Geologic Site of the Month

April, 2003

Beach Exposures of Tree Stumps in Wells Embayment

43° 19‘ 37.66“ N, 70° 32‘ 51.93“ W

Text by
Stephen M. Dickson

Introduction

Coastal beaches and dunes are landforms that move inland with rising sea level. Sand from the beach is washed into the dunes during coastal flooding and storms. Over centuries to millennia, the process of washover (sand carried by flood waters in the dune) conserves sand in the coastal dune and beach system as the ocean rises. This landward recycling process results in dunes that maintain their height in relation to coastal flooding. The frontal dune ridge forms an excellent defense against erosion and flooding caused by storm waves (Figure 1).

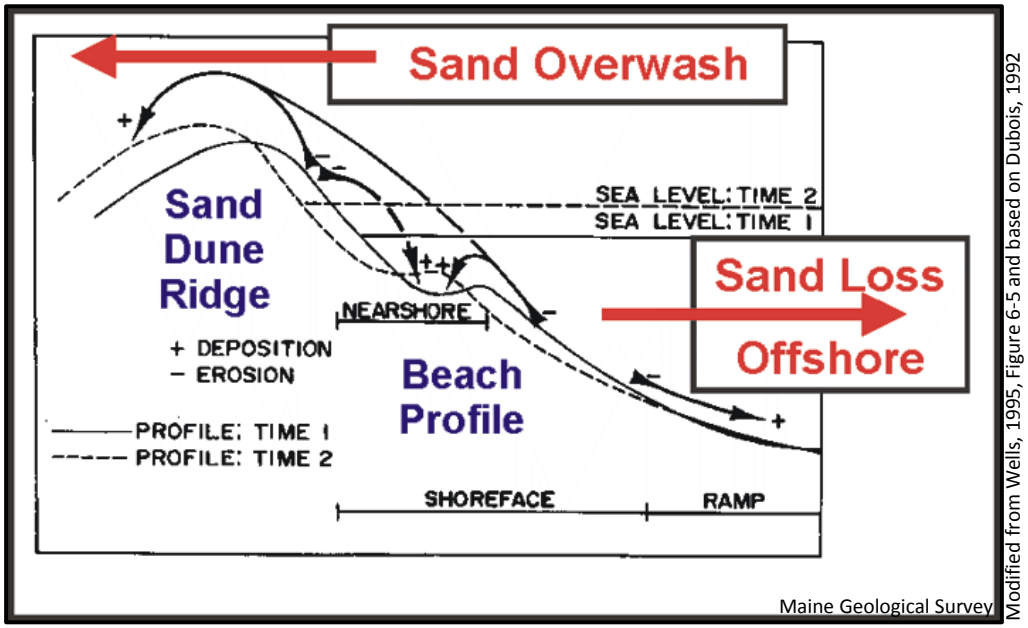

Figure 1. Coastal processes redistribute sand over time. As the ocean rises (from Time 1 to Time 2) the beach and dune profile changes (from solid to dashed lines). The process of landward deposition of overwash results in an upward and inland migration of the frontal dune ridge and preservation of the beach and dune landform.

Barrier Beach and Dune Migration

As the beach and dune migrate up and inland, this landform moves over the back barrier salt marshes and upland forest. If the dune system moves inland a distance greater than its width (perpendicular to the shoreline) the former upland may be exposed on the beach (Figure 2).

