Maine Geologic Facts and Localities
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A Summary of the 2017 State of Maine's Beaches Report

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Introduction

The 2017 State of Maine's Beaches Report summarizes observed changes of Maine beaches monitored as part of the State of Maine Beach Profiling Project (SMBPP; Maine Sea Grant, 2015) and the Maine Geological Survey's Maine Beach Mapping Program (MBMAP). The SMBPP uses trained volunteers to collect monthly beach profiles that start at a fixed benchmark (in the front or back dune or in a seawall) and continue shore-perpendicular to roughly the low water line using the Emery Method of beach profiling (Emery, 1961). Collected beach profile data is 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, Maine Sea Grant, Maine Coastal Program, and several municipalities.

Introduction

This report includes analysis of winter beach profiles – collected in March or April - from 2010 to 2017. These months are typically when beaches are most eroded, resulting in their "leanest" profile shapes – eroded dunes and flat or non-existent berms. Summer beach profiles – collected in August or September – are typically when the beaches are most sediment-rich, with wide berms and high dunes. Summer beach profiles from 2010 to 2016 were analyzed as part of the report.

An example of monthly winter beach profile data from Goose Rocks Beach in Kennebunkport is shown in Figure 1.

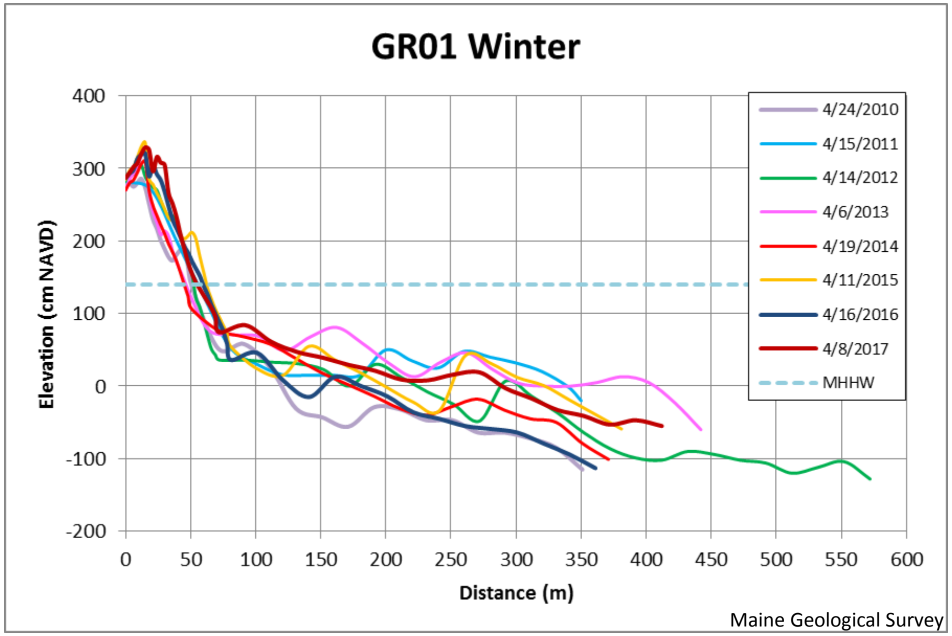


Figure 1. Example of winter beach profiles from profile GR01 at Goose Rocks Beach (Kennebunkport, ME) from 2010 to 2017 which were used for the 2017 beaches report.

Data Collection

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 is collected in the summer months using a Real Time Kinematic Global Positioning System (RTK-GPS) on an annual basis, and is compiled in GIS by the MGS. This data is then analyzed using USGS methodology (Thieler et al., 2008) to calculate shoreline change rates at cast transects along a beach. An example of MBMAP results from analyzing shoreline positions from 2010 to 2016 along Goose Rocks Beach in Kennebunkport is shown in Figure 2.

