to 2011, EG04 had nice growth of the dune, a stable berm, and growth of the beach. The 2012 profile showed significant erosion of the entire profile to its most erosive shape. No 2013 data existed. By 2014, the dune grew about 30 cm, and the berm and beach recovered well. 2015 saw additional dune growth, slight berm erosion, but gaining of elevation in the offshore back to 2011 levels. In 2016, the dune grew slightly, as did the rest of the profile. In 2017, the berm eroded slightly. The MHHW line has not moved significantly.

Summer EG04 = C (75). From 2010 to 2011, EG04 had dune growth, and berm loss. No 2012 data existed. By 2013, the dune grew more, but the berm and beach migrated landward, signifying erosion. Summer 2014 saw a stable dune, but additional loss of the dune toe/berm. 2015 and 2016 showed additional toe/berm loss, but dune growth. The beach seaward of the MHHW has changed very little.

Overall Summary: Although East Grand Beach profiles have shown berm loss and landward movement of the beach, they have also shown growth of dune crests, indicating an ample sediment supply to allow natural transgression to occur. **Overall Beach Grade: C (76)**.

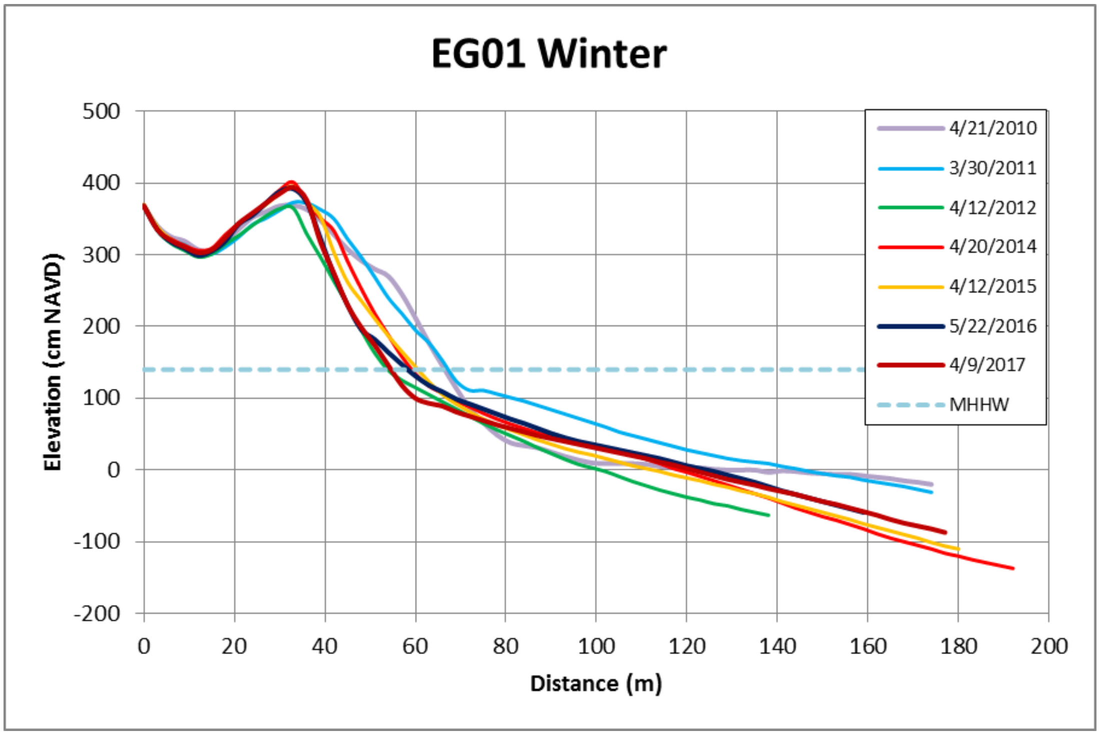

Figure 76. Winter beach profiles at EG01, East Grand Beach, Scarborough, ME..

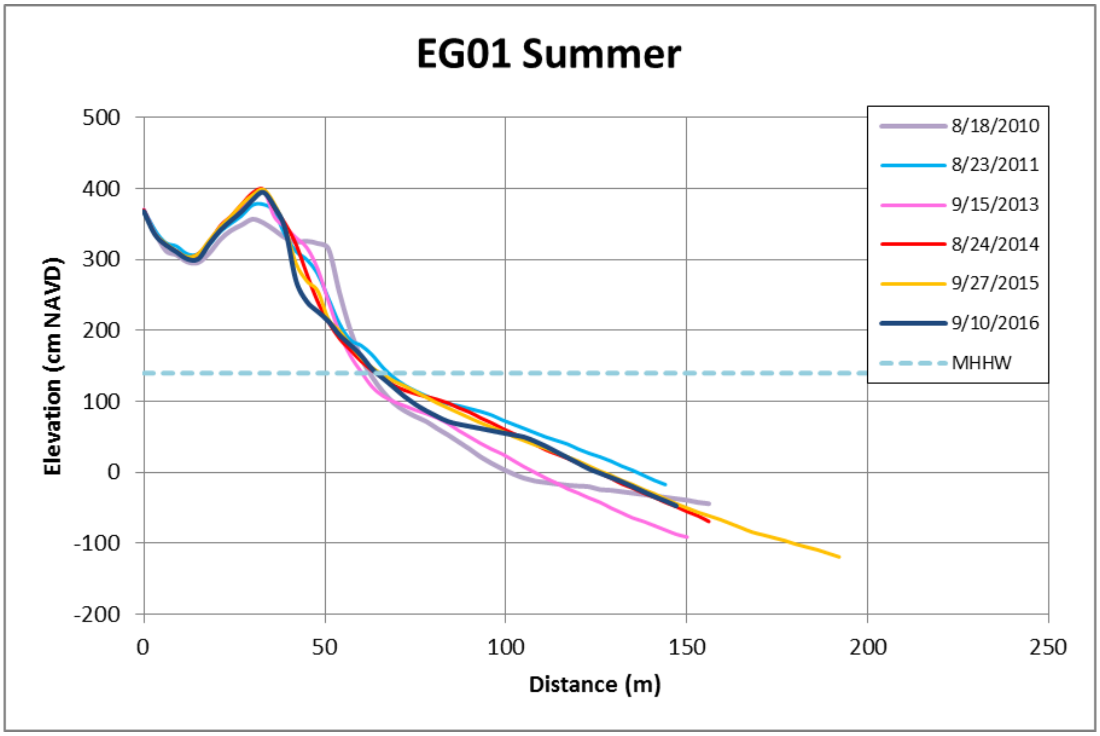

Figure 77. Summer beach profiles at EG01, East Grand Beach, Scarborough, ME.

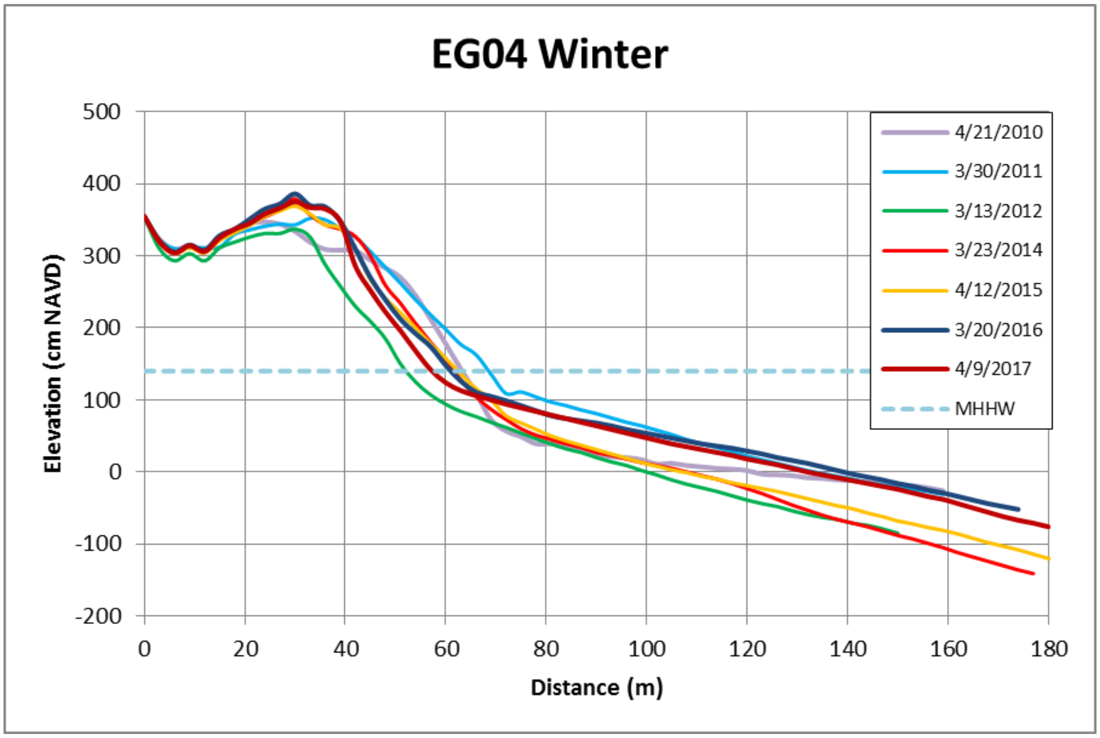

Figure 78. Winter beach profiles at EG04, East Grand Beach, Scarborough, ME.

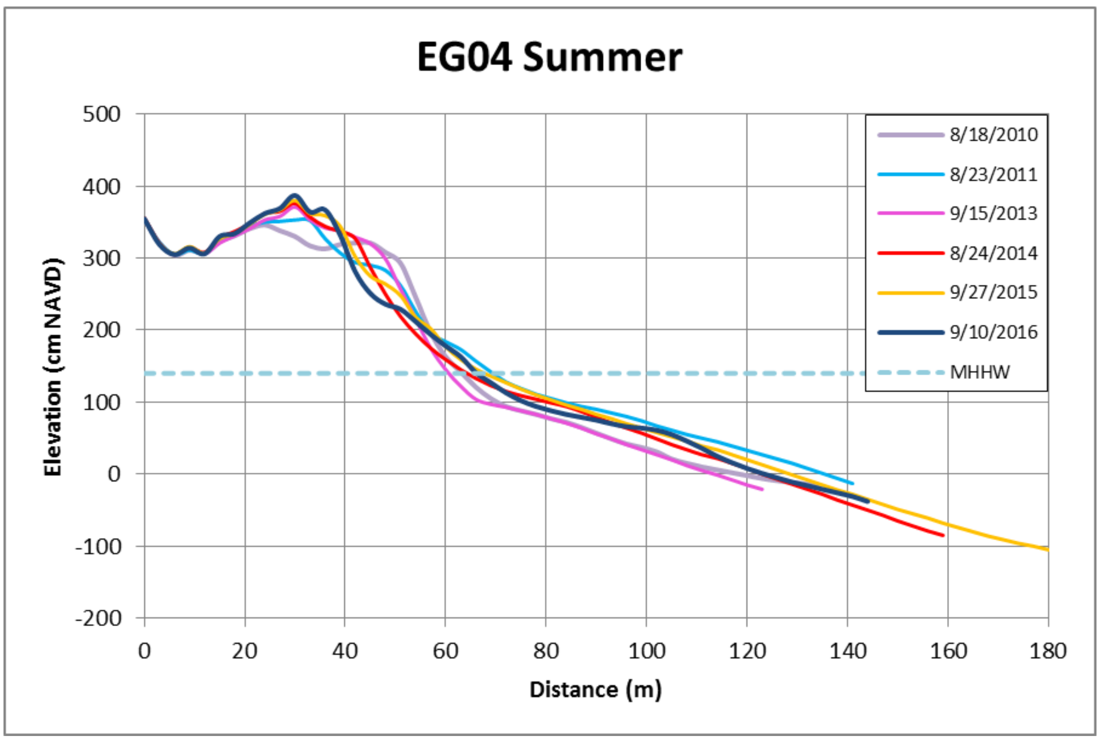

Figure 79. Summer beach profiles at EG04, East Grand Beach, Scarborough, ME.

<u>East Grand Beach and Pine Point MBMAP Score</u> = **Very Accretive (B+)**
East Grand Beach/Pine Point Score = Highly Accretive (A)
Pine Point Score = Somewhat Erosive (D+)

Almost this entire stretch of the shoreline is vegetated, stretching from a seawall in East Grand Beach to the west, east to the jetty at the Scarborough River (Figure 80). Based on observed shoreline change data, the shoreline was divided into two sections: East Grand Beach/Pine Point and Pine Point. The nodal point between the two sections is where the shoreline begins to curve to the east, just south of Hurd Park.

The **East Grand Beach/Pine Point section** (transects 2065-2267) stretches from a seawall northeast to south of Hurd Park. Along this stretch, the shoreline was **highly accretive** with a mean shoreline change rate of **+4.5 ft/yr (σ=2.3)**, with pockets of dune growth that exceeded +8 to +10 ft/yr. EG01 and EG04 are located in an area where the dunes appear to be growing at about +4 ft/yr.

The **Pine Point section** (transects 2268-2348) stretches from just south of Hurd Park east to the Scarborough River jetty. Along this stretch, the dunes were **somewhat erosive** with a mean shoreline change rate of **-1.3 ft/yr (σ=2.8)**. There is a segment of shoreline within this stretch with dune erosion rates on the order of -4 to -6 ft/yr (transects 2310-2330). Nearest the jetty, the dunes were very accretive to highly accretive, with dune growth averaging +2 to +4 ft/yr.

Overall, the dunes along **East Grand Beach and Pine Point Beach** were **very accretive** with a mean shoreline change rate of **+2.9 ft/yr (σ=3.6)**.

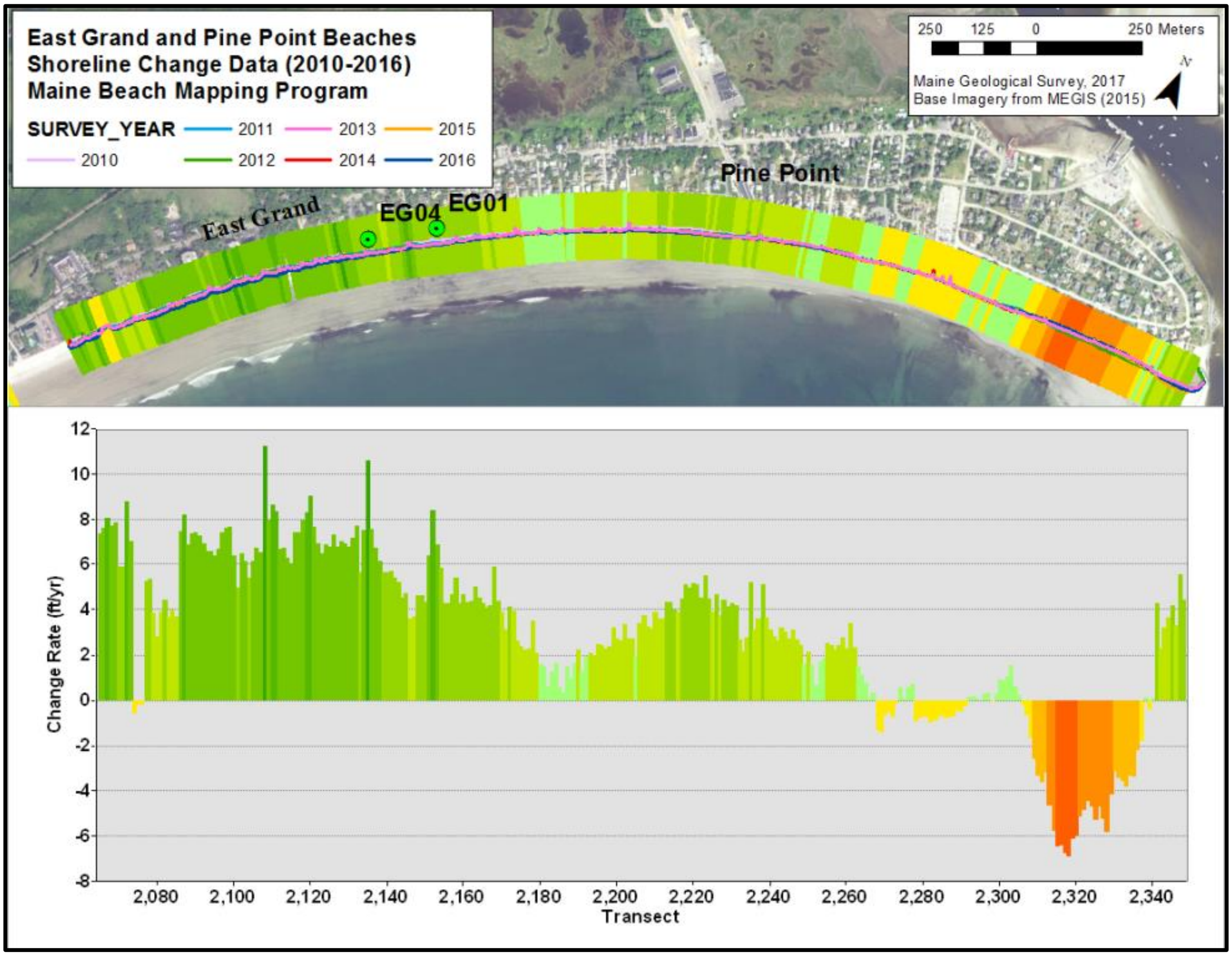

Figure 80. Shoreline change data (2010-2016) for East Grand and Pine Point Beaches, Old Orchard Beach and Scarborough, ME.

