The Maine Shore and the Army Corps:

A Tale of Two Harbors, Wells and Saco, Maine

by Joseph T. Kelley

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By discussing the problems of beach erosion and sand movement at Wells and Saco, Joseph Kelley and Walter Anderson demonstrate how single-minded, engineering approaches to complex, interdisciplinary coastal issues can create bigger problems than previously existed. As Kelley and Anderson explain, at both Wells and Camp Ellis, the Army Corps of Engineers was brought in to construct a harbor at no local cost to the community. This was accomplished by constructing jetties, and the result has been a persistent and serious problem of beach erosion. Over the years, the army has offered further technical solutions that have served only to exacerbate the problem. In pointing out the shortcomings of these solutions, Kelley and Anderson call for new action requiring federal, state, and local involvement. To do nothing, they argue, is to absorb the costs of letting nature run its course.

INTRODUCTION

For more than a century a conflict has been developing on the Maine coast. As the level of the ocean has risen, numerous beachfront properties have been lost, and thousands remain in danger (Kelley et al., 1989). At the same time, historic engineering structures, initially built to improve commercial navigation, are altering the natural location and movement of sand along some of our beaches. In discussing the recent histories of Wells Harbor and Beach and Camp Ellis Harbor and Beach, it is not our intention to discredit individuals within the United States Army Corps of Engineers, because the problems are, in part, of our own making. Rather, it is our intention to demonstrate how the single-minded, engineering approach of the army to complex, interdisciplinary coastal issues can create bigger problems on the coast than existed in the first place. In considering the problems that have evolved in Wells and Saco, it is painful, but worthwhile, to recall that they are all of our own making; we paid to create coastal engineering structures just as surely as we will pay for the damage they cause. Although there are no easy solutions to the existing problems in Wells and Saco, similar problems may be averted in the future by thoughtful planning involving a variety of disciplines beyond engineering. Challenged to achieve consensus on the Camp Ellis and Wells disputes, it is tempting to decide to let nature take its course. Ultimately, however, a hands-off approach may be the most costly of all options.

The difficulties at Camp Ellis and Wells are not unique to our state; similar conflicts between local coastal communities and the Corps of Engineers are occurring all around the country (Pilkey and Dixon, 1996). However, Maine has relatively few sand beaches and more private coastal land than other states (Ringold and Clark, 1980), so the problem is relatively large for us. A comparison of the economic value of beaches versus harbors in southern Maine has never been undertaken. Still, judging from the packed parking lots at marinas and coastal state parks, both boat and beach recreation hold significant economic value for Maine's coastal communities. It is similarly difficult to assess the ecological value of our southern coastal environments, but the relative lack of development of Maine's coastline compared to the coastlines of southern New England and the Middle Atlantic states greatly enhances the value of a Maine coast that remains relatively undeveloped. From both economic and ecological reasons, then, Maine citizens have good reason to concern themselves with beach and harbor development issues. Maine has led the nation in safeguarding beaches through the "Sand Dune Law" (now incorporated into the Natural Resource Protection Act, 38 M.S.R.A., sections 471-478), and in successfully resolving the Camp Ellis and Wells issues, which could once again take a leadership role in addressing the place of harbors in beach systems.

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Action by the Maine Legislature, however, will not completely resolve the problem described below. Leadership from the executive branch is essential to bringing state natural resource agencies and local environmental groups to the table. The congressional delegation will be needed to ensure that federal agencies participate. Legal, economic and scientific expertise, from government employees, university faculty and private companies will be essential to any sound solution. Finally, the Maine public, who are the major beneficiaries of sound beaches and well-sited harbors, must take a long-term interest in the coast. Although it is understandable that the public may take for granted Maine's beautiful coastline, the price to be paid by Maine citizens for neglecting to become involved in this issue will be to have the future use of this region determined by a small number of special interest groups.

