Geologic Site of the Month

April, 2002

# *Mile and Half Mile Beaches at Reid State Park, Maine*

43 46‘ 56.34“ N, 69 43‘ 18.23“ W

Text by
Stephen M. Dickson

## Introduction and Significance

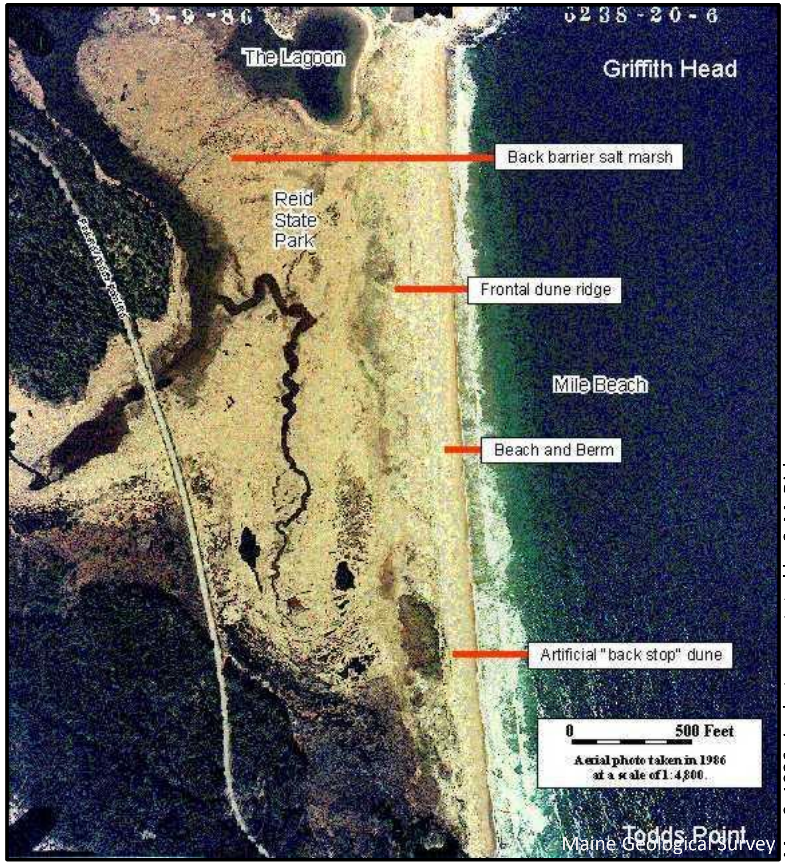
Reid State Park in Georgetown, Maine has two beautiful sand beaches: Mile and Half Mile Beaches. These beaches are located in the mid-coast region of Maine between the mouths of the Kennebec and Sheepscot Rivers (Figure 1). Both beaches are very linear, face southeast into the Gulf of Maine, and receive large surf.


From U.S. Geological Survey 7.5' Boothbay Harbor quadrangle map

**Figure 1**. Location of Reid State Park and southeast facing beaches from Griffith Head to Todds Point.

## Mile Beach

Mile Beach is located between two rocky promontories: Griffith Head (Outer Head) in the east and Todds Point (Little River Ledges) in the west (Figure 2).




May 9, 1986 air photo annotated by S. M. Dickson

**Figure 2.** Mile Beach with coastal sand dunes, back-barrier salt marsh and tidal channels. The Lagoon is a popular sheltered low-energy beach. Similar photos available from the Maine Geological Survey catalog