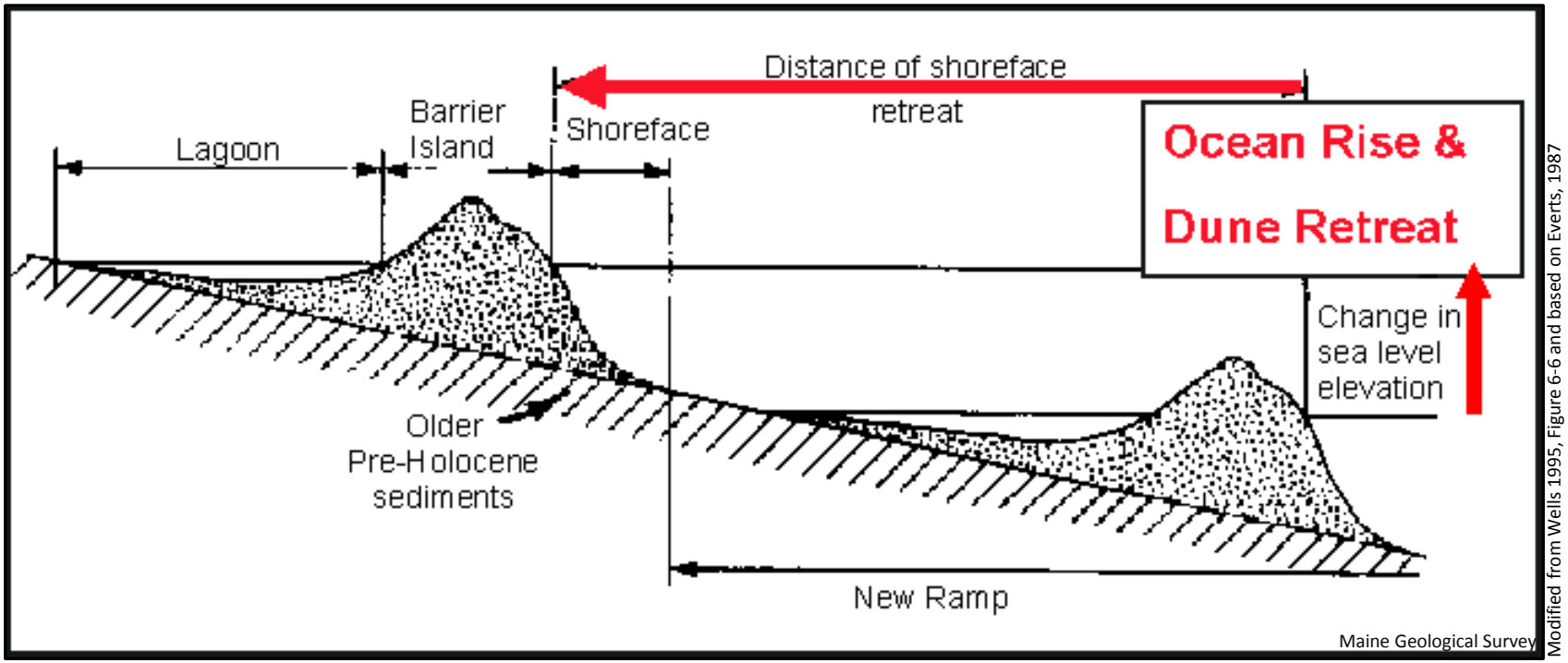

Figure 2. Barrier beach and dune migration inland with sea-level rise can result in the exposure of upland environments that are several thousand years old on the beach.

Sea-Level Rise in Wells Embayment

The region from Ogunquit to the Kennebunks is known as Wells Embayment. For thousands of years, the ocean along the embayment and the entire Maine coast has been rising (Kelley and others, 1996). At various times in the past when sea level was lower than at present, salt marshes formed behind the dunes at lower elevations. The top elevation of high and low salt marshes (*Spartina patens* and *S. alterniflora*) can be related to the height of the tides (mean high water) in the past.

The history of sea-level rise is recorded in buried sediments of back-barrier salt marshes in the Wells Embayment (Belknap and others, 1989; Gehrels, 1994; Gehrels and others, 1996; Kelley and others, 1988, 1992). With marsh coring and the analytical method of radiocarbon age dating, peat samples from different locations and depths are used to create an age-elevation curve (Figure 3).

Sea-Level Rise in Wells Embayment

Analysis of the results leads to a calculation of the rate of sea-level rise in the past. From about 5,000 years ago to 3,600 (calendar) years ago the rate of sea-level rise in Wells Embayment was 5.5 inches/century (1.4 mm/yr) and, since 3,600 years ago, the rate of sea-level rise slowed to 2.0 inches/century (0.5 mm/yr, Gehrels, 1994). In comparison, the current rate of sea-level rise, as measured by the Portland tide gauge is 7.5 inches/century (1.9 mm/yr, from 1912 to 2002), nearly 4 times faster than the rate over the last few thousand years.

