How a geologist comprehends the convoluted Connecticut coast

LEARNING FROM THE PAST TO MAKE BETTER DECISIONS IN THE PRESENT

By Ralph Lewis

Except as noted, all images from Connecticut's Sandy Shores

Editor's note: *Geologically speaking, the Connecticut coast is complicated. It's also unique, unlike most others along the Atlantic seaboard.*

In the new Connecticut Sea Grant-Connecticut College Arboretum book, ***Connecticut's Sandy Shores: An Introduction to the Geology, Ecology, Plants and Animals****, retired State Geologist Ralph Lewis gives a detailed explanation of how the forces of nature have shaped our Long Island Sound shoreline. Accompanied by numerous illustrations and photos, the description gives a comprehensive picture of how so many site-specific variations occur from Greenwich to Stonington, underscoring the importance of understanding each area individually before undertaking a coastal project.*

In this article, Lewis previews the chapter he wrote for the book by applying the information found there to an analysis of three sites: Meigs Point at Hammonassett Beach State Park in Madison; Rocky Neck State Park in East Lyme; and Bluff Point State Park in Groton.

In our area, the geologically diverse, irregular coast of Connecticut is sheltered from the high wave energy of the Atlantic Ocean by the presence of Long Island. This is a very different geologic setting than that of the comparatively homogeneous, sand-dominated shorelines of western Rhode Island, or southern Long Island, where easily transportable glacial sands and gravels are mobilized by high wave energy (Figure 1).

Owing to the protective presence of Long Island, wave energy in Long Island Sound (LIS) is comparatively low, and the coastline of Connecticut is composed of a variety of geologic materials, ranging from solid rock to fine sand and silt. The diverse geologic composition of the Connecticut coast has been nicely summarized in a report, with an accompanying map, authored by Arthur Bloom (Bloom, A.L, 1967, Figure 2). He describes the coast of Connecticut as being composed of a diverse set of geologic materials, each reacting to sea level rise and wave action differently.

Bloom divided the Connecticut coastline into seven coastal segments based on surficial deposits and bedrock exposures (Figure 2). He reported that only three of these areas show meaningful barrier beach development, and that the shape and physical makeup of Connecticut's irregular coastline results from the presence of the numerous points and necks (outlined in red, purple and black, Figure 3) that protrude into LIS because they are more resistant to wave action and sea-level rise than surrounding sandy/gravelly beaches and tidal marshes (yellow and green, Figure 3).

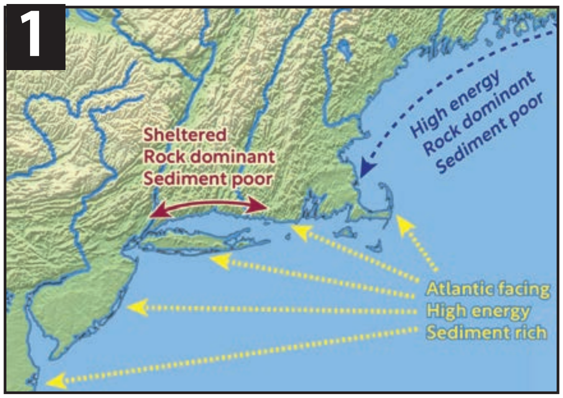

Figure 1. Image showing the regional distribution of three types of coastlines: a) Atlantic-facing, high-energy, highly-modified, sediment-rich coastline; b) high-energy, less-modified, irregular, rock-dominated, sediment-poor Gulf of Maine coast; and c) sheltered, very slightly modified, irregular, rock-dominated, often sediment-poor north shores of Long Island Sound.

