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Popham Beach, Maine: An example of engineering activity that saved beach property without harming the beach

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ABSTRACT

Beach and property erosion on coasts is a widespread and chronic problem. Historical approaches to this issue, including seawalls and sand replenishment, are often inappropriate or too expensive. In Maine, seawalls were banned in 1983 and replenishment is too costly to employ. Replacement of storm-damaged buildings is also not allowed, and a precedent case on Popham Beach, Maine required that the owner remove an unpermitted building from a site where an earlier structure was damaged. When the most popular park in Maine, Popham Beach State Park, experienced inlet associated erosion that threatened park infrastructure (a bathhouse), temporary measures were all that the law allowed. Because it was clear that the inlet channel causing the erosion would eventually change course, the state opted to erect a temporary seawall with fallen trees at the site. This may or may not have slowed the erosion temporarily, but reassured the public that "something was being done". Once a storm cut a new tidal inlet channel and closed off the old one, tidal water still entered the former channel and continued to threaten the bathhouse. To ultimately save the property, beach scraping was employed. Sand was scraped from the lower beach to construct a sand berm that deflected the tidal current away from the endangered property. This action created enough time for natural processes to drive the remains of the former spit onto the beach and widen it significantly. Whereas many examples of engineering practices exist that endanger instead of saving beaches, this example is one of an appropriate engineering effort to rescue unwisely located beach-front property.

1. Introduction

In recent decades, American society has moved away from armoring eroding shorelines with seawalls towards other approaches that impact the shoreline less and, to a degree, mimic natural processes. Although sand replenishment is the most important and widespread alternative to seawalls, it is very costly and temporary (Leonard et al., 1990; Lentz and Hapke, 2011). On a more local scale, efforts to protect beachfront property include beach scraping and temporary protective structures. Beach scraping involves bulldozing sand from the lower to the upper beach (Wells and McNinch, 1991; Kratzmann and Hapke, 2012), but not actually adding new material to the system. Temporary structures vary from Christmas tree mounds, hay bales (O'Connor et al., 2010) to various forms of sand-filled geotubes. The latter are often described as "temporary" and "harmless" protective structures by their advocates, but they act like seawalls in the face of wave attack, and are often only temporary because they are ultimately destroyed by storms (McQuarrie and Pilkey, 1998).

Popham Beach, Maine is part of the largest adjoining set of beaches in northern New England (Fig. 1). Sourced by the largest river in Maine, the Kennebec (Fenster et al., 2001), Popham Beach hosts an extremely popular state park alongside a community of 19th century summer vacation cottages. The storms and legal battles that impacted this beach in the 1970s and 1980s led Maine to introduce a sand dune law, the first ordinance in the United States banning seawalls and requiring property owners to remove buildings damaged by more than 50% by storms (Massey, 1984; Kelley et al., 1989; NRPA, 2012). This law withstood a legal challenge all the way to the Maine Supreme Court in the 1980s, which upheld the right of the State to protect its beaches without paying compensation for taking of property.

Recently, apparently natural changes in the location of a small tidal inlet on the southern boundary of the Popham Beach State Park have threatened park infrastructure and challenged the state to abide by its own rules even when they risk significant use of one of its most popular parks. Clearly a large public good exists in maintaining access to a popular state beach, but the example of using banned engineering practices to do so creates a situation that is difficult to reconcile with its past policies.

The history of storms and shoreline changes at Popham Beach, and the subsequent reaction of society to those changes, illuminates the challenges people face in trying to live with natural geomorphic changes and still enjoy coastal lifestyles, which most users expect and some demand. Herein, the geological setting of Popham Beach is described and what is understood of the coastal processes that formed and maintain this popular coastal location. Then the historical context