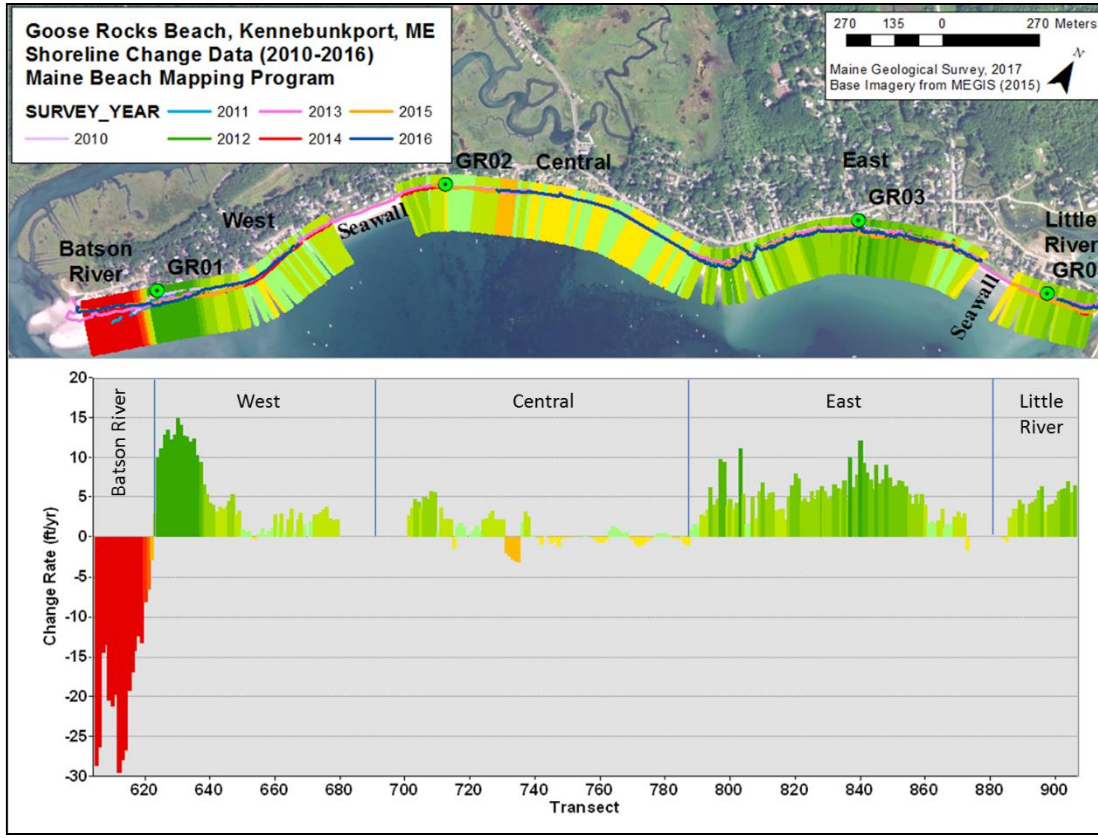
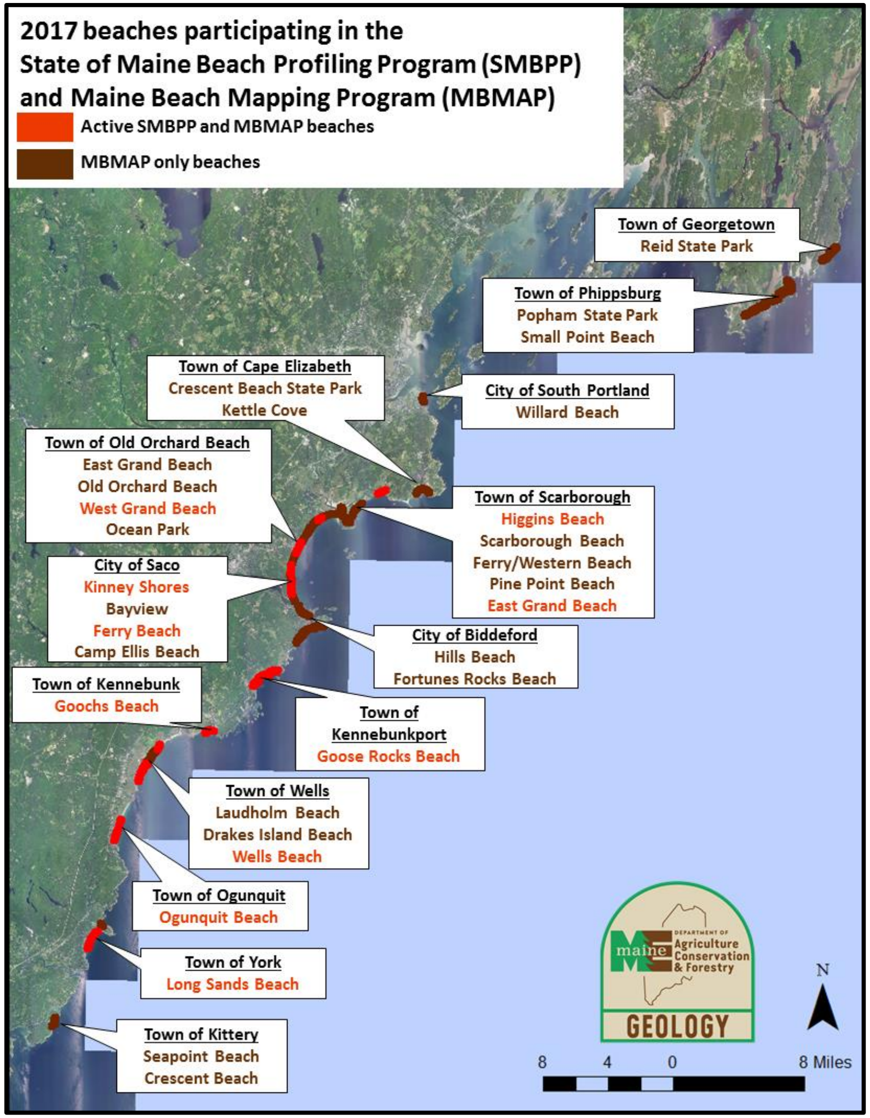