Ferry and Western Beaches, Scarborough

Ferry and Western Beaches are not part of the SMPP.

Ferry Beach and Western Beach MBMAP Score = Stable (C)
Ferry Beach = Somewhat accretive (B-)
Western Beach = Slightly erosive (C-)

Ferry and Western Beaches were divided into two separate sections of shoreline (Figure 81):

Ferry Beach (transects 2508-2601), located on the inside of and eastern bank of the Scarborough River; and
Western Beach (transects 2602-2705), located along the Prouts Neck Country Club.

The two are separated by a bedrock outcrop.

Along **Ferry Beach** the dunes were **somewhat accretive** with a mean shoreline change rate of **+1.3 ft/yr (σ=2.4)**. Along the stretch of shoreline to the north, the shoreline was generally stable to slightly accretive. East of this, the shoreline eroded slightly (less than -1 ft/yr), and then became accretive. There is a pocket of extensive dune growth (transects 2585-2595) where the shoreline accreted at over +8 to +10 ft/yr. Immediately adjacent to this (next to the outcrop), the shoreline eroded at around -4 ft/yr.

Along **Western Beach** the dunes were **slightly erosive** with a mean shoreline change rate of **-0.9 ft/yr (σ=2.7)**. At the western end of Western Beach, the dunes grew seaward between +2 and +4 ft/yr. Along the central stretch of Western Beach, the dunes eroded up to around -4 to -6 ft/yr – this was the stretch of shoreline that received beach nourishment in 2015, which built up the dunes, but did not result in enough seaward movement of the dune line to offset the years of erosion between 2010 and 2015. Future shoreline surveys will show how the beach nourishment and dune restoration activities may influence the dune erosion rates.

Overall, the dunes along **Ferry and Western Beach** were **stable** with a mean shoreline change rate of **+0.1 ft/yr (σ=2.8)**. Again, note that this stability is due to the offsetting trends of relative growth at Ferry Beach, and erosion at Western Beach.

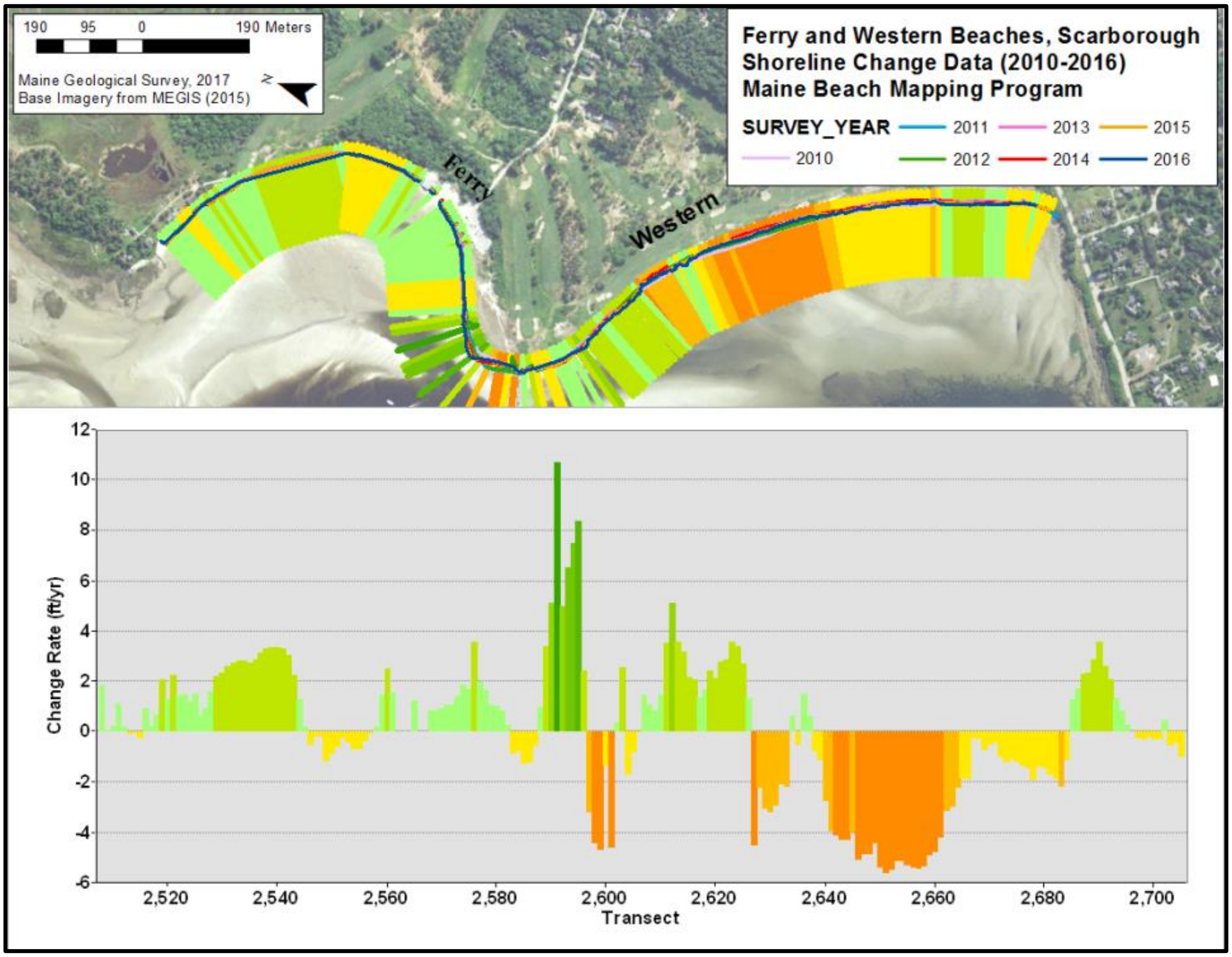

Figure 81. Shoreline change data (2010-2016) for Ferry and Western Beaches, Scarborough, ME.

Scarborough Beach, Scarborough

Scarborough Beach is not part of the SMBPP.

Scarborough Beach MBMAP Score = **Accretive (B)**
West = Very accretive (B+)
East = Stable (C)

Scarborough Beach is a naturally vegetated shoreline along its majority, except for a stretch of seawall at its southwestern end (Figure 82). The shoreline was divided into two sections based on shoreline change trends: west and east.

The **west section** (transects 2349-2460) stretches from the seawall north to just south of the "flagpole" and was **very accretive** with a mean shoreline change rate of **+2.5 ft/yr (σ=1.5)**. It did have a pocket of erosive dunes adjacent to the end of the seawalls along the southwestern part of the section. This section includes stretches of dune along the State Park that have grown at rates of +3 to almost +6 ft/yr.

The **east section** (transects 2461-2507) stretches from the flagpole to the rocky headland at the northern end of the beach and was **stable** with a mean shoreline change rate of **0.0 ft/yr (σ=1.0)**. However, it did have a stretch of erosive shoreline (up to -2 ft/yr) from transects 2461 to 2480. This was balanced out by dune growth (up to +2 ft/yr) from transects 2481 to the rocky headland.

Overall, **Scarborough Beach** was **accretive** with a mean shoreline change rate of **+1.8 ft/yr (σ=1.8)**.

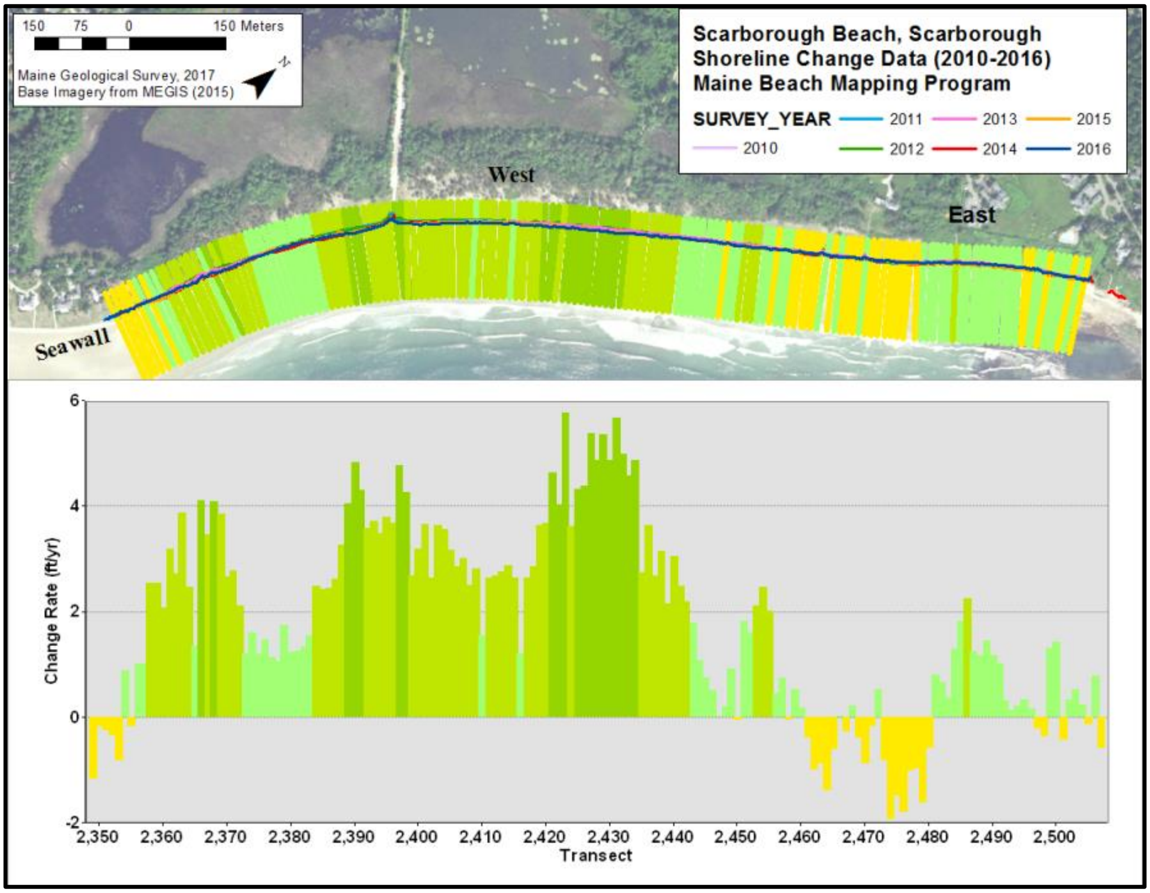

Figure 82. Shoreline change data (2010-2016) for Scarborough Beach, Scarborough, ME.

Higgins Beach, Scarborough

Three beach profiles (HI01, HI02, and HI03, Figure 83) were available for analysis. HI01(and HI01B, a backup point) are located in the rip-rap seawall along Bayview Ave. HI02 is located at a small seawall along the central portion of the beach, and HI03 is located in a wall landward of a natural dune area closer to the Spurwink River. Figures 84 to 89 show seasonal changes.

Figure 83. Location of beach profiles along Higgins Beach, Scarborough, ME.

Winter HI01 = B (85). The 2010 profile was the lowest, most erosive shape, likely eroding down to a historical erosional surface (such as peat). By 2011, it gained about 100 cm of sand vertically along its length. In 2012, this trend continued, with additional growth on the order of 20-40 cm along most of the profile; however, nearest the wall, the beach scoured and lowered. In 2013, HI01 eroded to within about 50 cm of the 2010 shape, and was steeper nearest the wall. Since 2014, the profile has remained quite stable, retaining a very similar shape adjacent to the wall, across the berm, and into the nearshore. The MHHW line was stable since it contacts the wall.

Summer HI01 = C+ (78). 2010 had a concave, erosive shape, with a steep sloped berm at the seawall. In 2011, it had minimal recovery, with slight elevation gains along the profile. 2012 had a large gain of sand nearest the wall, with a well-defined trough near the 40 m mark and a swash bar seaward of this. In 2013, it gained sand nearest the wall, but eroded to 2010 levels from 20 m seaward. In 2014, it lost sand at the wall, and gained slightly at the beach. In 2015, the profile gained sediment along its length, most notably against the wall. The profile remained stable in 2016 and gained additional sand near the wall. 2016 and 2012 were its best shapes.

Winter HI02 = C+ (78). 2010 was the most erosive shape. Slight recovery occurred in 2011. In 2012, HI02 lost sand at the seawall, but had a shallower slope with higher elevations on the beach. In 2013, it had a higher sand elevation at the wall; however, it eroded to near the 2010 shape out to about 40 meters. 2014 had the most sand rich profile, gaining all along the profile. 2015 had some loss adjacent to the wall, stability in the berm, and some loss seaward of 20 m. 2016 showed additional loss adjacent to the wall, berm, and along the profile. 2017 showed more loss at the wall, but seaward of 40 m, the highest profile. The MHHW moved landward about 8 m from 2010 to 2017.

Summer HI02 = C (75). The summer 2010 profile showed a steep shorefront, low berm, and a steep profile into the offshore. By 2011, the profile recovered well, with substantial amounts of sand gain and some of the highest elevations, especially within 30 m of the wall. By 2012, it eroded at the wall, lowering back to the 2010 level out to about 30 m. Seaward of this, out to about 80 m, a large bar formed, indicating a gain in sand; however, seaward of this bar, it lost elevation. In 2013, HI02 eroded significantly within 40 m of the wall, to below 2010 levels by 50 to 60 cm. In 2014, it steepened more nearest the wall, gained some sand from about 10 m to well offshore. In 2015, it gained sand closer to the wall, but lost slightly seaward of 25 m. In 2016, it gained additional sand at the berm, but lowered seaward of 40 m. The MHHW was stable since it comes into contact with the wall.

Winter HI03 = D (65). HI03 is influenced by the Spurwink River and undergoes extensive erosion and accretion. In 2010, it had several dune crests, and large volumes of sand seaward of the 40 m mark. By 2011, the dunes grew farther seaward – indicating accretion, but the profile steepened and lost elevation seaward of 40 m. In 2012, HI03 extensively eroded, resulting in scarping of the dune and a steep, concave and erosive profile. The 2013 profile had more dune loss, but a substantial gain in sediment at 10 m seaward. In 2014, dunes had rebuilt seaward substantially, indicating accretion. However, by 2015, this had all eroded back to near or below 2013 elevations. In 2016, the entire dune eroded, and the profile at the pin lowered by about 60 cm. In 2017, some elevation returned near the pin and along the profile, but the dune remained eroded. The MHHW moved approximately 10 m landward from 2010 to 2017. This profile is **highly dynamic and can undergo massive changes in a short time due to inlet dynamics.** MBMAP data discussed in the following pages showed these changes near HI03 very well.

