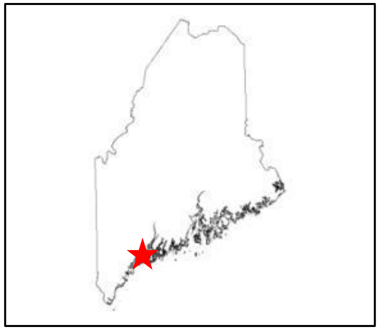
Geologic Site of the Month

February, 2006

Dune Restoration at Willard Beach in Simonton Cove South Portland, Maine



43° 38' 43.14" N, 70° 13' 38.92" W

Text by
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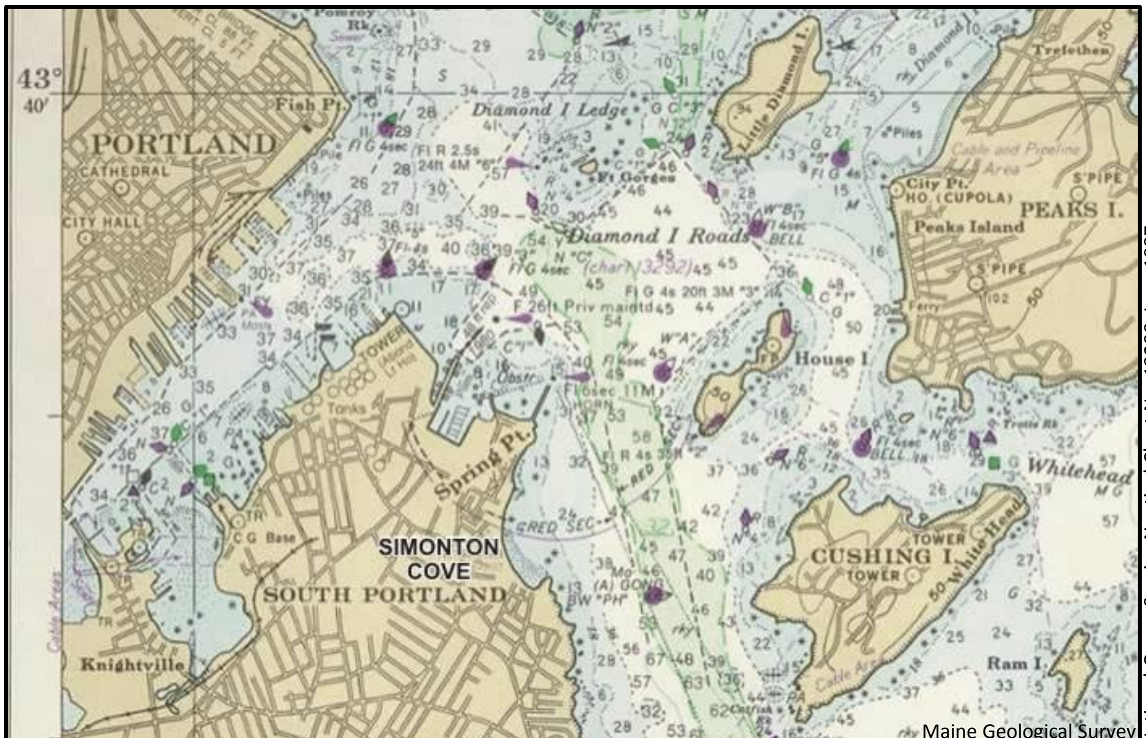
Introduction

Willard Beach is one of Maine's few urban beaches. It lies within the arcuate Simonton Cove on the eastern shore of South Portland. Facing east, the beach overlooks the Portland ship channel and beyond to Cushing and Peaks Islands in Casco Bay (Figure 1). The islands of Casco Bay shelter the beach from some waves although ocean swells can approach the cove from the south in the Portland ship channel.



