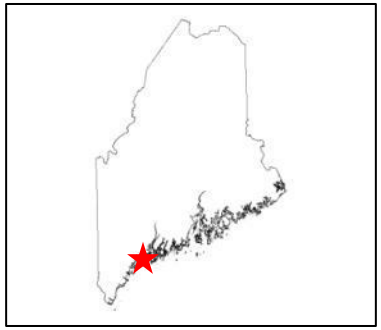
Maine Geologic Facts and Localities

June, 2006

Beach Nourishment at Western Beach Scarborough, Maine: Benefits for the Beaches and the Birds



43° 32‘ 15.98“ N, 70° 19‘ 11.58“ W

Text by
Peter Slovinsky

Introduction

Saco Bay, an arcuate embayment of approximately 7 miles, is located in southwestern coastal Maine, and contains the longest stretch of contiguous sandy beaches within the State of Maine (Figure 1). Western Beach is a small stretch of sandy pocket beach located along the south side of the Prouts Neck headland in Scarborough, at the northern end of Saco Bay and adjacent to the Scarborough River (Figure 2).

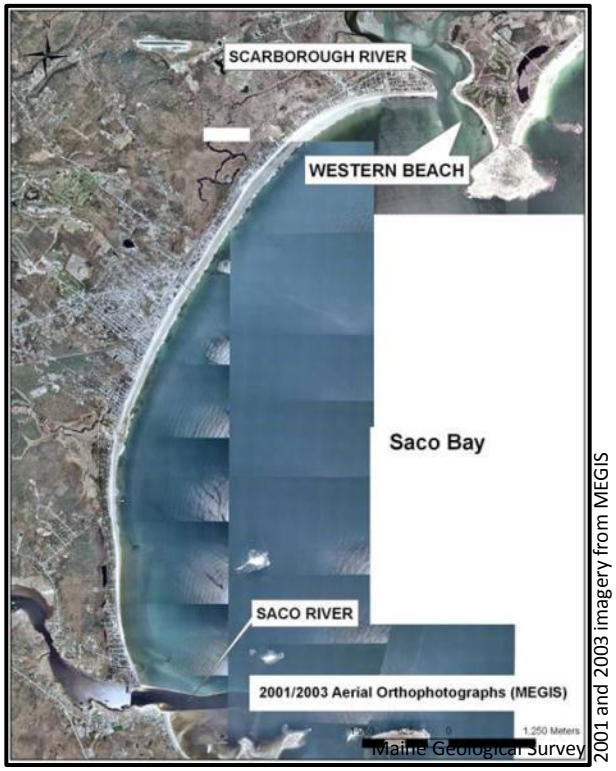


Figure 1. Saco Bay has the largest contiguous beach system in the state.

The Scarborough River

The Scarborough River serves as a "sediment sink" within Saco Bay; that is, it stores sediment that has migrated north up the Bay, originating from the Saco River and erosion of beaches to the south. Thus, one might expect that the beaches at the northern end of Saco Bay, including Western Beach, would be undergoing continual accretion. However, Western Beach has undergone periods of relatively rapid erosion, especially in recent years.

Figure 2. Aerial image of the Prouts Neck headland and Western Beach, adjacent to the Scarborough River. Note jetty and sand shoals extending offshore on the western side of the river.

Background: USACE

Some of the recent erosion seen at Western Beach may possibly be attributed to the stabilization and subsequent maintenance dredging of the Scarborough River by the U.S. Army Corps of Engineers (USACE) in 1962 (Figure 3). Prior to 1962, the main channel of the river migrated regularly in response to changes in wave climate, sediment supply, and storm events. These migrations changed the size and orientation of the river's main channel through the ebb-tidal delta, thus abandoning sand shoals and causing them to bypass former channel areas and provide sediment to both the Pine Point and Western Beach shorelines.

