SHORELINE CHANGES ON PLUM ISLAND, MASSACHUSETTS.[1]

ROBERT L. NICHOLS.

ABSTRACT. The northern end of Plum Island, a barrier beach, is forked. The eastern prong is approximately one and one-quarter miles long and at its widest point one-half a mile wide. Between the eastern and western prongs is a shallow body of water called the Basin.

A study of maps made by the U. S. Army Engineers shows that the eastern prong has been formed in the last 113 years.

In 1827 the northern end of Plum Island was not forked. Between 1827 and 1851 the eastern side retrograded about one-half a mile southward. The western side was modified later to form the western prong. Following this period of retrograding southward, a spit, attached to the eastern side, prograded northward so that by 1851 it was more than a mile long. Since 1851 this spit, the eastern prong, has greatly increased in size. Today it has an area of approximately .3 sq. mile.

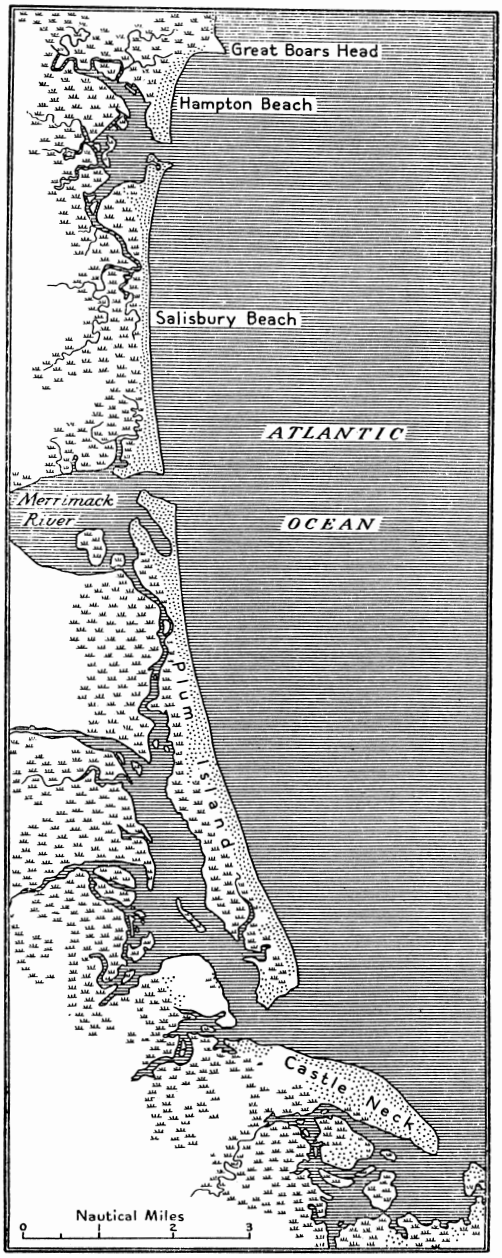
INTRODUCTION.

PLUM ISLAND is a barrier beach between seven and eight miles long and in most places between one-half and one mile wide. It is composed mainly of beach sands and gravels, dune sand, and marsh deposits, although on its southern end there are small areas of till, outwash, and marine clay. Salisbury beach, which is north of Plum Island, is also a barrier beach about four and one-half miles long composed of beach sands and gravels, dune sand, and marsh deposits. The Merrimack river reaches the ocean between Plum Island and Salisbury beach (Text Fig. 1).

The northern end of Plum Island is forked. The eastern prong, on which there are more than 100 cottages, is approximately one and one-quarter miles long and at its widest point one-half mile wide. The western prong is approximately 3500 feet long and as much as 1400 feet wide. Both the eastern and western prongs are composed of beach sands and gravels and dune sand. Between the two prongs is a shallow body of water, called the Basin, which is about one mile long and approximately 1000 feet wide (Plate I, Figs. 1 and 2). It has a muddy bottom, which is visible at low tide when the Basin is more or less completely drained.

A study of maps made by the U. S. Army Engineers shows that the eastern prong has been formed in the last 113 years.

[1] Published by permission of the Director, Geological Survey, U. S. Dept. Interior, and the Massachusetts Commission of Public Works.



Text Fig. 1. Index map showing Plum Island, Salisbury beach, and the Merrimack river.

HISTORIC CHANGES ON THE NORTH END OF PLUM ISLAND.

