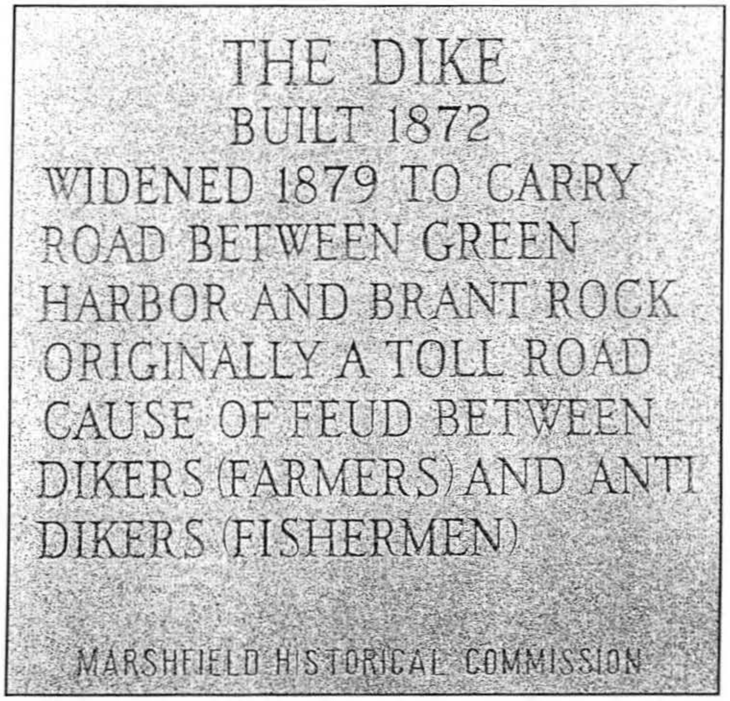
S·A·L·T M·A·R·S·H·E·S

Jewels of the Northeast

by GRAHAM S. GIESE and TRACEY I. CRAGO, WHOI Sea Grant



The McGraw-Hill Dictionary of Scientific and Technical Terms defines a salt marsh as "a maritime habitat" and, indeed, it is the image of salt marshes as habitat that one envisions when discussing the importance of these wetlands. Whether it's tall strands of "low marsh grass," *Spartina alterniflora*, growing along New England tidal creeks and providing shelter for mummichogs and killifish, or wide meadows of "high marsh grass," *Spartina patens*, that, together with the many other high marsh plants, harbor a variety of crawling, burrowing, or flying marsh-dwellers, these are the pictures we conjure up to portray a salt marsh. Such images are beautifully described in the 1969 scientific classic, *Life and Death of the Salt Marsh* by John and Mildred Teal.

To coastal geologists, on the other hand, salt marshes are best defined as "well-vegetated saline intertidal flats." Though less poetic and picturesque than the Teals', a geologist's perspective sees the most interesting aspect of a salt marsh to be the complex deposit of organic and inorganic sediment from which the marsh plants grow. In this rich sediment, salt marsh plants provide both materials and conditions that contribute to the sediment deposit in a process called "feedback."

THE MANY FACES OF SALT MARSHES

Because they are vegetated deposits of sediment lying within the limits of the tides, all salt marshes have another characteristic in common: They are all found in coastal waters sufficiently protected from storm-wave action to permit the survival of marsh grasses. Within these bounds, however, salt marshes in New England can take a variety of forms.

Perhaps the most common are the "fringing marshes" that extend out into tidal creeks and bays from bordering uplands. Depending upon tidal range and sediment supply, fringing marshes vary from narrow bands to wide expanses of vegetated deposits that can practically fill an entire embayment. As relative sea level rises and submerges the bordering upland, fringing marshes extend further inland and thicken.

Other marsh forms, however, are produced, not by processes related to coastal upland submergence, but rather to processes involved with the formation and migration of barrier beaches. For example, "back-barrier marshes," though superficially similar to fringing marshes, are very different in that they extend out into tidal creeks and bays from the landward side of barrier beaches. Back-barrier marshes extend up to the spring high-tide line on barrier beach dunes and widen as marsh plants colonize storm-produced overwash deposits. As a result, they are sometimes referred to as "overwash fan marshes." In some cases, storm waves can damage back-barrier marshes. The barrier beach migrates landward and covers and smothers marsh vegetation.