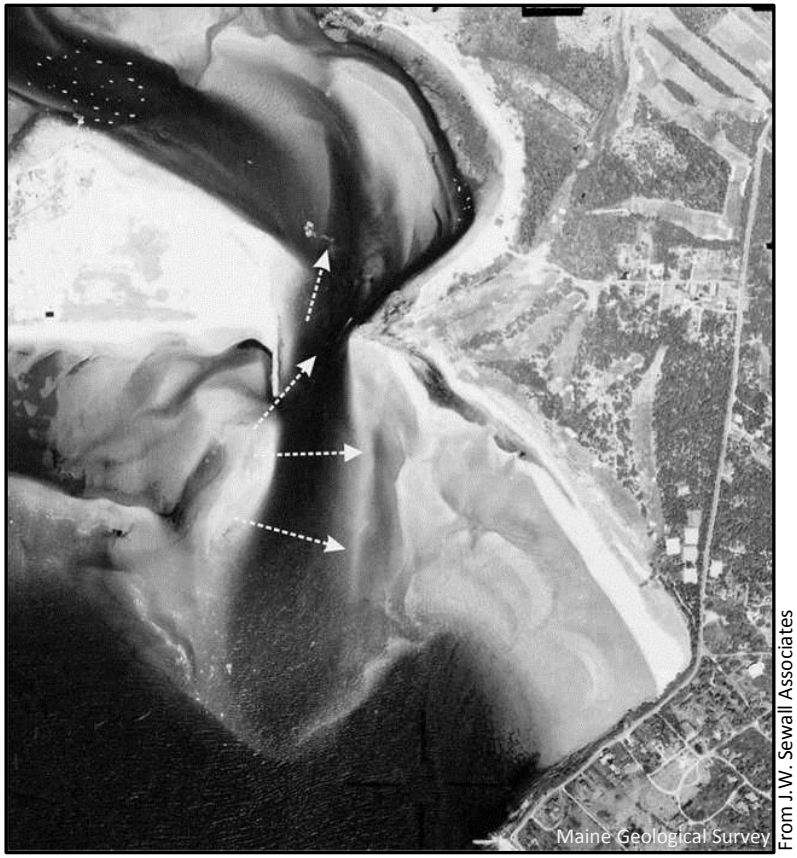


Figure 3. Aerial image from 1962 showing the morphology of the Scarborough River ebb tidal shoals and the newly built jetty. White arrows show the direction of shoal bypassing prior to the 1962 stabilization.

Background: USACE

Since the main channel was stabilized in 1962, it has remained relatively stationary, aside from the need for repetitive maintenance dredging by the USACE in order to maintain a navigable channel for both recreational and commercial vessels. As a result of the stabilization of the river, Western Beach underwent progradation for almost 20 years, until its most seaward extent in 1978 (Figure 4; Timson, 2003; Timson, 1989).

Figure 4. 1978 aerial photograph of Western Beach, taken during a higher tide. Note the increased width of Western Beach and the evident waves moving along the beach at its central portion

Background: Western Beach

This was most likely caused by the abandonment of sand shoals on the east side of the stabilized channel, which over time migrated to the northeast by wave action and welded onto Western Beach, until the sediment was depleted. Similar phenomena, with similar timescales have occurred at the beaches near the Saco River including Camp Ellis and Hills Beach (Kelley and others, 1995; Duffy and Dickson, 1995; Slovinsky and Dickson, 2003; USACE, 1992; USACE, 1961; USACE, 1955) and at Murrells Inlet in South Carolina (Hansen and Knowles, 1988).

Western Beach, since 1978, appears now to be undergoing a period of recession since the sediment that fed its shoreline is not being replenished by regular shoal bypassing events, inhibited by the main channel of the Scarborough River. Shoal bypassing has continued to a limited extent, evidenced by the regular shoaling of the main channel.

Background: Western Beach

Records of dredging at the Scarborough River indicate that large amounts of sediment are being removed from the system through maintenance dredging, thus not allowing the majority of sediment to successfully bypass the inlet and weld onto the Western Beach shoreline (Table 1). The sand shoals that are currently reaching Western Beach (that are not removed by dredging), are not at a frequency that can sustain a stable or prograding shoreline.