Figure 2. . Example of MBMAP shoreline change analysis for Goose Rocks Beach, Kennebunkport, ME. Note the extremely high erosion near the Batson River and the dramatic shift to accretion near GR01. The central portion of the beach was stable, while the remainder of the beach was highly accretive. Base imagery from MEGIS.

Beaches Profiled



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For the 2017 report, there were 10 beaches in 8 communities participating in SMBPP. MGS monitors 30 beaches (comprised of 35 different beach sections) in 14 different communities as part of MBMAP. Beaches participating in the SMBPP and MBMAP monitoring programs are shown in Figure 3.

Figure 3. Beaches participating in the SMBPP and MBMAP monitoring programs which were included in analysis for the 2017 report.

Factors influencing Beach Erosion: Sea Level Rise

Over the past century, sea level at Portland, Maine rose at an average rate of about 1.9 mm/yr. Over the past 20 years, this has increased up to about 3.1 mm/yr. Some of the highest annual mean sea levels ever recorded at Portland occurred in 2010, with 2010 having five of the highest recorded monthly values since measurements began in 1912 (Figure 4).

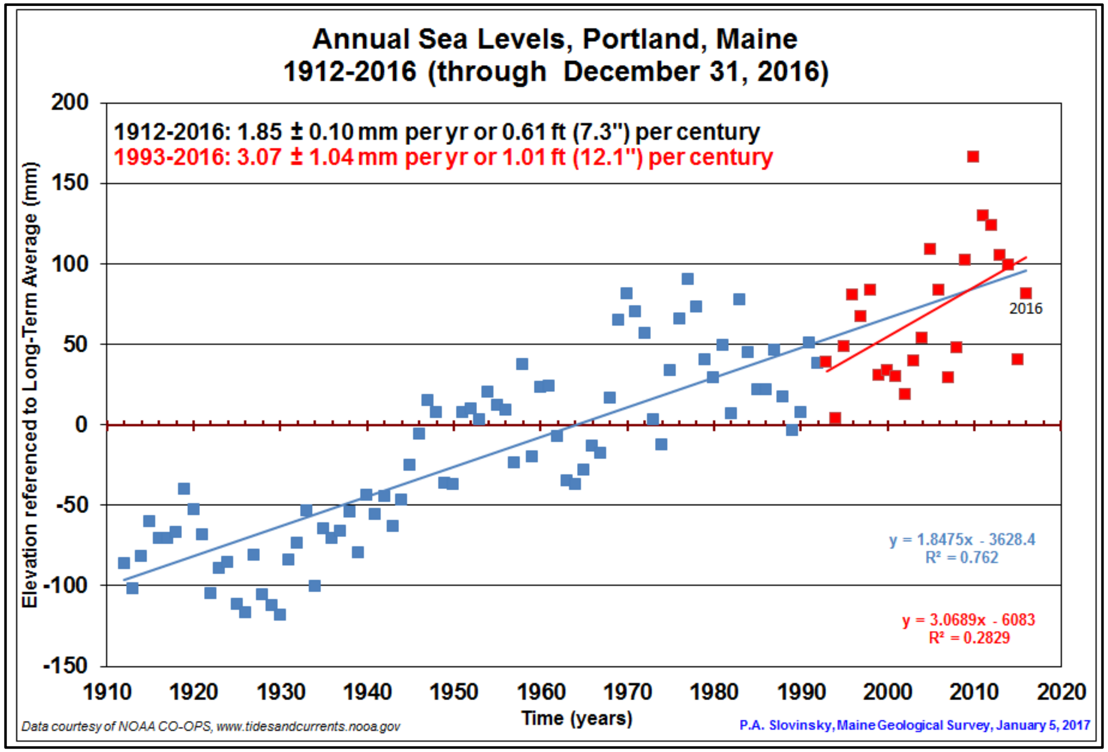


Figure 4. Annual sea level rise data for Portland, ME from 1912 through 2016. Data is referenced to the long-term average, which is the average of annual sea levels from 1912-2016. Data from NOAA CO-OPs.

Factors influencing Beach Erosion: Sea Level Rise

Research (Goddard et al., 2015; Yin and Goddard, 2013) determined that elevated sea levels in the winter of 2010 were likely caused by a combination of 1) atmospheric patterns (part of the North Atlantic Oscillation) which allowed formation of a number of northeast storms that moved up the coastline in the Gulf of Maine, and 2) a significant slowdown of the Gulf Stream portion of what is known as the Atlantic Meridional Overturning Circulation. This elevated sea levels along the entire East Coast of the United States (Sweet et al., 2009), which was most pronounced in the Gulf of Maine – Portland, ME sea levels were on average 5-6" above normal through the winter of 2010! Since then, sea levels fell to near the long-term average in 2015, then increased in 2016 and 2017 (Figure 5).

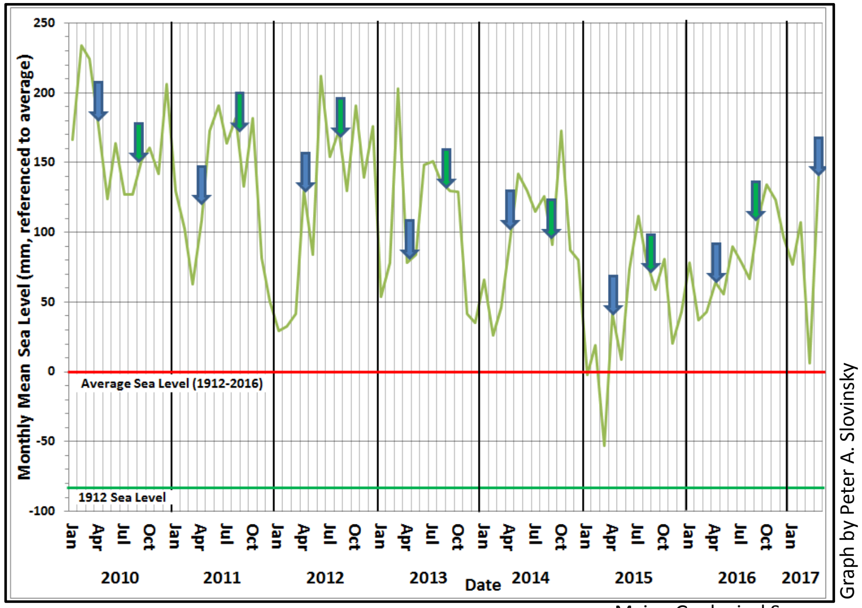
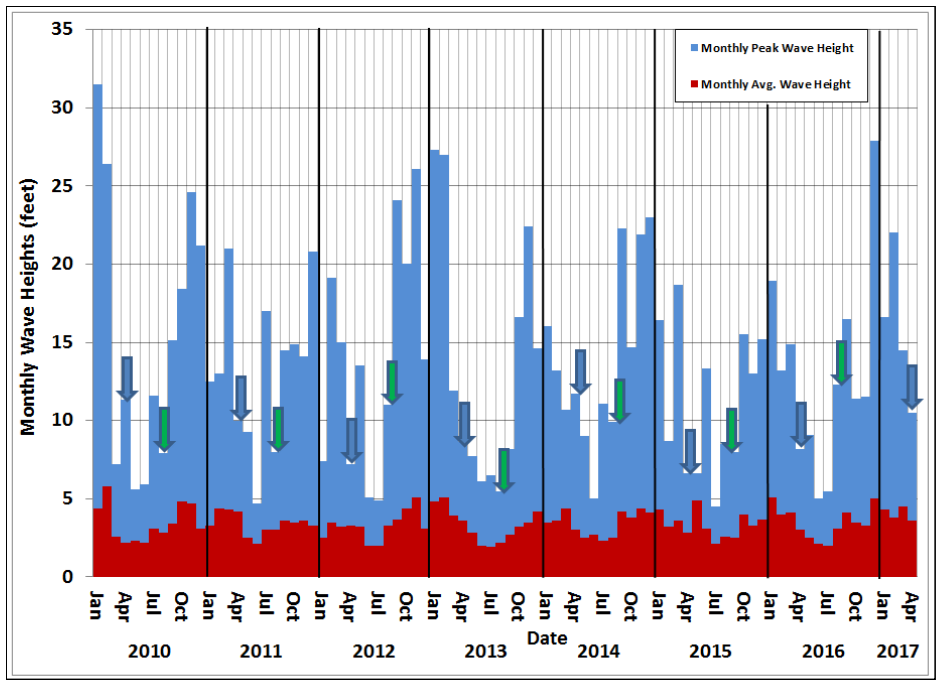