BEACH DYNAMICS

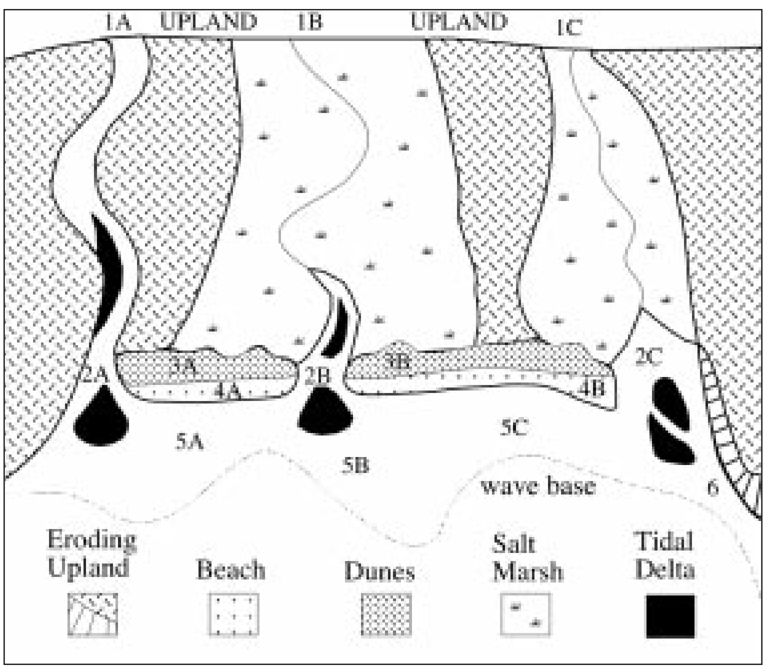
Through decades of observations coastal geologists have learned that human construction activity, in any place in the beach system, profoundly alters the overall system. Beaches are deposits of sand (and gravel) formed by waves (Figure 1). Sand may come from a river or from erosion of an older deposit of material left from the Ice Age (Figure 1, areas 1 and 6), but waves are required to move the sand. Waves are created by wind and generally come from the direction the wind blows. As waves enter shallow water, they reorient themselves in important ways to accommodate the shoaling conditions. Thus, predicting the precise movement of beach sand requires accurate predictions of wind direction and velocity, and complete understanding of water depths offshore. Because winds and waves are greatest in storms, prediction of beach erosion or growth requires predictions of storm frequency and intensity that are presently beyond our capability. Computer-based numerical models of beach behavior, though interesting as research tools, do not yet have the capacity to forecast changes in our beaches (Thieler et al., 2000).

Beach systems have several components that interact. The offshore part of the beach, the shoreface (Figure 1, area 5), starts where waves first begin to move sand, often in more than one hundred feet of water for large storm waves. The berm (Figure 1, area 4), where we put our beach blankets, and the intertidal zone are the familiar parts of the beach where we most commonly recreate. Sand in these areas is moved by waves in an onshore direction when the beach grows, or in an offshore direction when the beach erodes. The waves may approach a coast at an angle and move sand along the beach. Wind blows sand from the berm into the sand dunes (Figure 1, area 3), which serve to stockpile sand between large, infrequent storms. Finally, sand may reach the end of a beach and be drawn by tidal currents into a tidal inlet or delta (Figure 1, area 2).

Following its introduction to the sea, sand moves between the offshore, berm, dunes and tidal delta of a beach system in response to the wide variety of wave, wind and tidal processes that a coast experiences annually. The entire beach system responds to alteration of any of the components, sometimes rapidly, sometimes slowly. Thus, if we dig a hole in the beach where waves are active, the hole is quickly filled. The response of the beach system to removal of a tidal delta through dredging, or the response of the beach to construction of a jetty (a rock wall built perpendicular to the beach), is relatively slower and more complex. Because of the complexity of the system, and the lack of predictability of weather and waves, we cannot accurately predict the long-term consequences of our large-scale actions on beaches.