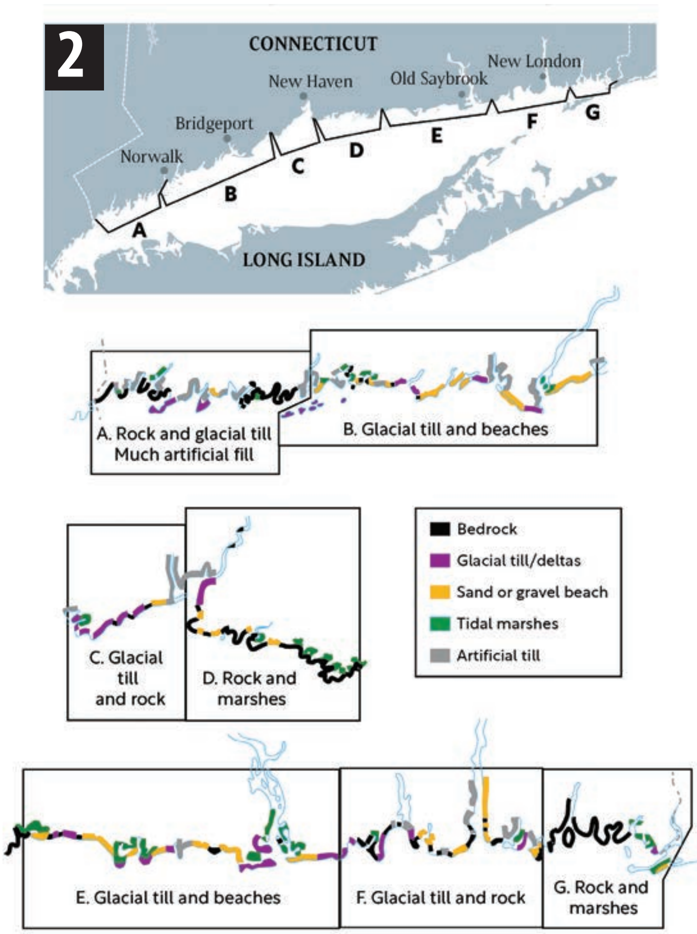

Figure 2 A-G. Connecticut's coastal types as adapted from Bloom (1967). Of the seven mapped areas, only segments (B) and (E) were categorized by Bloom as being composed primarily of glacial delta deposits with associated sand/gravel beaches and tidal marshes. The remaining segments are composed of bedrock and some combination of glacial sediment/marshes and artificial fill.