Figure 5. Monthly mean sea levels for Portland, ME from January 2010 through April 2017. Data has been adjusted so that "0" refers to the average long-term sea level from 1912-2016. Approximate times of beach profile data collection for winter (blue arrows) and summer (green arrows) are shown. Data from NOAA CO-OPs.

Factors Influencing Beach Erosion: Winter Storms

Northeasters typically cause erosion of Maine's beaches and dunes, especially during winter months. Generally, the winters of 2009-2010, 2010-2011, 2012-2013, 2014-2015, and 2016-2017 had some of the highest average and peak wave heights. Other winter years (2011-2012, 2013-2014, 2015-2016) were much calmer (Figure 6). Although peak wave heights in winter 2016-2017 were quite high, the events were mostly short-lived, and corresponded with low tides. For a much more detailed account of each winter's storms, please refer to the full beaches report.



Graph by Peter A. Slovinsky

Maine Geological Survey

Figure 6. 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.

Factors Influencing Beach Erosion: Winter. Storms

In winter 2009-2010, elevated sea levels combined with a weather pattern that allowed northeasters to track up the Gulf of Maine coastline and resulted in some of the worst erosion seen in the past 50 years. This was reflected by the number of beaches that were eroded down to historical surfaces. Numerous beaches had exposed peat (old marsh) deposits in winter 2010 (Figure 7).

Photo by Peter A. Slovinsky

Maine Geological Survey

Figure 7. Beach erosion at Higgins Beach, Scarborough in winter 2010. Note exposed peat surfaces and in-situ logs. Anecdotal evidence suggests this was the worst erosion in the past 50 years.

Review of Beach Responses from Analysis of SMBPP and MBMAP Data

A scoring system was used to assess beach changes from 2010 to 2017 collected by the SMBPP. Each beach profile was assigned a "grade," based on the amount of erosion, stability, or growth exhibited by both summer and winter beach profile shapes. An overall beach grade was assigned, as an average of all the summer and winter profile scores. This grading system is qualitative but similar to that used in previous reports.

The MBMAP shoreline change data were used to calculate linear regression rates (LRR, in feet per year, ft/yr) at 10-meter transect intervals along each beach. Mean values for each beach were calculated and then used to develop a grading system.

It's important to note that using a mean calculation for an entire beach is not necessarily representative of the beach's stability at all points. 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).

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

Figure 8. Scoring method used for the SMBPP and MBMAP datasets.

Discussion of SMBPP Scoring Results

Scores from the ten beaches participating in SMBPP are shown in Figure 9. Winter and summer profile scores were averaged to create an overall score for each beach, and the score was then compared with results from the 2015 beaches report, and the general trend (positive +; negative -, or equal =) described.