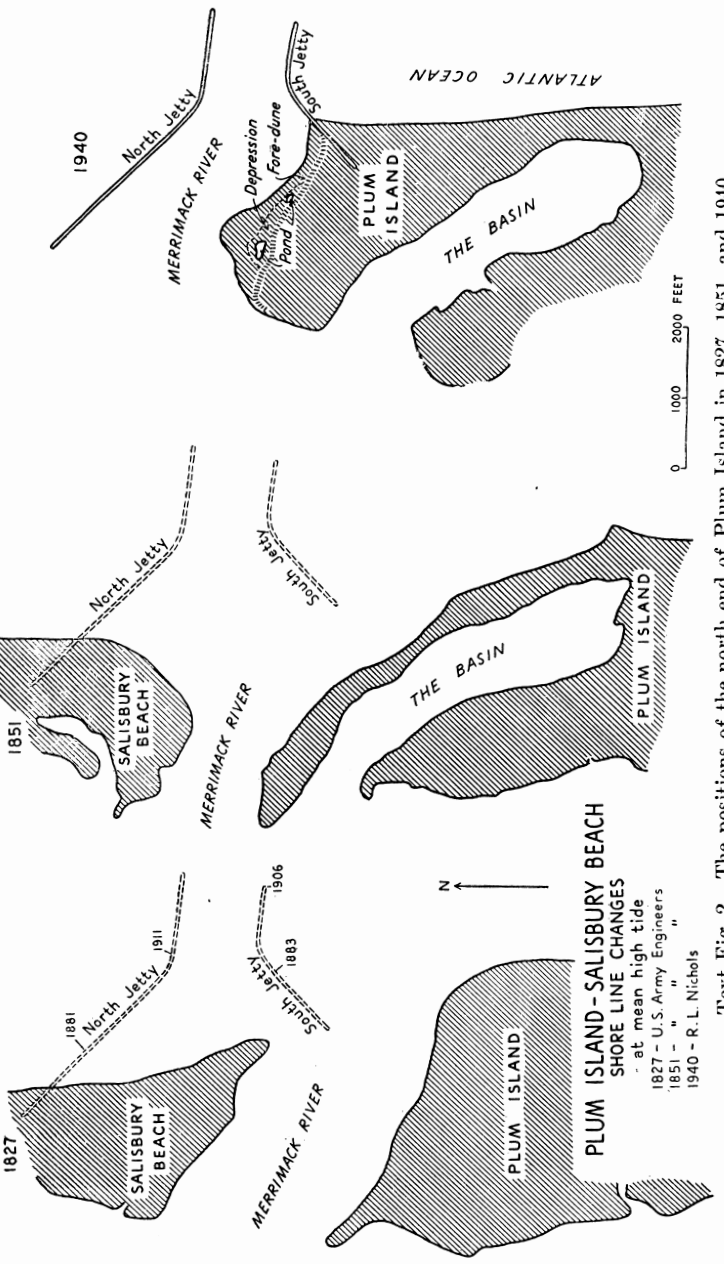
The positions of the shoreline of the northern end of Plum Island and the southern end of Salisbury beach in 1827 and 1851 are indicated in Text Fig. 2.

It will be noticed that the positions of both the northern end of Plum Island and the southern end of Salisbury beach in 1827 were about one-half a mile south of their positions in 1940. It is also clearly apparent that considerable changes took place in the 24 years between 1827 and 1851. A large area which had been land in 1827 was covered by water in 1851. During the first part of this period the eastern portion of the north end of Plum Island retrograded as much as one-half a mile to the south, whereas the extreme western part retrograded only a short distance. Although there is nothing in Text Fig. 2 to indicate that the southern end of Salisbury beach prograded south while Plum Island was retrograding south, it almost certainly did so.

Longshore currents, generated by waves which strike the coast obliquely, are responsible for the prograding of these beaches. If one side of an inlet is prograding because the quantity of material brought there by the longshore currents is greater than can be removed by the tidal and river currents running in and out of the inlet, the other side tends to retrograde because the inlet is so narrowed that the tidal and river currents have increased velocities and therefore increased eroding power. Howard[2] has recently described a very interesting example of this process. The inlets formed in the offshore bar of Long Island, New York, during the hurricane of 1938 were closed by man. It was found that as a bulldozer pushed material into one side of an inlet the other side was rapidly eroded by the currents, whose velocities had been greatly increased by the constriction of the inlet. Moreover, the side of an inlet which is not being prograded is eroded not only by tidal and river currents, but also by longshore currents.

Although a number of lines of evidence indicate that the longshore currents in general move from the northwest to the southeast along the northeastern coast of Massachusetts, it is seen from what follows that they change their direction from time to time.

[2] Howard, A. D.: 1939, "Hurricane Modification of the Offshore Bar of Long Island, New York," Geographical Review, Vol. XXIX, pp. 411-413.



Text Fig. 2. The positions of the north end of Plum Island in 1827, 1851, and 1940.

During the first part of the period 1827-1851 the northwest longshore currents were more effective than the southeast longshore currents. Following this period of southward retrograding for Plum Island a narrow spit which averaged about 400 feet in width and which was attached to the eastern side of Plum Island grew northwestward for a distance of more than a mile. While Plum Island was prograding northward the southern tip of Salisbury beach, as is indicated by Text Fig. 2, was retrograding northward. During this later period the southeast longshore currents were more effective than the northwest longshore currents. The Basin is the result of the formation of this spit. When first formed the Basin was undoubtedly several feet deep at low tide.