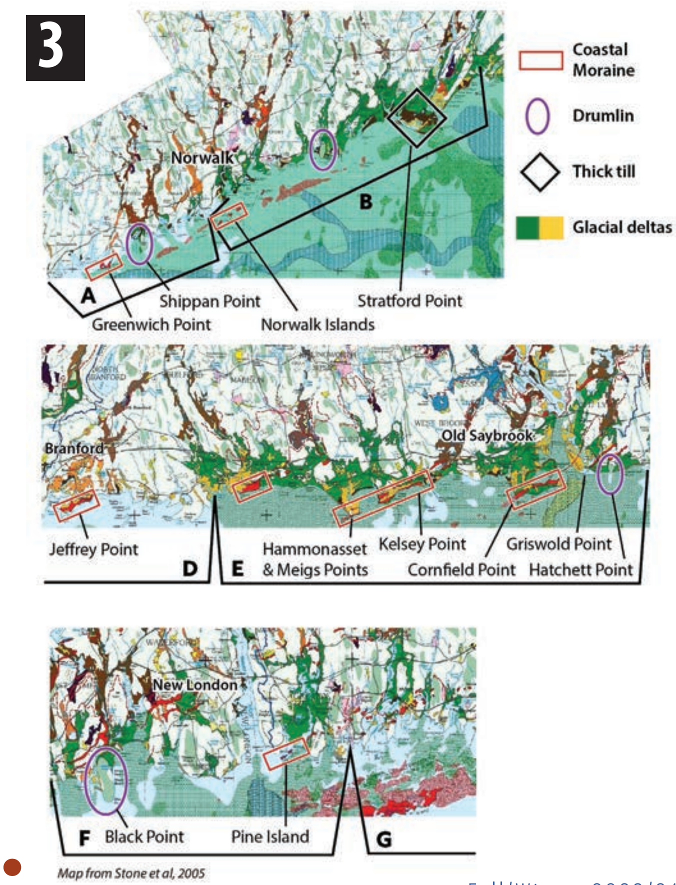

Figure 3 A-G. Excerpts from the Quaternary Geologic Map of Connecticut and Long Island Sound Basin (Stone, J.R, and others, 2005) showing the geology of Bloom's segments (A, B, D, E, F, and G). In addition to resilient bedrock outcrops, coastal moraines, drumlins and thick till deposits are commonly resilient enough to also form points and necks along the CT coast.

Left: A boulder-cobble-gravel beach (olive double arrow, Fig. 8) overlying solid bedrock that is being submerged in place.

In essence, the Connecticut coast is composed of whatever assortment of materials waves have to work with, and the irregularities that typify this shoreline result from the fact that each major shoreline component reacts to the rising waters of LIS differently because each has a set of physical characteristics that determine its resilience to wave action and sea-level rise. This discordant scenario of beach retreat works to maintain the coast's irregular shape which has implications for natural beach replenishment surrounding resilient points and necks.

Along the Connecticut coast, wave action against resilient points and necks seldom yields sufficient sediment to naturally replenish surrounding beaches. This paucity of nourishing sediment is further compounded by the fact that points and necks often act to interrupt the transport of sediment along the Connecticut coast because what wave energy is available is concentrated on the points and necks by wave refraction (Figure 4).

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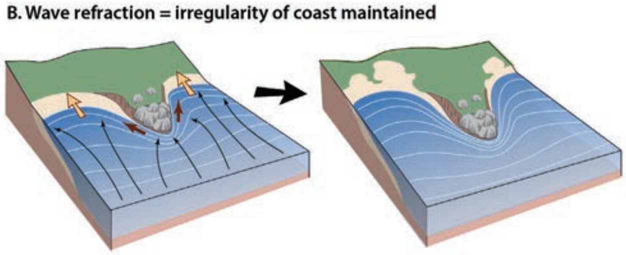

Figure 4 In the low-energy environment of the Connecticut coast, wave energy concentrated on a resilient point or neck by wave refraction (black arrows) typically yields little sediment, and what sediment is available is insufficient to adequately nourish surrounding sandy beaches through littoral transport (short brown arrows). Lacking an adequate supply of replenishing "outside" sediment, these beaches retreat landward faster than the adjacent, more resilient points or necks. As they retreat, they derive their "sandy" composition as wave action chews landward, through existing, sandy, glacial delta deposits and overlying marsh deposits (yellow arrows). The net result of all of this is perpetuation of coastal irregularity.

Figure 6. At Rocky Neck State Park, the resistant bedrock of the Lands End Peninsula is being submerged in place as LIS waters rise. Wave action against this type of bedrock point yields little or no sediment for replenishment of adjacent beaches. Photo: Ralph Lewis

