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NEW ENGLAND INTERCOLLEGIATE
GEOLOGICAL CONFERENCE

108th Annual Meeting

Guidebook for Field Trips along the Maine Coast from Maquoit Bay to Muscongus Bay

Edited by

Henry N. Berry IV and
David P. West, Jr.

Hosted by

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October 14-16, 2016

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The cover photograph is by Arthur M. Hussey II, to whom this guidebook is dedicated. Arthur Hussey was an accomplished photographer and his numerous photo collections highlighted many aspects of the natural beauty of southwestern Maine. The photo was taken by Arthur at a location about a kilometer south of Lookout Point along the western shore of Harpswell Neck. Arthur first began mapping in this area in 1962, and his 1965 NEIGC field trip visited exposures nearby. The view in the photo is towards the south and the exposures are east-dipping metamorphosed Ordovician volcanic rocks of the Cushing Formation. Arthur's hammer for scale.

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COASTAL BLUFF EROSION, LANDSLIDES AND ASSOCIATED SALT MARSH ENVIRONMENTS IN NORTHERN CASCO BAY, MAINE

By

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INTRODUCTION

Ongoing and impending climate changes have raised great concern for Maine's coastline. Although flooding of most of the high-relief rocky coast of Maine by rising sea level is not a great regional hazard, glacigenic silt and clay deposits present at sea level are among the sites most vulnerable to erosion. While the public is broadly aware of the threat posed by climate change to beaches and wetlands, bluffs of glacigenic material stand high and lull those not educated in their hazard into building expensive properties too close to the edge. There are few models available to guide the public or state agencies in assessing the danger of bluffs to erosion, and homeowners sometimes feel secure until it is too late to halt erosion. Through the course of this field trip we will visit several exemplary occurrences of coastal bluff erosion in southern Maine's Casco Bay. In addition, we will examine several salt marshes to consider the mechanisms controlling their reaction to the rising sea. The natural habit of shoreline retreat and ongoing erosion mean that every visit and photograph of a coastal site is a "*before.*" The shoreline is in a constant state of change.

Preparation

Walking to and along the base of the bluffs is best done with tall boots or water shoes. Mud on the flats can be deep in some places and care must be taken not to get stuck standing in the wrong place for too long. A plastic bag and change of footwear is recommended for the end of the trip.

GEOLOGIC SETTING

The Maine coast is underlain by a framework of Paleozoic bedrock, overlain by Late Pleistocene glacial materials and some Holocene sediment. The bedrock of Casco Bay (Fig. 1) strikes to the northeast and is complexly folded and faulted (Osberg et al., 1968; Hussey, 2015). Resistant units, generally of quartzite and volcanic rocks, project as headlands, peninsulas and chains of islands, while less resistant layers are eroded and form estuaries and embayments. The sheltering effect of the many islands and peninsulas leads to a wave-dominated outer coast with rock cliffs and gravel beaches, and an inner shore with abundant bluffs of glacigenic sediment and associated low-energy beaches and wetlands (Kelley, 1987). For the most part, Maine's exposed bedrock coast is eroding very slowly (Hapke et al., 2014, p. 140).

Glacial till and glacial-marine muddy sediment (locally known as the Presumpscot Formation, Bloom, 1963) unconformably rest on the bedrock, and are abundant all along the inner, sheltered coast of Maine. In Casco Bay, bedrock crops out at the shoreline along 20% of the 1250 km coastline, with glacigenic material forming bluffs along 27% of the coast (Kelley and Dickson, 2000). Salt marshes or low upland areas of glacial sediment comprise the remainder.

The dominant winds are from the north-northwest in fall, winter and spring, with storm winds and waves from the east and northeast. Summer wind and waves are from the south-southwest. Coupled with the bedrock alignment, the wind is severely fetch limited in its ability to produce waves from any direction but the southwest. The semidiurnal tides have a spring range just over 3 m, which means that wind-waves in the inner bay are relatively unimportant except at times of high tide when the wind is from the northeast (rarely) and southwest (summer).