National Ocean Service Nautical Chart No. 13290, June 1987

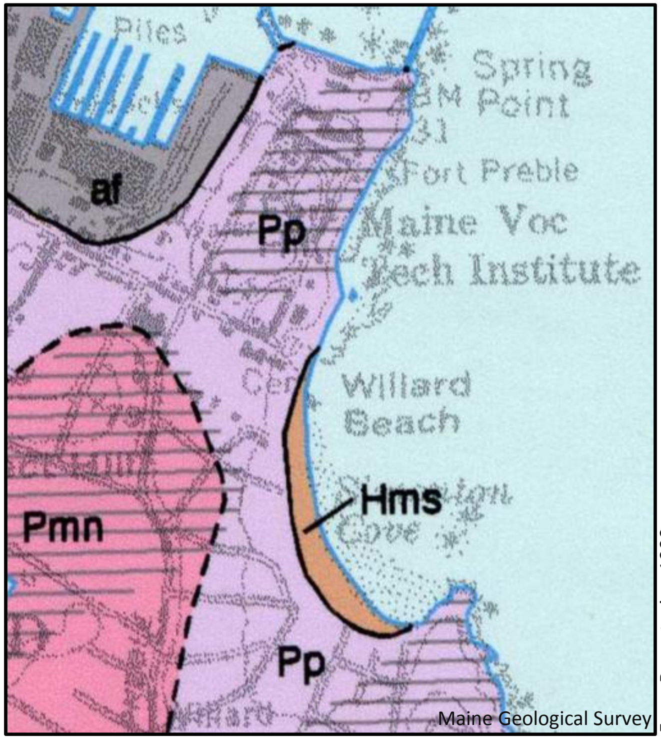
Figure 1. Nautical chart of the area around Simonton Cove.

Introduction

The cove is bordered on the north and south sides by bedrock headlands. The bedrock in this area is Ordovician in age and the folded metamorphic rocks are interesting in their own right and are described on a separate MGS bedrock geology page (Folded Metamorphic Rocks Near Willard Beach, South Portland). The northern edge of the beach and dunes tapers against bedrock cliffs that front the campus of Southern Maine Community College (SMCC). Over the bedrock surface are sediments primarily left by glaciers and modified by changes in sea level over the last 18,000 years. The most recent modification to the glacial sediment was the formation of Willard Beach by wave action over the last few thousand years (Figure 2; Bernotavicz, 1999).

Surficial Geology

Figure 2 is a portion of the Maine Geological Survey Surficial Geology map of South Portland. The beach and dunes are represented (in a general sense) by the Holocene marine sand (Hms) unit. The surrounding sediments include the glaciomarine Presumpscot Formation (Pp) that is only a very thin layer over bedrock in the hachured areas. Marine nearshore deposits (Pmn) and artificial fill (af) are two other map units in the upland area.



From Bernotavicz, 1999

Figure 2. Surficial Geologic map of the Willard Beach area. More details can be found by reading the full map and legend on the MGS web site (pdf format).

A Review of Willard Beach from Historical Air Photos

In the cove is a relatively sheltered beach and dune system that has been a very popular recreational location for over a century (Figure 3 and Figure 4). The extensive use of the beach prevented some of the natural dune vegetation from growing.

Photo ca. 1930s courtesy of L. K. Fink, Jr

Figure 3. An antique photograph of the central portion of Willard Beach indicates a level of recreational use that is similar to that of today. The seaward edge of the frontal dune vegetation is visible in the foreground and would continue past the utility pole and playground if left undisturbed by people. The Willard Haven Inn is in the background.

A Review of Willard Beach from Historical Air Photos

In Figure 3 the vestiges of a dune can be seen in the foreground. Some of the buildings were built on posts and it appears that wave action could reach them in storms due to the lack of a frontal dune (Figure 4).

Photo ca. 1930s courtesy of L. K. Fink, Jr

Figure 4. Antique photograph of Willard Beach from the southwest end looking northeast toward Spring Point. Notice how several buildings are built on posts directly over sand that slopes down toward the beach. This grade is probably a result of wave action across the sand surface. These structures could have been better protected if the dunes had been allowed to grow dune grass and trap sand. A higher dune would have limited the inland reach of storm waves.

A Review of Willard Beach from Historical Air Photos

Residential development has fringed Willard Beach for generations and a strong sense of community exists there today. In 1956, development consisted primarily of single-family homes (Figure 5), many of which were close to the beach and not protected behind sand dunes (Figure 6-8).

Figure 5. A vertical air photo of Willard Beach taken December 1, 1956. In the low angle winter sun, shadows fall on parts of the dunes. The open sandy beach extends up to the front of many homes (see details in Figures 6-8). The ground does not appear to be snow-covered, so light tones are sand.