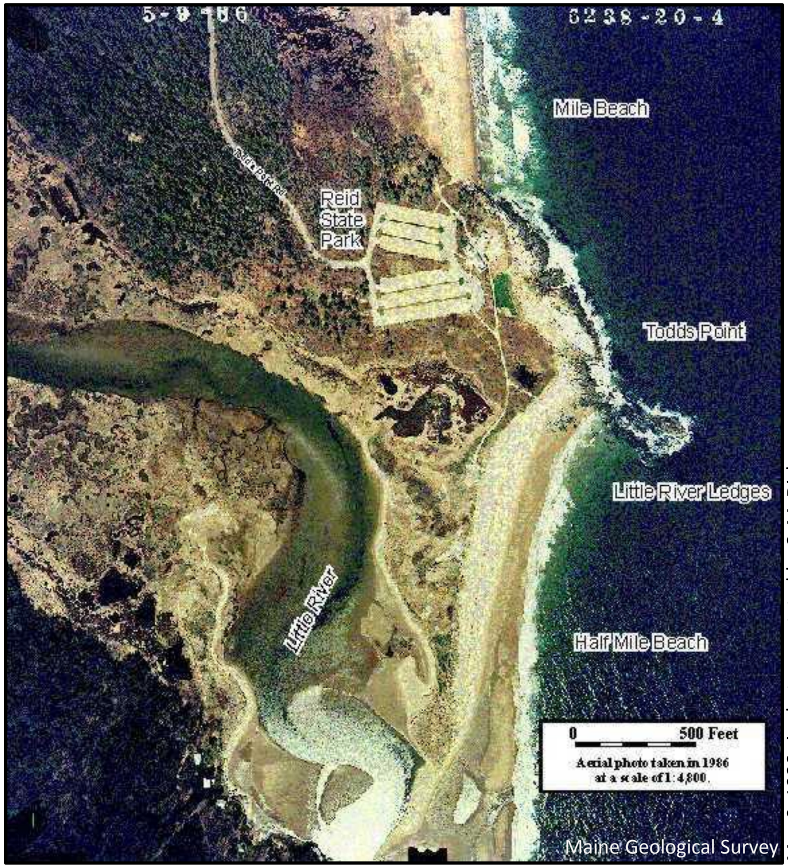
## Mile Beach

A continuous and high natural frontal dune protects a salt marsh and estuarine channels in the back barrier environment (Figure 3). An artificially high "back stop" dune is vegetated with shrubs on the landward side (above the life guard station). The artificial dune was built in the 1940s. See the discussion of Additional Facts in the text and also Figure 6 for beach profiles taken in front of this large dune. The sand fence along the seaward edge of the frontal dune helps trap wind-blown sand to fortify the frontal dune and also keeps foot traffic off the fragile American beach grass (Ammophila breviligulata) that holds the dune in place. The clear sand area seaward of the fence is called the berm; the intertidal beach profile has stranded seaweed on the beach face.


**Figure 3.** Mile Beach has a continuous high frontal dune ridge.

## Half Mile Beach

Southwest of Mile Beach is Half Mile Beach (Figure 4).




May 9, 1986 air photo annotated by S. M. Dickson

**Figure 4.** Half Mile Beach with coastal sand dunes, back-barrier salt marsh, and Little River tidal inlet and channel. Half Mile Beach forms a beach spit that tapers to the southwest and ends at the tidal inlet. Similar photos available from the Maine Geological Survey catalog.

## Half Mile Beach

This shorter beach is a true barrier spit that constricts the opening of the Little River and its extensive salt marsh (Figure 5).


Photo by SM Dickson

**Figure 5.** Oblique air photo of Half Mile Beach, back-barrier dunes, blowouts, salt marsh and pans (ponds), and edge of the Little River tidal channel. Meandering of the Little River has cut into the back dunes and left relict ridges. Foot traffic prevents fragile dune vegetation from growing along a path to the beach from Todds Point.

## Beach Profiles

Both beaches have similar sand characteristics. Compared to many Maine beaches, Mile Beach has coarser sand and has a rich orange-pink hue due to an abundance of feldspar minerals. Some sand grains are composed of dark-red mineral grains of garnet. Garnets have a higher specific gravity (density) than quartz or feldspar sand grains and can be selectively sorted by waves into red bands or patches on the beach. The beaches at Reid State Park have classic seasonal changes to the beach profiles with the formation of a broad berm in the summer and a low, convex up profile in the winter.

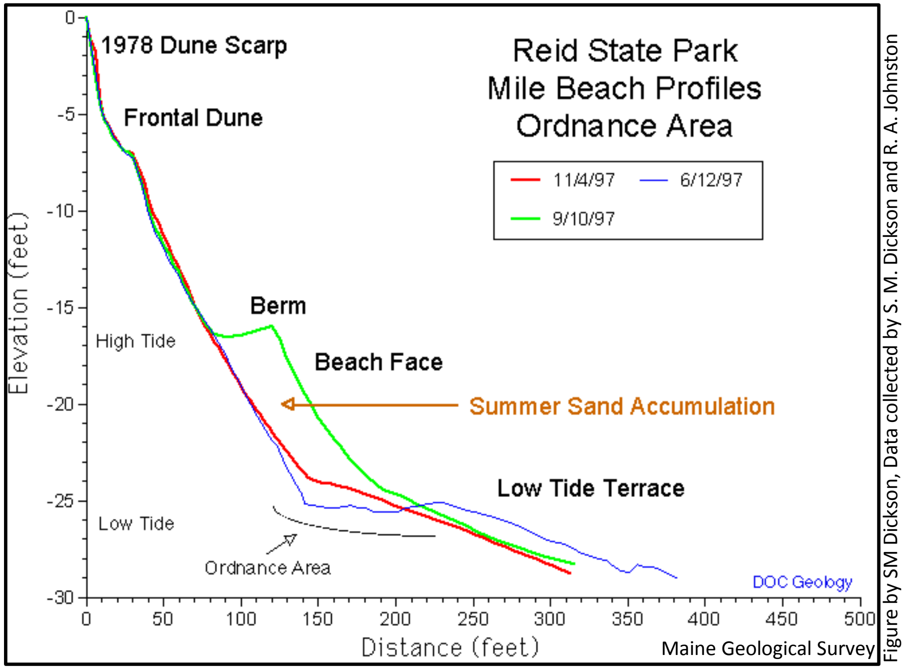



**Figure 6.** Beach profiles superimposed for three different dates showing the width and height of the berm (9/10/97) representing a full summer accumulation of sand on the beach. Fall storms removed the berm by 11/4/97. The beach profile was taken on Mile Beach near the artificial "back stop" dune (Figure 2).

## Beach Cusps

Most of the seasonal shifting of sand is probably involved in the formation of an offshore sand bar in the winter. The edge of the berm is often curved and beach cusps, made by wave action, often persist for days to weeks (Figure 7). Interaction of waves with the rocky headlands at either end of Mile Beach is probably responsible for the formation of ephemeral beach cusps.


Photo by JT Kelley

**Figure 7.** Beach cusps along Mile Beach are highlighted by the wet-dry line in the sand. Griffith Head in the background.