"Flood-tidal delta marshes," a second type of barrier beach–associated marsh, lie between fringing and back-barrier marshes, often appearing as isolated islands in back-barrier lagoons at high tide. Flood-tidal deltas form on the landward side of tidal inlets. They consist of sediment deposited when the strong inlet currents slow down as they enter the relatively unconstricted waters of back-barrier lagoons. Usually marsh grasses colonize the delta only after it has been abandoned by an active inlet; that is, after the inlet has closed or migrated alongshore away from the delta.

Tidal inlets play a critical role in the maintenance of all barrier beach–associated salt marshes. Because their size and number determine the volume of water entering back-barrier lagoons, tidal inlets control the tidal range within the lagoon. They also control the areas suitable for marsh development. As an extreme example, all inlets into a small back-barrier lagoon may close, with the result that the lagoon receives only freshwater inputs and can no longer support salt-marsh vegetation. A more common scenario is a gradual reduction in tidal range as inlets

Opposite page: This [illegible] in Marblehead, Mass. commemorates the age-old conflict between citizens who valued a salt marsh as a natural resource and those who did not. *Photo by Rachel [illegible]*

Left: The three salt-marsh groups associated with barrier beaches may be seen in this photograph of Great Sippewissett Marsh on Cape Cod. "Fringing marshes" extend seaward from the wooded upland in the upper center; "back-barrier marshes" extend landward from the barrier beach in the lower right; and a future "flood-tidal delta marsh" may develop on the crescent-shaped mid-channel sand deposits shown in the center of the photograph. *Photo by Dale Goehringer, WHOI.*

migrate along the shore, followed by a sudden increase when the barrier breaches and a new inlet is formed. The influence of barrier-beach and tidal-inlet changes on salt-marsh development within the Waquoit Bay system on Cape Cod has been studied by Brian Howes, Woods Hole Oceanographic Institution (WHOI) Sea Grant researcher, in collaboration with Richard A. Orson, a geologist in the geography and environmental sciences department at William Paterson College in Wayne, N.J.

SALT MARSHES PROVIDE LINK TO PAST

While geologists are interested in all sedimentary forms and the conditions under which they arise, salt-marsh deposits have a particular interest for them. Study of these deposits can reveal much about the environmental conditions of both the ancient and recent past, which, in turn, can provide useful information ranging from the effect of the industrial revolution on climate and sea level to the location of hydrocarbon reserves.

At Boston University, geologist Duncan FitzGerald has adapted a ground-penetrating radar device to study the history of beach systems, including salt marshes. By studying the composition and the layering of sediments, FitzGerald hopes to gain insight into the evolution of the systems and, in turn, predict how the systems will behave in the face of storms and rising sea level.

FitzGerald's wheelbarrow-transported radar can send signals up to 1.8 kilometers (60 feet) into underlying sand. Signals reflect off different density layers within the barrier and are sent back to the instrument. A printout of the signals reveals distinct layers and depths of sediment that can serve as a blueprint of how the barrier has been built up over time. In addition to providing a view of the past, information gleaned by FitzGerald's radar device, developed with MIT Sea Grant support, will be useful to coastal zone managers faced with the task of accommodating recreational and commercial development without compromising a beach system's ability to respond naturally to storms and rising sea level.

SALT MARSHES AS BUFFERS AND INDICATORS

Salt-marsh deposits are an important component of the sediment dynamics studied by coastal geologists. Their practical importance is well appreciated by most New England coastal residents because they provide a buffer against storm-wave damage for coastal uplands. When salt marshes are destroyed or sacrificed for development or diking, unexpected destruction may result, such as erosion of the upland and damage to homes and roads that have been placed there.