A Review of Willard Beach from Historical Air Photos

In fact, based on the shape of the shoreline and wide berm (the flat dry sand surface), relief of historical dunes was probably lost due to foot traffic and use of the beach for storing, launching, and hauling boats.

Photo No. PWN-2-3 courtesy of L. K. Fink, Jr

Figure 6. A detailed view of Figure 5 at the northeastern end of the beach near Myrtle and Beach Streets in 1956. Note the irregular appearance of the seaward dune edge in front of the houses and end of the streets. Some of the irregular dunes are due to human activity and some are due to storm erosion. At the upper right corner of the photo the dunes appear less disturbed. This trend appears also in Figure 5 along what is now the SMCC campus.

A Review of Willard Beach from Historical Air Photos

Figure 7. A close-up view of Figure 5 in the central section of Willard Beach in 1956 near Willow Street and Franklin Terrace. Note the boat on the beach near where the high-tide line would be. Vehicle traffic probably led to the loss of natural vegetation and relief landward of the high-tide line.

A Review of Willard Beach from Historical Air Photos

Photo No. PWN-2-3 courtesy of L. K. Fink, Jr

Figure 8. A detailed view of Figure 5 at the southwestern end of the beach near Willard and Deake Streets. Several boats are visible (some in shadows) near the end of Willard Street. The beach is narrow where it meets Deake Street, in part perhaps due to a seawall and in part due to the presence of the bedrock headland.

A Review of Willard Beach from Historical Air Photos

Willard Beach in 1964 appears quite similar to 1956 with a large open expanse of sand and few dunes (Figure 9). On the lower beach profile, structures associated with pipe outfalls can be seen. The large building at the end of Franklin Street (with a t-shaped roof) was removed in 1967 and a smaller structure built in 1976 sits in its place surrounded by open sand. A rock breakwater (known as the wharf jetty) extends from the bedrock headland southern end of the cove. Timson (1977) concluded that the wharf jetty had no significant influence on beach erosion.

Figure 9. In this photo from 1964 the tide appears lower and thus the intertidal portion of beach is wider. Boats can be seen moored in the cove.

A Review of Willard Beach from Historical Air Photos

By 1986 sand dunes with sparse vegetation had begun to build seaward of some homes (Figure 10-11). The bathhouse facility next to the traffic circle is partially surrounded by dune vegetation. These incipient dunes probably trapped sand and benefited from fewer people walking or driving across them.

Figure 10. The central and southern section of Willard Beach in 1986. The dry beach (white sand) at the southern end of the beach near Deake Street is absent, suggesting that the high tide reaches the seawall.

A Review of Willard Beach from Historical Air Photos

Dune vegetation (particularly the common American beach grass) is sensitive to foot traffic, so the plants do not survive if they are repeatedly walked on. Through a combined citizen and city effort, sand fencing and signs have allowed more dunes to increase in area and elevation in the last 20 years (visit the Maine Office of GIS online air photo viewer to see how complete the dunes are in 2003).

Photo courtesy of L. K. Fink, Jr.

Figure 11. Willard Beach near Beach and Myrtle Streets in 1986. A pipeline running across the lower beach causes an offset in the water line. Incipient frontal dunes are forming seaward of several houses and fence lines. Access points from the streets appear to have sand fencing to control foot traffic and to trap wind-blown sand.