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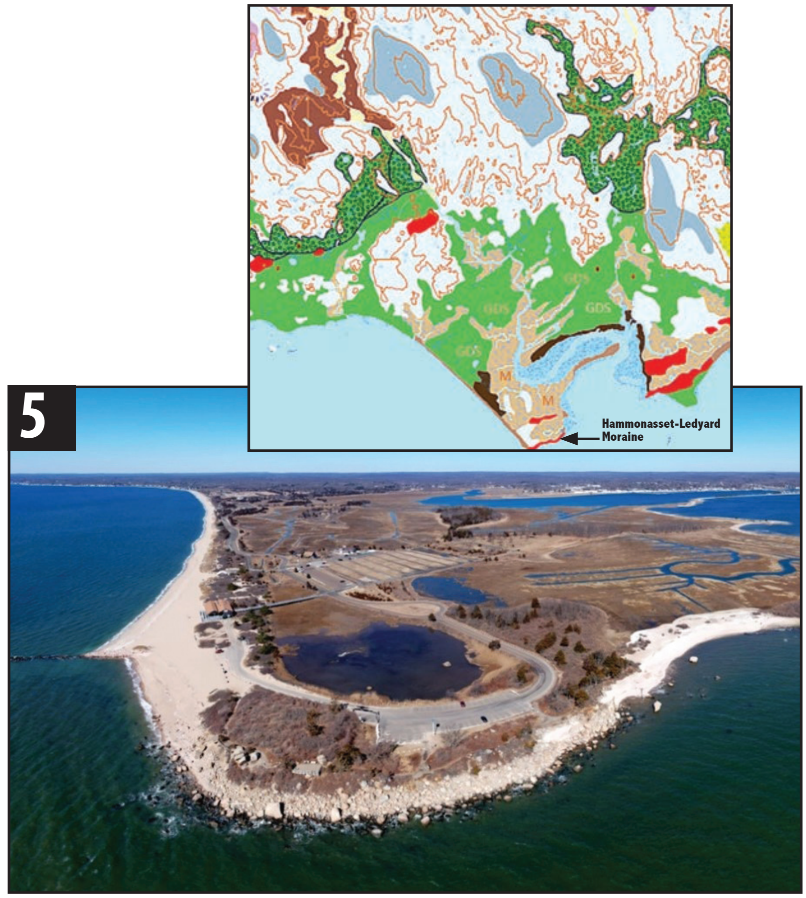

Figure 5 An aerial view of the Hammonasset-Ledyard Moraine Photo: Joel Stocker

Map credit, An annotated digital quadrangle excerpt from Stone, and others, 2005 (Source: DEEP ECO Map Catalogue).

Figure 7. Along the irregular north shore of Long Island Sound, wave refraction acts to sequester sandy glacial delta deposits (purple) between partitioning points and necks. The irregular configuration of this heterogeneous coastline is perpetuated by the generally slow retreat of resilient points and necks and the more rapid retreat of less resilient, low-flat glacial deltaic deposits. As long as this differential retreat and the accompanying wave refraction by points and necks persists, there is no chance for having extensive straight, sandy beaches along the north shore of LIS.

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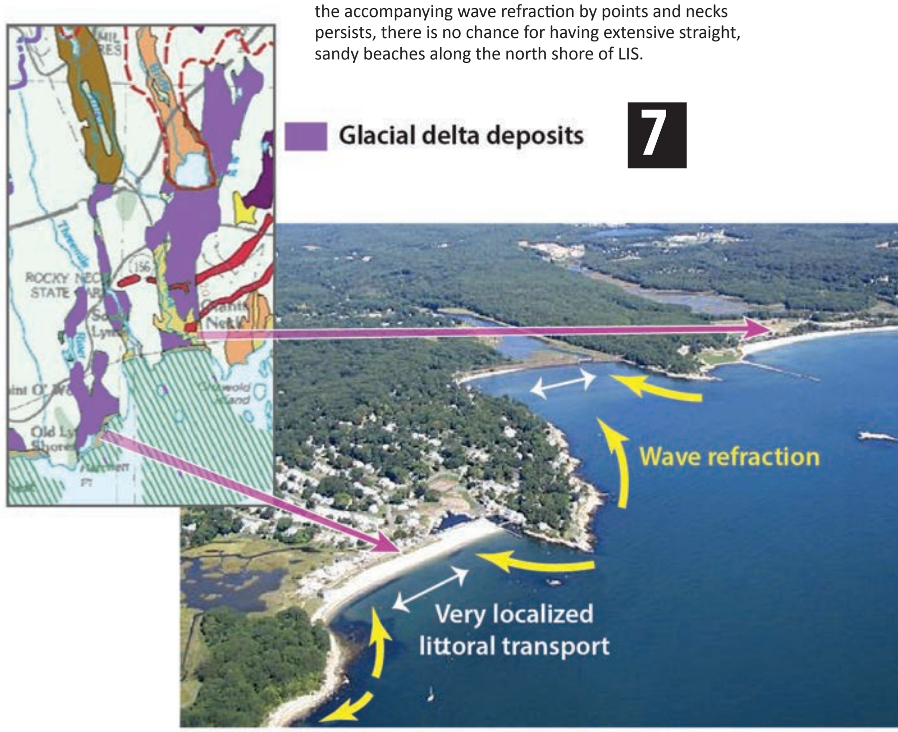