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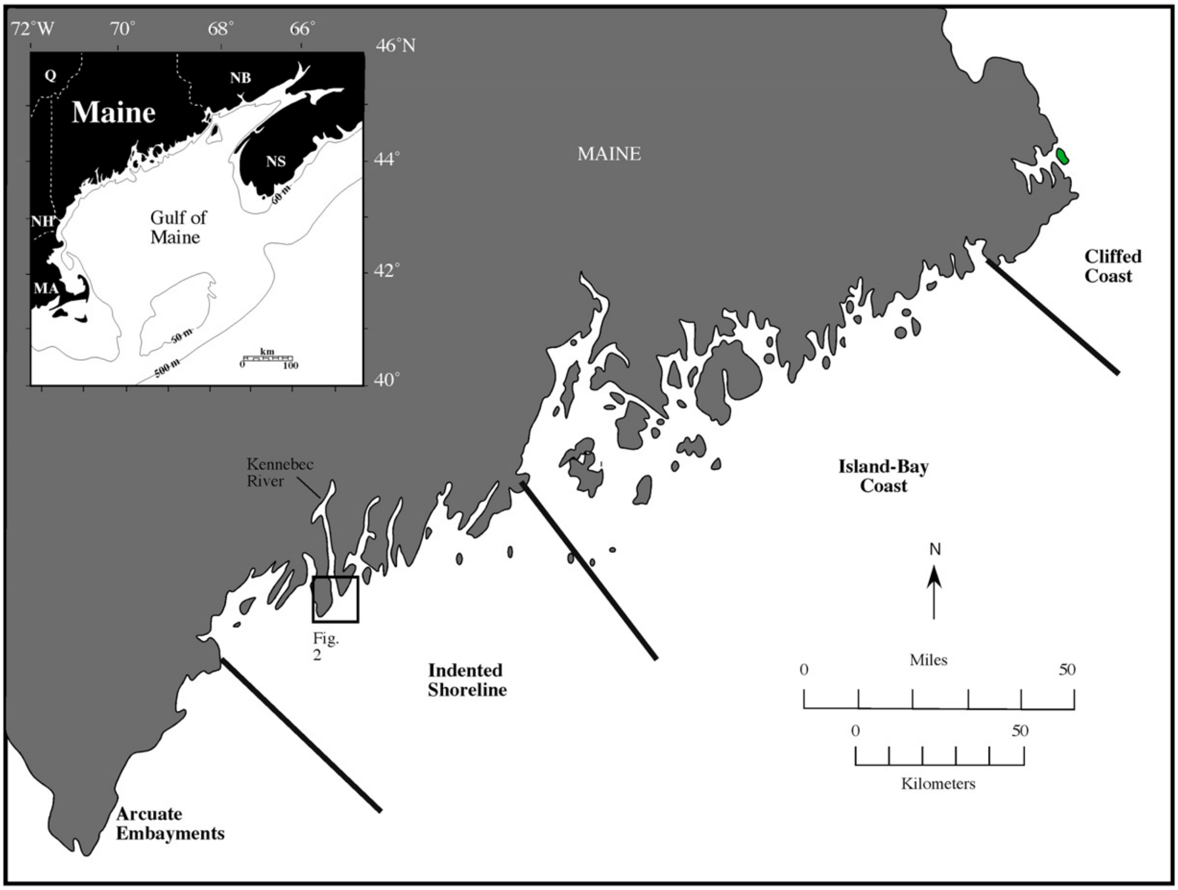

Fig. 1. Popham Beach is located in the Indented Shoreline compartment, within the box labeled Fig. 2 (modified from Kelley, 1987).

for the creation of a "Sand Dune Law" in Maine is presented. This is an unusual law in that it promotes living with rising sea level and natural changes in a state with relatively few beaches and a small population of beach recreationalists. Finally, the recent dilemma that confronted the state is described, as is the novel solution devised to respond to this situation.

2. Geological background and setting

2.1. Location

The coast of Maine is 3478 miles long and is framed by Paleozoic igneous and metamorphic rocks (Osberg et al., 1985). The resulting geologic structure forms four coastal compartments of varying orientation and possessing distinctly different coastal environments (Fig. 1) (Kelley et al., 1995; Kelley, 2004). Cliffs of bedrock dominate much of the coast with sand beaches comprising only 2% of the coast, or about 100 km, the smallest percentage of sandy coastline of any state in the United States (Ringold and Clark, 1980). Many beaches in the state are gravel, with sand beaches only common in the southern region and at the mouth of the largest river in the State, the Kennebec (Fig. 1).

Despite its passive continental margin setting, Maine does not possess Coastal Plain sediments (Cretaceous and younger), a distinctly different setting from most of the US East Coast. Glaciation removed these materials, and left behind numerous outcrops of till. During deglaciation, isostatic depression of the land allowed sea level to drown the coastal region to a depth of about 75 m (Kelley et al., 2010). Glacial-marine, muddy sediment blanketed this area and commonly overlies till and bedrock outcrops in most coastal embayments. Sea level fell to about 60 m below present by 12,500 B.P. and subsequently rose to the present level at an irregular rate (Barnhardt et al., 1997; Kelley et al., 2010). Contemporary sea level has risen about 2 mm/yr since early in the 20th (NOAA, 2012).

Popham Beach is located in the indented shoreline coastal compartment (Figs. 1 and 2), and at the end of a 20 km-long peninsula. The adjacent Kennebec River is the largest in Maine with a mean annual discharge of 280 m^3/s (Fenster et al., 2001). Tides in the study area are semidiurnal and have a 2.6 m mean range. Winds are dominantly from the north-northwest in fall and winter, but summer swells and wind are from the southeast–southwest. Because of the sheltering effects of nearby shoals and islands, typical waves reaching the beach are less than 0.6 m (FitzGerald et al., 2000). Extratropical storms occur several times each winter, with the largest storm waves from the northeast and east (Hill et al., 2004) and capable of developing 3 m waves at the beach (FitzGerald et al., 2000).

2.2. Regional sand budget

At its mouth, the narrow, bedrock confined channel of the Kennebec River may occupy a new post-glacial location as a result of glacial drainage pattern derangement. During spring freshets, the river drives its salt wedge onto the inner continental shelf and actively exports sand and mud (Fenster et al., 2001). When sand exits the river mouth, some travels directly seaward onto the inner shelf, whereas some sand and water diverges and follows a path between Pond and Wood Islands (Figs. 2 and 3) (FitzGerald et al., 2000). This sand encounters incoming waves, leading to deposition of a large bar (outer bar) seaward of Hunnewell Beach between Wood Island and Fox Island (Fig. 2).

Whereas sand is exported by the Kennebec River, the volume of this sand contribution is not known (Fenster et al., 2001). In addition, a sand and gravel deposit exists seaward of the river mouth, and extends to the lowstand position of sea level, about 10 km from the