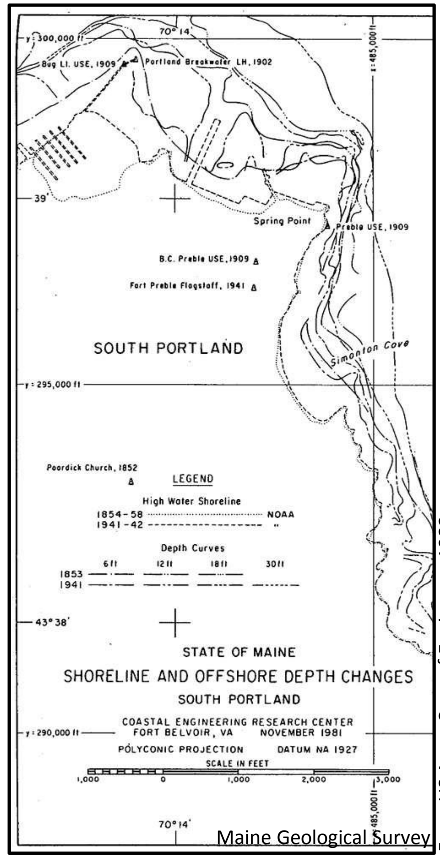
Historical Erosion Studies

Two studies of historical shoreline change have been completed for Willard Beach. In 1977 Barry Timson (a consulting geologist) completed a study for the City of South Portland. In his analysis, he concluded that the shoreline underwent periods of erosion and accretion. Erosion rates can be as high as 3 to 5 feet per year. From 1950 to 1976 there was a minimum net annual erosion rate of 0.65 feet per year (Timson, 1977). This report is available in an appendix to the Willard Beach System, Research Resource & Management Guide.

In 1982 the U.S. Army Corps of Engineers released a report on Willard Beach. By analyzing old maps and charts of depths offshore of the beach, the Corps noted that the 6, 12, and 18-foot depth contour lines all moved inland from 1853 to 1941.

Historical Erosion Studies

While some of the shift could be attributed to different surveying methods, some of the underwater beach profile may be getting steeper over time (Figure 12 and Figure 13). The line patterns in Figure 13 are the same as those shown in Figure 12, but in more detail.



From US Army Corp of Engineers, 1982

Figure 12. A portion of a regional map of the South Portland shoreline. Note the legend shows different line patterns for contours of water depths - 6, 12, 18, 30 feet - and the high water shoreline from the 1950's to the 1940's.

Historical Erosion Studies

This change in beach slope may indicate that sand is transported offshore. The Corps report suggested using a long-term erosion rate of 0.65 to 1.0 ft per year in beach planning.

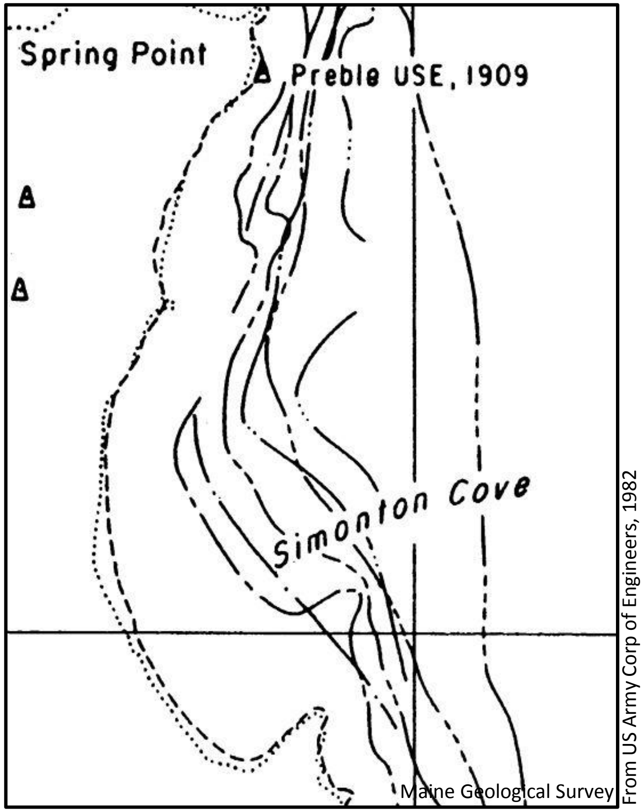
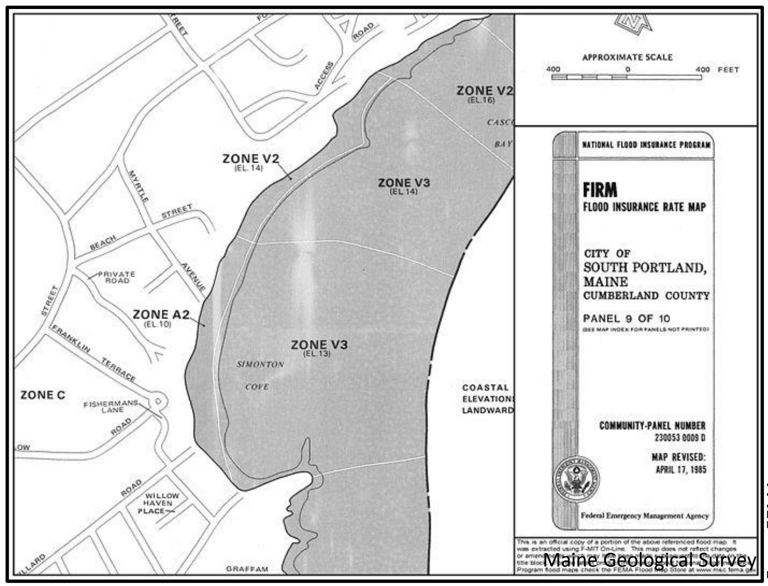


