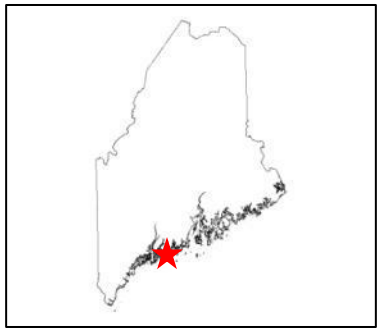
Geologic Site of the Month

January, 2010

Migration of the Morse River into Back Dunes at Popham Beach State Park, Phippsburg, Maine



43° 44‘ 0.38“ N, 69° 48‘ 33.49“ W

Text by
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Introduction

Popham Beach State Park is part of a large and complex beach system at the mouth of the Kennebec River (Figure 1). Hunnewell Beach is a continuous strand of sand from the east side of Popham Beach. Seawall Beach is a natural beach system and preserve west of the Morse River and the state park.

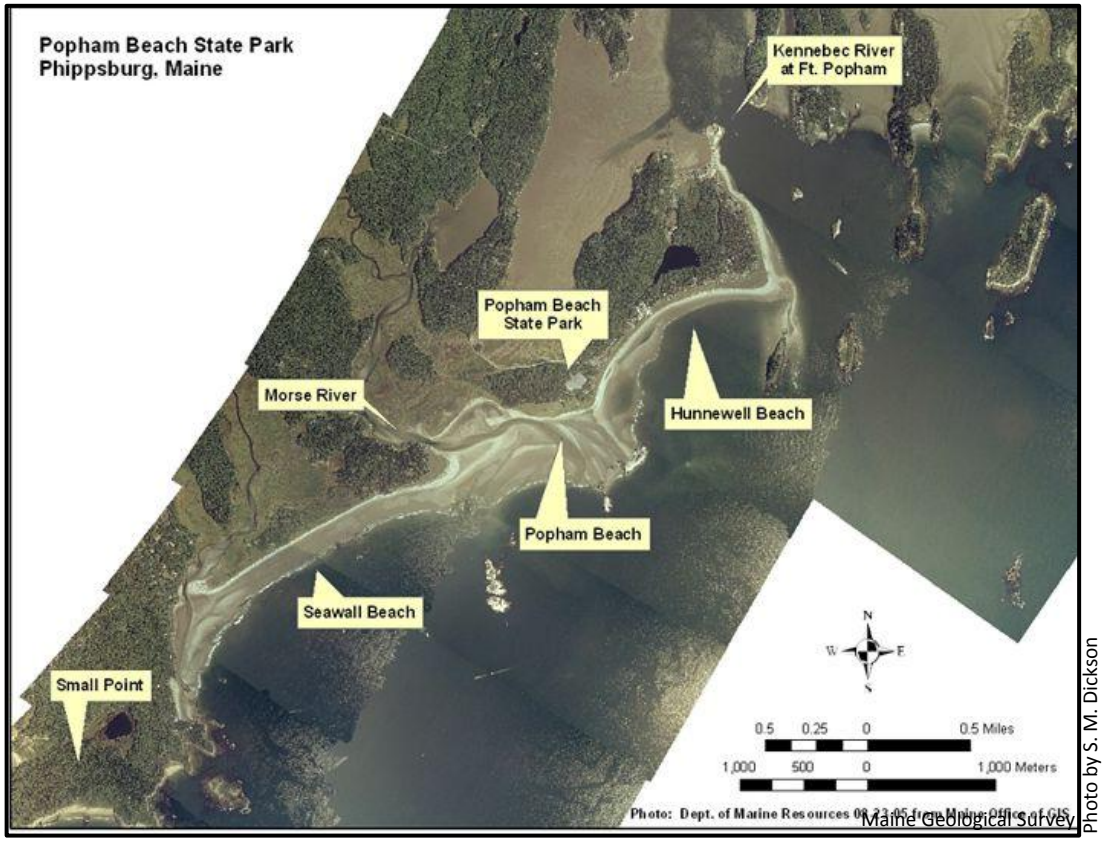

Figure 1. Aerial view of Popham Beach as part of a continuous sand system from the mouth of the Kennebec River in the east to Small Point in the west. This photograph mosaic was taken August 23, 2005 for the Maine Department of Marine Resources and is available via the Maine Office of GIS web site