Summer HI03 = D (65). From 2010 to 2011, HI03 maintained its elevation and overall shape, but eroded landward about 10 m. In 2012, the profile extensively eroded, resulting in significant loss of the whole dune system, and a steep, concave shape. In 2013, the dune system built out back to and seaward of the 2010 shoreline. By 2014, the dune had receded landward of the 2011 position. In 2015, the beach and dune eroded to near 2012 lows. In 2016, the dune returned and built seaward, about halfway between the low in 2012 and the high in 2013. From 2010 to 2016, the MHHW moved about 35 meters landward.

Overall Summary: Winter HI01 and HI02 have recovered generally well from extremely erosive shapes in 2010, and slightly less so in 2013. Changes in inlet dynamics at the Spurwink River have eroded large sections of beach and dune in the vicinity of HI03, though some recovery from lows in 2010 and 2012 did occur. **Higgins Beach Overall Grade: C (74)**.

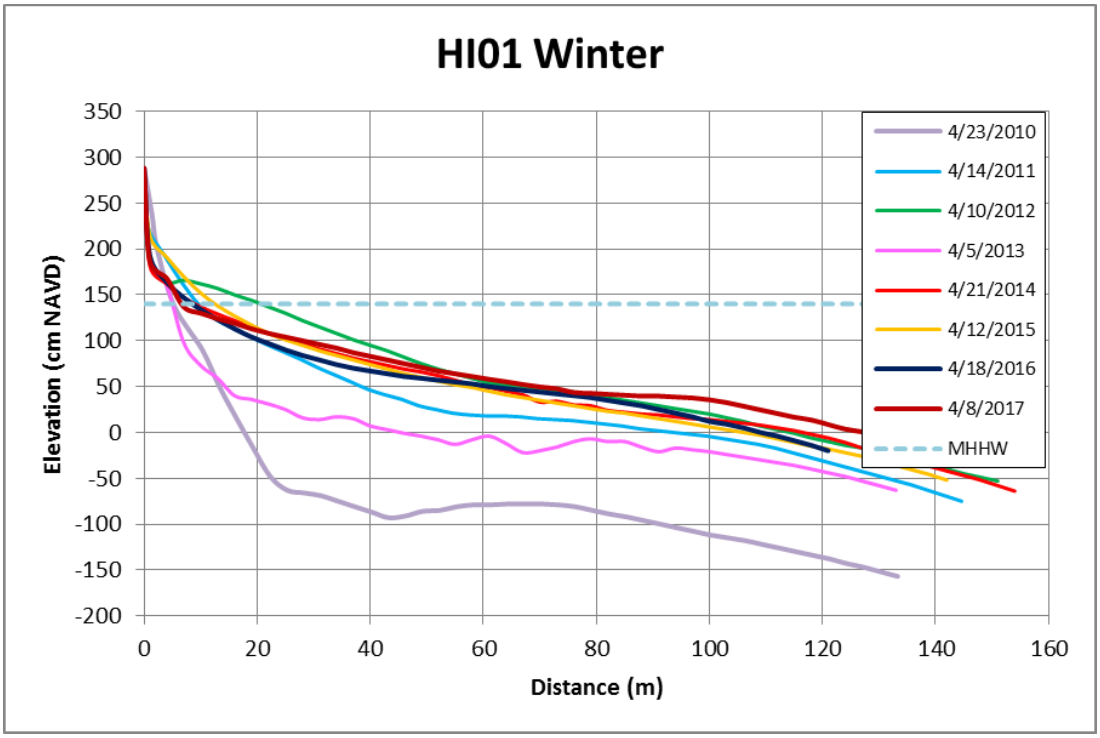

Figure 84. Winter beach profiles at HI01, Higgins Beach, Scarborough, ME.

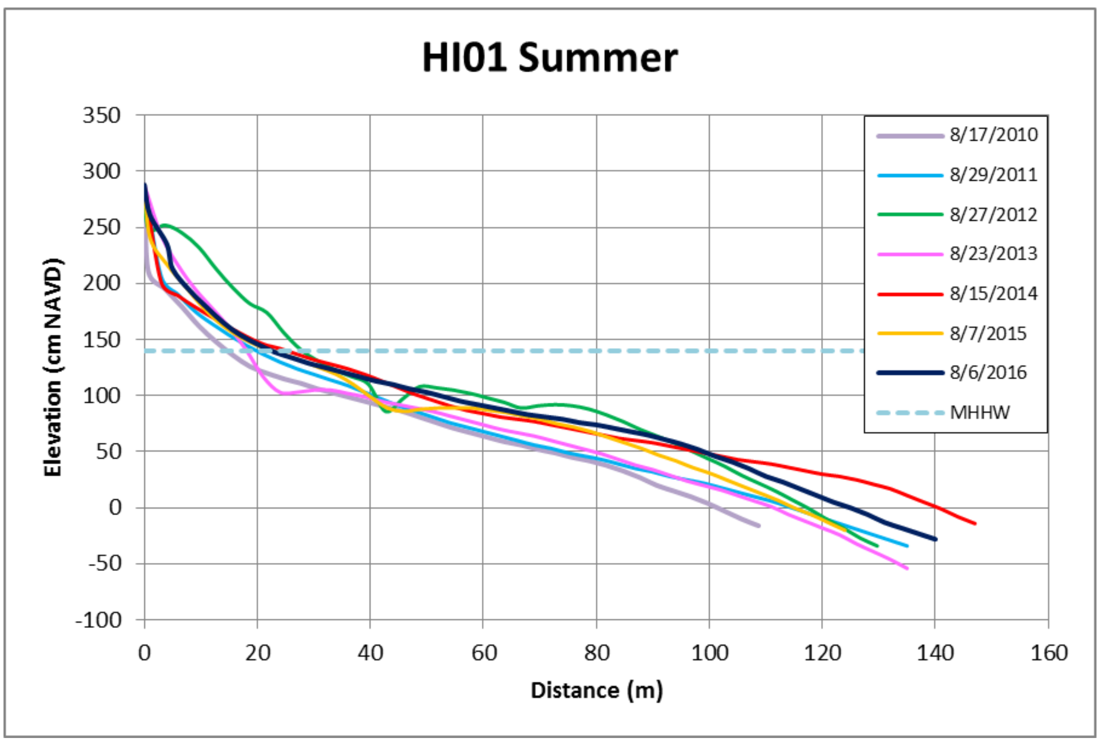

Figure 85. Summer beach profiles at HI01, Higgins Beach, Scarborough, ME.

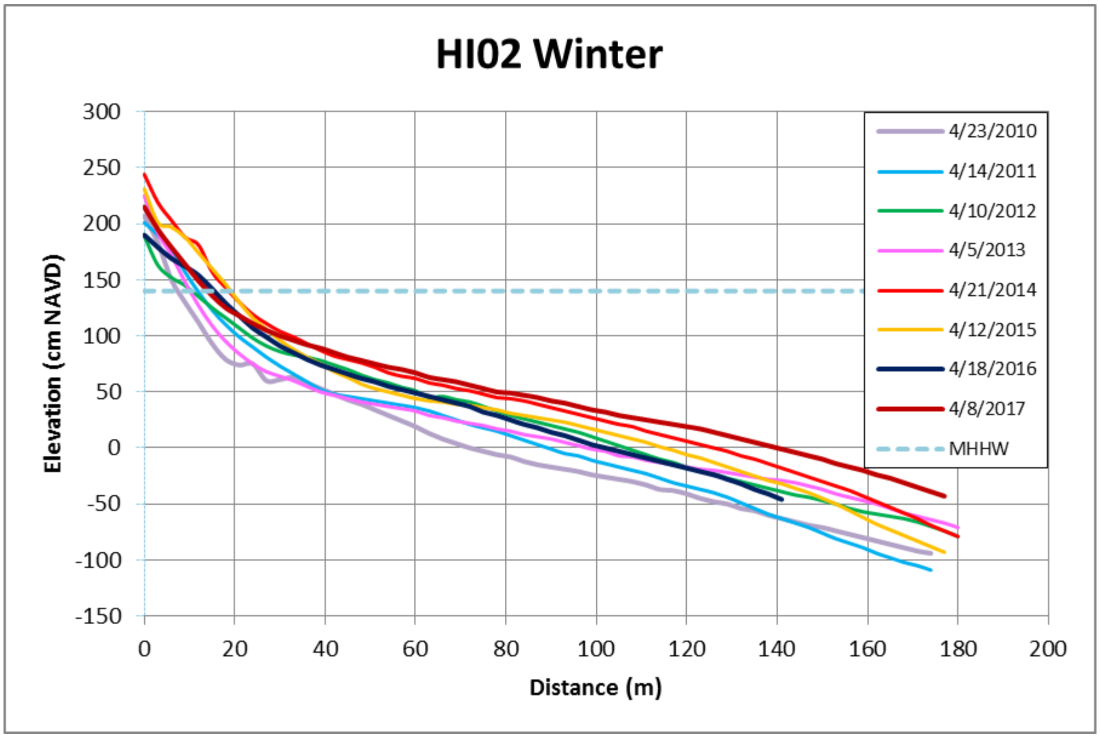

Figure 86. Winter beach profiles at HI02, Higgins Beach, Scarborough, ME.

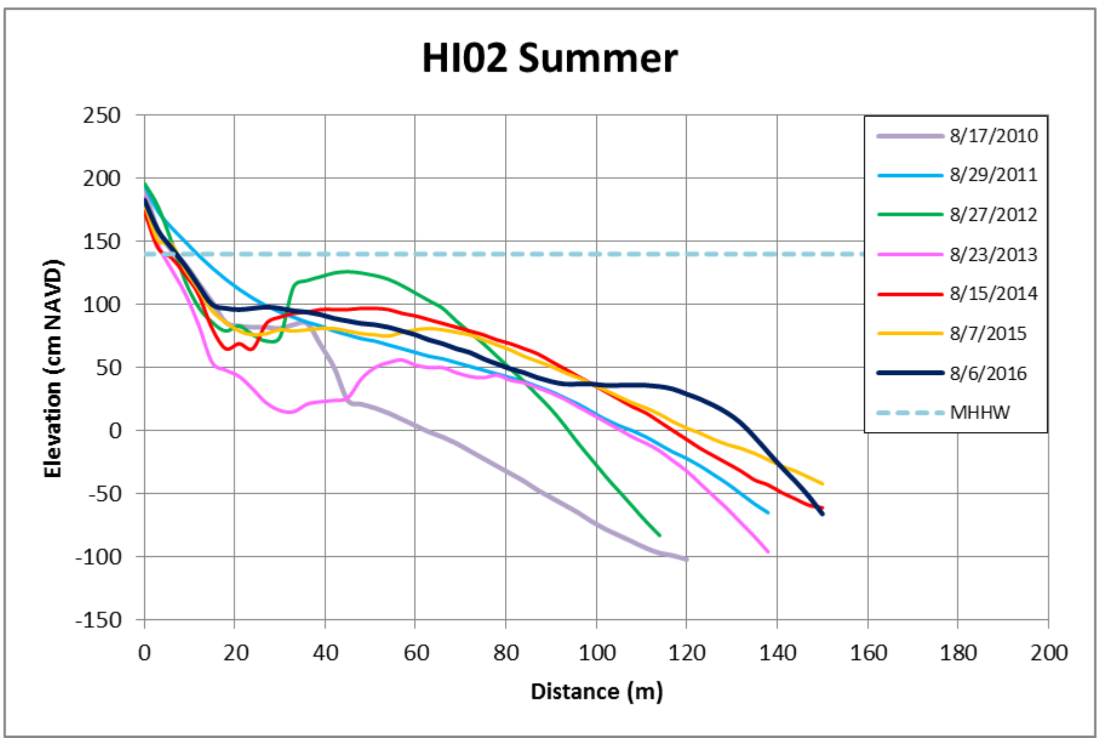

Figure 87. Summer beach profiles at HI02, Higgins Beach, Scarborough, ME.

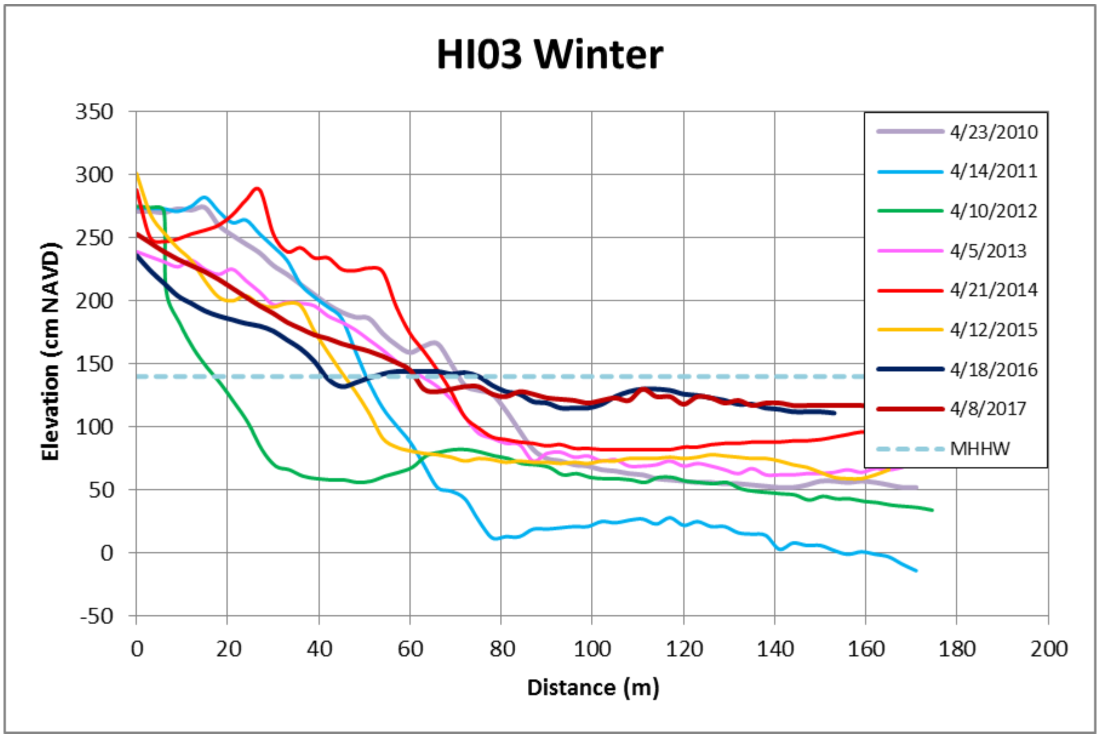

Figure 88. Winter beach profiles at HI03, Higgins Beach, Scarborough, ME.

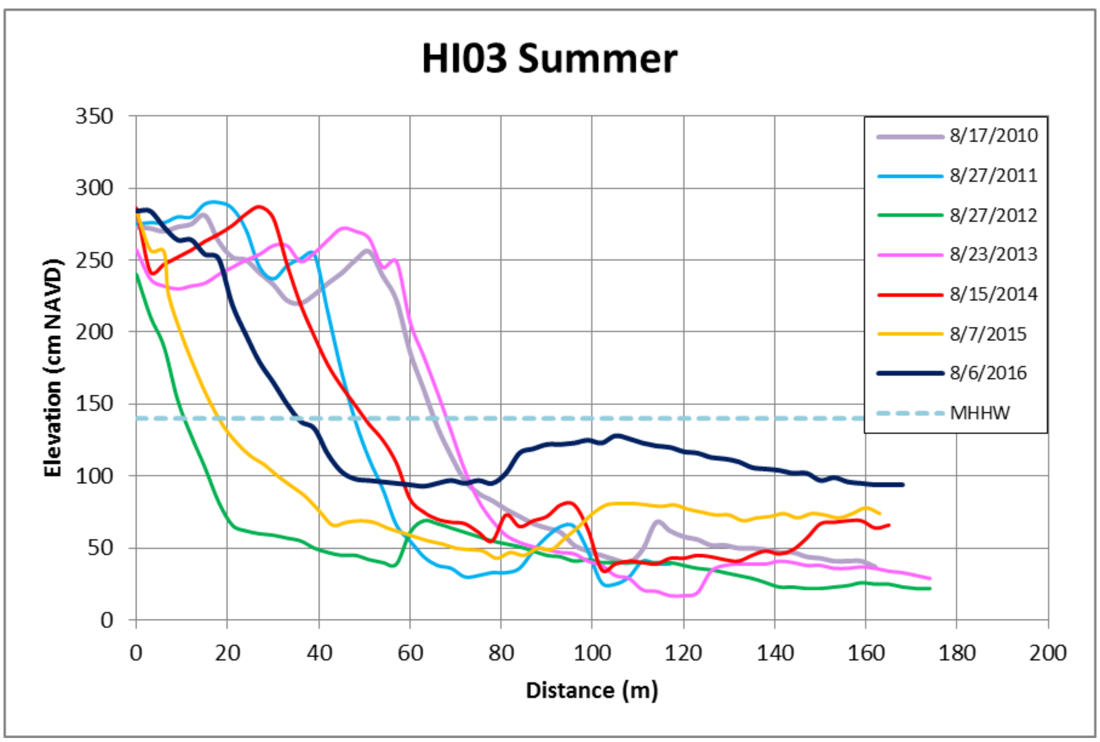

Figure 89. Summer beach profiles at HI03, Higgins Beach, Scarborough, ME.