Figure 13. A close-up view of the map in Figure 12 showing beach contours. The 1853 "high water shoreline" is dotted and the 1941 shoreline is dashed. If the maps are registered to each other correctly, the comparison suggests the high water shoreline moved seaward at a time when the submerged beach profile (6-, 12-, and 18-foot depths) moved inland, making the beach steeper overall.

Coastal Flooding in the Dunes

The elevation and inland extent of the 100-year coastal flood is represented on Flood Insurance Rate Maps (FIRMs) produced by the Federal Emergency Management Agency (FEMA). There are two V-zones in Simonton Cove (Figure 14). For most of the cove with buildings from Beach Street to Deake Street, the V-zone flood elevation is 13 feet NGVD (National Geodetic Vertical Datum of 1929). The northern part of the cove near SMCC has a slightly higher V-zone elevation of 14 feet due to a more open exposure to waves from the southeast.



From FEMA

Figure 14. A portion of the Flood Insurance Rate Map showing areas potentially flooded in a 100-year coastal storm (shaded gray areas). Wave and flood elevations are partially based on transects that run perpendicular to shore as reported in an associated Flood Insurance Study. Unfortunately, no transect or wave runup model was done in the central area of the beach (the V-zone EL 13 or A-zone EL 10). The next time this area is remapped, the flood boundaries and elevations may change, particularly since the beach and dunes have changed since 1985.

Coastal Flooding in the Dunes

NGVD should not be confused with tidal elevations reported in the news and elsewhere. NGVD starts at an elevation about 4.5 feet higher than the Mean Lower Low Water (MLLW) tidal datum. For comparison, the highest annual tide produced by astronomical conditions (not storms) is about 7.2 feet NGVD. So, in a general sense, the 100-year flood level is about five feet higher than the highest tides.

Most of the frontal dune is in a V-zone with an elevation of 13 feet NGVD. A V-zone represents an area where water depths are 3 feet or more over the beach elevation and ocean water has a "velocity" or surf coming ashore. V-zone flooding results from wave action in storm swells and a coastal storm surge or flooding that exceeds the normal high tide level. The A2-zone in Willard's dunes represents slower moving floodwaters and a lower height of water than the V-zone because some of the surf will have broken on the beach profile and frontal dune. All of the flood zones represent areas where beach and dune sand will be actively moved by water in a 100-year storm. Frontal dunes with a crest elevation over the 100-year flood elevation will provide more flood and erosion protection to buildings than dunes that are lower.

Topographic Mapping of Dunes

Recent improvements in topographic mapping from aircraft have allowed detailed measurements of beaches and dunes. The use of National Oceanic and Atmospheric Administration LIDAR (Light Detection and Ranging) data by the Maine Geological Survey allows examination of the elevations of the frontal dune and identification of areas where the dune ridge is lower than the 100-year floodplain. Topographic analysis is used to determine areas of active sand transport and erosion hazards. Over time, repeated surveys will allow more detailed erosion surveys and trends in dune elevations that will complement the monthly beach profile monitoring by SMCC (described below).

Topographic Mapping of Dunes

Figure 15 shows an example of the topography of Willard Beach and dunes in 2004. The shaded relief colors represent different elevations in the sand.