Previous Work

The dynamic nature of the beach and dune system has been studied by geologists from the University of Maine and Boston University as well as the Maine Geological Survey. We have previously reported on many aspects of this dynamic system including how the sand bar from the park to the Fox Islands was cut by the Morse River (Dickson, 2008a), how the spit at Seawall Beach has extended east and pinned the Morse River up against the state park (Dickson, 2008b), and how the Morse River began to show signs of changing its course to the sea in 2009 (Dickson, 2009).

Erosion at Popham Beach State Park continued to cut into the back dune pitch pine forest throughout 2009. The inland extent of erosion is farther than any recorded by geological measurements in the last 50 years and probably is the farthest inland the beach has moved in the last 100 years. Here we review erosion trends over the last 20 years and discover a pattern of dune loss that can be attributed to tidal currents flowing into and out of the Morse River with episodes of severe erosion during times of large storms and high tides.

Shoreline change can be mapped from historical aerial photographs and combined with ground surveys using a global positioning system (GPS) to better analyze trends in erosion and accretion (dune growth). In the examples here, the shoreline is delineated by the seaward edge of dune vegetation (usually American beach grass) or the toe of a vertical scarp (embankment) just below the seaward edge of vegetation. By comparing shorelines over time we can see which areas have lost or gained dunes. The first interval of time for comparison is from 1980 to 1986.

Historical Shoreline Change Patterns

Over 6 years the dunes eroded significantly on the western portion of Popham Beach. This loss is adjacent to the Morse River and, with an understanding the movement and migration of rivers, we can be confident that the loss is due, in part, to an easterly shift in the river's course toward the park's dunes. The outer bend in the river (during its flow to the sea on a falling or ebb tide) is called a "cut bank" and it is this portion of the channel that has eroded the dunes. As we will see in the following few figures, the cut bank shifts position over time - demonstrating a geological process called meandering.

Figure 2. A large area of dunes was lost between 1980 and 1986 as seen by comparison of the two historical shorelines. The base air photo is from 2005 so both historical shorelines appear in the channel.

Historical Shoreline Change Patterns

The second interval of comparison is from 1986 to 1991 (Figure 3). In this 5-year period some of the dunes lost previously grew back on the bank of the Morse River as well as the central dune field next to the large bar complex (tombolo; Dickson, 2008). This was an interval of net accretion to the dunes. The east portion of the state park beach remained relatively stable. Farther east along Hunnewell Beach the dunes also grew seaward.

Figure 3. Shoreline change from 1986-2001 based on historical aerial photographs.

Historical Shoreline Change Patterns

From 1991 to 2003 the Morse River eroded some of the dunes created after 1986 (Figure 4). The rest of the dunes remained remarkably stable for this 12-year period. West of the Morse River the dunes on the east end of Seawall Beach expanded slightly.

Figure 4. Shoreline change from 1991-2003.

Historical Shoreline Change Patterns

From 2003 to 2007 the Morse River removed a large area of dunes along the west beach (Figure 5). Initially, park dunes in the center beach lost area from 2003 to 2005. Erosion worsened after 2005 and removed dunes for two more years, bringing the shoreline up to the edge of the pitch pine maritime forest. The Morse River reoccupied a location not seen since perhaps the 1950s (Figure 12 of Dickson, 2008a). While the dunes of the west and central beach areas were lost, the east beach shoreline was relatively stable. Hunnewell Beach also lost dunes in this interval.

Figure 5. Shoreline change from 2003-2007 on a 2005 base image. The 2003 shoreline is from air photographs and the 2007 shoreline was recorded in the field with RTK-GPS.