Drone photo by Joel Stocker; inset map from Stone et al, 2005

A visit to a public access beach area that features sandy beaches and marshes surrounding a resilient point or neck is the best way to understand how the Connecticut coast is reacting to sea level rise. Three such beach areas are highlighted here.

HAMMONASSET BEACH STATE PARK

Meigs Point at **Hammonasset Beach State Park** in Madison is formed by a short segment of the Hammonasset-Ledyard Moraine (red, Figure 5 top). Extensive glacial delta sand and gravel deposits (GDS, Figure 5 top) and overlying marsh deposits (M Figure 5, top) lie landward of the moraine's protection.

When wave action attacks a moraine, finer sediments that form its matrix are winnowed out, leaving behind a resilient boulder cobble armor (Figure 5, bottom). Since this armored shoreline section is more resilient than the surrounding sandy glacial delta and marsh deposits, it retreats more slowly, and a moraine-armored point develops. The perspective offered by the photo at the bottom of Figure 5 clearly shows that wave-induced winnowing of matrix sediment from the short Meigs Point moraine segment could not possibly supply sufficient sand to replenish Hammonasset Beach to its left side. The sand composing the longest sandy beach in the state is being derived by waves chewing into the sand and gravel deposits of the largest coastal glacial delta in the state.

ROCKY NECK STATE PARK

In East Lyme, the sandy beach at **Rocky Neck State Park** is bounded on its eastern and western flanks by points that are composed of bedrock that is fairly solid and relatively free of weakness (e.g., layering and fracturing). Points and necks composed of this type of bedrock are highly resilient in the low wave energy environment of LIS because they are not easily exploited by wave action or other weathering agents like freeze-thaw and salt spray. Their glacially smoothed surfaces typically slope seaward and they are largely unaltered as the rising sea submerges them in place (Figure 6). Aside from a thin blanket of glacial till that is largely removed by the winnowing action of encroaching waves, this type of exposed solid bedrock yields precious little sediment for surrounding beach nourishment.

The Rocky Neck area is also a place where wave refraction associated with bedrock points induces landward littoral transport (yellow arrows, Figure 7) around the points. This tends to isolate sandy glacial deposits (purple, Figure 7 inset) because there is only localized sediment movement between the points (white arrows, Figure 7).

BLUFF POINT STATE PARK AND COASTAL RESERVE

Bluff Point State Park and Coastal Reserve in Groton provides a nice example of an observation stemming from Arthur Bloom's 1967 report and map (Figure 2). The Connecticut coast is composed of whatever assortment of materials waves have to work with (Figure 8).

The beach, just east of Bluff Point (Figure 8, olive double arrow), is made up of boulders, cobbles and gravels that were left behind as waves winnowed out the finer matrix from the glacial till that once covered fairly solid bedrock (Photo, page 8). This type of bedrock tends to be submerged in-place (Figure 6).

Figure 9 shows how highly fractured, less resistant bedrock often retreats as a bluff, rather than being submerged in place like the more resistant Lands End Peninsula (Figure 6).

The sediment supply for the Bluff Point-Bushy Point Beach-Spit (Figure 10) is derived from wave action mobilizing the sands of the extensive glacial delta that fills the bedrock valley between Jupiter Point and Bluff Point (green shading, Figure 8), and is home to the Groton-New London Airport.