Overall, two beaches scored a B, 4 beaches scored a C+, 1 beach scored a C, 2 beaches scored a C-, and 1 beach scored a D. When the scores from all beaches are combined and averaged, the overall score was a C(76). This is consistent with 2015 results, and indicates that beaches are, in general, stable or recovering since 2010.

The top scoring beaches were Goose Rocks Beach (81) and Ogunquit Beach (81). Ogunquit actually increased its score by 7 points, the largest positive increase of the beaches. Kinney Shores, Long Sands, West Grand, and East Grand all were stable to slightly accretive. Wells Beach was stable, while Higgins Beach, Goochs Beach and Ferry Beach (Saco) were slightly erosive to highly erosive. Goochs Beach had the largest decrease in scores from 2015. Overall, 6 of 10 beaches had the same or higher scores, while 4 of 10 beaches had lower scores than 2015.

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

Figure 9. Summary of SMBPP profile scores from 2010 to 2017 (winter) and 2010 to 2016 (summer).

Discussion of MBMAP Scoring Results

Overall results from MBMAP analysis is presented in Figure 10. Beaches are ranked based on averaged scores, and the table includes 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.

Discussion of MBMAP Scoring Results (2)

Figure 10. 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.

2017 Rank	Beach	Municipality	MBMAP Description	MBMAP Score	2016 Rate (ft/yr)	2015 Rate (ft/yr)	Trend
1	**Popham - Riverside**	Phippsburg	Very highly accretive	95	6.4	8.6	-
2	**Small Point**	Phippsburg	Very highly accretive	95	5.9	5.6	+
3	**East Grand/Pine Point**	Old Orchard/Scarborough	Highly accretive	92	4.5	3.0	+
4	**East Grand**	Old Orchard	Highly accretive	92	4.1	3.1	+
5	**Reid - Half Mile**	Georgetown	Very accretive	88	2.7	2.1	+
6	**Fortunes Rocks**	Biddeford	Accretive	85	2.3	2.6	-
7	**Reid - Mile Stretch**	Georgetown	Accretive	85	2.2	2.5	-
8	**Goose Rocks**	Kennebunkport	Accretive	85	2.0	1.3	+
9	**Scarborough**	Scarborough	Accretive	85	1.8	2.3	-
10	**Kinney Shores**	Saco	Accretive	85	1.7	1.3	+
11	**Ocean Park**	Old Orchard	Accretive	85	1.6	1.5	+
12	**Willard**	South Portland	Accretive	85	1.5	1.9	-
13	**Hills**	Biddeford	Somewhat accretive	82	1.3	1.0	+
14	**Ferry**	Scarborough	Somewhat accretive	82	1.3	0.8	+
15	**Bayview**	Saco	Somewhat accretive	82	1.2	-1.0	+
16	**Crescent**	Kittery	Somewhat accretive	82	1.2	0.6	+
17	**Long Sands**	York	Slightly accretive	78	1.0	1.0	=
18	**Ogunquit**	Ogunquit	Slightly accretive	78	0.9	-0.2	+
19	**West Grand**	Old Orchard	Slightly accretive	78	0.8	0.9	-
20	**Wells**	Wells	Slightly accretive	78	0.7	-0.6	+
21	**Drakes Island**	Wells	Slightly accretive	78	0.6	-0.2	+
22	**Crescent**	Cape Elizabeth	Stable	75	0.4	0.6	-
23	**Kettle Cove**	Cape Elizabeth	Stable	75	0.2	0.6	-
24	**Popham - Center Beach**	Phippsburg	Stable	75	0.1	0.2	-
25	**Reid - Little River**	Georgetown	Stable	75	0.0	-	
26	**Seapoint**	Kittery	Stable	75	-0.3	-1.0	+
27	**Goochs**	Kennebunk	Slightly erosive	72	-0.8	-1.8	+
28	**Western**	Scarborough	Slightly erosive	72	-0.9	-4.4	+
29	**Pine Point**	Scarborough	Somewhat erosive	68	-1.3	-1.0	-
30	**Popham - West Beach**	Phippsburg	Erosive	65	-2.1	0.2	-
31	**Ferry Beach**	Saco	Very erosive	62	-2.5	-3.9	+
32	**Laudholm**	Wells	Very erosive	62	-2.6	-3.9	+
33	**Popham - Hunnewell**	Phippsburg	Extremely erosive	55	-7.6	-12.1	+
34	**Popham - East Beach**	Phippsburg	Extremely erosive	52	-8.6	-	
35	**Higgins**	Scarborough	Extremely erosive	52	-10.9	1.6	-
	Average (for all beaches)		**Stable**	**77**	0.3	0.4	-

statistically signifcant change in the shoreline change trend (light blue)

Discussion of MBMAP Scoring Results (3)

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 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).