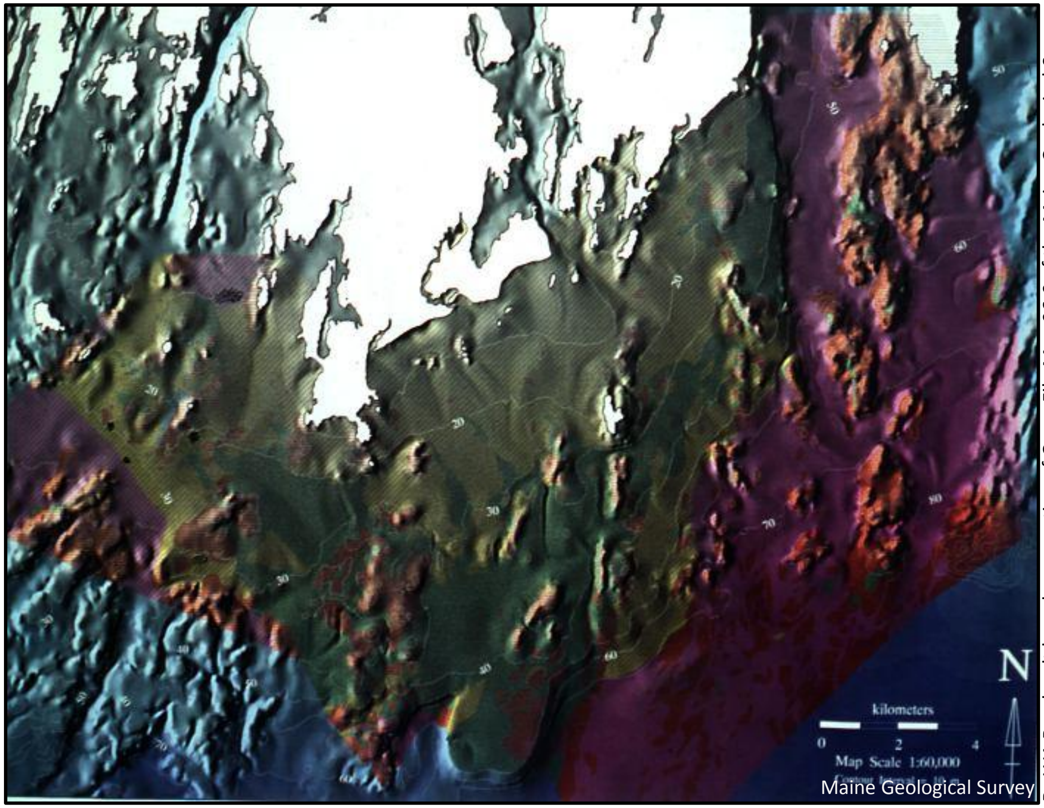
## Geological History

Mile and Half Mile Beaches are located in an interesting geological setting. Many coastal barrier beaches and dunes in Maine are located adjacent to rivers that supplied sand to the sea. Fluvial sand is primarily derived from river-bank erosion of glacial deposits. At the coast, sand is reworked and concentrated along the shoreline by marine processes (waves, currents, tides) into coastal beaches and sand dunes. Routinely reworked by wind and waves, sand has accumulated into dunes over thousands of years. While the beaches at Reid State Park are near two rivers: the Sheepscot and Kennebec, it is unlikely that modern rivers supply sand that makes up these beaches.

The Sheepscot River channel is very deep and muddy and does not carry sand this far to sea (Belknap and others, 1986). The Kennebec River is very sandy, but studies of sand transport near the river mouth (FitzGerald and others, 1989; Fenster and FitzGerald, 1996; Fenster and others, 2001) suggest that river sand is most likely accumulated on Pond Island Shoal and Popham Beach on the west side of the river mouth. This leaves the offshore as the most likely source of beach sand at Reid State Park.

## Geological History

In fact, there is a large sand accumulation offshore of the mouth of the Kennebec River (Barnhardt and others, 1996; Barnhardt and others, 1997) that is in the form of a submerged delta (Figure 8).




By WA Barnhardt based on a portion of Open-File Map 96-9 of the Maine Geological Survey

**Figure 8.** Shaded relief map of surficial geology of the offshore from Casco Bay (left) to Southport Island (right). The Kennebec River is in the top center of the map and the Sheepscot River is in the top right. Green colors represent sand (olive green) and fine gravel (dark green) of the Kennebec paleodelta. Pink colors are muddy sediment and the orange color is bedrock. Contours are in meters.

## Geological History

This delta was created at a time of much lower sea level (Kelley and others, 1996) and consequently called a "paleodelta" (Belknap and others, 1989). The sand of the Kennebec paleodelta is actively being reworked by storms, some of which can transport sand toward the beach (Dickson, 1999). The offshore sand source and oceanographic processes are the most likely reason there is a coastal barrier at Reid State Park.

Geological investigation of the thickness and age of the dunes and beach has determined some interesting facts (Buynevich and FitzGerald, 1999). Sand extends below Mile Beach to depths of over 10 m (33 ft) and in a few places is as thick as 30 m (100 ft). Sand beneath Half Mile Beach is less thick; it is from 3 to 25 m (10 to 80 ft).