Higgins Beach MBMAP Score = **Extremely Erosive (F)**
West = Somewhat erosive (D+)
East = Extremely erosive (F-)

Only a small section of the main Higgins Beach shoreline is naturally vegetated and not fronted by seawalls. The majority of the natural shoreline is in the eastern portion of the beach, nearest to the Spurwink River. The beach was divided into two sections: west and east (Figure 90).

Dunes along the **west section** (transects 2843-2934), a small section of natural dune with seawalls to the east and west, were **somewhat erosive** with a mean shoreline change rate of **-1.1 ft/yr (σ=1.0)**. Profile HI01 is located just to the west of this stretch of natural shoreline, but in the seawall.

The **east section** (transects 2907-2934), along natural dunes that stretch from the wooden crib seawall to the Spurwink River, was **extremely erosive** with a mean shoreline change rate of **-14.1 ft/yr (σ=4.6)**. Profile HI03 is located within this section, in a stretch of beach where the dunes have eroded at rates of -8 to -10 ft/yr. Erosion gets even worse (to -15 to -20 ft/yr) closer to the Spurwink River.

Overall, **Higgins Beach** was **extremely erosive** with a mean shoreline change rate of **-10.9ft/yr (σ=6.8)**. Note that this mean value is *highly influenced* by the extremely negative shoreline changes near the Spurwink River.

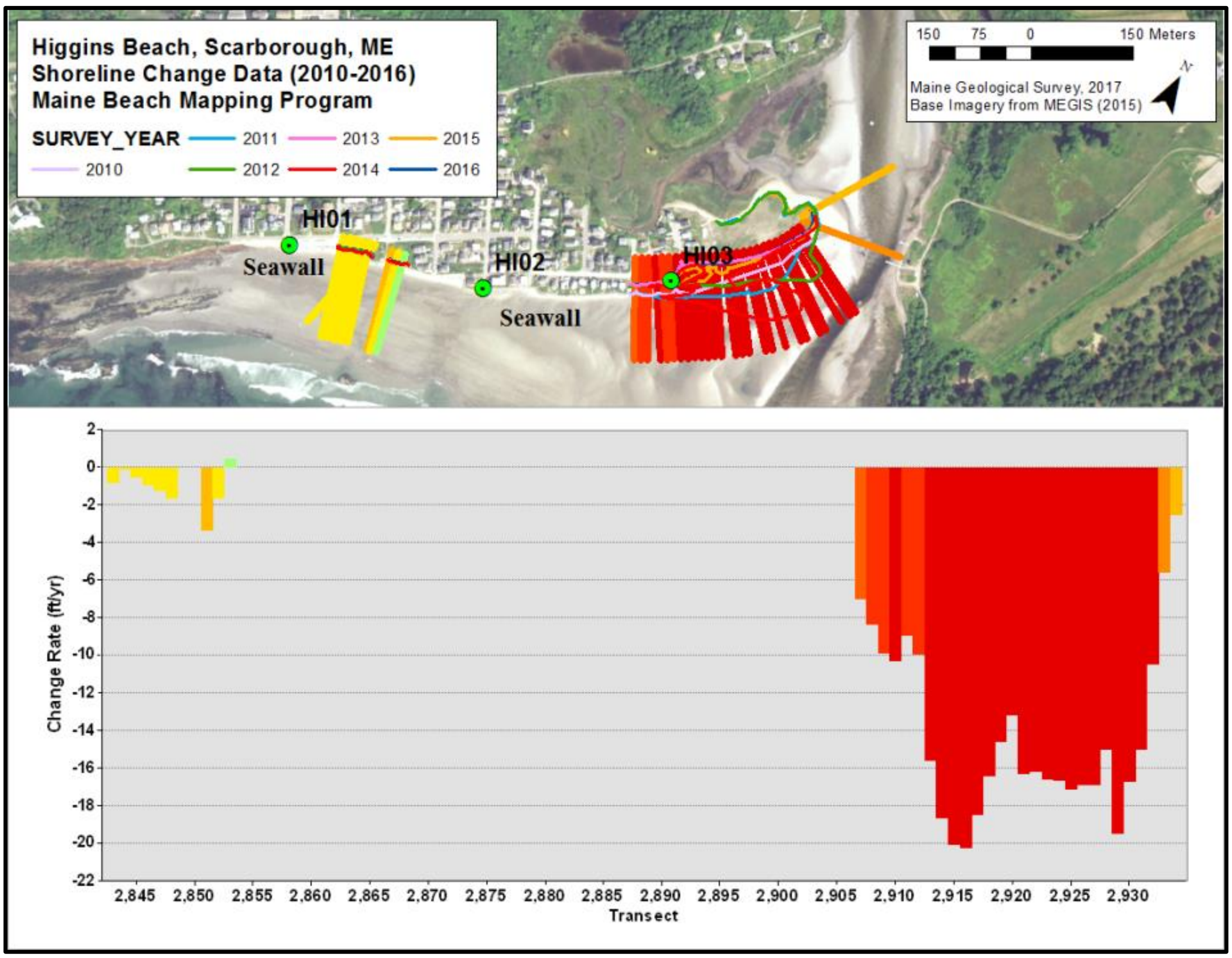

Figure 90. Shoreline change data (2010-2016) for Higgins Beach, Scarborough, ME.

Crescent Beach, Cape Elizabeth

Crescent Beach is not part of the SMBPP.

Crescent Beach MBMAP Score = **Stable (C)**
West = Slightly erosive (C-)
Central = Accretive (B)
East = Stable to slightly erosive (C)

Crescent Beach is an approximate 1.3 km long pocket beach at Crescent Beach State Park (Figure 91). Crescent Beach has two swashes, small inlets, which do influence beach shapes nearby. Based on shoreline change trends, the beach can be divided into three distinct sections: west, central, and east.

The **west section** (transects 2706-2752) extends from the headland to the west to just east of the first swash and was **slightly erosive** with a mean shoreline change rate of **-0.8 ft/yr (σ=0.9).** The more erosive segments of this section, which eroded up to almost -3 ft/yr, were adjacent to the swash.

The **central section** (transects 2753-2814) extends from the western swash to the east to near the easternmost dune walkover and was **accretive** with a mean shoreline change rate of **+1.6 ft/yr (σ=1.7)**. This section did have highly accretive (+ 4 ft/yr) sections, and erosive (-2.5 ft/yr) segments, adjacent to the eastern swash.

The **east section** (transects 2815-2842) extends from near the easternmost dune walkover to the vehicle access at the eastern end of the beach and was **stable to slightly erosive** with a mean shoreline change rate of **-0.5 ft.yr (σ=0.7)**.

Overall, **Crescent Beach** was **stable** with a mean shoreline change rate of **+0.4 ft/yr (σ=1.7)**.

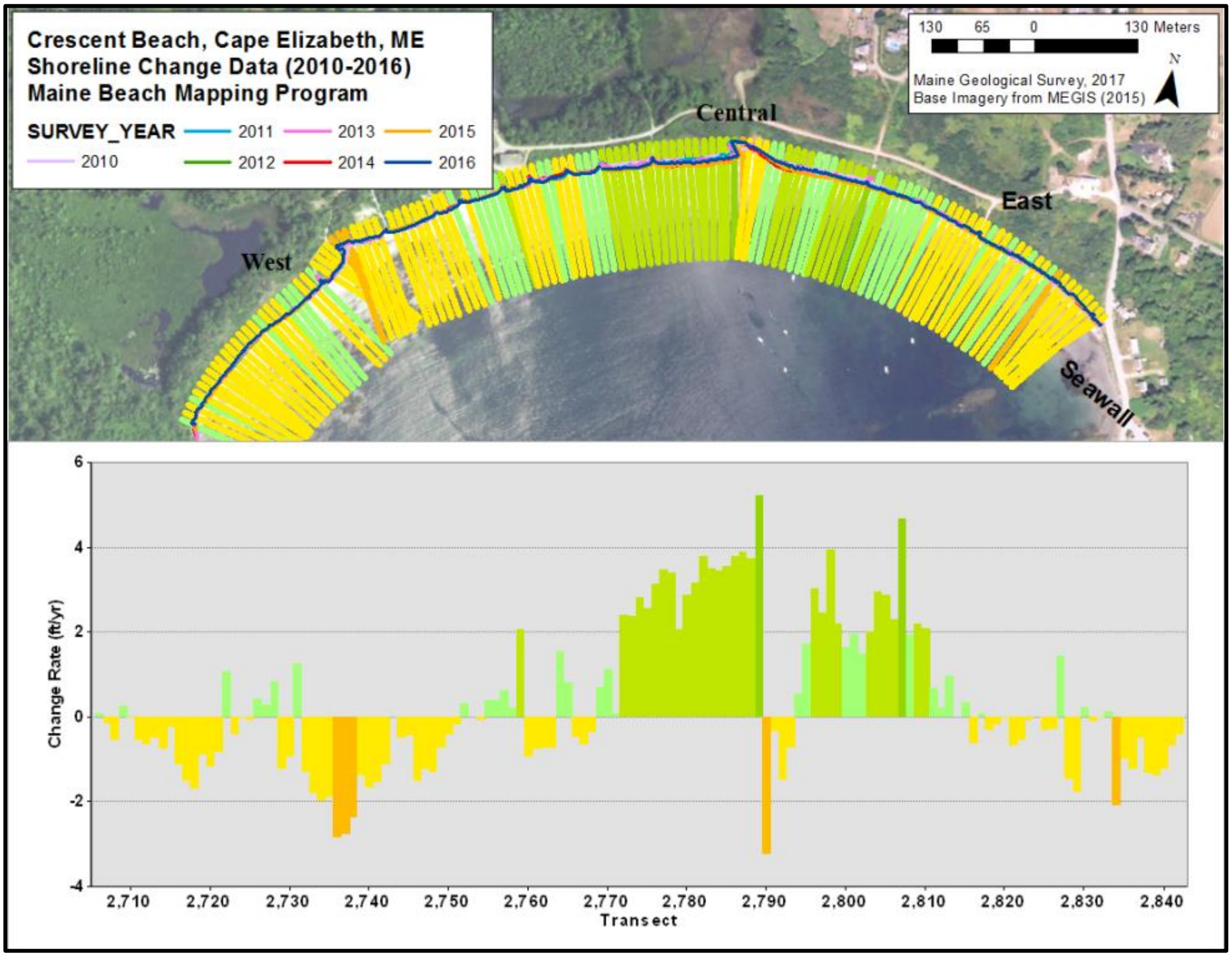

Figure 91. Shoreline change data (2010-2016) for Crescent Beach, Cape Elizabeth, ME.

Kettle Cove, Cape Elizabeth

Kettle Cove is not part of the SMBPP.

Kettle Cove MBMAP Score = **Stable (C)**

Kettle Cove is a small pocket beach just to the southeast of Crescent Beach (Figure 92). Shoreline change at the beach was variable, with pockets of erosion and accretion ranging from -1 ft/yr to +1 ft/yr. Overall, **Kettle Cove** was **stable** with a mean shoreline change rate of **+0.2 ft/yr (σ=0.7)**.

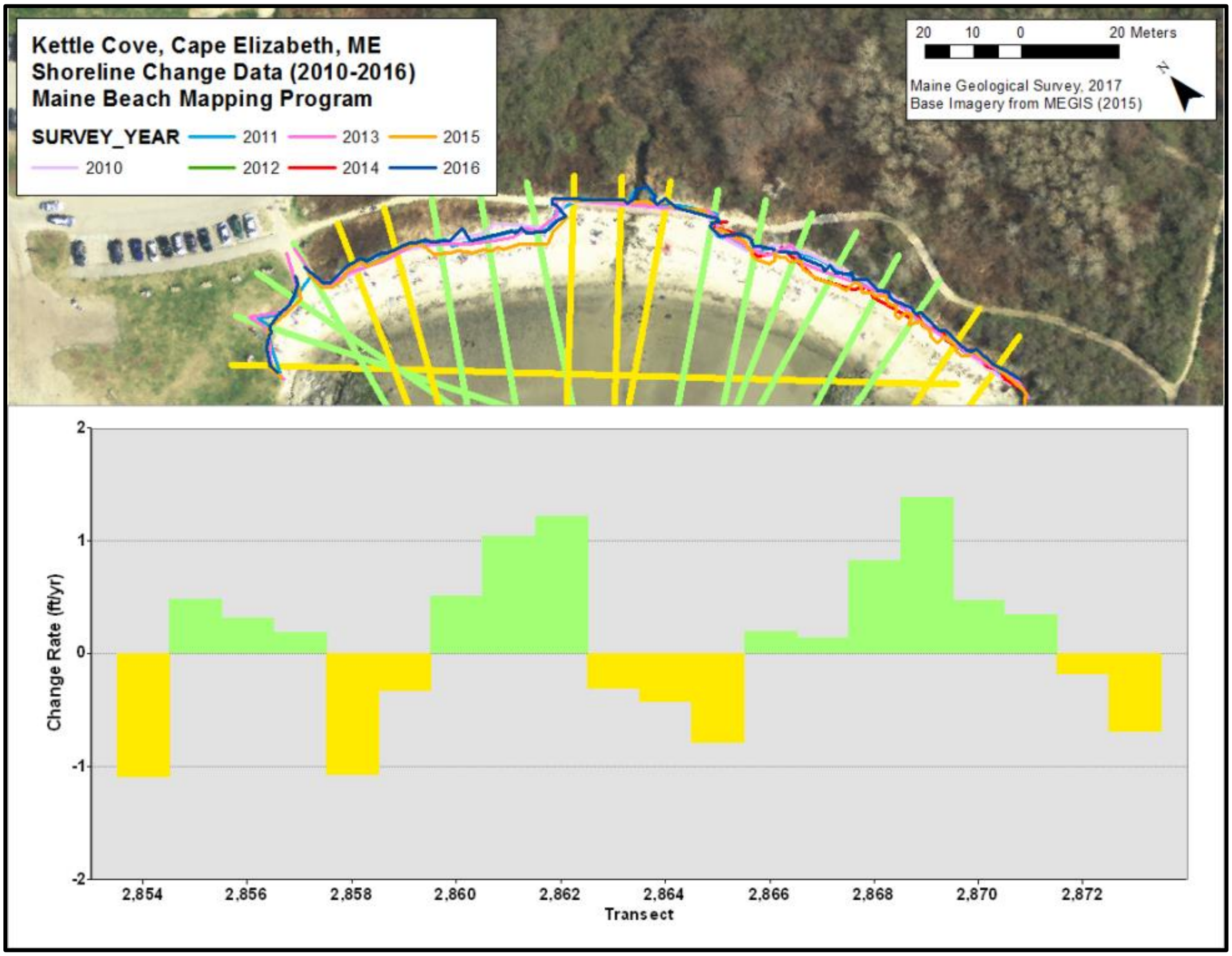

Figure 92. Shoreline change data (2010-2016) for Kettle Cove, Cape Elizabeth, ME.