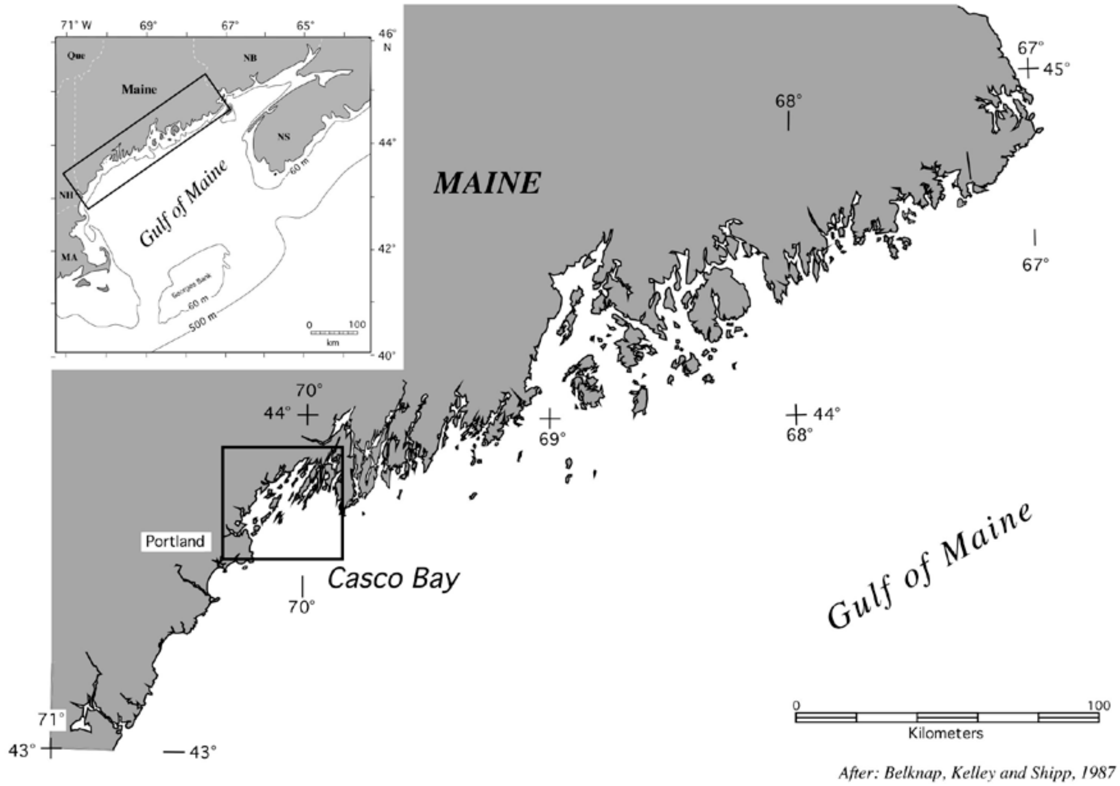


Figure 1 – Location map, Casco Bay, WC coast of Maine (after Belknap et al., 1987).

BLUFFS

Bluffs in Casco Bay are composed generally of till or glacial-marine muddy sediment (Kelley et al., 1989). They range from very slight up to 15 m (Fig. 2). The till is mostly thin ground moraine underlying the

Figure 2 – Bunganuc Bluff glaciomarine Presumpscot Formation exposure, J.T. Kelley, April 2003.

glacial-marine sediment. One moraine stretches discontinuously from the Portland peninsula to Cousins Island, where it is exposed on the northwest coastline (Fig. 3). Bluffs of glacial-marine sediment are more common than those of till. These bluffs have also been involved in major historic landslides throughout Casco Bay and upstream, along its estuaries and river valleys, as well as slower, chronic erosion.

Much of the bluff sediment is well preserved; found as unweathered, fine grained silts and clays representative of the deconstructed, pulverized Maine granites and sandstones from inland, a.k.a. glaciogenic rock-flour (Thompson, 2015). The mass and extent of the Presumpscot Formation exhibits the erosive force of a glacier's passage. Depositional volumes vary across the extent of the formation due to the lively nature of tidal glacier margins during a retreat. As such, the soft shoreline's distribution is not uniform and consequently its sensitivity to erosion will vary by site and by chance. While silts and clays tend to interlock there is little to no chemical source, lime or iron, present here to cement the formation's sediments (Andrews, 1987). Consequently the material strength is greatly governed by pore-pressure and saturation of groundwater. Too much water can liquefy the mass and cause dramatic failure.