## Geological History

Cores taken through the beach and back dunes show vertical layers of sand over salt marsh peat (Figure 9). The figure shows sand overlying peat in core RO-5 on the beach and thick high marsh overlying low marsh peat in core RO-5A. The first peat to form may have done so in a back-barrier environment behind Todds Point about 3570±140 (radiocarbon) years ago (Buynevich and FitzGerald, 1999). This old sample of salt marsh suggests that beaches and dunes of Reid State Park may have been in existence for over 3000 years.

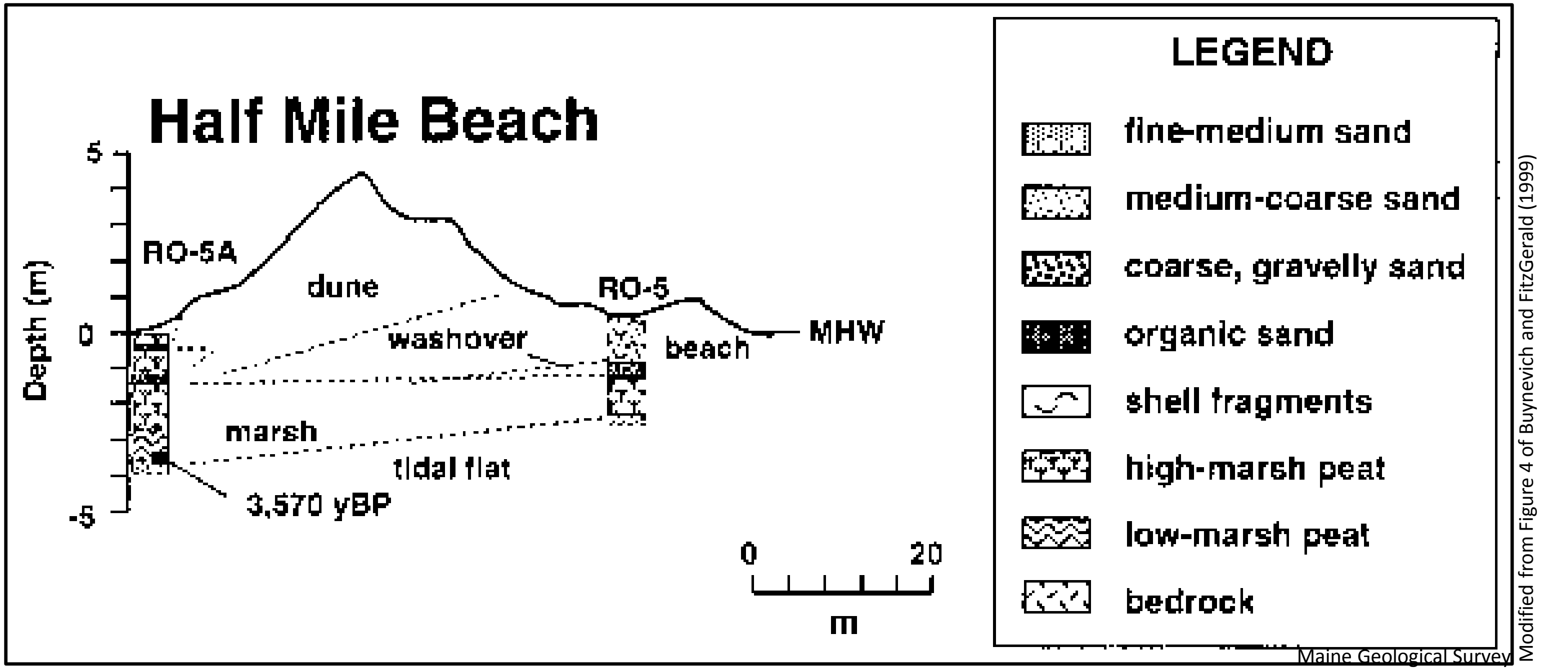



**Figure 9.** Illustration of a topographic cross-section over Half Mile Beach showing the elevation of the frontal dune ridge. The position, depth, and composition of two cores, one from the beach and the other from the back-barrier marsh near Todds Point are shown with a compressed horizontal scale (vertical exaggeration is 4x).

## Geological History

Since sea level has risen over the last 3000 years (Kelley and others, 1996), the beaches and dunes have probably moved inland from their origin at a location farther out to sea. This conclusion is supported by two facts. First, high-marsh peat forms just near the elevation of high tide to spring high tide in protected environments. Core RO-5A (Figure 9) has a vertical thickness of over 2.5 m (8.2 ft) of high-marsh peat next to the Little River. The only way this type of peat can form is through the continual aggradation or upbuilding of plant matter and sediments over time as sea level has risen. Second, peat underlies the present dune and beach (Figure 9) and, after periods of severe winter beach erosion tree stumps can be found exposed near the low-tide line on Mile Beach near Todds Point.

## Geological History

These stumps are in situ (not drift wood) and once grew when sea level was perhaps 3 m (10 ft) lower than present so the roots were above the level of salt water at high tide. Consequently, the beach and dunes have migrated inland a minimum of 60 m (200 ft) at Half Mile Beach and 120 m (400 ft) at Mile Beach, and probably much more, over the last 3000 years.


**Figure 10.** Exposed tree stump and roots on the low-tide terrace of Mile Beach near Todds Point. Several stumps and overlying salt marsh peat are exposed by beach erosion in late winter or early spring of some years. Scale is 16 cm (6.5 in) long.