Willard Beach, South Portland

Willard Beach is not included in the SMBPP.

Willard Beach MBMAP Score = **Accretive (B)**

Willard Beach is a small pocket beach in South Portland (Figure 93). Since 2010, overall **Willard Beach** has been **accretive** with a mean shoreline change rate of **+1.5 ft/yr (σ=1.2)**, with small pockets of beach with much higher (up to +4 ft/yr) accretion rates. Dunes at Willard Beach are actively managed by the Willard Beach community; their efforts appear to have paid off with consecutive years of dune growth.

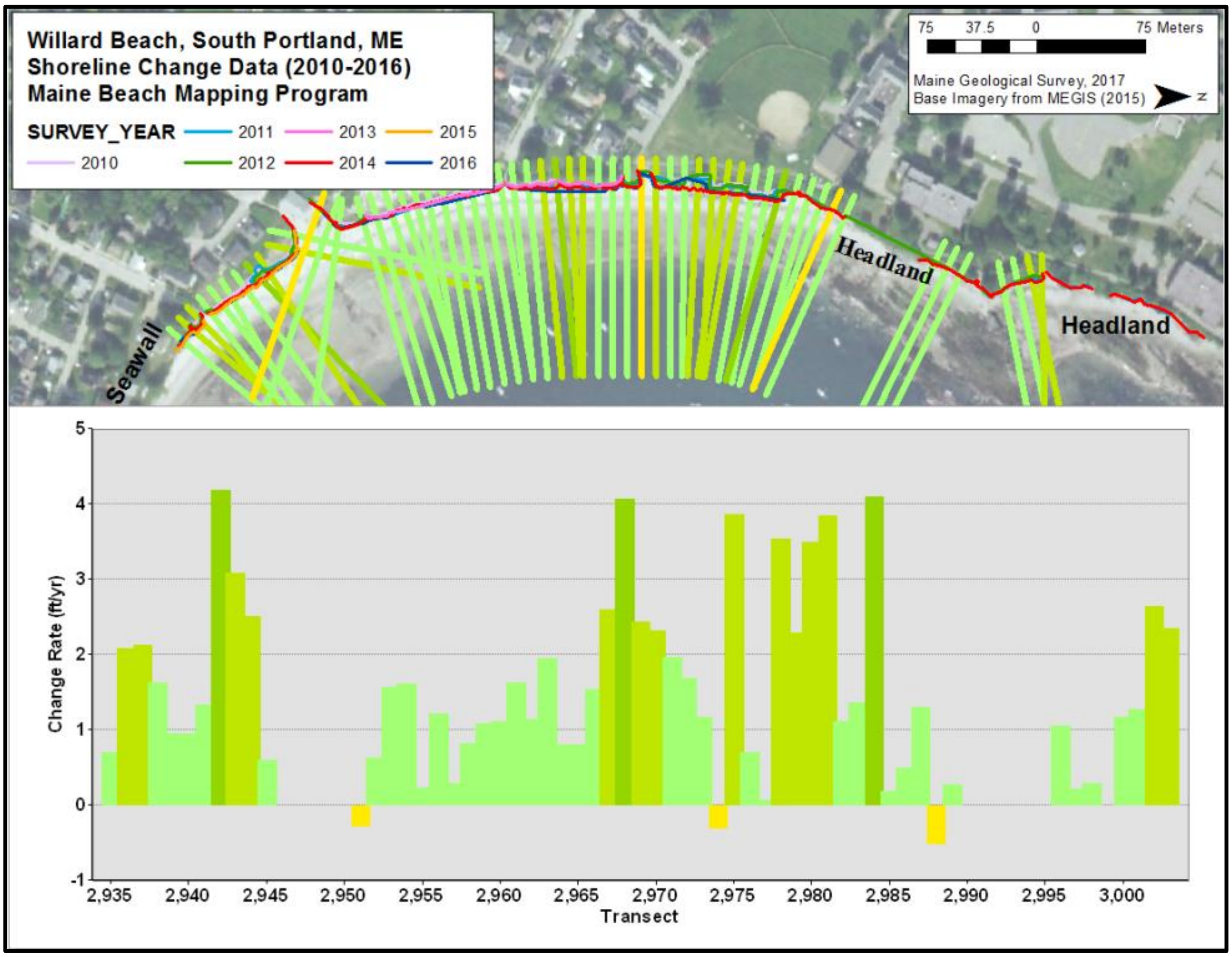

Figure 93. Shoreline change data (2010-2016) for Willard Beach, South Portland, ME.

Small Point Beach, Phippsburg

Small Point Beach is not included in the SMBPP.

Small Point Beach MBMAP Score = **Very Highly Accretive (A).**
West = Highly accretive (A-)
Central = Highly erosive (F+)
East = Extremely accretive (A+)

Small Point Beach is a barrier spit beach that extends southwest from a bedrock headland to the Sprague River. The beach is in a natural state, with extensive sand dunes (Figure 94). Note that MBMAP data was available from 2011-2016 only (no survey was completed in 2010). Based on data, the beach was divided into two distinct sections: west, central, and east.

The **west section** (transects 3013-3169) extends from the Sprague River west to a rocky headland and was **highly accretive** with a mean shoreline change rate of **+4.3 ft/yr (σ=2.6).**

The **central section** (transects 3180-3208) is just east of the headland, and its dunes were **highly erosive** with a mean shoreline change rate of **-3.4 ft/yr (σ=3.1).**

The **east section** (transects 3209-3236) extends from the rocky headland east to the Morse River and was **extremely accretive** with a mean shoreline change rate of **+24.8 ft/yr (σ=16.3)**. Closest to the Morse River, dunes have accreted at rates that exceed +45 ft/yr - these are the *highest dune accretion rates in the state*.

Overall, **Small Point Beach** was **very highly accretive** with a mean shoreline change rate of **+5.9 ft/yr (σ=10.1)**. This trend is skewed heavily by the east section.

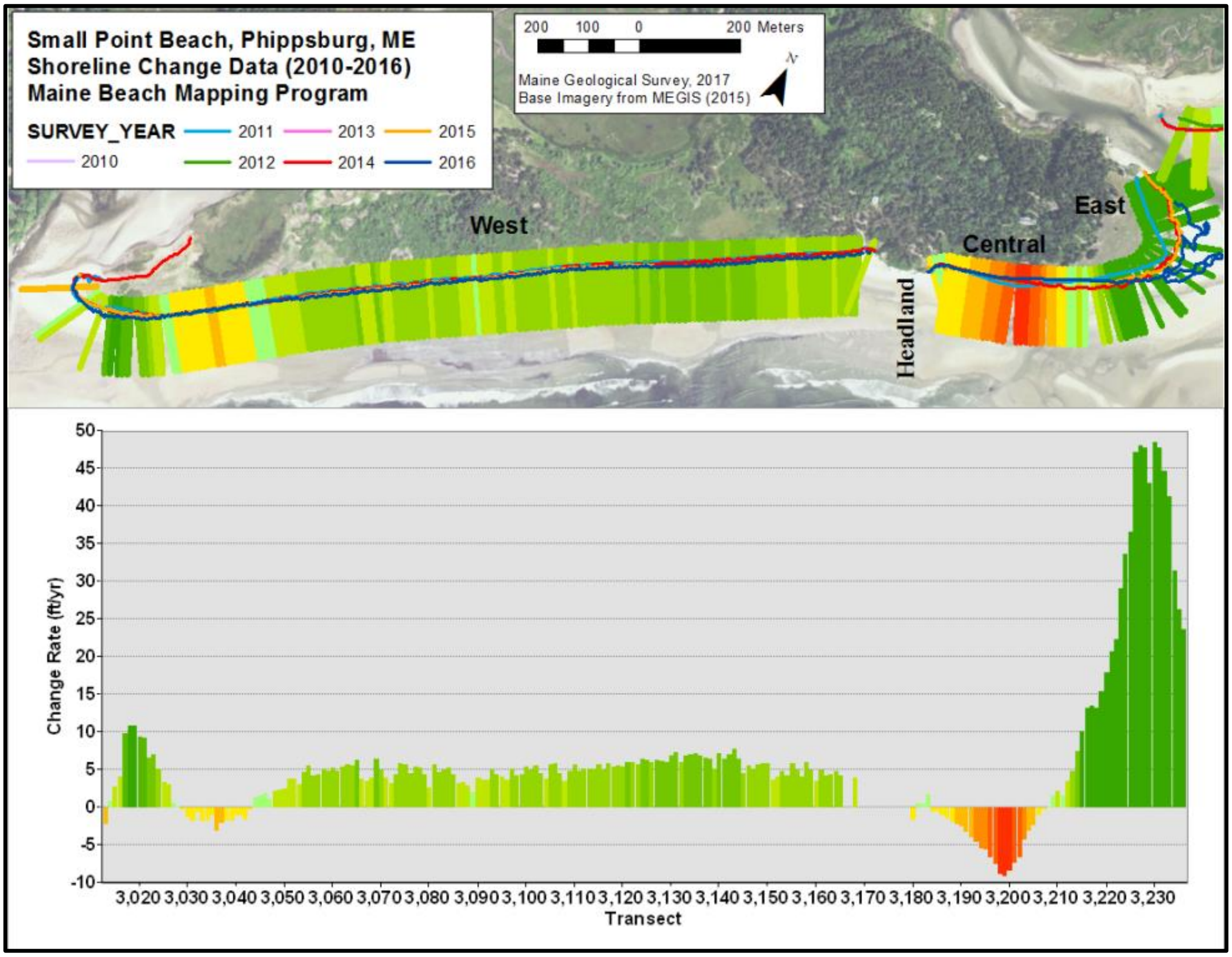

Figure 94. Shoreline change data (2010-2016) for Small Point Beach, Phippsburg, ME.

Popham Beach Complex Beaches, Phippsburg

The beaches along the Popham Beach Complex are not included in the SMPP.

Popham Beach MBMAP Score = **Erosive (D)**
West Beach = Erosive (D)
Center Beach = Stable (C)
East Beach = Extremely erosive (F)
Hunnewell Beach = Extremely erosive (F)
Riverside Beach = Very highly accretive (A)

Popham Beach is a large beach system complex, stretching from the mouth of the Morse River to the west, east-northeast and curving to the north, inside the mouth of the Kennebec River. Aside from a small seawalled area, the majority of the beach is vegetated and surveyed as part of MBMAP (Figure 95). The beaches within the complex were divided into several different sections based on shoreline change trends (from west to east):

- **West Beach** (transects 3239-3280), located along the Morse River spit at Popham Beach State Park;
- **Center Beach** (transects 3281-3374), located along Popham Beach State Park to the Fox Island tombolo;
- **East Beach** (transects 3375-3433), located along Popham Beach State Park eastwards to the seawall;
- **Hunnewell Beach** (transects 3453-3548), from the seawall to the Wood Island tombolo; and
- **Riverside Beach** (transects 3549-3650), from the Wood Island tombolo north to Fort Popham.

Along **West Beach** the dunes were **erosive** with an average change rate of **-2.1 ft/yr**. Nearest to the Morse River, the dunes were stable to accretive (up to +5 ft/yr), but the dunes in the area of the spit nearest to Center Beach eroded at up to -10 ft/yr. This erosion is likely due to migration of the Morse River channel, which cut into the dunes as it migrated to the east.

Along **Center Beach** the dunes were generally **stable** with an average change rate of **+0.1 ft/yr**. However, there was a lot of variability in the shoreline change along this stretch, with pockets of erosion (up to and over -5 ft/yr) along the main portion of the beach, and accretion near the Fox Island tombolo to around +15 ft/yr.

Along **East Beach** the dunes were **extremely erosive** with an average change rate of **-8.6 ft/yr**. The entire stretch has been consistently eroding since 2010, though erosion nearest the Fox Island tombolo is lower than closer to the seawall.

Along **Hunnewell Beach** the dunes were **extremely erosive** with an average change rate of **-7.6 ft/yr**. The western end of the beach is eroding at slightly lower rates (around -5 ft/yr) than the eastern end of the beach, closest to the Wood Island tombolo. Here, erosion rates are some of the highest in the entire state, reaching -10 to -25 ft/yr!

Around the corner of the Wood Island tomobolo is **Riverside Beach**, also known as Coast Guard Beach. The dunes along this stretch of shoreline were **very highly accretive** with an average change rate of **+6.4 ft/yr**. The southern half of Riverside Beach actually accreted at rates of between +10 and +15 ft/yr, some of the highest in the state. The portion of the beach from roughly the former Coast Guard station north to Fort Popham changed at much lower rates, and had some pockets of erosion, especially nearest to Fort Popham.

Overall, the beaches along the **Popham Beach Complex** were **erosive** with an average shoreline change rate of **-1.7 ft/yr (σ=7.9)**. The variability in the shoreline change rates along the complex reflects the dynamic nature of this area.

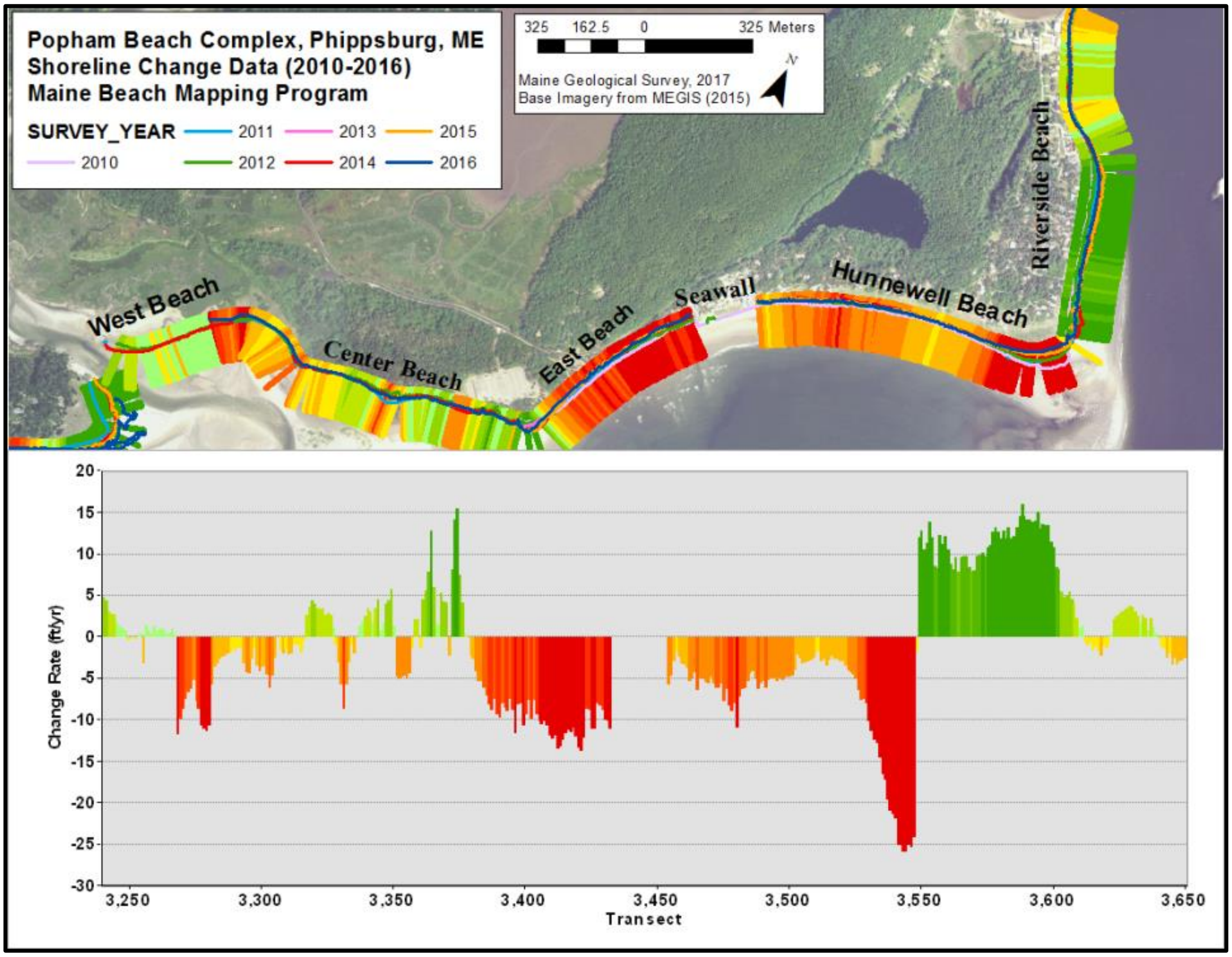

Figure 95. Shoreline change data (2010-2016) for the Popham Beach Complex, Phippsburg, ME.