Figure 3 - Cousins Island till bluff, 11/16/12, Kara Jacobacci.

To inform the public about the hazards of bluff erosion, the Maine Geological Survey produced a series of Bluff Hazard Maps http://www.maine.gov/dacf/mgs/pubs/online/bluffs/bluffs.htm (Kelley and Dickson, 2000). These are available free on line and characterize the coast in terms of no bluff, stable bluff, unstable bluff and highly unstable bluff. The coastal environment at the toe of the bluff was also mapped as part of this series (Fig. 4).

Although waves are not the driving force in bluff erosion in Maine as they are in other places in the country (Kelley, 2004; Komar, 2004) and rarely cut notches in the base of bluffs, they remain important. Keblinsky (2003) studied the bluffs in the Freeport Quadrangle and concluded that the direction of the bluff exposure to waves (southwest) and length of unrestricted fetch were major controlling factors on bluff stability. The reason for this is not that waves directly impact bluff very often, but that they remove slumped debris and set up future erosion. It is this interval between successive bluff-erosion events that ultimately controls the rate of shoreline retreat on Maine's bluff coast. Kelley and Hay (1986) described the cycle of bluff erosion followed by stabilization by fringing marsh (Fig. 5). The length of this cycle is not well known, probably decades to centuries, and most likely is related to composition and elevation of the bluff, exposure to wave erosion, and degree of disturbance (Kelley et al., 1987, Belknap and Kelley, 2015).

Highly unstable bluff with an unvegetated bluff face and a salt marsh shoreline. Sediments on the bluff face are exposed and fallen tree trunks lie at the base of the bluff. A salt marsh has recently formed on the tidal flat, partly on the top of an old landslide deposit.