## Geological History

Another interesting consequence of the elevation of the sea is how salt water enters the back-barrier salt marshes. The Little River has a classic tidal inlet with the full ebb and flow during a 3 m (10 ft) tide. The salt marsh and lagoon (Figure 2 and Figure 11) behind Mile Beach has an inlet controlled by a bedrock sill.


**Figure 11.** The low-energy beach shoreline of the lagoon behind the dunes of Mile Beach. In the distance is the back-barrier salt marsh. See Figure 2 for an aerial view of the lagoon.

## Geological History

The ledge here confines the lateral movement of the channel to a narrow opening. The bedrock also limits the exchange of salt water during the lower part of the tidal cycle. In many ways, the rock sill acts as a dam. About 2000 years ago sea level was probably low enough to prevent the tides from entering the lagoon (Nelson and Fink, 1980). Prior to that time the back barrier environment was probably a fresh water marsh with a small stream that drained to the sea over the bedrock sill. As a result of this controlling bedrock sill, the oldest salt marsh in the park is behind Half Mile Beach and Todds Point.

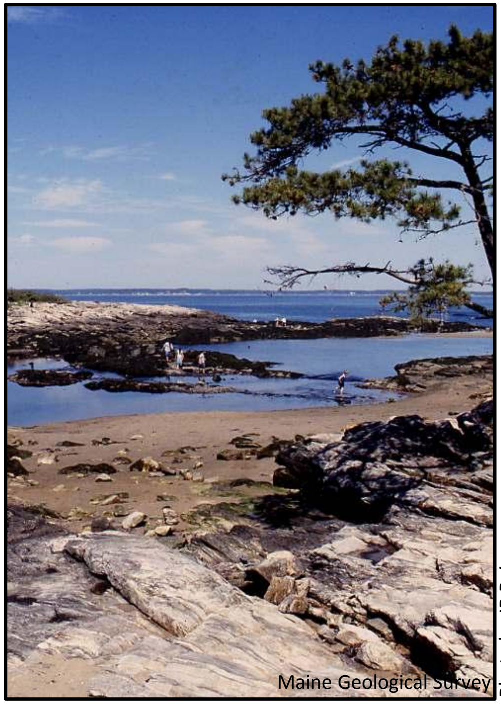
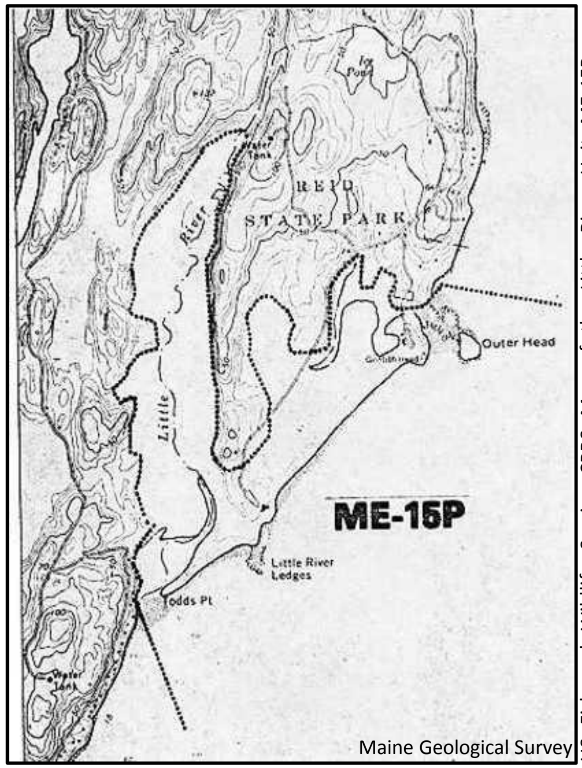



Photo by JB Poisson

**Figure 12.** Bedrock ledge is exposed in the intertidal shoreline of Reid State Park where tidal flow enters and exits the lagoon (Figure 11). The view is looking east into the wide and deep Sheepscot Bay.

## Coastal Barrier Resources System

The beaches, dunes, and wetlands at Reid State Park are undeveloped except for a few roads, parking areas and park concession facilities. The undeveloped condition qualifies the beach, dunes, and wetlands to be Unit ME-15P of the federal and state Coastal Barrier Resources System (Figure 13).




US Fish and Wildlife Service CBRS Map of the Little River Unit ME-15P, 10/24/1990, on the Boothbay Harbor 7.5' U.S. Geological Survey quadrangle map.

**Figure 13.** The boundary of the Coastal Barrier Resources System at Reid State Park is shown by the dotted line. Due to the limited amount of coastal development in the dunes and adjacent bedrock headlands, this area is sufficiently undeveloped to qualify for inclusion in the CBRS and is called the Little River Unit ME-15P. Note how the system boundary is inclusive of the back-barrier salt marshes including the inland extension of the Little River salt marsh.

## Additional Facts

Maine coastal barriers are protected by state and federal laws. Maps of all of the Maine CBRS are available for review at the Maine Geological Survey office in Augusta. For more information about the CBRS see the CBRS Fact Sheet.