Reid State Park Beaches, Georgetown

The beaches along Reid State Park are not included in the SMBPP.

Reid State Park Beaches MBMAP Score = **Accretive (B)**
Little River = Stable (C)
Half-Mile Beach = Very Accretive (B+)
Mile-Stretch Beach = Accretive (B)

Reid State Park is comprised of two large beach systems separated by a rocky headland (Figure 96). Based on shoreline change data, the beaches were divided into three distinct sections, including:

- **Little River** (transects 3720-3761), located along the river-side of the Little River and Half-Mile Beach;
- **Half-Mile Beach** (transects 3762-3810), from Little River to Todd's Point headland; and
- **Mile stretch Beach** (transects 3840-3874), from Todd's Point to Griffiths Head.

Along **Little River** the dunes were **stable** with an average change rate of **0.0 ft/yr (σ=3.8)**. However, this average is misleading, as the river has pockets of erosion and accretion that range from +8 ft/yr to -8 ft/yr, which average out to a "stable" stretch of beach.

Along **Half-Mile Beach** the dunes were **very accretive** with an average change rate of **+2.7 ft/yr (σ=1.8).** Closer to the Little River, the dunes grew up to between +4 and +6 ft/yr, while nearest Todd's Point, they grew less or eroded slightly.

Along **Mile-Stretch Beach** the dunes were **accretive** with an average change rate of **+2.2 ft/yr (σ=1.8).** The entire stretch of beach accreted over the study period.

Overall, **Reid State Park Beaches** were **accretive** with an average shoreline change rate of **+1.9 ft/yr (σ=2.3)**.

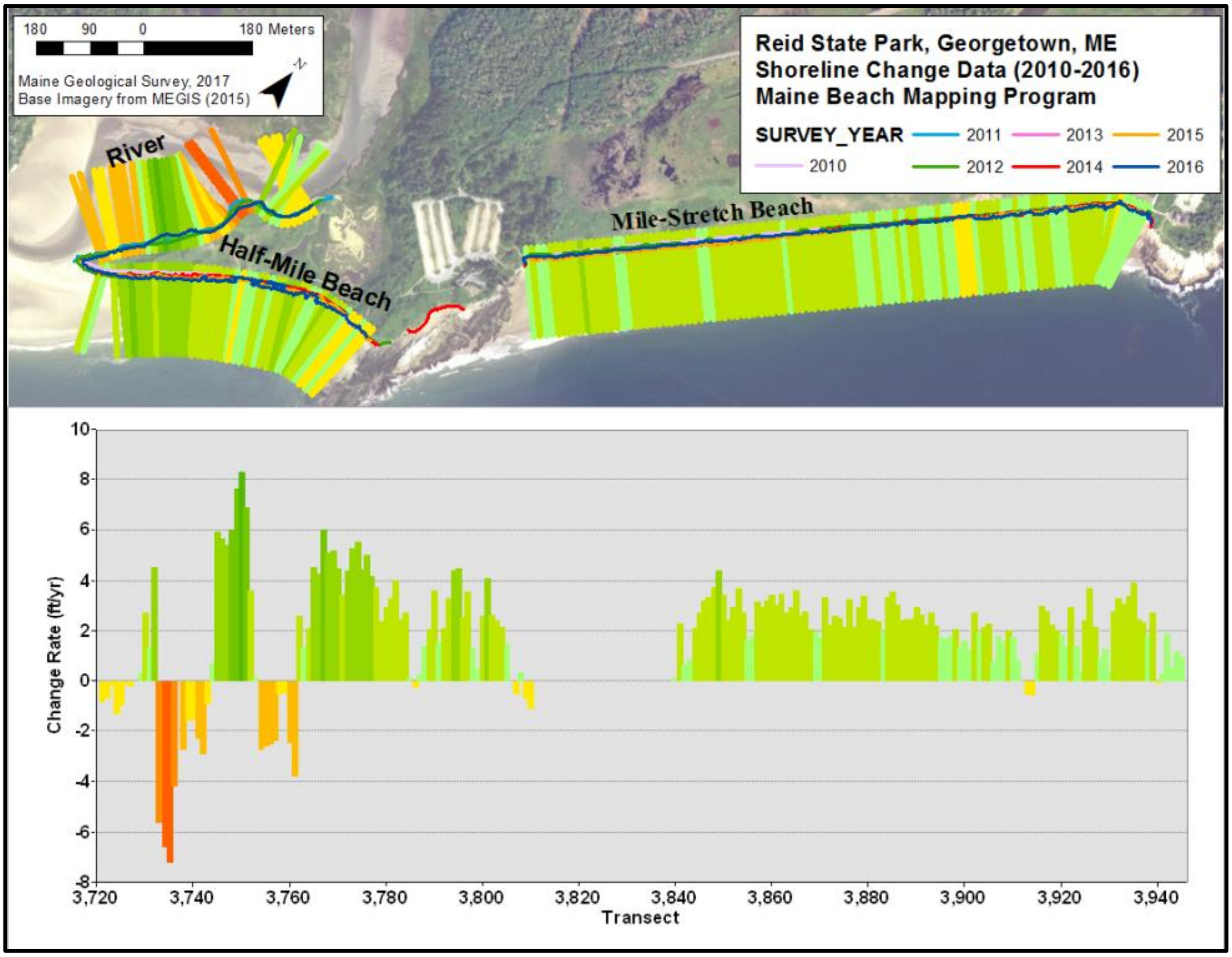

Figure 96. Shoreline change data (2010-2016) for Reid State Park beaches, Georgetown, ME.

Discussion of State of Maine Beach Profiling Project (SMBPP) Results

Overview of the Grading System

The 2009, 2011, 2013, and 2015 reports (Slovinsky et al., 2015; Slovinsky et al., 2013; Slovinsky and Dickson, 2011; 2009) used a lettered grading system and matching color coded system to provide a *qualitative* overview of the overall status of the beaches. Each beach was "scored" using a number and letter grade, with a corresponding color-coded system outlined in the beginning of this report: green, A or B; yellow, C; red, D or F. These grades were averaged for winter profiles, summer profiles, and overall (all) profiles for each beach system. Based on feedback from volunteers and conference attendees, this type of system was a better way of communicating beach changes than quantitative statistical methods.

The 2017 report uses a similar system, and uses the 2010 beach profiles from April (for winter) and August (for summer) as the "starting point" for comparison with subsequent data through 2017. This scoring system was first shown in Table 2, and is revisited in Table 3 on the following page for ease of review.

In doing the grading for this time period, one cannot simply compare a 2010 profile with a 2015 profile and determine whether or not a beach grew, eroded, or stayed stable. In some cases, 2010 was not the worst shape for a profile, but was instead 2011 or 2013. In other cases, a beach may have built back from a 2010 shape through 2012, but then eroded heavily in 2013, and recovered slightly in 2014 or 2016. *All of these subtle changes would be lost if only comparing a starting profile from 2010 and an ending profile in 2016 or 2017. Thus, profiles from each year were compared in determining the grade for a profile.*

Of course, one of the limitations of using "snapshots" in time (roughly the same month from each year, as is the case in this report) 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 (or erosion). As much as possible, we confirmed trends using additional data not displayed in this report. However, this is something that is unavoidable unless all monthly profiles are displayed, which would be overwhelming.

It's also very important to note that in the grading system used, a score of a "C" is not necessarily considered to be "average", but should be considered "satisfactory". Thus, a beach that was relatively stable from 2010 to 2016 (or winter 2017), which is good, may have scored a C *because it did not show erosion, and it did not show growth*. Similarly, a beach that grew over a few years, but then eroded in the past year or two (or underwent a massive erosive event in one year) could have also scored a C, since C is also listed as satisfactory but cautionary. Using this scoring system, generally, beaches that have grown in consecutive years generally scored an A or a B, depending on the amount of growth. Beaches that have eroded in consecutive years generally scored a D or an F, depending on the amount of erosion.

Based on observations of profiles and from the field, the winters of 2010, 2013, and 2017 generally had some of the most erosive profile shapes of all years. At many locations, beaches were eroded down to historic erosional surfaces. For example, large peat deposits or old tree root systems were exposed at Higgins Beach, Goochs Beach, Laudholm Beach, and Ogunquit Beach. 2017 appeared particularly erosive at Goochs Beach.

2017 Report Results

The overall results for beaches profiled as part of the SMBPP are presented in Table 3. This table shows the averaged winter, summer, and overall score results from for each of the ten profiled beaches, ranked from highest overall score to lowest overall score. The overall score from the 2017 assessment is also compared with the score from the 2015 report, along with a corresponding trend. The trend simply reports whether the beach scored better (+), worse (-), or stayed about the same (=). The table also summarizes important notes from each beach in terms of the overall trends observed.

Unfortunately, for 2017, the SMBPP lost profiling teams at Drakes Island Beach, Laudholm Beach, and Scarborough Beach, so no profiling data from those beaches can be reviewed.

Based on overall averaged scores from 2010 to winter 2017, the beaches had an overall grade of a C (76) – equal to the 2015 report, broken down as follows:

- No beaches scored an A;
- 2 beaches (20%; Ogunquit and Goose Rocks) scored a **B**;
- 7 beaches (70%; Kinney Shores, Long Sands, West Grand, East Grand, Wells, Higgins, Goochs) scored a **C**;
- 1 beach (10%) scored a **D** (Ferry Beach); and
- No beaches scored an F.

Of the beaches that score a C, Kinney Shores, Long Sands, West Grand, and East Grand showed stability to slight growth, while Wells, Higgins and Goochs showed stability to slight erosion.

The overall scores, when compared with 2015 scores, had trends of 5 increasing scores (50%), 4 decreasing scores (40%), and 2 scores which stayed the same (20%). However, the averaged overall score was the same as the 2015 score (76). The largest change in scores occurred at Goochs Beach, which fell from a 79 to a 71 in terms of the overall score.

Overall, winter profiles from 2010 to winter 2017 had an average grade of a C (77), broken down as follows:

- No beaches scored an A;
- 4 beaches (40%; Ogunquit, Goose Rocks, Kinney Shores, and West Grand) scored a **B**;
- 4 beaches (40%; Long Sands, Wells, East Grand, and Higgins) scored a **C**;
- 2 beaches (20%; Goochs and Ferry Beach) scored a **D**; and
- No beaches scored an F.

Overall, the summer profiles from 2010 to 2016 had an average grade of a C (75), broken down as follows:

- No beaches scored an A;
- 2 beaches (20%; Long Sands and Goose Rocks) scored a **B**;
- 7 beaches (70%; Ogunquit, Kinney Shores, Wells, Goochs, West Grand, East Grand, and Higgins) scored a **C;**
- 1 beach scored a **D** (10%; Ferry Beach); and
- No beaches scored an F.

Overall, Goose Rocks was the best performing beach, with an overall score of an 81; profiles showed good dune growth along most of the beach, in both winter and summer. Ogunquit Beach also tied for first place with an overall 81 score, though it had some erosion of dunes in 2015 and 2016, showed good recovery.

Many of the beaches overall showed good stability to slight growth, including Kinney Shores, Long Sands, West Grand, East Grand. Wells and Higgins overall showed stability to slight erosion. Only two beaches – Goochs Beach and Ferry Beach in Saco showed more pronounced and prevalent erosion.

It’s interesting that winter beach profiles scored slightly better than summer profiles – this was the case at 7 of the 10 beaches. At some locations, the winter 2017 beach profile had the best shape since 2010. This was likely due to slightly decreased winter wave action, which mostly occurred during neap tides in winter 2017. This likely resulted in less erosion than usual.

One trend we noted that is of concern is that although many of the profiles had **dunes that remained stable or grew**, many of these same profiles saw continued **erosion of the beach and berm**.

Overall Rank	Beach	Municipality	2017 SMBPP Scoring			2015 Score	Trend	Notable Trend Observed
			Winter	Summer	Overall			
1	**Goose Rocks**	Kennebunkport	82	81	81	78	+	Growth along western and central portions of beach. GR01 and GR02 scored best overall.
1	**Ogunquit**	Ogunquit	83	78	81	74	+	Stable MHHW, dune erosion in 2014 and 2016, then growth in 2017.
2	**Kinney Shores**	Saco	82	75	79	77	+	Stability and dune growth, highly variable berm.
2	**Long Sands**	York	77	80	79	81	-	LS03 performed better than LS01.
2	**West Grand**	Old Orchard	83	76	79	78	+	Dune growth but variable and slightly eroding berms.
3	**East Grand**	Old Orchard	77	75	77	77	=	Healthy dune growth and transgression, but berm and beach losses.
4	**Wells**	Wells	75	75	75	74	+	General erosion from 2010 to 2013, with recovery since 2015, but dune erosion at northern end.
5	**Higgins**	Scarborough	76	73	74	75	-	HI01 stable, HI02 stable, HI03 erosive.
6	**Goochs**	Kennebunk	69	73	71	79	-	Erosive trend, especially in winters 2016 and 2017; GO01 and GO02 worse than GO03 and GO04.
7	**Ferry Beach**	Saco	65	68	67	69	-	Generally, continued erosion of berms and dunes since 2010. FE03 was best, FE04 worst.
Averages			**77**	**75**	**76**	**76**	**=**	**Overall scores indicate general stability since 2010.**

Table 3. Summary of SMBPP profile data from 2010 to 2017.

Discussion of Maine Beach Mapping Program (MBMAP) Results

Overview of the Grading System

The 2017 Beaches Report included analysis of MBMAP vegetation shoreline position data collected from summer/fall 2010 to 2016.

It's important to note that MBMAP shoreline change data documented the *changes in the seaward extent of the vegetation line* along the surveyed beach. This technique only captures the changes in the dune, either seaward growth or landward erosion. Since SMBPP data collects topographic transects across the beach, including the berm and the beach, and is scored on overall changes (not at just the dune), analysis of MBMAP data may show slightly different trends or scores than SMBPP data.

The scoring system used for analysis of MBMAP data followed the scoring protocol outlined in Table 2. Generally, if a system was very highly accretive, it scored an **A (95)**; accretive, it scored a **B (85)**; slightly accretive, stable, or slightly erosive, it scored a **C (75)**; erosive, a **D (65)**; and very highly erosive, an **F (55)**. Scores could have a plus (+) or minus (-), which added or subtracted three points to the numerical score, respectively.

Using this system, a beach that had a **stable shoreline**, or a corresponding shoreline change rate of near zero (0.0) scored a **C.** Shorelines with either slight erosion or accretion (less than 1 foot per year either way) became either a **C-** or a **C+**, respectively.

2017 Report Results

Overall results from MBMAP analysis is presented in in Table 4. This table ranks beaches based on averaged scores, provides the calculated shoreline change rates, the corresponding MBMAP score, the 2015 rate, the change from the 2015 rate, and notes distinct shoreline change trends. There were a total of 35 different beaches surveyed as part of MBMAP. Note that many "beaches" were divided into sections. For example, Popham Beach was divided into five different sections (from east to west, West Beach, Center Beach, East Beach, Hunnewell Beach, and Riverside Beach). These sections were many times driven by distinct changes in shoreline change rates.