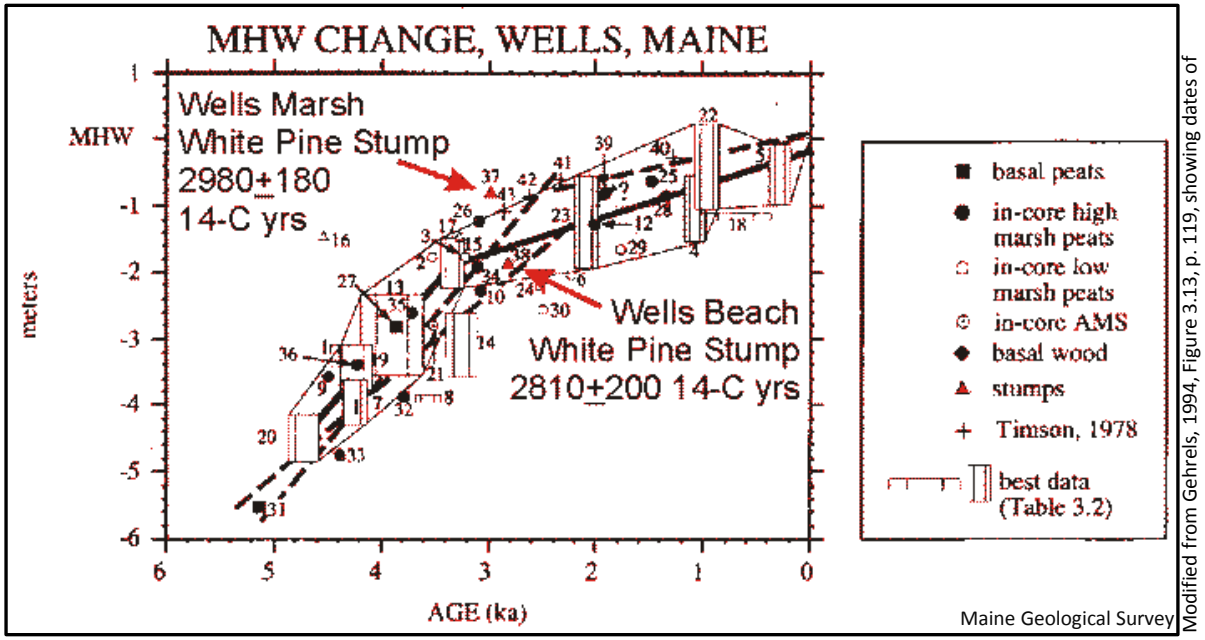

Figure 3. A graph of the ocean rise along the shore of Wells Embayment over the last 5,000 years (1,000 yrs = 1 ka) incorporating radiocarbon ages and elevations (MHW = mean high water) for salt marsh peat, wood samples, and two stumps (red triangles).

Locations of Tree Stumps on the Beach: Wells Beach

There are notable locations of tree stumps in the intertidal zone of beaches in Wells (Figures 4-7) and Kennebunk (Figures 8-12). These stumps are most easily found during the late winter or early spring after winter storm waves have eroded the beach and when the tide is low.

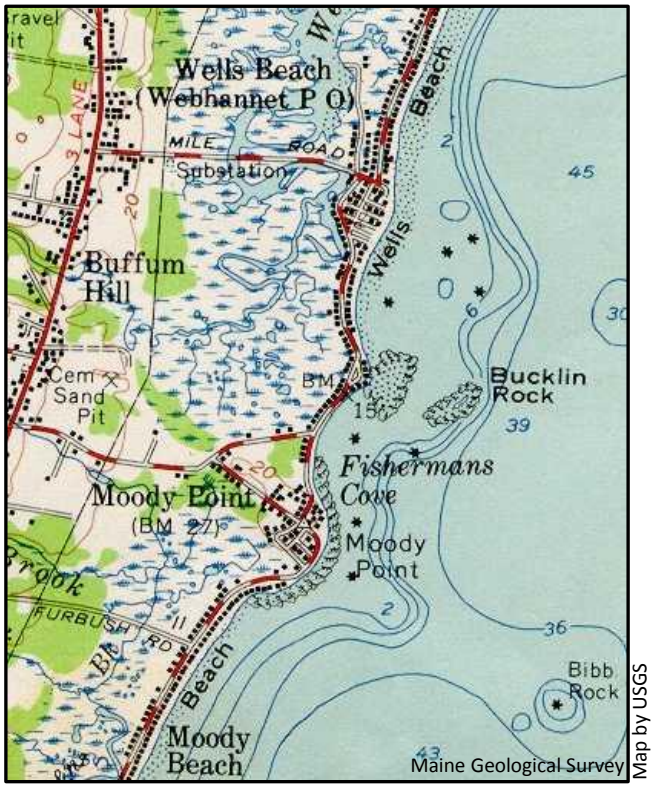

Figure 4. A portion of the 1956 USGS 15' topographic map of Wells Beach in the vicinity of Casino Point (at Mile Road) and Moody Point. The beach between Casino Point and Bucklin Rock has had tree stumps exposed in the intertidal area in the 1950s.