Similar to the armored shoreline of the Hammonasset-Ledyard Moraine (Figure 5, bottom), wave action attacking the Bushy Point moraine has winnowed out finer sediments that form its matrix, leaving behind a resilient boulder cobble armor (Figure 11).

As the agents of change gain more advantage in the battle to rearrange our coast, the changes they bring about tend to have greater negative impacts on coastal populations and infrastructure. That, in turn, spurs the strong human drive to "fix" things and restore beloved coastlines to "the way they used to be."

When considering measures aimed at "fixing" local coastal problems, it is very important to be keenly aware that not all beaches function in similar ways. Before replicating a "fix" simply because it worked elsewhere, project designers must gain a good understanding of the physical setting where the candidate project worked and determine its degree of compatibility with the physical setting where the prospective project is to be located.

Figure 8. Coastal types featured at Bluff Point State Park. Bushy Point and Pine Island, armored moraine segments (red); Bushy Point-Bluff Point Beach, barrier spit (light brown); glacial delta deposits between Jupiter and Bluff Points (green); Bluff Point fractured bedrock outcrop (dark brown star); boulder-cobble-gravel beach overlying solid bedrock (olive double arrow); Map credit: An annotated digital quadrangle excerpt from Stone, and others, 2005; Source: DEEP ECO Map Catalogue: https://cteco.uconn.edu/map_catalog.asp

Figure 9. A: Photo of the outcrop of fractured bedrock that retreats as a bluff on the west side of Bluff Point (dark brown star, Figure 8). The fractures visible in the photo allow water to penetrate the rock and break it up through freeze-thaw cycles. B: A more solid type of bedrock, that tends to be submerged in place, is exposed at the base of the bluff. Photos: Ralph Lewis

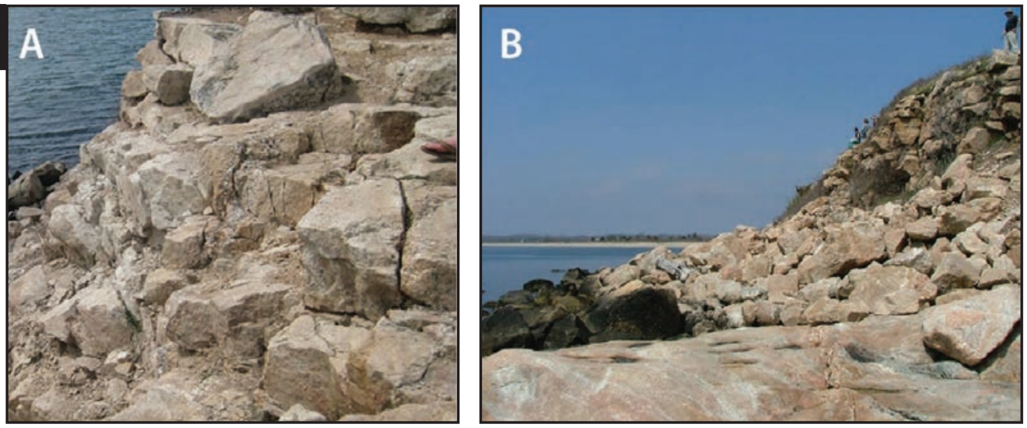

Figure 10. Looking north across the sandy Bushy Point Beach Spit to the glacial delta surface that the Groton-New London Airport was constructed on. Photo: CT DEEP

Figure 11. A view from Avery Point looking east at the armored “Bushy Point” moraine segment that forms Pine Island. Photo: Ralph Lewis

Connecticut’s Sandy Shores: An Introduction to the Geology, Ecology, Plants and Animals *can be purchased for $18 plus shipping from Connecticut Sea Grant by sending a request to:* michelle.marcaurele@uconn.edu