Discussion of MBMAP Scoring Results (4)

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, 76).

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

Maine Beach Mapping Program - Newly Available and Coming Information

The Maine Geological Survey created a web map 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 information on how beaches are mapped, and what shoreline change statistics are calculated (and what they mean).

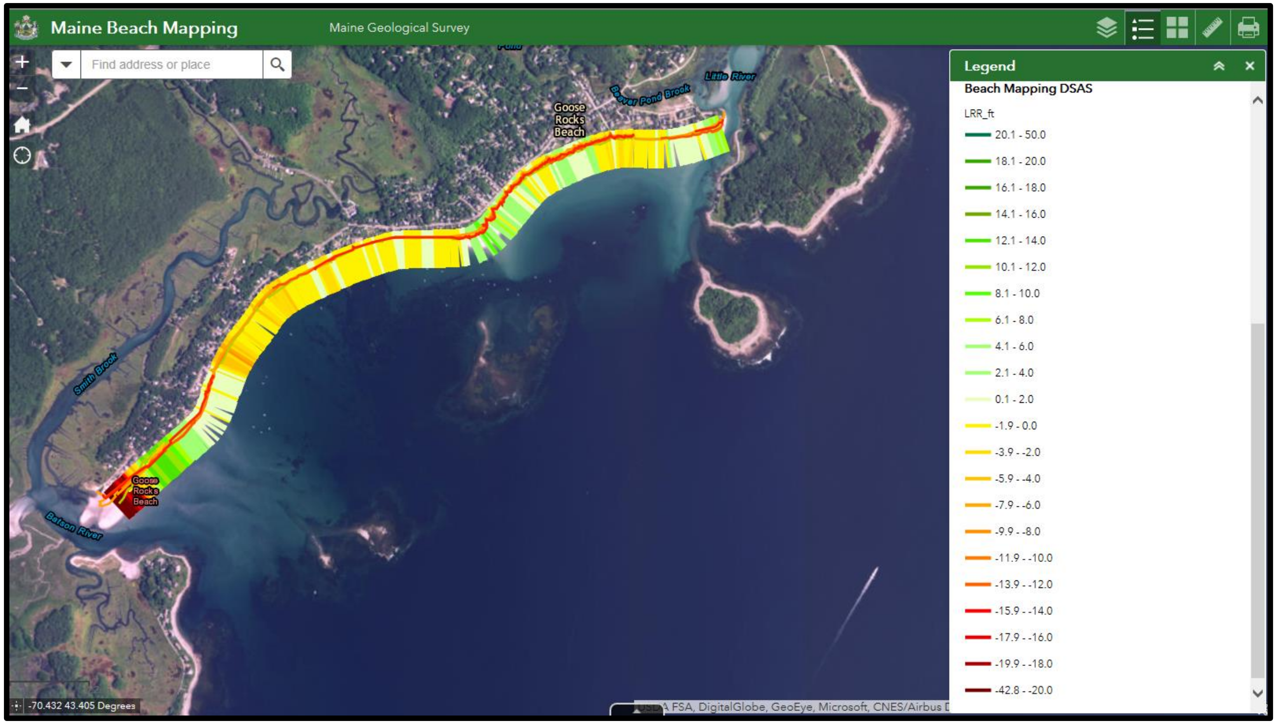


Figure 11. Maine Geological Survey's Maine Beach Mapping Program (MBMAP) online viewer showing Goose Rocks Beach, Kennebunkport, ME showing shoreline change rates (in linear regression rate, feet/year).

Maine Beach Mapping Program - Newly Available and Coming Information

In addition, MGS will be including new shoreline change information from this summer's (2017) MBMAP field mapping program. This season, MGS began 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.

Maine Beach Mapping Program - Newly Available and Coming Information

Figure 12 shows calculated dry beach widths from Ferry and Western Beach in Scarborough, as measured in June 2017. Along Ferry Beach, the dry beach is quite narrow – 25 feet or less – for the majority of the beach until near transect 80 where it increases to between 50-75 feet.