Locations of Tree Stumps on the Beach: Wells Beach

Figure 5. Air photo of Moody Beach (foreground), Moody Point and Wells Beach (background) with the expansive Webhannet River salt marsh and forested upland behind heavily developed sand dunes.

Locations of Tree Stumps on the Beach: Wells Beach

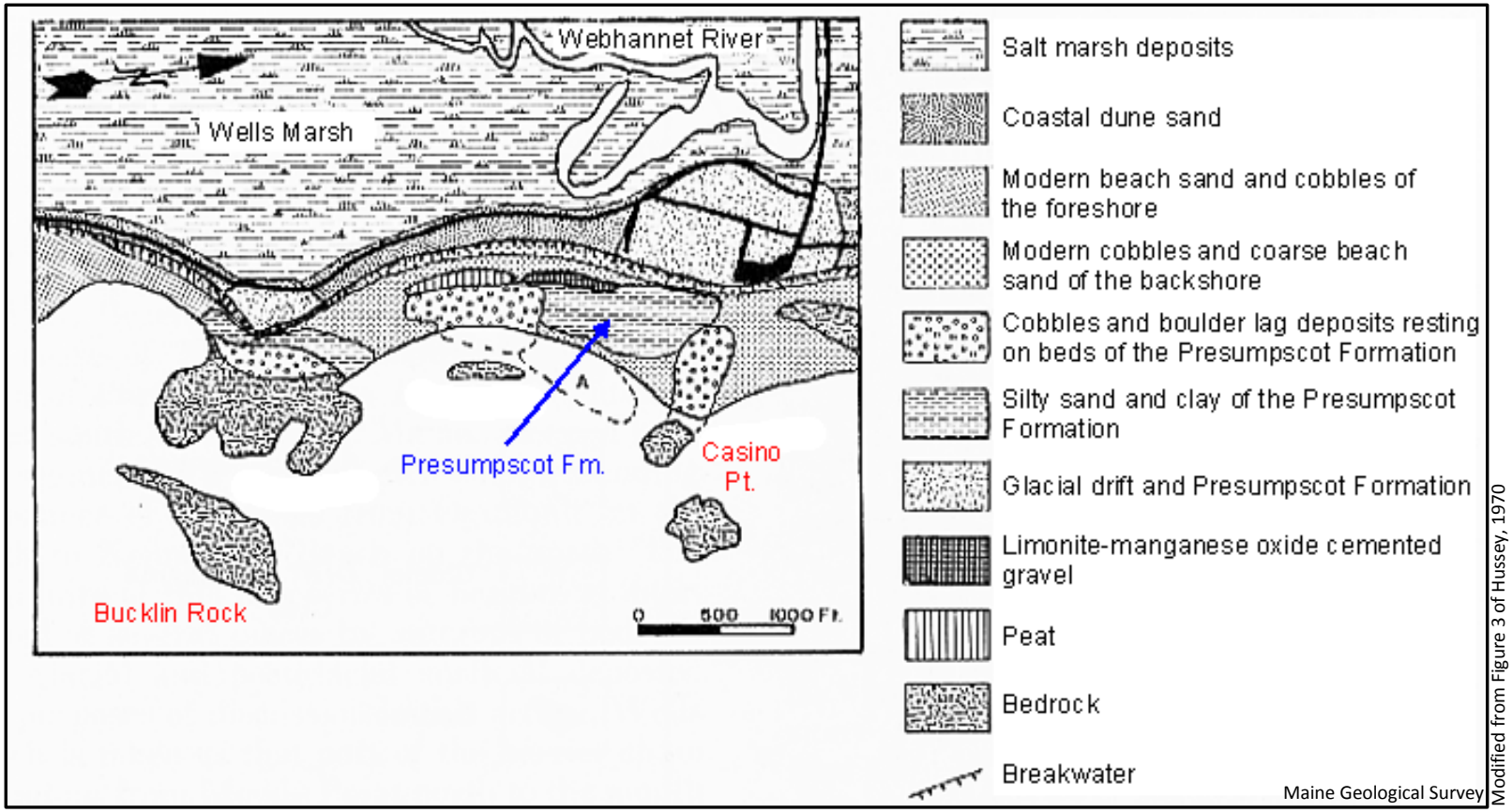

Figure 6. A geologic map of the middle segment of Wells Beach between Casino Point and a headland near Bucklin Rock. This map by Hussey (1970) represents conditions after erosion by storms in 1969. The exposed ice-age Presumpscot Formation, just below Casino Point, reveals how thin the modern beach sand deposits are.