The Groundhog Day Storm of 1976 caused extensive coastal flooding at Reid State Park. Morrill and others (1979) measured flooding as high as 2.7 m (8.7 feet) above the predicted high tide. This flooding was the result of both wind pushing coastal water onto the shore and wave runup due to large surf. Such an event may have caused sand to be washed off the beach profile and up into the sand dunes and possibly over the frontal dune ridge. Storm flooding results in deposition of sand in the dunes called washover. Repeated storm sedimentation helps maintain the dune elevation as sea level gradually rises.

Before the park was established, World War II Navy fighter pilots trained by firing rockets at floating targets just offshore of Mile Beach. From 1944 to 1946 planes from Brunswick Naval Air Station flew over the ocean, beach, dunes, and marsh and fired 3- and 5-inch diameter practice ordnance (Hoey, 1997a, b, c) at a barge moored just off the beach as they approached land. The exceptionally large dune (Figure 2 and Figure 3) within the frontal dune ridge was built as a "back stop" for aviator target practice.

In 1976 erosion exposed metal ordnance at the southwest end of Mile Beach (Nelson and Fink, 1980). During subsequent periods of beach profile erosion, such as in the January and February 1978 blizzards, ordnance probably settled to greater depths below the beach.

## Additional Facts

Beach erosion in the winter and spring of 1997 exposed some fragments of the WWII ordnance suggesting that the beach experienced unusually deep erosion during winter storms (Figure 14). Most of the ordnance recovered in a November-December 1997 cleanup effort by the U.S. Army Corps of Engineers came from the beach face just above and landward of the low-tide terrace (Figure 6). The January 1998 and May 1997 Field Localities illustrate beach profile changes and have examples of the rocket ordnance.


Photo by JT Kelley

**Figure 14.** World War II practice ordinance was exposed on the beach by winter erosion of the beach profile near the low-tide terrace. Department of Conservation geologists and park personnel examined the metal tip of a three-inch "dummy" rocket used for Navy aviator training.

## Activities: Grain Size Sorting

Walk along either beach and observe changes in the size of grains of sand. Walk up and down the beach profile and pick up a sample of sand from the berm near the dune edge, beach face, and low-tide terrace (if the tide is low). Compare these to see where the coarsest sand grains are. Note which places the coarsest and finest grains come from. These grains are sorted by wave action on the low-tide terrace and beach face. Both wind and waves transport sand on the berm and next to the dune. Close to the dune the influence of waves decreases and the relative importance of wind increases in transporting sand. Wind-blown sand tends to be quite fine-grained and well sorted.

Keep the beach face sample in your hand and carry it along on your walk. Compare sand samples from the beach face as you go and search for a coarsening or fining trend. In general, grains tend to become finer in a "down drift" direction. That is, grains become smaller in the direction of sand movement. Are you walking up drift or down drift?

## Activities: Wave Observation

The river of sand moving along a beach is also known as the "longshore drift" or "littoral drift." Longshore (or littoral) currents which move sand along the beach are typically generated by waves approaching the beach at an angle. The strength of the longshore current is determined by the size of the waves washing on the beach and by the angle they make as they break in the surf zone. Waves that have crest lines parallel to the beach (approach at a small angle) tend to break or "dump" in unison. Waves that approach at an angle tend to break or "peal" in one direction along the beach.

## Activities: Wave Observation

Figure 15 shows waves breaking at an angle on Mile Beach. The waves approach the beach at a small angle, shoal, rise to a breaking point, and then spill as a plunging breaker. In this example, the wave breaks from left to right in the photo so it would generate a longshore drift to the southwest away from Griffith Head toward Todds Point.