Of the 35 beaches surveyed:

- **4 beaches (11%) were highly accretive to very highly accretive** (scoring an A);
- **12 beaches (34%) were somewhat accretive to very accretive** (scoring a B);
- **9 beaches (26%) were stable to slightly accretive** (scoring a C or C+);
- **3 beaches (9%) were stable to slightly erosive** (scoring a C or C-);
- **4 beaches (11%) were somewhat erosive to very erosive** (scoring a D); and
- **3 beaches (9%) were extremely erosive** (scoring an F)

Thus, 25 beaches, or approximately 71% had dunes that were either stable or accreting from 2010 to 2016. **Seven beaches, or 20%, were somewhat erosive to very erosive, while only 3 beaches (9%) were extremely erosive.** ***This is a positive trend. The overall average shoreline change rate for all beaches surveyed was +0.3 ft/yr, indicating relative stability with a slightly positive or growing trend from 2010 to 2016.***

The three beaches with the best dune growth from 2010 to 2016 were Riverside Beach (Popham Beach, Phippsburg), Small Point Beach (Phippsburg), and East Grand Beach/Pine Point (Old Orchard Beach and Scarborough). The three beaches with the worst dune erosion were Hunnewell Beach (Phippsburg), East Beach (Phippsburg), and Higgins Beach.

As noted previously, using an averaged linear regression rate for a whole beach system does not reflect smaller patterns of erosion and accretion within a larger system. For example, Riverside Beach section of Popham Beach had the highest positive shoreline change rate while the Hunnewell Beach section (just around the corner) had the highest negative shoreline change rate from 2010 to 2016. This reflects how dynamic smaller segments of beaches within an overall larger beach system can be. Hence, this is why we added a *notable trends* descriptive section to the Table. This allows the variations within each larger system to be discussed, even though an overall shoreline change rate may indicate stability, erosion, or accretion.

In the Saco Bay system, the dunes at the northernmost end of the bay, in Pine Point, were somewhat erosive, especially about half-way between Hurd Park and the jetty at the Scarborough River. This is likely driven by a nearshore trough which helps focus wave energy into the area. Just south of this (in Pine Point to East Grand Beach), the dunes were highly accretive almost along the entire stretch. Dunes in the middle third of the bay (West Grand Beach, Ocean Park and south to Kinney Shores and Bayview) were slightly accretive to accretive. In the southern third of the bay (Ferry Beach), the dunes were very erosive. This trend reflects the northwards movement of sand along the beaches in Saco Bay.

It is apparent that beach and dune systems adjacent to tidal inlets can undergo extremes in terms of accretion or erosion. For example, some of the **highest (both positive and negative)** mean shoreline change rates calculated for dunes occurred adjacent to tidal inlets. Some of these include, from north to south:

- Riverside Beach, adjacent to the Kennebec River (accretion up to +10 to +15 ft/yr);
- Hunnewell Beach, adjacent to the Kennebec River (erosion up to -20 to -25 ft/yr);
- Small Point Beach, adjacent to the Morse River (accretion up to +40 to +45 ft/yr);
- Higgins Beach, adjacent to the Spurwink River (erosion up to -20 ft/yr);
- Goose Rocks Beach, adjacent to the Batson River (erosion up to -25 to -30 ft/yr); and
- Laudholm Beach, adjacent to the Little River (erosion up to -10 to -15 ft/yr).

These results truly show how dynamic tidal inlets can be in terms of influencing neighboring beach and dune stability.

In terms of comparison with 2015 scores, 20 of 33 (two beaches were new surveys, and are not compared with 2015) or 61% saw a positive change in the shoreline change rate, while 12 beaches or 36% saw a decrease in the rate, and 1 stayed the same. Many of the shorelines saw only slight changes, indicating that the shoreline change rates remained roughly the same as 2015 (9 beaches).

It's important to note that only three beaches, Bayview (Saco), Western (Scarborough) and Higgins (Scarborough) saw *statistically significant* changes in the shoreline change rate. That is, the changes observed *exceeded the standard deviation of the calculated change rate*.

The overall average MBMAP score for all surveyed beaches indicated that beaches were **stable to slightly accretive** with an average with a slightly positive trend **(+0.3 ft/yr)** and an average score of **C+ (77)**. This overall score compares well with the overall averaged SMBPP grade (also a C+, 77).

Continued MBMAP shoreline change monitoring of the dunes adjacent to inlets will help keep track of these dynamic areas. In addition, MBMAP data from all the beach systems provides a great snapshot of dune health, and also places the changes seen at individual beach profiles into the larger geomorphic context of changes to Maine's beaches over time.

2017 Rank	Beach	Municipality	MBMAP Description	MBMAP Score	2016 Rate (ft/yr)	2015 Rate (ft/yr)	Trend	Notable Trends/Beach Sections Observed
1	**Popham - Riverside**	Phippsburg	Very highly accretive	95	6.4	8.6	-	High accretion south, pockets of erosion near Fort.
2	**Small Point**	Phippsburg	Very highly accretive	95	5.9	5.6	+	High accretion west, erosive central (near headland), extremely accretive east (near Morse River).
3	**East Grand/Pine Point**	Old Orchard/Scarborough	Highly accretive	92	4.5	3.0	+	Accretive to highly accretive to just south of Hurd Park.
4	**East Grand**	Old Orchard	Highly accretive	92	4.1	3.1	+	Accretive except for adjacent to seawall at north end.
5	**Reid - Half Mile**	Georgetown	Very accretive	88	2.7	2.1	+	Highest accretion near river, slight erosion near Todds Point.
6	**Fortunes Rocks**	Biddeford	Accretive	85	2.3	2.6	-	Very accretive west, accretive east.
7	**Reid - Mile Stretch**	Georgetown	Accretive	85	2.2	2.5	-	Accretive along entire beach.
8	**Goose Rocks**	Kennebunkport	Accretive	85	2.0	1.3	+	Extremely erosive at Batson River, veryhighly accretive west, slightly accretive central, very highly accretive east, and accretive near Little River.
9	**Scarborough**	Scarborough	Accretive	85	1.8	2.3	-	Very accretive west (to flagpole), stable east with small pockets of erosion.
10	**Kinney Shores**	Saco	Accretive	85	1.7	1.3	+	Accretive with small section of erosion in central portion, near submerged outcrop.
11	**Ocean Park**	Old Orchard	Accretive	85	1.6	1.5	+	Mostly accretive, small area of erosion at southern end of Ocean Park.
12	**Willard**	South Portland	Accretive	85	1.5	1.9	-	Accretive along entire beach.
13	**Hills**	Biddeford	Somewhat accretive	82	1.3	1.0	+	Accretive south, erosive central, very accretive north.
14	**Ferry**	Scarborough	Somewhat accretive	82	1.3	0.8	+	Stable to slightly accretive; high accretion an erosion near outcrop.
15	**Bayview**	Saco	Somewhat accretive	82	1.2	-1.0	+	Highest accretion in Kinney Shores.
16	**Crescent**	Kittery	Somewhat accretive	82	1.2	0.6	+	Stable to slightly accretive along entire beach.
17	**Long Sands**	York	Slightly accretive	78	1.0	1.0	=	Stable to slightly accretive, some erosion near seawall.
18	**Ogunquit**	Ogunquit	Slightly accretive	78	0.9	-0.2	+	Stable south, highly accretive central, slightly accretive north.
19	**West Grand**	Old Orchard	Slightly accretive	78	0.8	0.9	-	Erosion in central, highest accretion south of pier.
20	**Wells**	Wells	Slightly accretive	78	0.7	-0.6	+	Slightly accretive south, stable central, somewhat accretive north.
21	**Drakes Island**	Wells	Slightly accretive	78	0.6	-0.2	+	Somewhat accretive south, slightly erosive central, somewhat accretive north.
22	**Crescent**	Cape Elizabeth	Stable	75	0.4	0.6	-	Slightly erosive west, accretive central, stable to slightly erosive east.
23	**Kettle Cove**	Cape Elizabeth	Stable	75	0.2	0.6	-	Variable pockets of slight erosion and accretion, stable overall.
24	**Popham - Center Beach**	Phippsburg	Stable	75	0.1	0.2	-	Pockets of erosion and accretion, extremely high accretion at Fox Island tombolo.
25	**Reid - Little River**	Georgetown	Stable	75	0.0	-		Pockets of high erosion and high accretion but overall stable.
26	**Seapoint**	Kittery	Stable	75	-0.3	-1.0	+	Slightly accretive near path, otherwise stable to slightly erosive.
27	**Goochs**	Kennebunk	Slightly erosive	72	-0.8	-1.8	+	Stable to very erosive nearest jetty.
28	**Western**	Scarborough	Slightly erosive	72	-0.9	-4.4	+	Accretive west, erosive central (where beach nourished)
29	**Pine Point**	Scarborough	Somewhat erosive	68	-1.3	-1.0	-	Slightly erosive west, highly erosive central, accretive near jetty.
30	**Popham - West Beach**	Phippsburg	Erosive	65	-2.1	0.2	-	Stable to accretive near Morse River, highly erosive east.
31	**Ferry Beach**	Saco	Very erosive	62	-2.5	-3.9	+	Erosive along entire beach except near dune restoration just south of seawall.
32	**Laudholm**	Wells	Very erosive	62	-2.6	-3.9	+	Stable to slightly accretive along beach, hihgly erosive near spit.
33	**Popham - Hunnewell**	Phippsburg	Extremely erosive	55	-7.6	-12.1	+	Extremely erosive along beach to Wood Island tombolo; erosion to -25 ft/yr.
34	**Popham - East Beach**	Phippsburg	Extremely erosive	52	-8.6	-		Extremely erosive along entire stretch of beach from Fox Island tombolo to seawall.
35	**Higgins**	Scarborough	Extremely erosive	52	-10.9	1.6	-	Somewhat erosive pocket dunes; extremely erosive near Spurwink River (up to -20 ft/yr).
	Average (for all beaches)		**Stable**	**77**	0.3	0.4	-	Slight decrease in the averaged shoreline change rate.

statistically signifcant change in the shoreline change trend

Table 4. Summary of MBMAP data for 2010 to 2016. Note that many of the beaches have equal MBMAP scores, yet have been ranked 1-35 – in such cases, beaches with equal scores are arbitrarily ranked. The scores have also been compared with 2015 results, and the general trend (+, =, or -) shown. Note that two beaches don't have previous scores for comparison. Note that statistically significant trends are marked in light blue.

Combined SMBPP and MBMAP Scores

For the ten beaches that participated in both SMBPP and MBMAP, overall combined scores were calculated. The beaches were then ranked based on the average score. This average score was compared with the trend since 2015 and shown in Table 5.

Similar to Table 3 (SMBPP-only scoring table), Goose Rocks Beach had the best overall averaged score of an 83. East Grand Beach and Kinney Shores tied for second, mainly because of very good MBMAP scores. Higgins Beach and Ferry Beach (Saco) had the worst averaged scores.

In comparing the 2017 averages with results from the 2015 report, 5 beaches (50%) had a positive trend, 1 stayed the same, and 4 had a negative trend.

Rank	Beach	Municipality	SMBPP Scoring			MBMAP Scoring	2017 Average (SMBPP/MBMAP	2015 Average	Trend from 2015
			Winter	Summer	Overall				
1	**Goose Rocks**	Kennebunkport	82	81	81	85	83	79	+
2	**East Grand**	Old Orchard	77	75	77	92	81	81	=
2	**Kinney Shores**	Saco	82	75	79	85	81	77	+
3	**Ogunquit**	Ogunquit	83	78	81	78	80	74	+
4	**West Grand**	Old Orchard	83	76	78	78	79	78	+
5	**Long Sands**	York	77	80	79	78	78	80	-
6	**Wells**	Wells	75	75	75	78	76	74	+
7	**Goochs**	Kennebunk	69	73	71	72	71	74	-
8	**Higgins**	Scarborough	76	73	74	52	67	76	-
9	**Ferry Beach**	Saco	65	68	67	62	65	67	-
Averages			**77**	**75**	**76**	**76**	**76**	**76**	**=**

Table 5. Summary of combined SMBPP and MBMAP data for the ten beaches monitored by both programs.

Discussion of Factors affecting the Health of Maine's Beaches

In the last two State of Maine's Beaches reports (2011 and 2013), many beaches and dunes were showing signs of erosion, which caused concern in many municipalities. In the 2015 report, we determined that 73% of Maine's beaches showed positive trends (stable to growing). This was a good trend, signifying that beaches were recovering from erosive "lows" of 2010 (due to elevated sea levels and frequent nor'easter storms) and a subsequent stormy season in 2013.

In this report, we determined that **71% of Maine's monitored beaches were stable to accretive.** This is a continued, positive trend.

Influence of Storm Events

During periods of high waves, high storm tides, and coastal flooding, beaches and dunes can be severely eroded in a matter of days. Such major short-term events, like the largest storm in the last 7 years (on February 25, 2010 with waves over 30 feet, see Figure 5; late January 2017), left beaches eroded and very sand-starved going into that summer and even beyond. Repeated storms (with waves of 20-25 feet, such as in the winter of 2012-2013, see Figure 5, or 2014-2015, Figure 6), left little time for beaches to regain sand before the next storm and also left beaches in an eroded state leading into the following summer. Conversely, winters with generally lower wave heights due to a lower number of storms (for example, 2011, 2012, 2014, and 2016) generally allowed beaches to recover well.

The winter of 2015-2016 was comparatively less stormy with lower wave heights and storm tides that resulted in less surf and flooding in the dunes. That winter there was ample surf in the 10 to 15-foot range but no storm waves rose above 20 feet. Minor coastal flooding and splashover were aided a few times by astronomically high tides that combined with minor storm surges as seen April 7, 2016.

The winter of 2016-2017 had more large storms and even one time when waves were up to 28 feet on January 24th. This was a more typical storm season and similar to the winters of 2012-2013 and 2014-2015. Despite larger waves this winter than the previous one, *many storms arrived on neap tides (relatively low high tides) so storm surges did not often result in significant coastal flooding. Some of the largest surges occurred near the time of low tide also minimizing the storm's impact on the dunes*.

In retrospect, the strong El Nino conditions across the northern hemisphere in the winter of 2015-2016 appear to have reduced the intensity of storms in the Gulf of Maine for a year. That winter, wave heights and storm surges were unable to rise frequently above the beach profile and reach the frontal dune. The maximum wave height in the winter of 2015-2016 was about 10 feet lower than that in the following 2016-2017 storm season that had a peak of 28 feet offshore of the southern Maine beaches.

Influence of Sea Level Rise

Since 2009, sea level in Portland has been 6 to 8 inches higher than the average for the last 100 years (Figure 2). From 2009 to 2010 "winter" sea level along the Maine beaches rose nearly 8 inches in one year (Figure 3). From a record high sea level in February 2010 through the end of 2016, sea level has returned to near the 100-year average at the end of this assessment. This average, however, is still 3.2 inches higher than the 1912 average in Portland. Even a few inches of higher sea level can help storm tides exceed flood stage and allow surf higher into the dunes with greater frequency. This was clearly the case given the findings of the previous reports on the impacts of the 2010 season. Since the high in April 2010, sea levels dropped to a low in April of 2015; since then, sea levels have risen again. For perspective on this "falling sea level," the average sea level for 2010-2016 was still 4 inches (10.7 mm) above the 1912-2016 average and 7 inches (19 mm) above what it was in 1912.

Influence of Tidal Inlets

In general, many of the beaches that fared the worst were influenced by adjacent tidal inlets and rivers, another compounding force that affects local sand budgets. For example, Laudholm Beach in Wells, adjacent to the Little River inlet, has consistently been one of the worst scoring beaches. At Goose Rocks Beach, though overall the beach scored well, some of the worst erosion of all beaches occurred at the dunes directly adjacent to the Batson River. The portion of Higgins Beach adjacent to the Spurwink River had some of the highest dune growth in the 2015 report (using shoreline change data from 2010 to 2014). However, in this report, this area had some of the highest erosion of any of the beaches.

Tidal inlets and adjacent beach orientation can result in some of the highest erosion and accretion rates directly adjacent to one-another. This occurred at Popham Beach beaches and at Hunnewell Beach, which was one of the most erosive sections of any beach, and adjacent Riverside Beach, which was one of the most accretive sections of beach reviewed in this report.