Dredge Year	Volume (yd^3)	Disposal Site
1956	128099	Inshore
1962	150000	Offshore
1965	32577	Offshore
1969	47000	Offshore
1973	188800	Offshore
1975	9090	Offshore
1996	90000	Nearshore
2005	90000	Western Beach
Total	735566	
Yearly Average	15012	

Maine Geological Survey

From the Program for the Study of Developed Shorelines, 1996; Kelley and others, 1995; and Normandeau Associates, 1994

Table 1. Historic Scarborough River dredging by the USACE.

Background: Western Beach

Additionally, in response to river stabilization and dredging, it appears that the ebb-tidal delta has migrated in a southeasterly direction, farther offshore (Timson, 2003; Timson, 1989). This may be due to the stabilization, sand bar buildup, and regular maintenance of the main channel of the river, which can no longer naturally shoal and migrate at the previous location, closer to shore (Figure 5).

Figure 5. Oblique aerial photograph from 1987 showing shoal bypassing occurring, but farther offshore. The jetty causes the buildup of a sand bar that acts as a littoral barrier, and shoals must come around this barrier in order to migrate to Western Beach. Note the shoal locations off of Western Beach.

Background: Western Beach

This offshore migration of the ebb delta has, in turn, led to shoaling at the Prouts Neck Yacht Club and subsequent minor bypassing that continues to occur, but well offshore (Figure 5 and Figure 6).

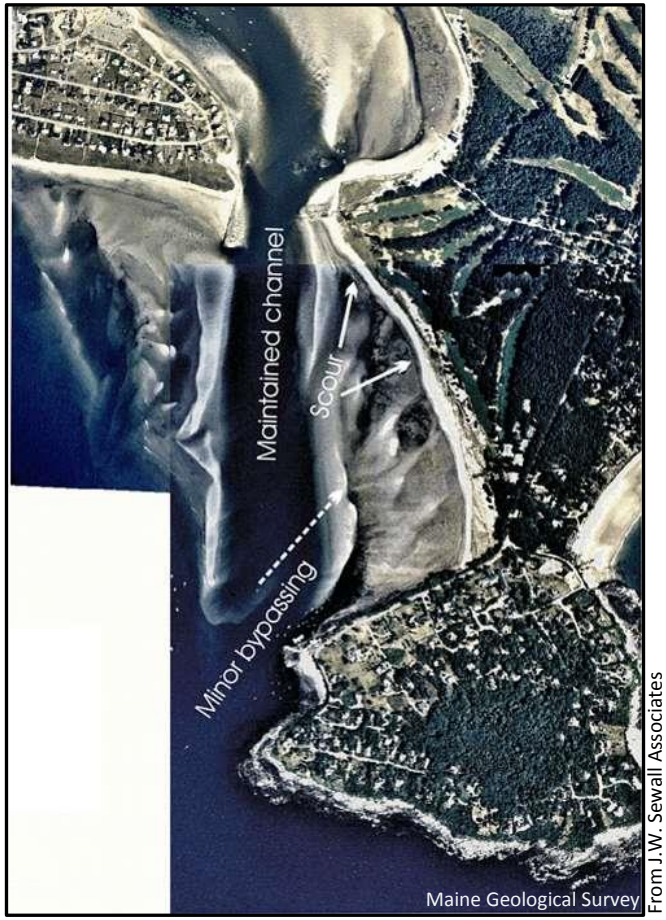


Figure 6. Aerial photograph from 1995 showing the Western Beach, Scarborough River, and Pine Point area.

Background: Nourishment Project

Flood tidal currents also appear to play a role in erosion at Western Beach. Along the central-to-northwestern portions of the beach, it appears that this portion of the beach is fronted by a deeper scour channel (see Figure 5 and Figure 6). Sediment in this section of the shoreline appears to be scoured by flood tidal currents, with some moved towards and onto the beach, while much appears to be transported past Ferry Rocks and into the river, shoaling the anchorage at Ferry Beach.

In early 2004, the USACE was approached by the Town of Scarborough for a maintenance dredge due to the fact that the Scarborough River had again shoaled to the point where commercial and recreational vessels were having difficulty navigating the channel and harbor area. MGS suggested that if dredging was initiated, dredged materials should be placed at Western Beach as the beneficial reuse of dredged material.