Historical Shoreline Change Patterns

From 2007 to 2009 the Morse River continued to remove both dunes and topple trees in the pitch pine forest (Figure 6). Erosion came closer and closer to the parking lot and new bath house facilities built in the spring and summer of 2009 at the southwest corner of the parking lot. The Morse River continued to meander closer and closer to park infrastructure.

Figure 6. Shoreline change from 2007-2009. The 2007 shoreline is from July and recorded with a high-precision RTK-GPS. The 2009 shoreline is from November and with a less precise hand-held GPS so not as accurate.

Historical Shoreline Change Patterns

Figure 7 summarizes shoreline changes since 1980 shown individually in Figures 2 through 6.

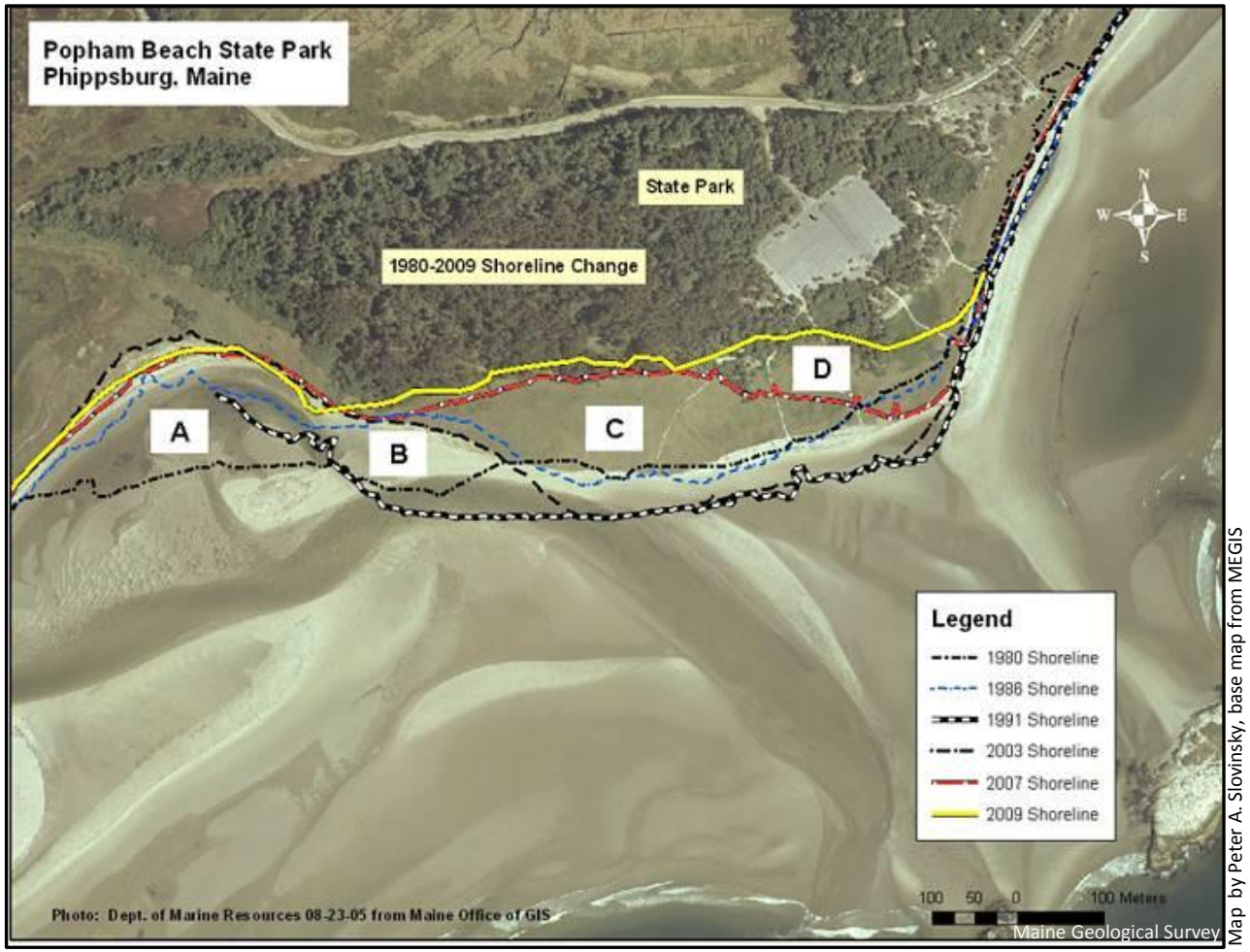

Figure 7. Complete series of shoreline change positions from 1980 to 2009 at Popham Beach State Park. Note the loss of dunes progresses from west (A) to east (D) over time as the Morse River channel meanders east.