Other Influencing Factors

The 2015 report discussed the role of unusually cold temperatures, such as during the winter seasons of 2013-2014 and 2014-2015. Because of this, the upper portion of the beach in the vicinity of the berm and into the dune was often frozen and sometimes buried in deep snow. This likely aided in helping stabilize beach profiles. Although the winters of 2016 and 2017 were not as cold, there was a decent amount of snowfall, which likely helped protect beaches from erosion. It seems likely that icy and snowy conditions do help reduce beach erosion on the upper profiles during the height of the winter storm season.

As shown in the data in this report, 71% of Maine's beaches are in satisfactory to good condition relative to the last 5 years. Most beaches did not experience similar trends overall. This is likely due to the orientation of the beaches and the types of storms they are most affected by (i.e., northeasters vs. southeasters). For example, Goose Rocks Beach scored well, even during higher storm seasons.

Another important influencing factor is the role of beach nourishment and nearshore sediment placement. In 2015, portions of Goochs Beach, Wells Beach, and Western Beach were nourished by the U.S. Army Corps of Engineers. At Goochs Beach, dredged material was placed as a nearshore "feeder" adjacent to the western jetty at the Kennebunk River. Profile GO03, nearest to where the nourishment occurred, performed the best of all Goochs profiles.

Similarly, at Wells Beach, beach nourishment was completed in 2015. In the 2015 report, MBMAP data indicated that the beach was, on average, eroding at a rate of about -0.6 ft/yr. In the 2017 report, that rate was +0.7 ft/yr. Although these numbers are within the standard deviation of the data, the difference in the trends is notable.

At Western Beach in Scarborough, a dredging project placed over 100,000 cubic yards of sediment onto Western Beach. Our 2015 report only included MBMAP shoreline position data through 2014 – so the influence of the nourishment project was not captured. In the 2015 report, Western Beach had one of the worst erosion rates of all the beaches, with an average shoreline change rate of -4.4 ft/yr. In the 2017 report, with just two additional years of data collection, the mean shoreline change rate was -0.9 ft/yr, a dramatic reduction and statistically significant, change. Nourishment has allowed for stable berm and dune conditions which allow vegetation growth at the dune. We expect this trend to continue as dune vegetation stabilizes at the beach.

Maine Beach Mapping Program - Newly Available and Coming Information

Recently, the Maine Geological Survey has created a web-viewer application where the public can view and access shoreline positions and calculated shoreline change rate information from the Maine Beach Mapping Program (MBMAP). The site allows for the plotting of different shoreline positions and viewing of calculated shoreline change rates as color-coded transects along the shoreline. The site also includes Frequently Asked Questions, and includes information on how beaches are mapped, and what shoreline change statistics are calculated (and what they mean). Please visit http://www.maine.gov/dacf/mgs/hazards/beach_mapping/index.shtml for more information. Figure 97, below, provides an example of the viewer showing shoreline change data at Goose Rocks Beach, ME.

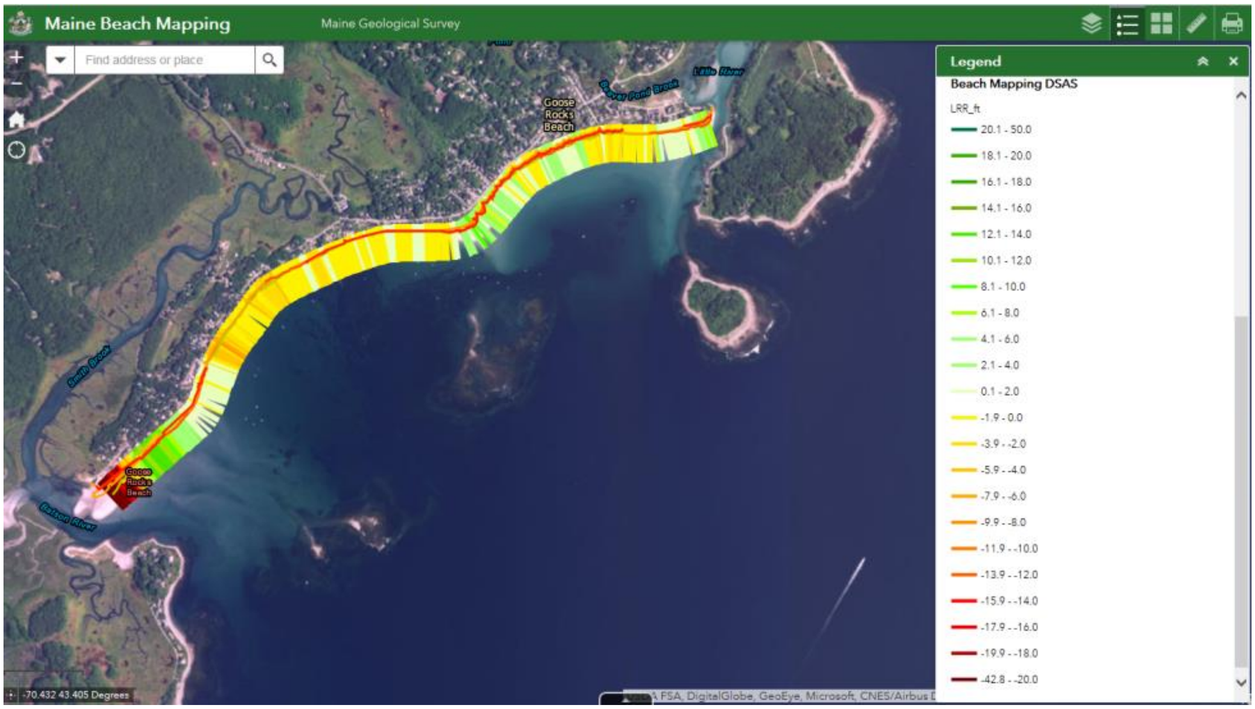

Figure 97. Maine Geological Survey's Maine Beach Mapping Program (MBMAP) online viewer showing Goose Rocks Beach, Kennebunkport, ME shoreline change rates (in linear regression rate, feet/year).

In addition, MGS will be including new shoreline change information from this summer's (2017) MBMAP field mapping program. Although using the seaward edge of dominant dune vegetation is a good proxy for shoreline change, it does have some limitations.

First, in areas that have shoreline protection structures (such as rip-rap or bulkheads), many times there is no dune grass present, so the "shoreline" is not monitored. This is the case for many large stretches at many of Maine's beaches, including Wells Beach, Goose Rocks Beach, and Fortunes Rocks Beach. Second, using the edge of dune vegetation as a proxy for the shoreline results in including anthropogenic influences such as dune restoration or creation.

In order to address these issues, this season, MGS began also surveying the approximate mean higher-high water line, or MHHW. For most of southern Maine's beaches this correlates to about +1.4 m (140 cm) NAVD88. This line was shown on the SMBPP beach profile graphs in this report in order to give readers an idea of how high above the normal high water line the beach profiles extend.

Surveying of the MHHW elevation along Maine's beaches will provide an additional "shoreline" which can be used for shoreline change analyses, especially in those areas where there is no dune vegetation or there are seawalls. If there is erosion along a beach, the +1.4 m contour will migrate inland. If there is accretion, the +1.4 m contour will move seaward. This contour can be compared from year to year to see how the elevation changes position along the beach.

In addition, surveying of the MHHW in addition to the edge of dune vegetation (or seawall) will allow for the calculation of the summer dry beach width. The dry beach width is simply the horizontal distance from the MHHW to the edge of dune vegetation or to a seawall. The dry beach width is vital to understanding how much "recreational space," on average, is available along a stretch of beach.

Figure 98 shows the dry beach widths from Ferry and Western Beach in Scarborough, as measured in June 2017. Dry beach widths are divided into 25-foot increments. Along Ferry Beach, the dry beach is quite narrow – 25 feet or less – for the majority of the beach until near the outcrop and day-marker (near transect 80) where it increases to between 50-75 feet.

Along Ferry Beach, the dry beach is quite narrow – 25 feet or less – for the majority of the beach. Just past the outcrop and day-marker (near transect 90), along Western Beach, the dry beach width increases to between 25-50 feet. Along the rest of Western Beach, the dry beach width increases from around 50 feet at its western end, to between 100 and 160 feet at its central section (transects 110-160), before decreasing to around 25 feet again at the eastern end of Western Beach. The 2015 beach nourishment project by the US Army Corps of Engineers was completed in this area (transects 110-160).

This information will be included for all MBMAP beaches in updates to the online web-viewer after completion of the 2017 summer field season, and will be available in subsequent beaches reports.

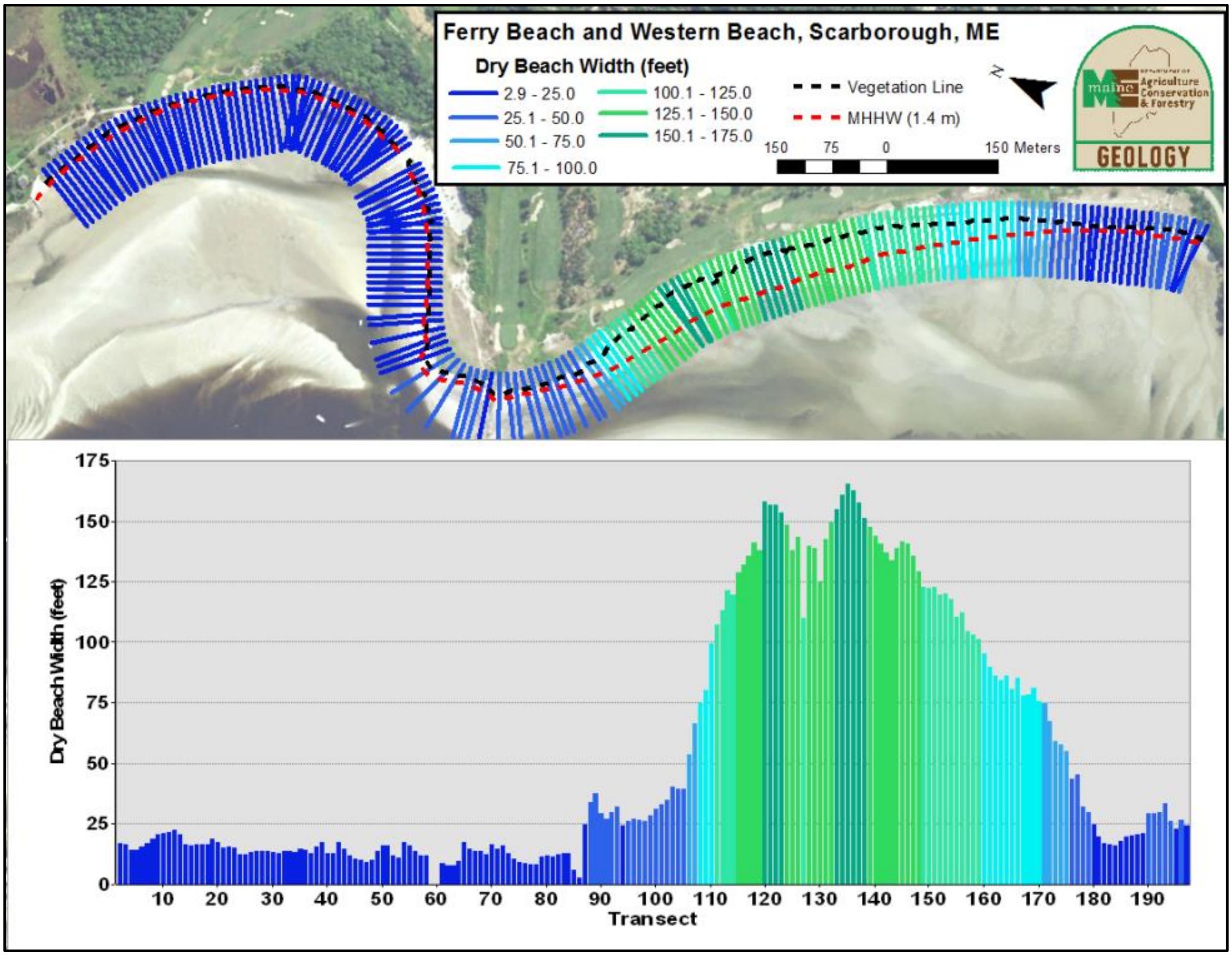

Figure 98. Dry beach width (DBW) calculated using the June 2017 vegetation line and the Mean Higher High Water (MHHW) line for Ferry and Western Beaches, Scarborough, ME.

Conclusions

The 2017 State of Maine's Beaches Report used beach profile data and vegetation line survey data to analyze beach and dune changes from 2010 to 2016 (or 2017 for winter beach profiles). At the beginning of this report, we reviewed trends in storms and sea level rise during which data were collected – two major factors that influence the shape of the dunes and berms. Trends in mean sea level showed that between 2010 and 2016, sea levels rose to peaks in 2010 and 2013, fell slightly in 2014, 2015, and rose slightly in 2016. Wave data indicated that storms were less severe in the winters of 2011, 2012, 2014, and 2016 than they were in 2010, 2013, and 2015. In 2015, while there were many winter storms, sea levels were lower than in previous years. Although 2017 did have a few larger events, they occurred mostly at lower tides, so that the overall storm tides were lower, and had less of an impact on dunes.

Analysis of available beach profile data from 2010 to 2016 (or winter 2017), in addition to surveys of vegetated frontal dune positions from summer 2010 to summer 2016 showed that:

- High sea levels, combined with a very active northeaster storm track in the *winter of 2010 resulted in heavy erosion of many beaches and some of the worst beach profile shapes in the last 7 years*.
- Beach profiles recovered relatively well in 2011 and 2012, with *some of the highest beach profile shapes* – in terms of berms and dunes – being achieved.
- In 2013, strong winter storms negatively impacted beach profiles and dunes. Combined with slightly higher than normal sea levels, this created erosive conditions. *Many beach berms and dunes were eroded to, or in some cases, below winter 2010 elevations.*
- In 2014, fewer storm events and lower sea levels *allowed for recovery of beach profiles and dunes*. Some profiles had their highest elevations during this time.
- 2015 was characterized by intense cold and copious amounts of snow. This helped stabilize beach berms and dunes. Combined with the lowest mean sea levels over the past 7 years, this *allowed continued recovery at many beaches*.
- In 2016, a slightly lower number of storm events – of generally lower duration and intensity, in addition to occurring generally at lower tides – *resulted in continued recovery of dunes, but erosion of many berms.*
- In winter 2017, although a few larger storms occurred, they again occurred at lower tides, *minimizing dune erosion but still allowing for berm erosion*.
- Overall, from 2010 to 2016, *71% of monitored beaches showed stability to growth; 20%, were somewhat erosive to very erosive; and only 9% were extremely erosive. This is a positive trend.*
- *The overall average shoreline change rate for all beaches surveyed was +0.3 ft/yr, indicating relative stability with a slightly positive or growing trend from 2010 to 2016.*
- Many beaches had dunes that were stable or grew from 2010 to 2015; however, at some of these same beaches, berms and beaches underwent erosion.
- Maine beaches scored an overall mean **C (76).** Based on the way we have used the scoring systems for SMBPP and MBMAP data, we consider this to be a **positive result, indicating overall stability to slight growth from 2010 to 2017.**

The State of Maine's Beaches Report series provides volunteer monitors, general public, and local, regional, and state decision-makers and managers with a better sense of the status of southern and mid-coast Maine beaches. Data supporting this report, collected by volunteer monitors, is vital to better understanding monthly, seasonal, and yearly patterns of beach change. This data helps us understand the longer term trends of beach changes along the southern Maine coast, and how beaches respond to storm events and variability in sea level.

Although the Maine Geological Survey does conduct annual shoreline surveys as part of the Maine Beach Mapping Program (MBMAP), we do not have the personnel or funding to support monthly beach profiling efforts. 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 SMBPP.

As usual, analysis of summer 2017 profile data, from July or August, would help determine the latest trends in beach profile response to previous winters. Due to the timing of the Maine Beaches Conference in July 2017, we are unable to include summer 2017 profiles.

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