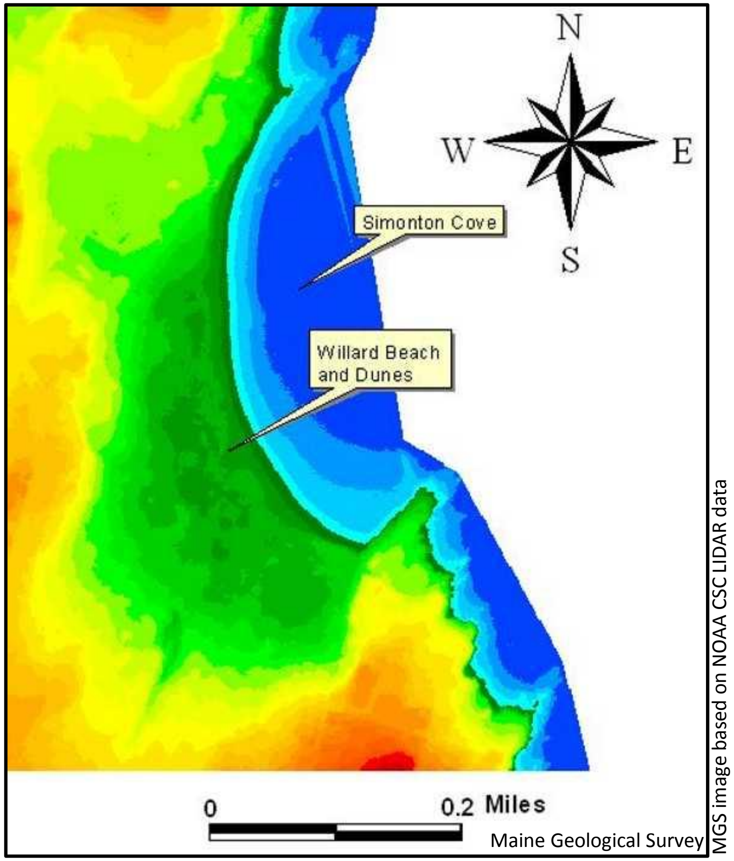


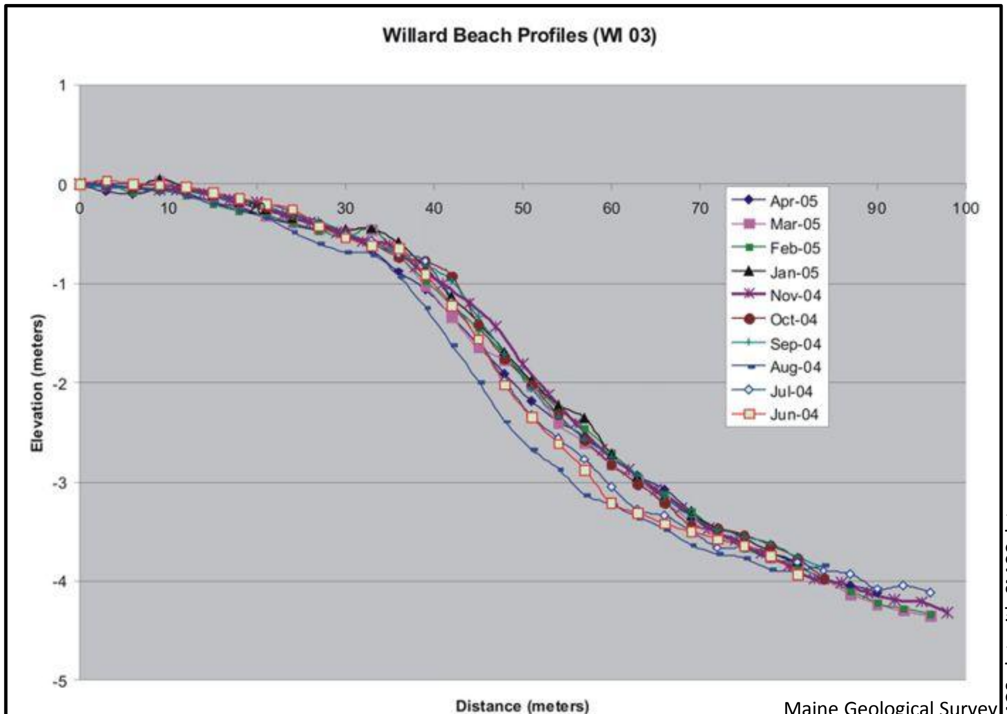
Figure 15. A topographic representation of Simonton Cove (blue) and adjacent beach and dunes (dark green) based on a 2004 NOAA LIDAR survey. Color changes represent 1 meter elevation intervals.