Historical Shoreline Change Patterns

Since 1980 when the dunes were at their largest extent, Popham Beach State Park has lost a lot of sand dunes and pitch pine forest. The pattern of dune loss is one of cutting by the Morse River from west to east over nearly three decades. During that time, however, there was a period from about late 1980s through the 1990s when the Morse River did not erode the park's dunes in any large way. Early in the new millennium the Morse River became more active in its easterly meandering and more damaging to the state park dunes. The most dramatic loss of park land happened from 2005 to 2007, a relatively short period of time.

The summary figure shows how very significant land loss can take place in only a few years as dunes are eroded by swift currents at a tidal inlet associated with a small river system.

Storm Erosion in December 2009

Storms contribute to abrupt shoreline change and loss of coastal sand dunes. The map series above records both the meandering of the Morse River as well as storm erosion. In late 2009, a series of fall and winter storms allowed the Morse River to become elevated and sweep away large amounts of sand in a matter of hours. A storm on December 12 elevated the tide an additional 1.5 feet and resulted in minor coastal flooding over the 12-foot level (Figure 8).

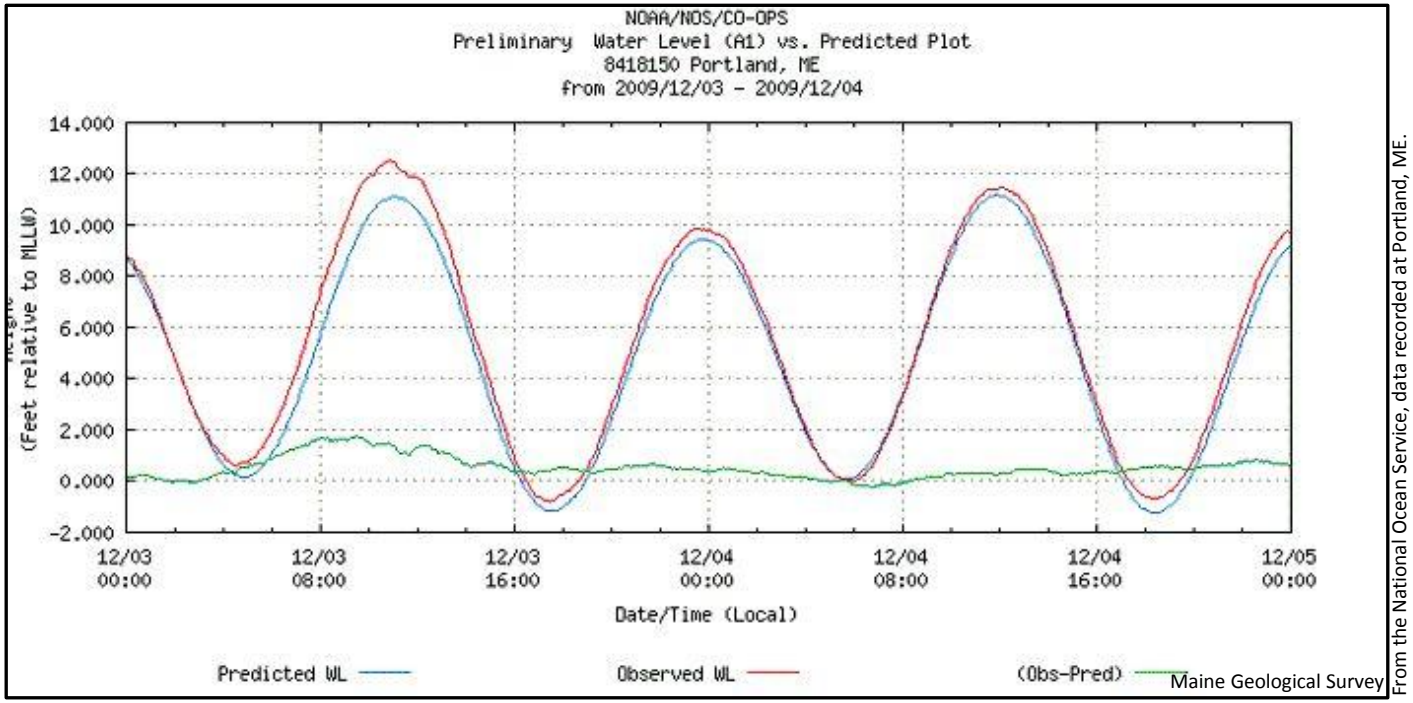

Figure 8. Storm tides along the coast included a surge of about 1.5 feet on top of a large 11-foot tide to extend the water level to over 12 feet. This high water level combined with offshore waves peaking at 12 feet every 8 seconds around the time of high tide allowed surf to impact the dunes and undermine trees at Popham Beach.

Storm Erosion in December 2009

Offshore waves in this storm were 12 feet high and they broke offshore of Popham Beach State Park and moved ashore as smaller waves that eroded the dunes (Figure 9).