Along Western Beach, the dry beach width varies between 25-50 feet until where the 2015 beach nourishment project was completed. Here (transects 115-160) the dry beach increases dramatically to between 50-75 feet, and up to 100 feet in some sections. This increase in dry beach has been one of the driving factors in successful piping plover and least tern nesting in the spring and early summer of 2017.

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.

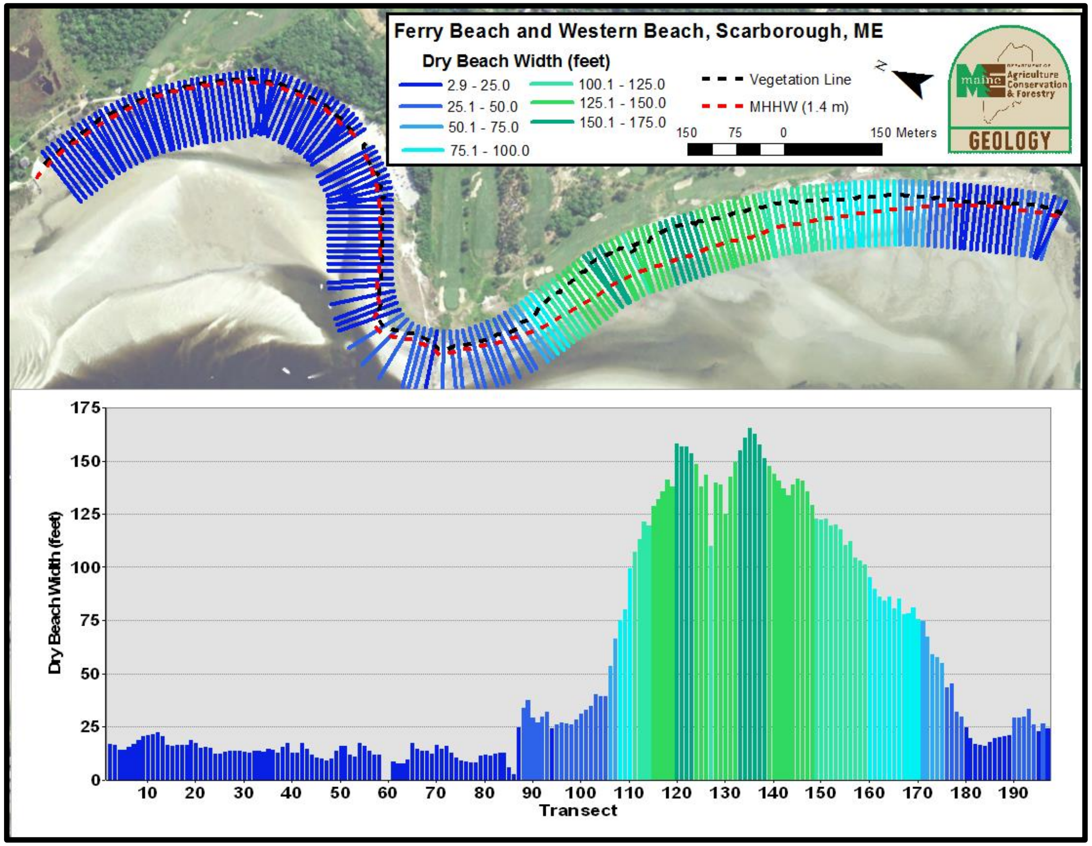


Figure 12. Dry beach width (DBW) calculated using the June 2017 vegetation line and the Mean Higher High Water (MHHW) line for Ferry and Western Beaches, Scarborough, ME.

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). 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 data showed that:

- High sea levels, combined with a very active northeaster storm track in the winter of 2010 resulted in some of the worst erosion at beaches in the last 7 years.
- The winters of 2009-2010, 2010-2011, 2012-2013, 2014-2015, and 2016-2017 had some of the highest average and peak wave heights. Other winters (2011-2012, 2013-2014, 2015-2016) were calmer, allowing for beach recovery and growth.
- 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 was +0.3 ft/yr, indicating relative stability with a slightly positive or growing trend from 2010 to 2016.
- 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**.

Conclusions

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.

The full text and figures of the 2017 Maine's State of the Beaches report is available online.

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