Improved Dunes through Local Management

Beach profile monitoring by faculty and students at SMCC takes place on a monthly interval. The surveys along six transects from the dune to the low tide line monitor sand elevation changes over time. Each month a transect line from the dunes across the beach to the water line is made perpendicular to shore and along the same path. The starting point (the origin on the graph) is used each time so relative changes can be detected in the shape of the profile. The vertical elevation is relative to the starting point and not to the tides or land elevations such as NGVD. The rise and fall of beach elevations is affected by many factors including erosion by storms, transport along the beach by currents, and structures on the beach such as the pipe lines and seawalls.

Improved Dunes through Local Management

Figure 16 shows a transect down the beach in the vicinity of Myrtle Avenue. The upper and lower parts of the profile show the most steady positions while the greatest change occurs on the central and steepest section. These data show that the beach elevation changes about half a meter (1.5 feet) in the course of a year. In any particular storm, the beach may change that much in elevation in a tidal cycle or two, but often that sand is returned to restore the profile in a few days or weeks of calmer waves.



MGS plot with SMCC data

Figure 16. A time series of beach profiles measured by a team of students from SMCC with faculty from the Environmental Science and Technology program.

Improved Dunes through Local Management

Dune access paths that focus foot traffic in specific areas and a 2003 beach management plan (The Willard Beach System, Research Resource & Management Guide by The Willard Neighborhood Beach Committee) have led to higher and wider dunes along the beach. These bigger dunes afford more protection to homes. Big dunes also provide a storage bank of sand that can buffer ocean flooding by absorbing wave energy. In severe winter storms dune sand can be released to the beach to break waves farther offshore. The neighborhood-led committee of citizens has developed improvements to access paths that benefit the dunes (Figure 17 and Figure 18). Stranded seaweed is better managed and used, in part, for a nutrient supply for dune vegetation.

Improved Dunes through Local Management

In Figure 17 sand fencing has been placed seaward from the edge of dune vegetation from the prior year. Through the growing season, rhizomes (roots) of American beach grass will extend beyond the fence and propagate over the sand. New shoots of the grass will trap sand and lead to higher dune elevations. Foot traffic and erosion by storms will break the stems and limit the seaward growth of the vegetation.

Figure 17. A May 7, 2002 photo of an entrance path to Willard Beach next to the sewer pumping station. See Figure 18 for the change in beach grass over one summer growing season.

Improved Dunes through Local Management

In Figure 18 American beach grass has extended roots beyond the sand fencing to propagate on the open sand and begin to restore a frontal dune. Sand fencing limits foot traffic to narrow paths through the frontal dune and also traps wind-blown sand. The combination of fencing and vegetation results in the frontal dune ridge building higher over time and increasing in sand volume. This volume is helpful in providing a protective (sacrificial) buffer for storm erosion and also helps limit inland flooding from coastal storm surges.

Figure 18. An August 2, 2002 photo of the growing frontal dune in the vicinity of the sewer pumping station.

Improved Dunes through Local Management

Through beach cleanup efforts, citizens and the city remove debris that strands on the beach (with the exception of seaweed; Figure 19). Water quality is tested regularly in the summer as part of the Maine Healthy Beaches program to advise swimmers about unsafe conditions if they arise. The City of South Portland maintains the recreation facilities and manages beach cleanups and litter removal.

Figure 19. A November 4, 1988 photo of Willard Beach with a stranded lobster boat. In some cases, seaweed is hauled back to the water where it releases its sand on the intertidal or subtidal beach profile, then floats back to Casco Bay.

Conclusions

Willard Beach in Simonton Cove in South Portland, Maine has experienced over a century of intense "working waterfront" use for commercial fishing and recreational boating and sun bathing. The protected pocket beach has continual use due to the proximity of year-round homes and a college campus. In the last few decades, awareness of the importance of dunes in preventing coastal flooding, protecting properties, and reducing erosion has led to a citizen-led beach management initiative that has succeeded in restoring much of the frontal dune. Protecting the dunes has had the benefit of avoiding the need for expensive beach nourishment (considered in 1982) and for avoiding serious erosion and flooding near beachfront homes in severe storms.

References and Additional Information

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