Photos by SM Dickson

Figure 9. (Left) Surf crashes over the Fox Islands tombolo from two directions. The Morse River ebbs along the dunes from right to left carrying sand suspended by the surf toward West Beach from the central portion of the dunes. (Right) The Morse River cuts directly into the pitch pine forest with a vertical drop just beyond the picnic table. Fallen trees have been grouped into bundles (creating a "tree wall") to dissipate waves and slow river currents along the bank.

Storm Erosion in December 2009

Along low dunes, waves overtopped them and flooding extended inland (Figure 10). Five minutes after this photograph was taken two trees along the shoreline (just left of the barricade on the path) fell into the surf. The Morse River runs along the dunes and storm flooding helped undermine the trees.

Figure 10. A view from the seaward side of the bath house looking south toward the beach. Note the pavement in the foreground surrounds the bath house and shows how near the overtopping and erosion is from the new infrastructure.

Storm Erosion in December 2009

In consultation with resource and regulatory agencies, the Department of Conservation decided to take action in December 2009 to slow the effects of storms with the goal of keeping the shoreline from reaching the bath house (Figure 11).

Figure 11. Erosion continues to narrow the beach, increase risk to swimmers, remove a mature pitch pine forest in the back dunes, and threaten park infrastructure including new bath houses. The Fox Islands tombolo (sand bar) is on the right beyond the bend in the Morse River.

Storm Erosion in December 2009

Fallen pine trees were gathered from along the beach (Figure 11) and bundled with rope on the bank of the Morse River adjacent to the bath house to create a raft along the dune scarp (Figure 12).