Figure 4 - detail from Bryant et al., 2002

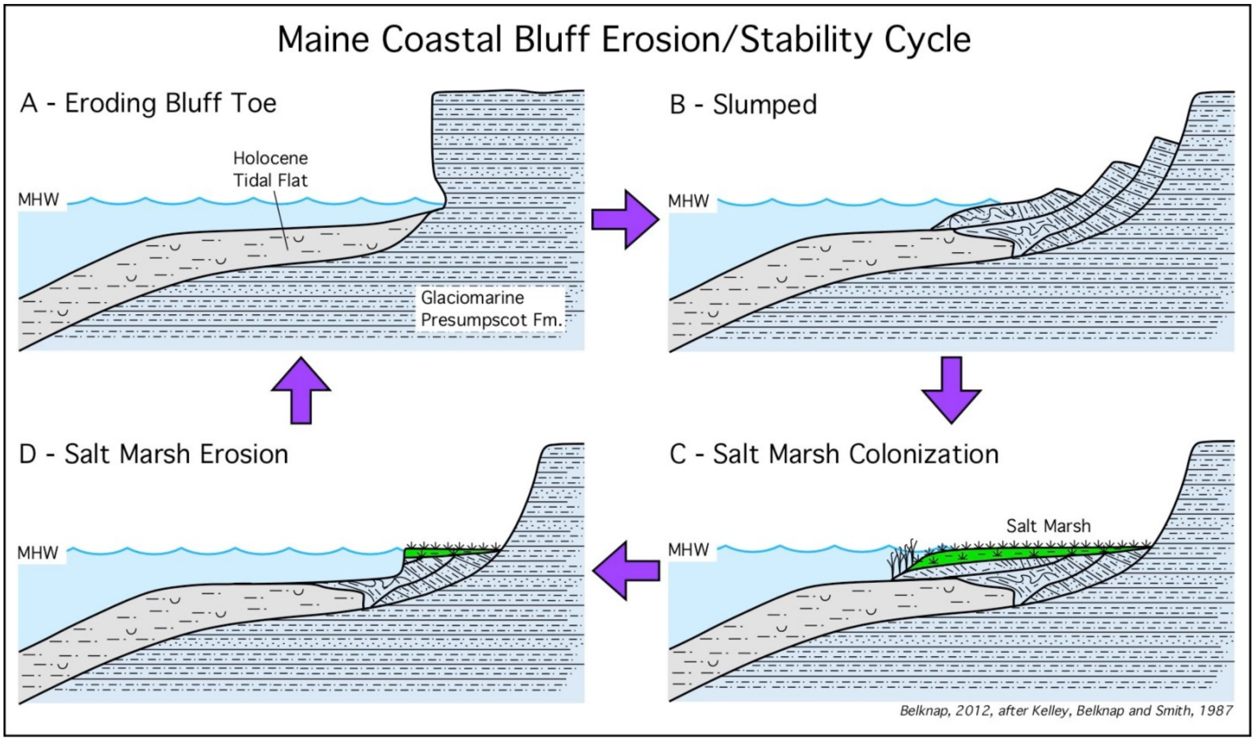


Figure 5 – Maine bluff evolution model, Belknap and Kelley (2015) after Kelley and Hay (1986), Kelley et al. (1987).

SALT MARSHES

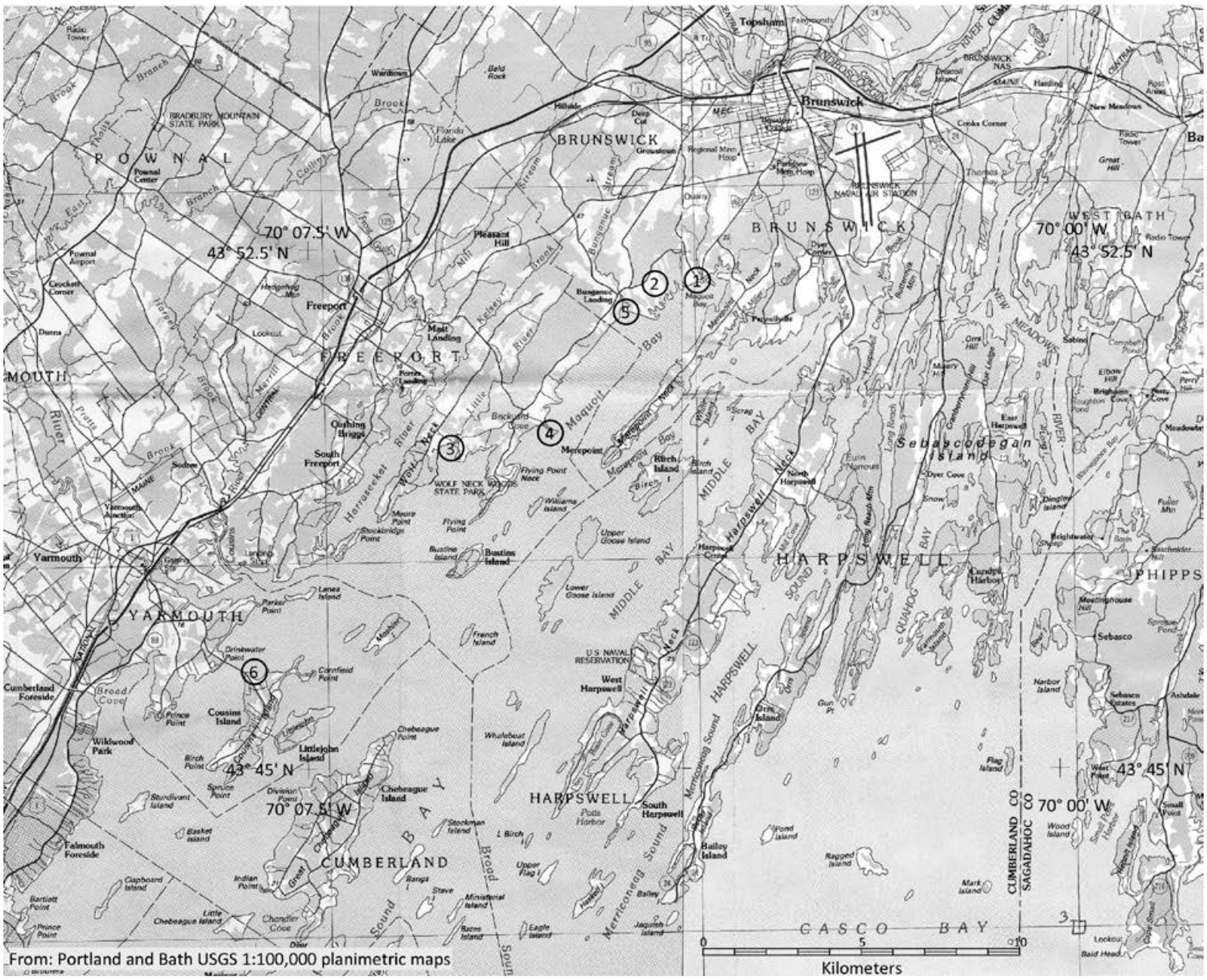
Salt marshes occur throughout the area of the field trip. Eroding bluffs are the major source of mud to mudflats and salt marshes this region (Hay, 1988). As bluffs yield sediment to tidal flats, tidal currents move the mud into coves where it is deposited in accretionary salt marshes. During the Colonial Era, massive clear-cutting of the upland near the coast for timber (e.g., Cronon, 1983) led to rapid bluff erosion and accompanying marsh growth. Today's more vegetated bluffs are more stable than in the past, and some of the early marsh growth is eroding.