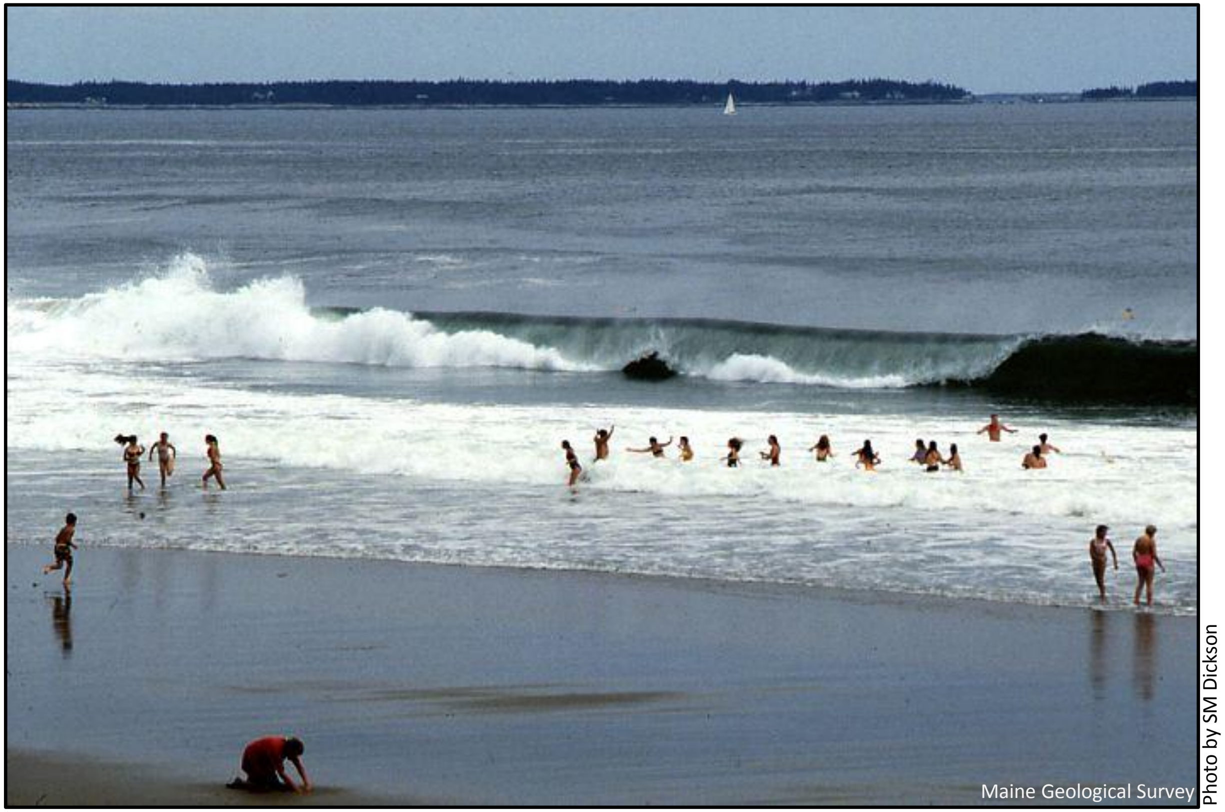



**Figure 15.** Ocean swells break on Mile Beach near Griffith Head (out of view to the left).

## Activities: Wave Observation

Fine sand will move along the beach more quickly than coarse sand so there will be some selective sorting by waves and the alongshore current. Observe the size and angle of waves washing ashore. Estimate their height and period (count the seconds between crests arriving ashore or breaking). At a later time, compare what you observed with data recorded by buoys offshore. In the future you will have a better idea of the size of the surf down at the beach based on readings at wave-rider buoys you can access on the internet from home or the classroom.

## Activities: Beach cusp measurement and berm width

From time to time the berm on Mile Beach is scalloped into rhythmic beach cusps (Figure 7). This irregular shape consists of horns and cusps that protrude and recede from the average berm crest. Sometimes there can be more than one berm on the beach profile due to changes in the tidal range from a large (spring) range to a small (neap) range which allows more than one set of beach cusps to be temporarily preserved. As the tides change over a month, a larger range and different wave conditions will rework the cusps into a linear berm or another cuspate berm. Figure 3 shows a relict cuspate topography in the berm; this relief can be seen in the undulations of the sand fence.

Walk along the berm and look for variations in the edge and top of the berm. Is the berm crest linear or curved? Are there fresh or old cusps cut into the berm? Is there more than one berm? As you walk the beach notice how the berm width changes. Which end of Mile Beach has the biggest berm (and hence best beach blanket space)?

Measure the wavelength of the cusps by counting the paces from crest to crest. Are the crests all the same distance apart? Record the distance (number of paces) of several crests and calculate the average wavelength. Chances are the next visit to the beach the cusps will be a different size or perhaps not even present. As you walk the length of the beach does the cusp wavelength change? Does it increase or decrease up drift or down drift?

## Logistics

Access, facilities, dates of operation, directions, fees for admission, etc. for Reid State Park.

Topographic map: Boothbay Harbor 7.5' quadrangle, scale 1:24,000, U.S. Geological Survey. Available for purchase from the Maine Geological Survey web site. This quadrangle may be available at other Maine locations.

National Ocean Service nautical charts: No. 13295 Kennebec and Sheepscot River Entrances, scale 1:15,000. No. 13293 Damariscotta, Sheepscot, and Kennebec Rivers, scale 1:40,000. Available from National Ocean Service.

National Ocean Service tide predictions

## References and Additional Information


Barnhardt, W. A., Belknap, D. F., Kelley, A. R., Kelley, J. T., and Dickson, S. M., 1996, Surficial geology of the Maine inner continental shelf; Cape Elizabeth to Pemaquid Point, Maine: Maine Geological Survey (Department of Conservation), Geologic Map 96-9, Scale 1:100,000.

Barnhardt, W. A., Belknap, D. F., and Kelley, J. T., 1997, Stratigraphic evolution of the inner continental shelf in response to late Quaternary relative sea-level change, northwestern Gulf of Maine: Geological Society of America, Bulletin, v. 109, p. 612-630.

Belknap, D. F., Shipp, R. C., and Kelley, J. T., 1986, Depositional setting and Quaternary stratigraphy of the Sheepscot Estuary, Maine: a preliminary report: Geographie Physique et Quaternaire, v. XL, no. 1, p. 55-69.

Belknap, D. F., Shipp, R. C., Kelley, J. T., and Schnitker, D., 1989, Depositional sequence modeling of late quaternary geologic history, west-central Maine coast: Studies in Maine Geology, Volume 5 - Quaternary geology, Maine Geological Survey, p. 29-45.

Buynevich, I. V., and FitzGerald, D. M., 1999, Structural controls on the development of a coarse sandy barrier, Reid State Park, Maine: Coastal Sediments '99.