The existence of two prongs at the north end of Plum Island shows that only the east side of the northern end retrograded appreciably because only here did the longshore, tidal, and river currents have sufficient force to cause retrogression. Thus the western part of the northern end remained, forming the western prong. The spit that was attached to the eastern side and prograded northward later formed the eastern prong.

It would be expected that the spit would curve to the northwestward up the Merrimack river, as such curving usually happens under the conditions described. At the end of such a spit some material is swept landward by the flood-tide, and other material is swept seaward by the ebb-tide and the river currents. The material that is swept seaward, however, is continually removed by the waves and longshore currents, whereas a large part of the material swept landward tends to remain there. The spit, therefore, tends to curve inland. Moreover, by throwing material from the ocean side of the spit to its bay side, the waves also help the spit to curve inland. After the spit becomes curved, further growth at its distal end merely continues the curve.

From 1851 to 1940, as shown by Text Fig. 2, the northern end of Plum Island continued to prograde, and the southern end of Salisbury beach to retrograde. It will be noticed that the western prong of Plum Island did not prograde during this time; instead the extreme northern end of the prong retrograded a short distance because no large waves could strike it either on its eastern or on its western shores and therefore no strong longshore currents were available to carry material to

its northern end. The retrogression noted has been caused by weak currents and waves acting against it at this point. The area added to the northern end of Plum Island between 1940 and some date between the years 1827 and 1851 was approximately .3 sq. mile. As the thickness of the fill is approximately 30 feet and as a cubic foot of this material weighs approximately 100 lbs., the weight of the material deposited was approximately 12,500,000 tons or enough to fill 250,000 freight cars of 50 tons each. The older part of the eastern prong is covered by sand dunes; the younger part has none. The more recent growth of the northern end of Plum Island has also formed a depression which contains two small ponds. This depression, together with the ponds, is slowly being filled by material washed in by waves and blown into it by the wind. Part of the material washed in by waves is deposited as foreset beds on the oceanward side of the depression. These beds are more than 15 feet long. While the spit was prograding the Basin was slowly being filled by wind-blown sand and by the fine material deposited by the Merrimack river. When the eastern prong was narrow, material was washed into the Basin by waves.

The jetty at the north end of Plum Island was built in 1883. It extended from the shoreline into deep water. Today more than 1000 feet of the part of it that was originally in deep water is covered by the sands of Plum Island.

Sand has been rapidly accumulating during the last ten years or more in shore from the jetties, especially on the Plum Island side. Some of this sand may have been deposited by the Merrimack river; some of it may have been blown from Salisbury beach and Plum Island; some of it may have been derived from the sand bar on the seaward side of the jetties.

In a manuscript on Plum Island Schalk[3] says, "We may safely assume that the [Merrimack] river is not now transporting new material to the beaches." The author, however, thinks there is a possibility that the Merrimack is supplying *sand*, especially during floods, to the north end of Plum Island. A small amount of the sand accumulating in shore from the jetties was undoubtedly blown from Plum Island and Salisbury beach. A sand bar has formed off shore from the jetties. Its

[3] Schalk, M.: 1936, "A Textural Study of Certain New England Beaches," Doctorate Thesis submitted to Division of Geological Sciences, Harvard Univ., pp. 50-51.

configuration has been determined by the currents moving in and out between these jetties, by wave action, and by the longshore currents. Two processes tend to move this sand between the jetties and up the river, the flood-tide current and wave action. On the other hand, the ebb-tide current and the river discharge tend to carry such material seaward through the jetties. These currents are so rapid and turbulent along the north end of Plum Island that they carry sand in suspension. During the winter, when wave action is strongest, it may well be that the net result is to move sand inland between the jetties. During the summer, when the waves are not so strong, the net effect may be in the other direction. It seems safe to say, however, that these processes account for some of the material that is being deposited on the north side of Plum Island.

EARLIER FORMED BASINS.

During some future period of strong northwest longshore currents Salisbury beach may prograde and Plum Island retrograde southward. If this should continue long enough the Basin would be destroyed. If after this a period of southeast storms should ensue an eastern prong might form again on Plum Island, thus producing another basin. A study of maps made in 1741 (not reproduced here) and 1816 suggests that one basin, and possibly two, presumably formed and then destroyed by the mechanism outlined above, may have preceded the present basin.

ACKNOWLEDGMENTS.

Thanks are due to Dr. L. W. Currier of the Geological Survey, U. S. Department of the Interior, for reading and criticizing the manuscript. Freeland K. Abbott, Alwyn F. Marston, and Chauncey W. Waldron, Jr., all students at Tufts College, helped in the mapping.

BARNUM MUSEUM,
TUFTS COLLEGE, MASS.