Subsequently in December 2004, the USACE conducted a dredging project that removed 90,000 cubic yards of sediment from the federal river channel and anchorage, and disposed of the material on Western Beach as a beach nourishment project. This nourishment project was designed to increase the recreation beach ("berm") of Western Beach, thereby increasing the protective width of the beach and afford continued recreational activities for the public.

Pre-Nourishment Conditions

MGS has been monitoring the Western Beach shoreline using field photography, aerial photography and GIS, and Real Time Kinematic (RTK) Global Positioning Systems (GPS). Photographs from November 2002 show the field condition of the vegetation line and beach (Figure 7 and 8).

Figure 7. Photographs from November 2002 show the field condition of the vegetation line and beach. The beach has been eroded back into the golf course such that course greens were being undermined and scarped. (Left) Looking northeast along the scarp cut into the dune and green. (Right) Close up of scarping and undermining of green.

Pre-Nourishment Conditions

Figure 8. (Left) Looking northwest along Western Beach of tree that has been undermined and now sits on the beach and in the swash zone. (Right) Looking northwest along Western Beach.

Pre-Nourishment Conditions

The beach has been eroded back into the golf course such that course greens were being undermined and scarped. Photographs in the months prior to nourishment, from March 2004, show continued erosion of the beach and undermining of the course (Figure 9). MGS was also able to compare Light Detection and Ranging (LIDAR) topographic data from flights in 2000 and 2004, available from the National Oceanic and Atmospheric Administration's Coastal Services Center.

Figure 9. Photographs in the months prior to nourishment, from March 2004, show continued erosion of the beach and undermining of the course. (Left) Looking northwest along Western Beach. Note the stump in the left hand portion of the photograph; this is what remains of the tree in Figure 8. (Right) Looking southeast along Western Beach.

Pre-Nourishment Conditions

Applicable grids were created and subtracted (i.e., topography from the 2000 LIDAR was subtracted from the 2004 LIDAR), resulting in the data shown in Figure 10. By comparing these snapshots of topography, it appears that intertidal and berm growth occurred along the northwestern portion of the beach (red shading), while beach and dune erosion dominated along the central to southeastern portions of the beach.

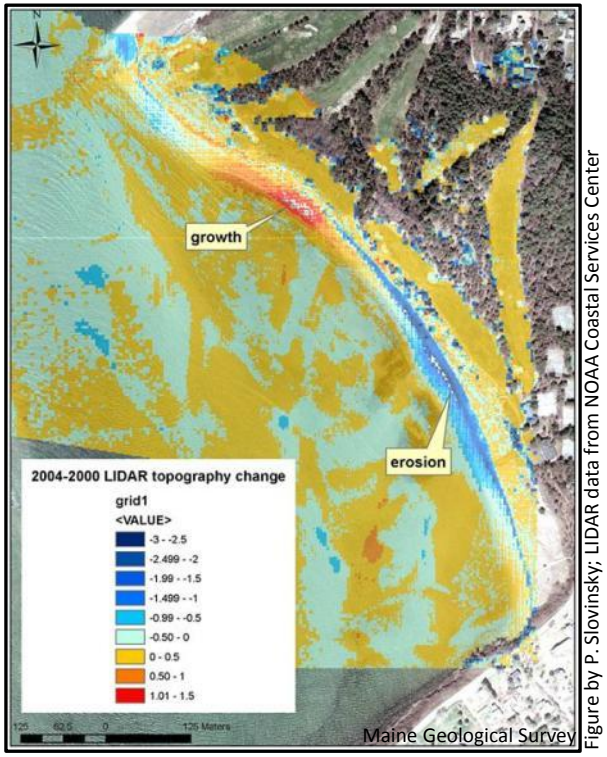


Figure by P. Slovinsky; LIDAR data from NOAA Coastal Services Center

Figure 10. Results from grid subtraction of 2000 LIDAR topographic data from 2004 LIDAR data. Areas of orange and red along the beach mark growth (accretion), while areas in blue generally mark erosion. Elevation changes are in meters

Beach Nourishment and Post-Nourishment Conditions

In December 2004, the USACE dredged 90,000 cubic yards of sediment from the main channel and anchorage area of the Scarborough River, and placed the material at Western Beach as the beneficial reuse of dredged material using hydraulic pumps.