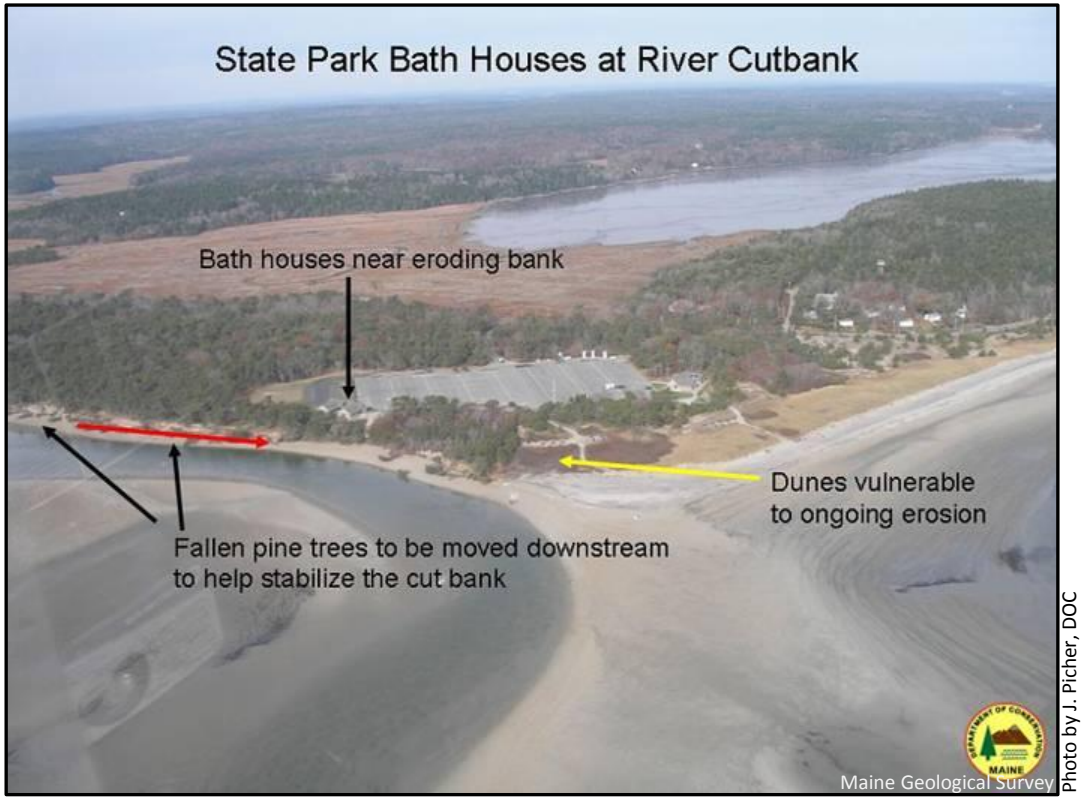

Figure 12. The cut bank was eroding at a rate of 10 to 15 feet a week in November 2009. Plans to slow erosion include moving fallen trees into the vicinity of the bath houses in order to slow the removal of sand by tidal currents and widen the beach to break waves farther from the cut bank. Additional erosion may occur to the right of the arrow until the river changes to a straighter course to the sea.

Storm Erosion in December 2009

Ropes were used to tie the bundles to upright trees farther inland to hold them in place and to keep them from floating out to sea in storms (Figure 13). The goal of the "tree wall" was to slow the speed of the Morse River on the cut bank so less sand could be removed in storms and to help break the surf action on the dunes at high tide to minimize scour.

Figure 13. View from the west beach area of the tree bundle, path barricade, and bath house in the background. Trees were grouped in December 2009 to slow cut-bank erosion and surf action along the Morse River at Popham Beach.

Waiting for the Morse River to Shift Course

A photographic flight by the Department of Conservation in November 2009 over Popham Beach State Park provides a different perspective of the tidal inlet, channel course, and dune system. From overhead it is possible to trace out the curved Morse River channel and see where the outer cut banks of the meanders are (Figure 14).

Figure 14. Meandering of the Morse River channel as seen from the air.

Waiting for the Morse River to Shift Course

Looking upstream to the back-barrier salt marsh system and Seawall Beach it is possible to see how the river flows out from behind the dunes and takes a sharp bend on the ebb-tidal delta and turns toward the state park (Figure 15). It is estimated that the pitch pine maritime forest trees are about 100 years old. This may be the farthest inland the Morse River has meandered since the mid 1800s or earlier.

Figure 15. Air view looking up the Morse River.

Waiting for the Morse River to Shift Course

The Morse River has shown signs of starting to cut a new, and more direct, course to the sea across the Seawall Beach spit (Dickson, 2009). The narrowest part of the spit system is directly across from the river mouth where it exits from the back-barrier salt marshes (Figure 16).