Locations of Tree Stumps on the Beach: Wells Beach

Figure 7. A 1955 photograph by Arthur Hussey, II of a wave-abraded tree stump on the middle segment of Wells Beach. By April when this photo was taken, there was very little sand on the beach. A layer of salt marsh peat covered the roots that grew into a deeper sand layer. Note the small shovel for scale.

Locations of Tree Stumps on the Beach: Kennebunk Beaches

Lords Point has been eroded dramatically over the last sixty years. A building on the point was destroyed by storms and is now gone (compare Figure 8 and Figure 10). In the pocket beach just east (right) of Lords Point are drowned, intertidal tree stumps from an upland setting that existed several thousand years ago. As a consequence of sea-level rise of over a three feet in the last few thousand years, the shoreline in this cove has migrated inland a considerable distance.

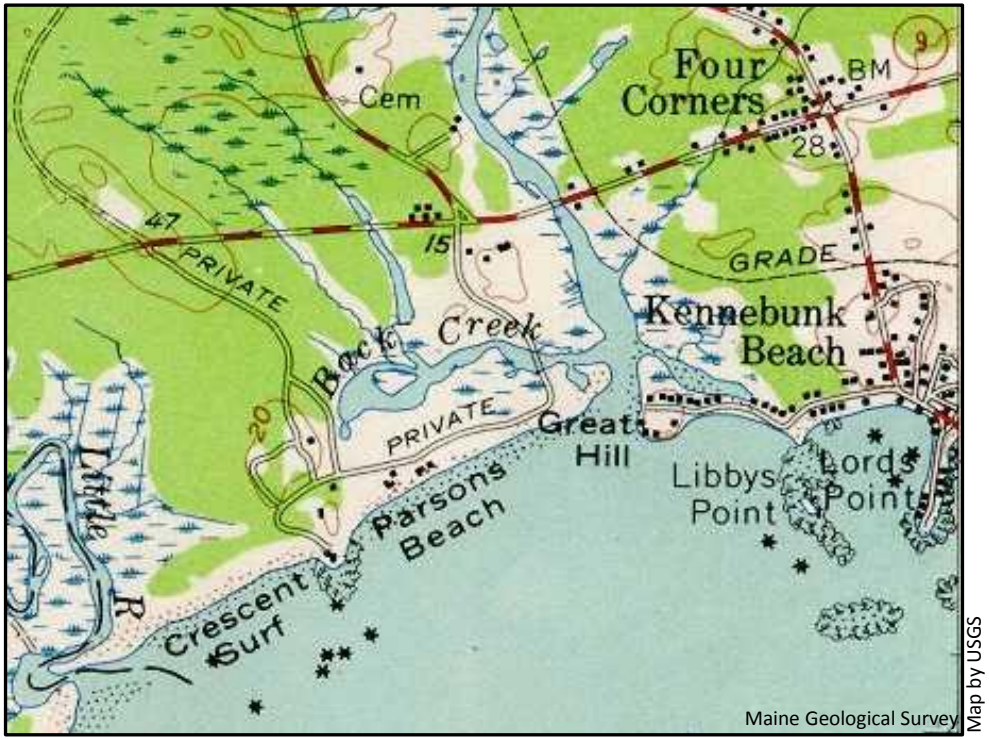

Figure 8. A portion of the 1956 USGS 15' topographic map of Kennebunk Beach in the vicinity of Libbys and Lords Points. The cove between the two points has tree stumps in the intertidal area.

Locations of Tree Stumps on the Beach: Kennebunk Beaches

Figure 9. Kennebunk Beaches with shoals and a gravel tombolo (the gravel bar in the foreground) made from the remnants of Libby Point. Lords Point is the central peninsula with houses. The protected cove between Libby Point and Lords Point has many intertidal tree stumps. Goochs Beach is in the top right corner.