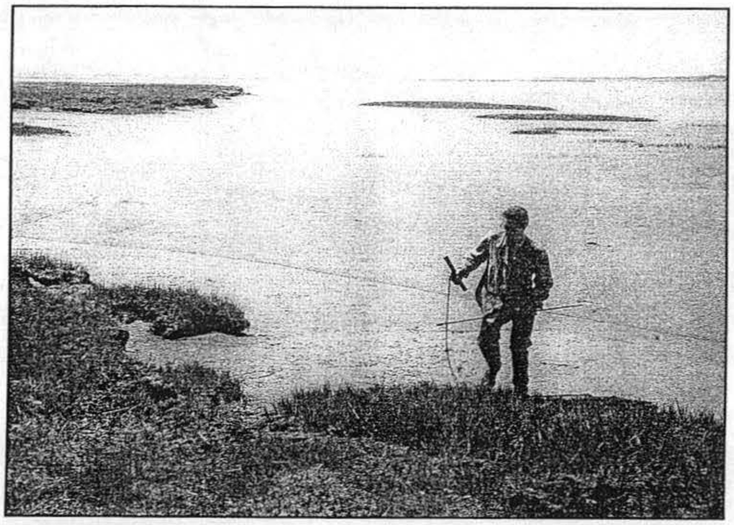
Studies conducted at the University of New Hampshire (UNH) between 1987 and 1990 analyzed stress in coastal marsh ecosystems. Supported by the Maine/New Hampshire Sea Grant Program, Ted Loder, UNH professor of earth sciences; Fred Short, research associate professor of marine and natural resources at Jackson Estuarine Laboratory; and Charles Vörösmarty, research assistant professor of the Institute for the Study of Earth, Oceans, and Space and of earth sciences at the Complex Systems Research Center, documented, and later modeled, tidal-marsh response to human activities in the coastal zone—particularly activities that served to alter tidal hydrology (the study of water, especially its natural occurrence, characteristics, control, and conservation). As the human population continues to grow in coastal areas, hydrologic changes are becoming increasingly common as a result of development pressures, such as sewage and industrial waste disposal, agricultural and urban runoff, dredge-and-fill operations, and coastal construction of roads and building sites. The well-documented results of this research serve as a strong scientific basis for anticipating potentially damaging human activities in the coastal zone.

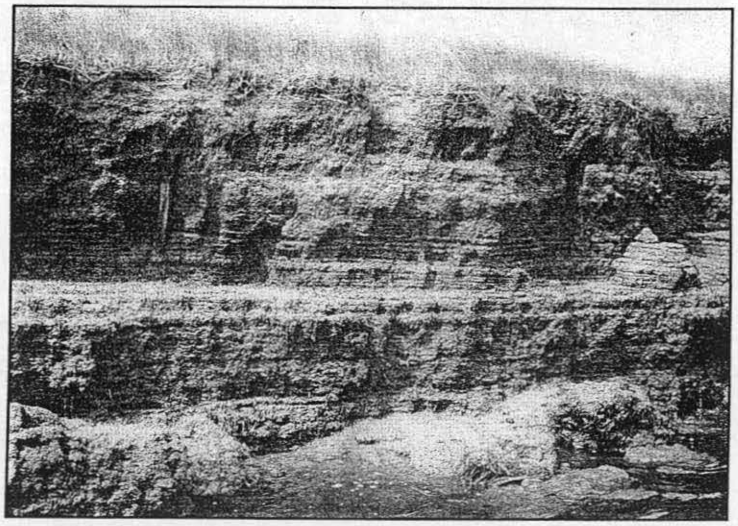
PEAT FORMATION

The "soil" of a salt marsh, called peat, consists of a mixture of organic and inorganic materials and, in that respect, is similar to terrestrial soils. But unlike its earthly cousin, salt-marsh peat can develop into extraordinarily thick deposits. The organic component of peat is supplied mainly by the degradation of roots, stems, and leaves of marsh plants, while the inorganic component may have many sources. In the case of New England marshes, sources of inorganic components of peat could be tidally transported sediments, wave-driven overwash deposits, and sediments that have eroded from bordering uplands. All that is required for the formation of thick peat deposits is the proper growing conditions for marsh grasses—saline, intertidal flats free from powerful waves and currents and human disturbances—and rising relative sea level—an increase in the level of the sea with respect to the land, regardless of whether it is produced by rising global seas or subsiding land, or both, as is true today throughout New England.