Photos by Mike Walsh, USACE

Figure 11. (Left) Photograph showing the dredge working within the federal anchorage area of the Scarborough River. (Right) Photograph of the dewatering of dredged material on Western Beach.

Beach Nourishment and Post-Nourishment Conditions

MGS helped designate the areas for fill placement in order to maximize the lifetime of the beachfill. The design of the fill was to increase the dry beach width by adding elevation and width to the berm, the relatively flat area between the edge of high water and the dune vegetation line. Figures 11 and 12 includes photographs, taken by the USACE, showing the nourishment process at Western Beach.

Figure 12. Photograph of mounds of dredged material on Western Beach prior to grading with equipment.

Beach Nourishment and Post-Nourishment Conditions

Post-nourishment photos showing the completed berm are shown in Figure 13 (January 2005) and Figures 14-15 (April 2005).

Figure 13. (Left) Photograph looking northwest along the nourished portion of Western Beach. Note the dramatic increase in beach width. (Right) Photograph looking southeast along the nourished beach.

Beach Nourishment and Post-Nourishment Conditions

It is apparent from the photographs that the dry beach width was dramatically increased.

Figure 14. (Left) Photograph looking southeast from the northwestern seaward limit of the beach nourishment. Note stake in foreground. (Right) Photograph looking southeast from near the vegetation line showing width and depth of nourishment fill.

Beach Nourishment and Post-Nourishment Conditions

In order to document the effectiveness of the nourishment project, MGS used the RTK-GPS from its Nearshore Survey System to field survey both the wrack and vegetation lines of the post-nourishment beach. This data was collected in June 2005, with a follow-up collection in September 2005.

Figure 15. Photograph looking northwest near the southeast corner of Western Beach.

Beach Nourishment and Post-Nourishment Conditions

MGS was able to use this data within a Geographic Information System (GIS) to quantify the growth of the beach at Western Beach using the pre- and post-nourishment vegetation and wrack lines. Figure 16 shows the evolution of the wrack line from pre (2001) to post (June 2005) nourishment beach conditions and the dramatic increase in the dry beach, which went from approximately 69,000 square feet to over 335,000 square feet (an almost five-fold increase).

Figure by P. Slovinsky; Photo from MEGIS

Figure 16. Aerial orthophotograph (2001) showing the position of the wrack line in 2001, and post-nourishment, as located in the field by MGS using RTK-GPS in late June, 2005

Beach Nourishment and Post-Nourishment Conditions

This resulted in an approximate 6-acre gain in the dry beach. Pre- and post-nourishment beach profiles, collected by volunteers in the Maine Beach Profiling Monitoring Project are shown in Figure 17. Note the increase in the height and width of the beach by July 2005.