Marshes also occur at the base of bluffs following landslides (Kelley et al., 1988). These sorts of geomorphological settings are found where a landslide deposit is planed off by waves and a low salt marsh colonizes the surface. Related to the bluff cycle (Fig. 5), marshes of this sort provide vivid documentation of a past landslide, with contorted glaciomarine mud underlying colonizing marsh (Figs. 6, 7).

Figure 6 (previous page) – crumbled appearance of fine-bedded glaciomarine mud within slump outrunner block on the tidal flat, toe of Bunganuc bluff, 05/18/86 (D.F. Belknap).

Figure 7 - Contorted glaciomarine mud from former slump, overlain by colonizing low salt marsh. Scale is 20 cm. Little Flying Point, Casco Bay, 05/20/85 (D.F. Belknap).

On this trip we will have an opportunity to see an important landform on salt marshes, salt marsh pools. These are permanent bodies of water on the surface of the marsh (Wilson et al., 2010). Wilson et al. (2010) addressed the question of whether pools are the last vestiges of a tidal flat, indicators of a drowning marsh, or simply temporary disturbances to the marsh in favor of the last hypothesis. Cores through pools show more salt marsh below the water, but pools also drain and refill with marsh sediment. Though Maine is losing salt marsh to the open water of pools (Table 3.13, Wilson, 2010), many pools recover and fill rapidly with low salt marsh peat before becoming capped with high salt marsh.



Field trip location map – Yarmouth, Freeport and Brunswick area, Maine.

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ROAD LOG

Mileage

0.0 The Assembly Point is Wharton Point, near the head of Maquoit Bay. To get there from the north and southbound on I-95: EXIT 28 Brunswick onto US-1 N Coastal Route/Brunswick & Bath,

2.8 Right turn onto Church Road,

3.9 Left turn onto Woodside Road,

6.1 Right turn onto Maquoit Road, arrive at Wharton Point.

STOP 1: WHARTON POINT

Warton Point was a Colonial-Era shipyard that has undergone many changes over time (Fig. 8). The surficial geology consists of eolian sandy deposits unconformably overlying the Presumpscot Formation (Fig. 9).

Figure 8 - Wharton Point from the air, looking SE, May 30, 2012.

Figure 9 - Steeply dipping beds of eolian sand unconformably overlie glacial-marine mud in a tidal creek at Wharton Point.

The sand was likely derived from erosion of the Brunswick Sand Plain to the northeast. This sand plain is a regressive fluvial deposit that formed as post glacial sea level to near the present elevation, and the deposit likely blocked the Kennebec/Androscoggin Rivers from entering the sea here. In the 18th Century, this was a sand flat, but changed with coastal deforestation to supply logs for British masts. Mast boats from Britain loaded logs here and at nearby Mast Landing as well as built and repaired vessels. The silting in of the area from enhanced bluff mud filled the old shipyard and allowed salt marsh to grow seaward (Fig. 10).

Figure 10 - Eroding salt marsh at Wharton Point exposed Colonial-Era worked log.