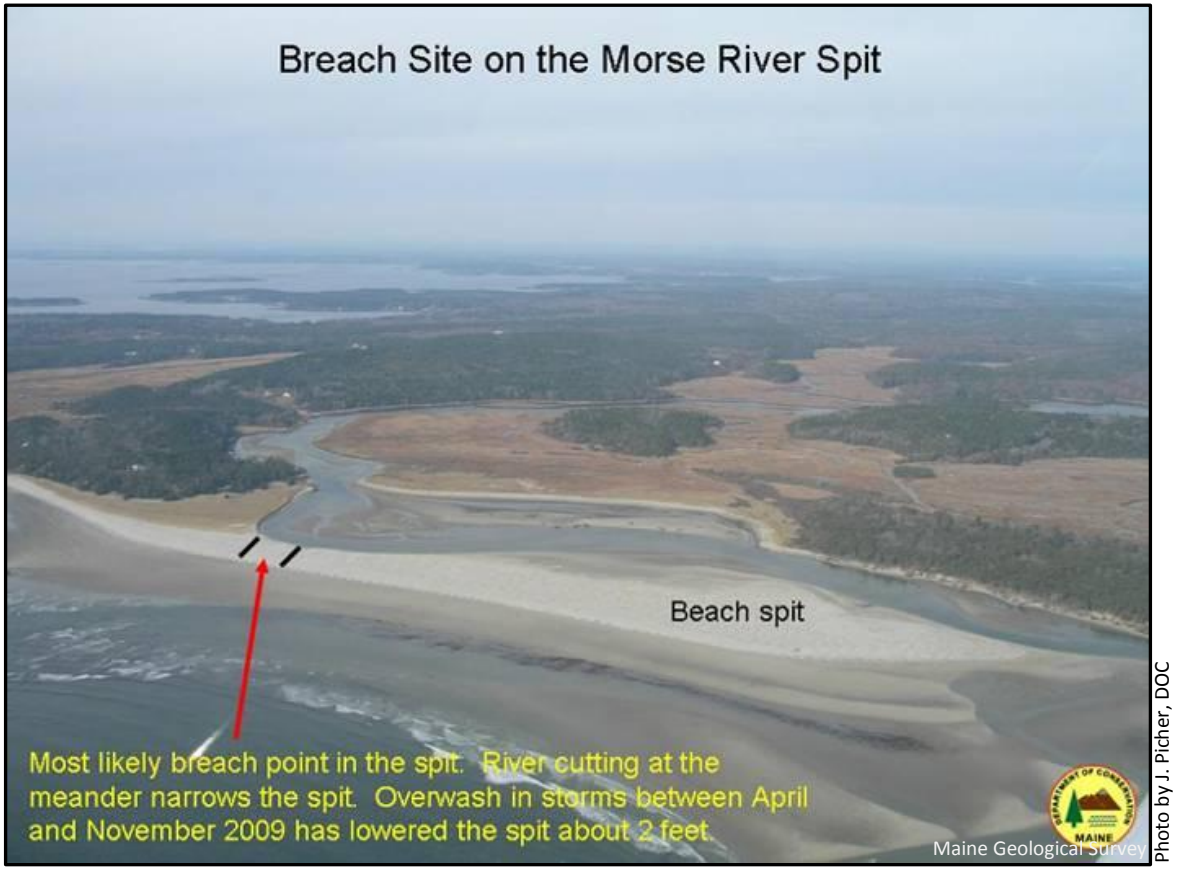

Figure 16. Air view of the possible breach site on the Seawall Beach spit.

Waiting for the Morse River to Shift Course

In November the spit appeared to show signs of being cut by the river (Figure 17). This area appears to have lowered and widened in the same area where downcutting had been previously noted in April (Dickson, 2009 Figure 12, Figure 13, and Figure 14).