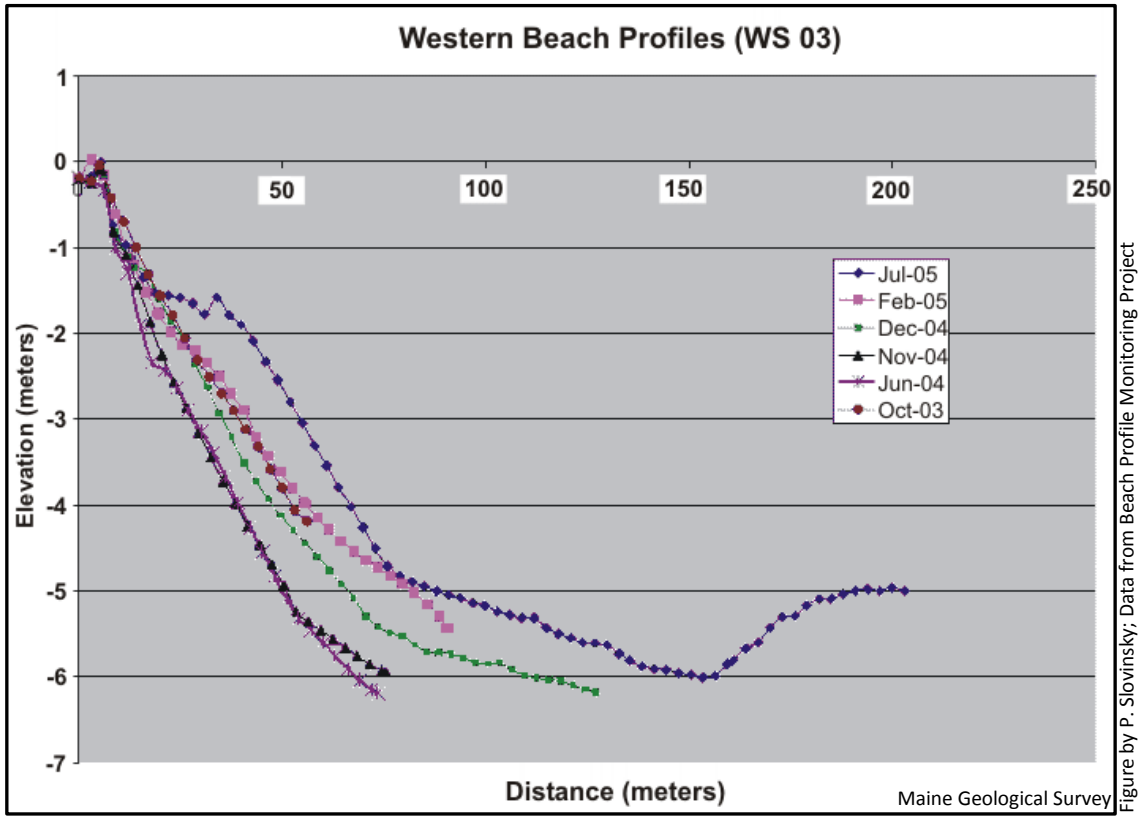


Figure 17. Figure showing the differences in pre- and post-beachfill beach profiles. Note the increase in both the elevation and width of the beach in July 2005

Beach Nourishment and Post-Nourishment Conditions

The Maine coastline was battered by a series of northeast storms in May 2005 that resulted in erosion of many of the dunes along the shoreline. Based on the data collected at Western Beach in June 2005, it appears that the nourished beach and berm performed very well and were not significantly eroded due to the storms.

The nourishment not only increased the storm-protection and recreational portion of the beach, but also resulted in the successful creation of nesting habitat for endangered and threatened bird species such as piping plovers and least terns. In fact, both species successfully nested at Western Beach in the summer of 2005, which has not been seen for many years. The Maine Audubon Society (MAS, 2005) documented 2 piping plover nests and 40 least tern nests at Western Beach during 2005.

Beach Nourishment and Post-Nourishment Conditions

The identified nesting areas subsequently were fenced off and MGS surveyed the location of the fenced area in June 2005. Approximately 134,000 square feet of the newly created beach (40%) was designated as nesting habitat (Figure 18).

Figure by P. Slovinsky; Photo from MEGIS

Figure 18. 2001 aerial orthophotograph with the field surveyed location of the vegetation line, wrack line, and fenced shorebird nesting area from June 2005.

Conclusion

Beach nourishment at Western Beach has proven to be successful in terms of widening the dry recreational beach and berm, thereby creating a more effective buffer from storms, and at the same time, creating vital nesting habitat for endangered and threatened shore birds.

In order to imitate the sediment bypassing process that would naturally occur in the absence of a maintained, navigable channel within the Scarborough River, periodic nourishment at Western Beach is required. Since the navigable channel of the river shoals approximately every 5 years, sediment might be placed at Western Beach if erosion has removed the previous nourishment and adverse environmental impacts are avoided, at an interval similar to the shoaling and subsequent federal dredging. The Town of Scarborough, Prouts Neck Association, and the USACE should consider formulating a long-term, proactive management plan for sediment within the Scarborough River navigation project that includes regular placement of sediment at Western Beach, along with the possibility of dredged sediment placement updrift in Saco Bay. The USACE should consider Saco Bay as part of its Regional Sediment Management (RSM) program since it maintains federal channels and anchorages at both the Saco and Scarborough Rivers, both vital to the health of the beaches within Saco Bay.