Contemporary bluff erosion supplies less sediment than during the first times of tree cutting, and so the salt marsh at Wharton Point is eroding on its margins and pools have developed in its interior. To evaluate the health of the marsh, Kristin Wilson used time-series air photos to measure the area and number of pools over time. Between 1964 and 2001, the Wharton Pt marsh added 180 pools but only lost 1% of its area. Many of the new pools are new and some pools have been breached by a tidal creek, drained and. A study of one infilled pool that is by ^{210}Pb and ^{137}Cs methods showed how rapidly the pool filled in after it drained compared to the adjacent high salt marsh refilled (Wilson et al., 2010).

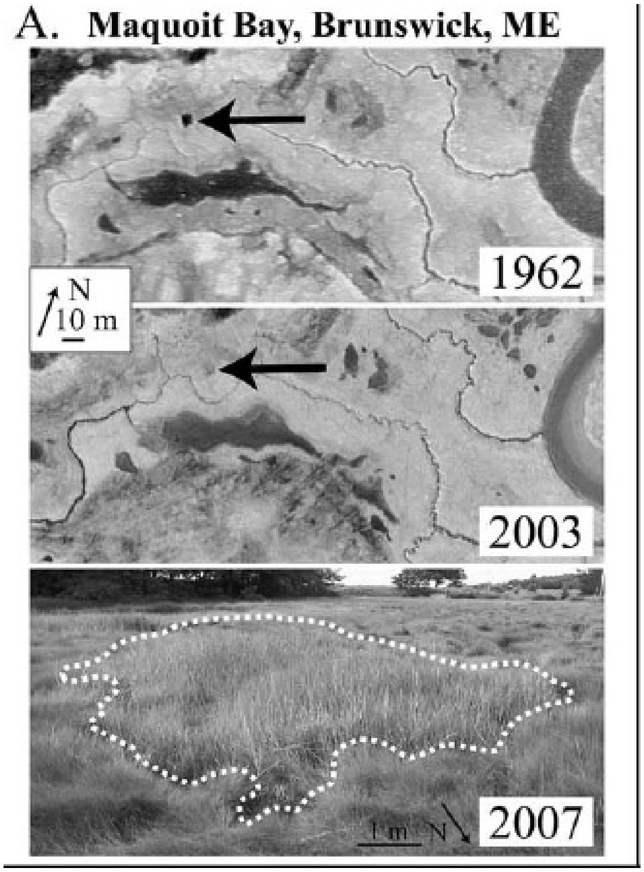

Figure 11 - Changes in a salt marsh pool at Wharton Point (Wilson et al., 2010).

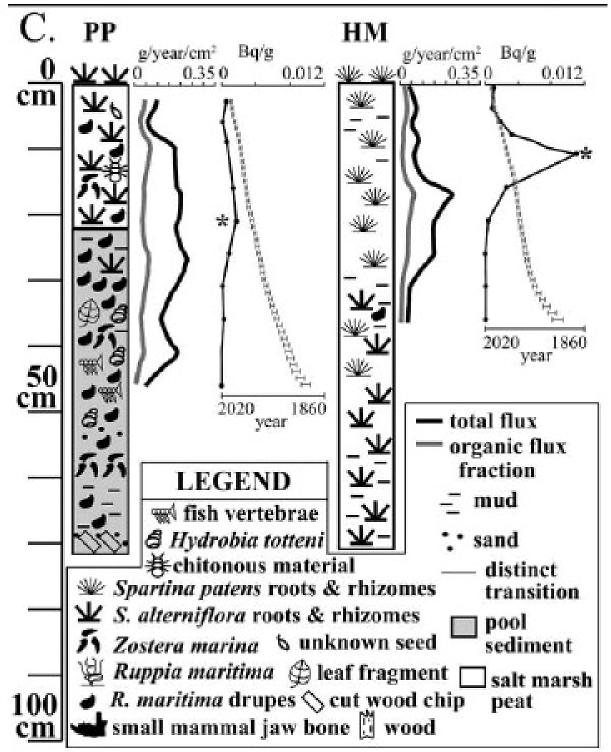

Figure 12. Core log from the filled pool and adjacent high marsh, with fossils indicative of pool sediment (Wilson et al., 2010). ^{210}Pb and ^{137}Cs data reveal the rapid accumulation of sediment in the filled pool.

STOP 2: TOWN PARK.

0.0 From Wharton Point: Head NW on Woodside Road,
0.5 Left turn onto Bunganuc Road,
0.6 The Park is on the left, a dirt lot.