Locations of Tree Stumps on the Beach: Kennebunk Beaches

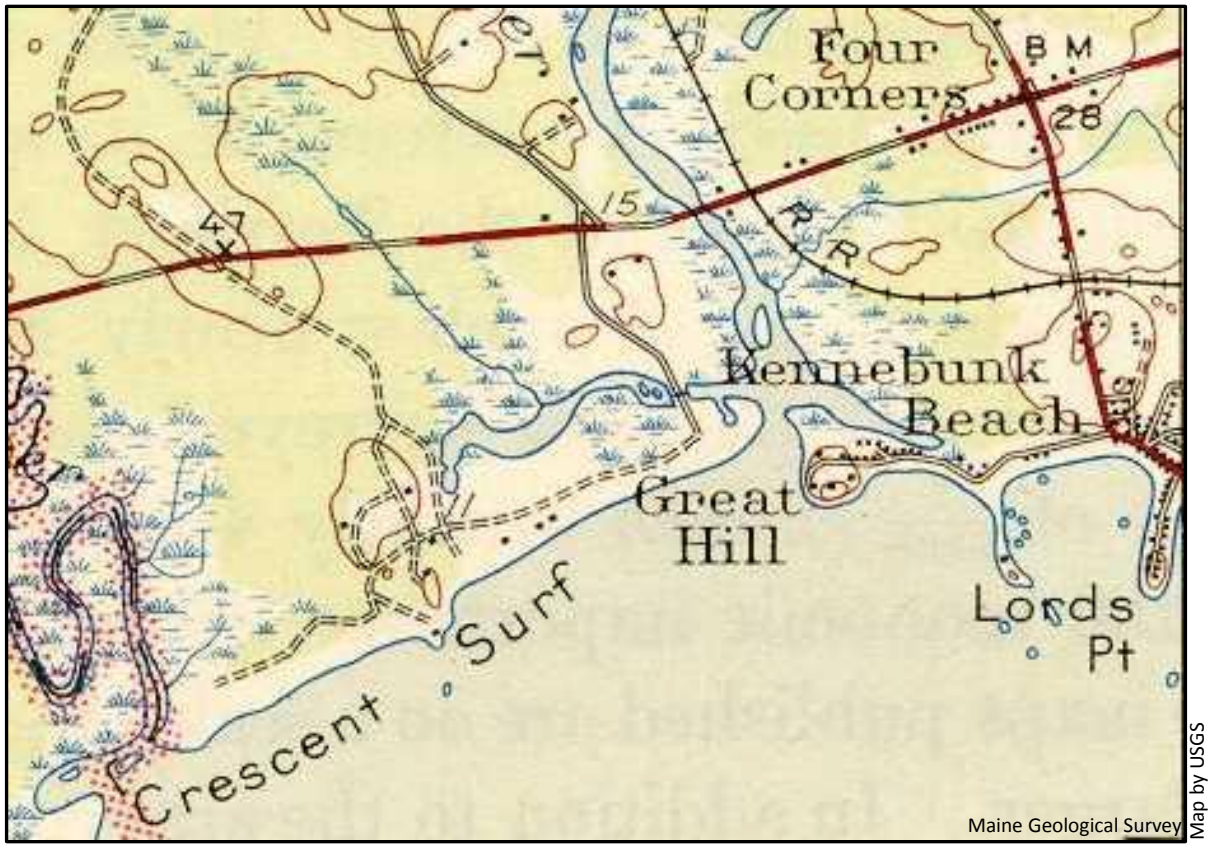

Figure 10. A portion of the 1944 USGS 15' topographic map of Kennebunk Beach in the vicinity of Libbys and Lords Points. Note the presence of a building (black square) on Lords Point. Also note the small brown circle (above the "o" in Lords) that represents a 20-foot contour in elevation at the time the building was there. Compare this map to the 1956 map in Figure 8 to see the land lost from erosion and shoreline change.

Locations of Tree Stumps on the Beach: Kennebunk Beaches

Figure 11. A portion of the 1959 USGS 15' topographic map of Kennebunk Beach in the vicinity of the Kennebunk River. Middle Beach, just west (left) of Oakes Neck is another site of stumps on the beach. Goochs Beach is east of Oakes Neck.

Locations of Tree Stumps on the Beach: Kennebunk Beaches

Figure 12. Two relict tree stumps from Middle Beach in Kennebunk.

Stumps on other Maine Beaches

Stumps have been reported on several other Maine beaches. In Georgetown, Mile Beach at Reid State Park has tree roots exposed periodically after winters with severe erosion. Robinhood Cove, also in Georgetown, has a sheltered beach tombolo (sand bar) adjacent to the Nubble. At this site, Bradley (1953) reported eastern white pine, *Pinus strobus*, stumps exposed in the intertidal zone. One of these was determined to be 4150±200 radiocarbon years old. In Scarborough, Western Beach, adjacent to the Prouts Neck headland, had tree stumps exposed on the beach in 1951 and 1952 (Bradley, 1953) but their ages were not determined.