References and Additional Information

Duffy, W., and Dickson, S. M., 1995, Using Grid and Graph to Quantify and Display Shoreline Changes: ESRI User Conference Proceedings.

Hansen, M., and Knowles, S. C., 1988, Ebb-Tidal Delta Response to Jetty Construction at Three South Carolina Inlets, in Aubrey, D. G., and Weishar, L. (editors), Lecture Notes on Coastal and Estuarine Studies: Hydrodynamics and Sediment Dynamics of Tidal Inlets, Springer-Verlag, New York, p. 364-381.

Kelley, J. T., Barber, D. C., Belknap, D. F., FitzGerald, D. M., van Heteren, S. and Dickson, S. M., 2005, Sand Budgets at Geological, Historical and Contemporary Scales for a Developed Beach System, Saco Bay, Maine: Marine Geology, v. 214, p. 117-142.

Kelley, J. T., Belknap, D. F., Fitzgerald, D. M., Barber, D. C., Dickson, S. M., van Heteren, S., Fink, L. K., and Manthorp, P.A., 1995, A Sand Budget for Saco Bay, Maine: Maine Geological Survey, Open-File Report 95-1, 40 p.

Maine Audubon Society, Summer, 2005, Piping Plover and Least Tern Newsletter.

Maine Beach Profile Monitoring Project

Maine Geological Survey, 2004, Imaging Nearshore Bathymetry Using a Personal Watercraft: The MGS Nearshore Survey System.

Maine Office of Geographic Information Systems, Maine Aerial Photography Viewer, 2001 aerial orthophotographs.

NOAA Coastal Services Center, Topographic Data.

Normandeau Associates, 1994. A Dredged Material Management Study for Coastal Maine and New Hampshire: Prepared for the U.S. Army Corps of Engineers, New England Division.

Program for the Study of Developed Shorelines, 1996, The U.S. Beach Nourishment Experience: New England, East Coast Barrier Islands, Gulf of Mexico and Great Lakes Shorelines: Duke University.

References and Additional Information

Sewall, J. W. and Associates, Inc., (various dates), Aerial photographs from 1962, 1978, 1995.

Slovinsky, P. A., and Dickson, S. M., 2003, Variation of Beach Morphology along the Saco Bay Littoral Cell: An Analysis of Recent Trends and Management Alternatives: Maine Geological Survey, Open-File Report 03-78, 57 p.

Timson, B. S., 2003, Correspondence to M. Walsh, U.S. Army Corps of Engineers, Re: Effects of Past Dredging Activity and Dredge Material Placement on Least Tern/Piping Plover Habitat at Western Beach, Scaborough Inlet, Scarborough, Maine: Timson Associates, Hallowell, ME.

Timson, B. S., 1989, Effects of Dredge Material Placement on Western Beach, Prouts Neck, Scarborough, ME: Report prepared for the Town of Scarborough, Timson, Schepps, and Peters, Inc., Hallowell, ME.

U.S. Army Corps of Engineers, 2005, Regional Sediment Management Program.

U.S. Army Corps of Engineers, 1992, Camp Ellis Beach, Saco, Maine, Beach Erosion Study, Section 111 Reconnaissance Report: U.S. Army Corps of Engineers, New England Division, Waltham, MA.

U.S. Army Corps of Engineers, 1976, Camp Ellis Beach, Saco Maine, Beach Erosion Reconnaissance Report: U.S. Army Corps of Engineers, New England Division, Waltham, MA.

U.S. Army Corps of Engineers, 1961, Beach Erosion Control Report on Cooperative Study of Hills Beach, Biddeford, Maine: U.S. Army Corps of Engineers, New England Division, Waltham, MA.

U.S. Army Corps of Engineers, 1955, Beach Erosion Control Report on Cooperative Study of Saco, Maine: U.S. Army Corps of Engineers, New England Division, Waltham, MA.