A gentle hike along high ground, with heavily gullied edges and bounded by tidal marshland, brings us to a bedrock outcrop responsible for anchoring and supporting the ridge. This is a natural demonstration of the control that bedrock can have on the geomorphology of these environments.

STOP 3: LITTLE RIVER, WOLFE'S NECK FARM. (1.5 hours) Lunch Stop.

0.0 From Town Park: Head S on Bunganuc Road,
1.4 Becomes Flying Point Road, continue
2.1 Left turn onto Lower Flying Point Road,
0.3 Right turn onto Burnett Road,
1.1 Move through Recompence Camp and Wolfe's Neck Farm, arrive at small bridge over Little River outlet.

The bluffs here at Little River are in various states of erosion, failure, and natural stabilization. This stop provides a good opportunity to see these various forms alongside one another in a singular environment. Of particular interest is the evidence for a full rotational slide and the exposed clay exhumed at the toe of the slump.

STOP 4: LITTLE FLYING POINT. (45 minutes)

0.0 From Little River, retrace:
1.1 Burnett Road, left turn onto Lower Flying Point Road,
0.3 Right turn onto Marietta Lane / L.L.Bean Paddling Center, continue down dirt road to parking lot.

We are here to see a steeply eroded and bare faced bluff bounded by more stabilized, vegetated, shoreline that is defended by two large slumps from previous events. The slumps have been heavily colonized by Spartina marsh grasses but show evidence of being overrun in high water events and have experienced some toe-erosion themselves. The profile of the mudflat shows the focus of wave energy and the resulting erosion.

Little Flying Point also features high biological activity and its own shorebird "shell midden."

STOP 5: BUNGANUC BLUFF (60 Minutes)

0.0 From Little Flying Point, retrace: right (N) turn onto Lower Flying Point Road, right turn onto Flying Point Road,
2.1 becomes Bunganuc Road, continue
0.7 Right turn onto Bunganuc Landing.

Please be respectful of the private home setting.

Bunganuc Bluff is a large unstable bluff in an active state of retreat standing near the end of the long, narrow, Maquoit Bay. Here we see the interaction of human development and a naturally vulnerable system as well as the potential influence of private armoring projects on adjacent bluff forms. Evidence of previous landslides is present in the tidal flat.

STOP 6: COUSINS ISLAND. (45 minutes) (Outhouse)

0.0 From Bunganuc Bluff: right turn onto Bunganuc Road, 100 ft slight left turn onto Casco Road,
1.8 Cross Pleasant Hill Road onto Church Road,
1.9 Left turn onto US-1 S / Pleasant Street,
0.9 Merge onto I-295 S (Portland/Freeport),
11.6 EXIT 17 YARMOUTH, Merge briefly onto US-1 S,
100 ft Left turn across US-1 S onto ME-88 S,
1.6 Left turn onto Princess Pt. Road,
0.3 Left turn onto Gilman Road,
1.3 Gilman Road becomes Cousins Street, continue across bridge, left turn into parking lot at the end of the bridge.

Here we visit an alternative environment where the bluffs are predominantly composed of glacial till and thus stand taller and are more cohesive because of the coarser sediments. Look to the western side of the island (right hand when approaching over the bridge) to catch a glance of the most prominent features before we get up close. Significant long-shore transport and channel erosion between the island and the mainland challenges the development of a mudflat at the base of the bluffs and makes for a large sand spit on the lee side of the bridge's foundation.

On arrival, at the seaward edge of the parking lot, a chain-link fence bars the top edge of a slope failure actively responding to the concentration of surface water flow from the open lot. Looking northward the beach is littered with boulders freed from the retreating shoreline.

When approaching the bluffs on the western face of the island it becomes clear that beach has been overtopped by vegetal mats freed from earlier landslides and that grasses have colonized the newly introduced sediments. This works to shield the sensitive bluff toe from incoming wave action, as all along the shoreline undercutting of these features is evident. Looking closely at the bare surfaces is an opportunity to see the variety of sediments present in the bluff and the relative softness of the wet clays, which facilitates soil creep and risk of more catastrophic failure.

CONCLUDE TRIP: Return to NEIGC HQ

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NOTES