Most of coastal Maine has had a very similar history of sea-level change during the last several thousand years. Other beaches may have stumps exposed from time to time, particularly after winters with severe beach erosion. Peat is often exposed in and around the ancient tree stumps or by itself (see Duffy and others, 1989 for an example of peat exposed in Biddeford). If you walk the beach in late winter or early spring you may find these relicts of past landforms near the mid-tide level.

Additional Links

MGS Marine Geology index page with additional information and links

Beach and Dune Aerial Photos of Maine Beaches

Topographic maps available for purchase from the Maine Geological Survey

Digital historical topographic maps available for analysis

Field Locality - Reid State Park

References and Additional Information

Belknap, D. F., Shipp, R. C., Stuckenrath, R., Kelley, J. T., and Borns, H. W., Jr., 1989, Holocene sea-level change in coastal Maine: in Anderson, W. A., and Borns, H. W., Jr. (Eds.), Neotectonics of Maine: studies in seismicity, crustal warping, and sea level change, Maine Geological Survey (Department of Conservation), Bulletin 40, p. 85-105.

Bradley, W. H., 1953, Age of intertidal tree stumps at Robinhood, Maine, Amer. Jour. Science, v. 252, p. 543-546.

Dubois, R. N., 1992, A re-evaluation of Bruun's Rule and supporting evidence. Jour. Coastal Research, v. 8, p. 618-628.

Duffy, W., Belknap, D. F., and Kelley, J. T., 1989, Morphology and stratigraphy of small barrier-lagoon systems in Maine: in Ward, L. G., and Ashley, G. M. (Eds.), Physical processes and sedimentology of siliciclastic dominated lagoonal systems: Marine Geology, v. 88, nos. 3-4, p. 243-262.

Everts, C. H., 1987, Continental shelf evolution in response to a rise in sea level, in Sea-level Fluctuation and Coastal Evolution, Nummedal, D., Pilkey, O. H., and Howard, J. D., Eds., Society of Economic Paleontologists and Mineralogists, Tulsa, Oklahoma, p. 49-57.

Gehrels, W. R., 1994, Holocene sea-level changes in the northern Gulf of Maine; regional trends and local fluctuations determined from foraminiferal analyses and paleotidal modeling: Ph.D. dissertation, University of Maine, Orono, Maine, 351 p.

Gehrels, W. R., Belknap, D. F., and Kelley, J. T., 1996, Integrated high-precision analyses of Holocene relative sea-level changes; lessons from the coast of Maine: Geological Society of America, Bulletin, v. 108, no. 9, p. 1073-1088.

Hussey, A. M., II, 1959, Age of intertidal tree stumps at Wells Beach and Kennebunk Beach, Maine, Jour. of Sedimentary Petrology, v. 29, no. 3, p. 464-465, table.

References and Additional Information

Hussey, A. M., II, 1970, Observations on the origin and development of the Wells Beach area, Maine, Maine Geological Survey, Bulletin 23, p. 58-68.

Kelley, J. T., Dickson, S. M., Belknap, D. F., 1996, Maine's history of sea-level changes: Maine Geological Survey, Fact Sheet.

Kelley, J. T., Almquist-Jacobson, H., Jacobson, G. L. Jr., Gehrels, R. and Schneider, Z., 1992, The geologic and vegetative development of tidal marshes at Wells, Maine, U.S.A.: Research Report to the Wells National Estuarine Research Reserve and the National Oceanic and Atmospheric Administration, 73 p.

Kelley, Joseph T., Belknap, Daniel F., Jacobson, G. L., Jr., and Jacobson, H. A., 1988, The morphology and origin of salt marshes along the glaciated coastline of Maine, USA: Jour. of Coastal Research, v. 4, no. 4, p. 649-666.

Timson, B. S., 1978, New carbon-14 dates (pdf), The Maine Geologist, v. 4(3), p. 6.

Wells, J. T., 1995, Effects of sea level rise on coastal sedimentation and erosion, in: Climate Change - Impact on Coastal Habitation, D. Eisma, Ed. Lewis Publishers, Boca Raton, Florida, p. 111-136.