ROLE OF SALT MARSHES IN STUDYING SEA-LEVEL RISE

Because marsh grasses grow only intertidally, peat thickness





Opposite page: UNH graduate students Michelle Dzierzeski and John Paquin installing test wells in a salt marsh in North Hampton, N.H., March 1989. This work was part of a Sea Grant–sponsored study of the impacts of human activities on coastal salt-marsh ecosystems. *Photo by Steve Adams, New Hampshire Sea Grant.*

Left, above: This unidentified researcher in Barnstable Marsh assisted WHOI researcher Aldred Redfield in the ground-breaking studies that he carried out with Meyer Rubin in the 1950s and 1960s. *Photo by Aldred Redfield, WHOI.*

Left, below: Layered sequences of marsh peat exhibited at a tidal channel in Barnstable Marsh on Cape Cod. In response to relative sea-level rise, new layers of peat form on top of older marsh surfaces, preserving deposits that provide researchers with important information about past environmental conditions. *Photo by Aldred Redfield, WHOI.*

beneath a present-day marsh indicates the rise in relative sea level that has occurred since the beginning of marsh growth—a fact used by WHOI researcher Alfred Redfield and his colleague, Meyer Rubin, in 1962 to estimate recent changes in relative sea level at Barnstable, Mass., on Cape Cod. By taking cores of Barnstable marsh peat from the marsh interior to its landward edge and using carbon-14 (^{14}C) methods to date the "basal" peat samples—those immediately above the marsh base—they produced a relative sea-level curve covering the past 10,000 years.

Somewhat similar but more sophisticated methods are presently being used by Connecticut Sea Grant–supported researchers Johan C. Varekamp, associate professor, and Ellen Thomas, associate research professor, both of Wesleyan University, to explore the relationship between relative sea-level change and climate change over the past 2,000 years. By studying peat cores from coastal marshes at Clinton, Conn., they hope to obtain a detailed history of the rates of relative sea-level rise along the southern Connecticut coast. Prior Sea Grant–supported research by Varekamp and Thomas led to the development of "relative time resolution," a concept meaning that, while the exact time sequence of events is known, and they can more or less assess the duration of the environmental changes, they cannot yet place the events in a rigid, precise, historical time frame. The researchers are now concentrating on putting their present records into chronological order and extending them back to 0 B.P. (before present).

Another Connecticut Sea Grant–funded study, led by Richard A. Orson, Connecticut College Arboretum research associate, and R. Scott Warren and William A. Niering, professors of botany at Connecticut College in Stonington, Conn., represents an attempt to improve existing knowledge of, and the ability to predict, marsh development—particularly during periods of accelerated submergence along the Northeast coast. By providing a detailed account of the last half century of tidal-marsh development at Barn Island in Stonington, these researchers hope to gain a more complete understanding of the factors that are both responsible for, and preserved in, the peat record. This information will aid planners and conservationists in determining possible courses of action in the restoration and protection of the coastal zone as accelerated submergence begins reducing wetland area.

SALT MARSHES IN JEOPARDY

The salt marshes of southern New England face more immediate threats than that of an accelerated sea-level rise. In our attempt to protect seaside homes from erosion, and navigation channels from shoaling, we have employed coastal engineering practices that—while often providing the protection for which they were designed—have frequently deprived salt marshes, and the barrier beaches that protect them, of their sediment supply. In order to "improve" tidal inlets, some channel-dredging projects have cut directly through flood-tidal delta marshes; and in an attempt to reduce flooding of marsh-fronted property, sea walls have been constructed that prevent the landward migration of high marsh in response to rising sea level.

Concern over the loss of New England salt marshes is nothing new. In the 1880s, Marshfield, Mass., fishermen ("anti-dikers") fought with local farmers ("dikers") in a vain attempt to prevent the blocking of tidal flow to valuable marshland north of Green River. The Marshfield dike and others in many parts of New England were completed—often to ease the way for rail transportation. In recent years, however, many former salt marshes have been restored in Connecticut, Rhode Island, and Massachusetts. So the news is not all bad; with increased consciousness of the importance of salt marshes to so many aspects of our lives, we have a reasonable chance of protecting this valuable resource for future generations.

■ *Graham S. Giese is Marine Advisor and Tracey I. Crago is Communicator for Woods Hole Oceanographic Institution Sea Grant.*