Buynevich, I. V. and FitzGerald, D. M., 2000. The coastal geology of Popham and Reid Beaches, in Yates, M. G., Lux, D. R., and Kelley, J. T. (editors), Guidebook for field trips in coastal and east-central Maine: New England Intercollegiate Geological Conference, 92nd Annual Meeting, Dept. of Geological Sciences, Univ. of Maine, Orono, p. 226-237.

Dickson, S. M., 2001, Beach and dune geology aerial photos: Open-file maps on a photo base with interpreted geology and legend, Maine Geological Survey, 1:4,800 scale. Catalog Numbers: 01-459 Half Mile Beach, Little River; 01-460 Half Mile Beach, Reid State Park; 01-461 Mile Beach, Reid State Park; 01-462 Griffith Head, Reid State Park.

Dickson, S. M., 1999, The role of storm-generated combined flows in shoreface and inner continental shelf sediment erosion, transport, and deposition: Ph.D. dissertation, School of Marine Sciences, University of Maine, 321 p., 1 plate.

Fenster, M. S., and FitzGerald, D. M., 1996, Morphodynamics, stratigraphy, and sediment transport patterns of the Kennebec River estuary, Maine, USA: Sedimentary Geology, v. 107, p. 99-120.

## References and Additional Information

Fenster, M. S., FitzGerald, D. M., Kelley, J. T., Belknap, D. F., Buynevich, I. V., and Dickson, S. M., 2001, Net ebb sediment transport in a rock-bound, mesotidal estuary during spring-freshet conditions: Kennebec River estuary, Maine: Geological Society of America, Bulletin, v. 113, p. 1522-1531.

FitzGerald, D. M., Buynevich, I. V., Fenster, M. S., and McKinlay, P. A., 2000, Sand circulation at the mouth of a rock-bound, tide-dominated estuary: Sedimentary Geology, v. 131, p. 25-49.

FitzGerald, D. M., and Fink, L. K., Jr., 1987, Sediment dynamics along an indented coast; Popham Beach-Kennebec River, Maine, in Kraus, N. C. (editor), Coastal Sediments '87: American Society of Civil Engineers, New York, New York, p. 2047-2061.

FitzGerald, D. M., Lincoln, J. M., Fink, L. K., Jr., and Caldwell, D. W., 1989, Morphodynamics of tidal inlet systems in Maine, in Tucker, R. D., and Marvinney, R. G. (editors), Studies in Maine Geology, Volume 5 - Quaternary Geology: Maine Geological Survey , p. 67-96.

Fink, L. K., Jr., and Nelson, B. W., 1980, The morphological record of dynamic processes active in Maine's swash-aligned beach systems (abstract): Geological Society of America, Abstracts with Programs, v. 12, no. 2, p. 35.

Hoey, D., 1997a, Explosives cleanup to close state park: Portland Press Herald, November 21, 1997.

Hoey, D., 1997b, Warhead cleanup at state park delayed: Portland Press Herald, August 21, 1997.

Hoey, D., 1997c, State Park ordnance cleanup "a success": Portland Press Herald, December 9, 1997.

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

Komar, P. D., 1998, Beach processes and sedimentation, second ed.: Prentice Hall, Upper Saddle River, New Jersey, 544p.

Nelson, B. W., 1979, Shoreline changes and physiography of Maine's sandy coastal beaches: M.S. thesis, University of Maine, Orono, 302 p.

Nelson, B. W., and Fink, L. K., Jr., 1980, Geological and botanical features of sand beach systems in Maine: Maine Sea Grant Publications, Bulletin 14, 163 p. (originally published by Maine State Planning Office, Critical Areas Program, Planning Report 54).

## References and Additional Information

Morrill, R. A., 1977, Maine coastal flood of February 2, 1976: U. S. Geological Survey, Open-File Report 77-0533, 40 p.

Morrill, R. A., Chin, E. H., Richardson, W. S., 1979, Maine coastal storm and flood of February 2, 1976: U. S. Geological Survey, Professional Paper 1087, 20 p.

Smith, C. L., and Ruter, B. D., 1996, Morphodynamics of a reflective sand beach, Reid State Park, Maine (abstract): Geological Society of America, Northeastern Section, 31st Annual Meeting, Abstracts with Programs, v. 28, no. 3, p. 100.

Sullivan, J. J., IV, 1998, Alongshore variation in erosion and deposition on a reflective sand beach, Reid State Park, Maine (abstract): Geological Society of America, Northeastern Section, 33rd Annual Meeting, Abstracts with Programs, v. 30, no. 1, p. 77.

Trudeau, P. N., 1979, Ecology of barrier beaches in south-central Maine (Popham Beach State Park, Reid State Park, and Small Point Beach): Ph.D. dissertation, University of Massachusetts, Amherst, Massachusetts, 412 p.

Trudeau, P., Godfrey, P. J., and Timson, B. S., 1977, Beach vegetation and oceanic processes study of Popham State Park beach, Reid State Park beach, and Small Point beach: Maine Department of Conservation and U. S. Department of Agriculture, Soil Conservation Service, Resource Conservation and Development Project, 144 p.

## References and Additional Information

Coastal Sand Dune Geology Maps of Reid State Park are available from the Maine Geological Survey.

Maine Coastal Barrier Resources System

Conference Showcases Beach Monitoring Program by Susan White.

National Data Buoy Center

Northeastern Regional Association of Coastal and Ocean Observing Systems (NERACOOS)

Maine Geological Survey Marine Geology Web Page