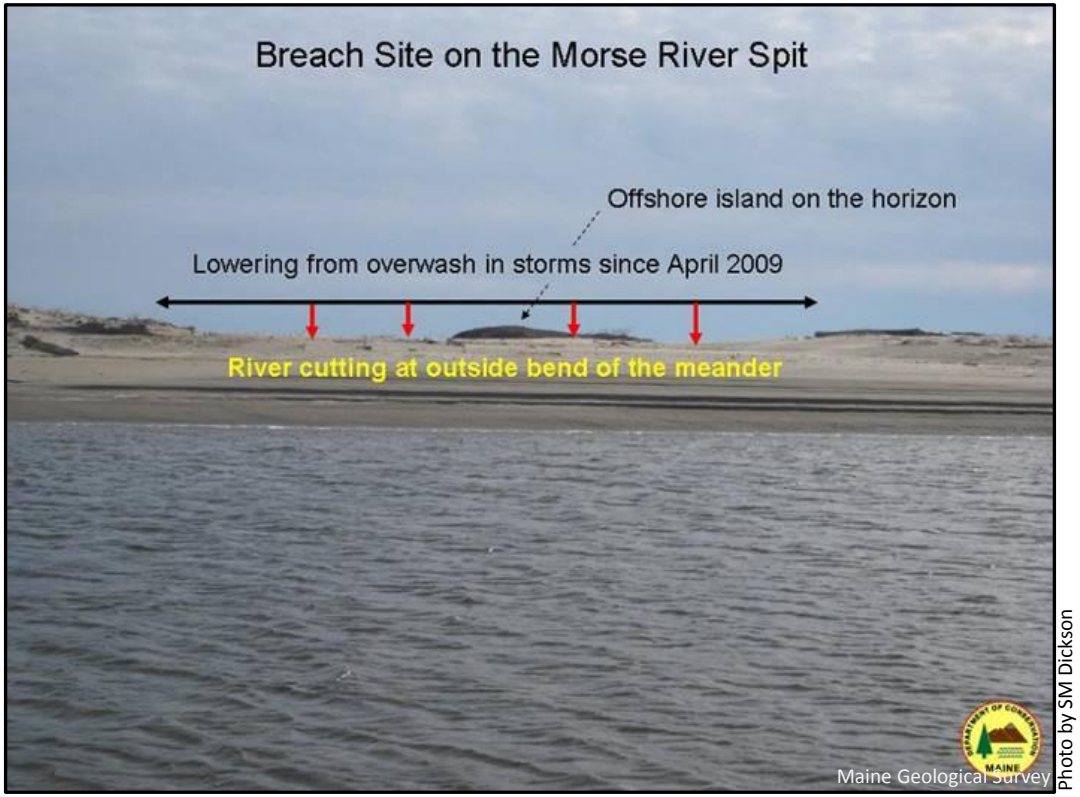

Figure 17. View of potential breach site and recent spit lowering. Photo taken at 1:55 p.m. when the Portland tide gauge was 4.8 ft MLLW about two hours after low tide. The lowest spit elevation may be 10 to 11 ft Mean Lower Low Water and showing 5 ft of relief above the river level. The river channel is a few feet deeper than MLLW in some places.

Waiting for the Morse River to Shift Course

The December 12 storm surge resulted in the Morse River ebbing across the spit around the time of high tide, but the scour did not lower the level of sand enough to change the course of the river. It may take a larger storm or a series of severe storms to breach the spit. Alternatively, the river may thin the spit even further as the meandering process continues to lead to channel shoaling and greater sinuosity. A thin spit will have less sand that needs to be removed by a storm and would more likely result in a breach that is permanent. Over time it seems likely that the spit will be breached one way or another and erosion of the dunes at the state park will end for several decades.

A walk on Popham Beach is always a different experience from one day to another and certainly from one year to the next. Keep the historical meandering in mind if you visit the beach and, if visibility is good, look across to the Seawall Beach spit to see if it shows new signs of thinning or lowering and ultimately changing the course of the Morse River. You may be able to see dramatic changes to the coastal geology and ecosystem over several trips to the beach in a single year.

References and Additional Information

Dickson, S. M., 2008a, Tombolo breach at Popham Beach State Park, Phippsburg, Maine.

Dickson, S. M., 2008b, Seawall and Popham Beach Dynamics, Phippsburg, Maine.

Dickson, S.M., 2009, Storm and Channel Dynamics at Popham Beach State Park, Phippsburg, Maine.

Meandering and other physical properties of rivers

Coastal barrier beach and dune systems of the U.S.