Figure 1:

Natural environments of a beach system include the subaerial beach (berm, 4a, b), the submarine beach, (shoreface, 5a, b, c), the dunes (3a, b), and the tidal inlets and their deltas (2a, b, c), as well as such sand sources as rivers (1a, b, c) and bluffs (6). Each of these environments (2, 3, 4, 5) is connected to the others through an exchange of sand. If one environment is altered or removed, the others are affected (modified from Kelley, 1995).



Camp Ellis, Saco, Maine

The Saco River begins in the White Mountains and enters Saco Bay as one of the largest rivers in the region. Saco Bay hosts both the largest beach and salt marsh system in the state of Maine (Kelley et al., 1989). Camp Ellis is a small, recreational and fishing community at the mouth of the Saco River, on the southern end of Saco Bay (Figure 2).

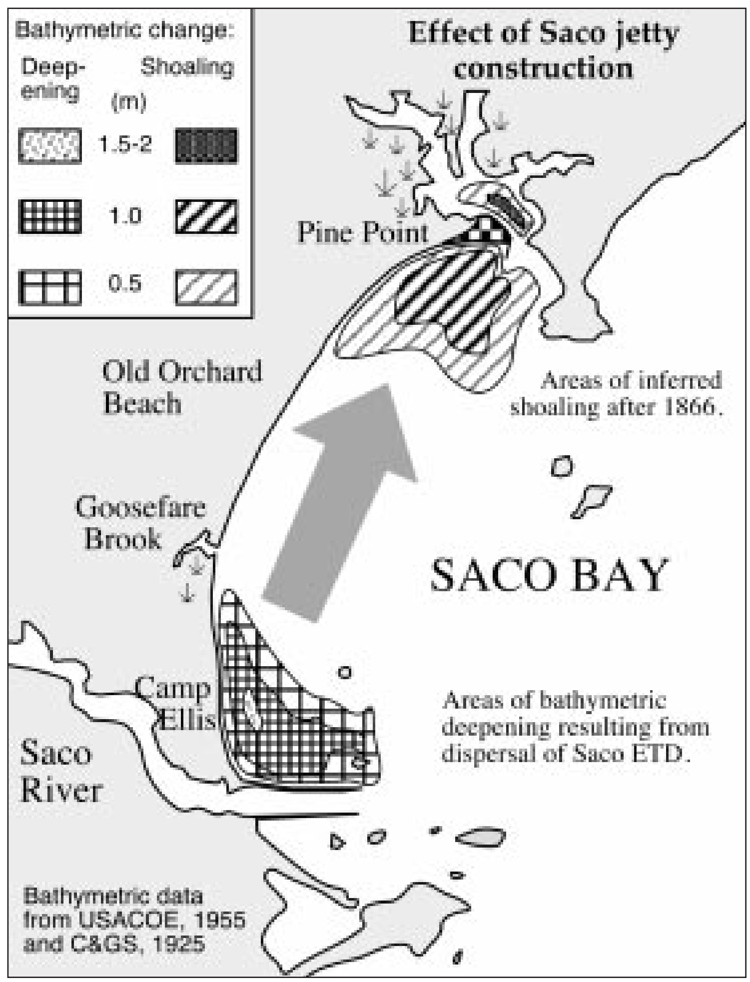
Long before there was a Camp Ellis, all of the earliest European visitors to Saco Bay complained of the difficulty of navigating past the tidal deltas at the mouth of the Saco River (Figure 3b). The problem became more acute in the mid-19th century as the mills in Biddeford and Saco sought to export goods and import coal. In 1866, the United States Army Corps of Engineers (USACOE) was asked to improve river navigation, which they did by removing shoals and erecting a rock jetty on the north side of the river mouth. Although the army initially recognized that sand traveled down the Saco River ("The river…during spring freshets carried large quantities of sand…(to) just below Factory island…whereby the material was deposited" (USACOE, 1886), they built a jetty, or rock wall perpendicular to the beach, to block the movement of beach sand which both entered and exited the river mouth with the tides.

Following jetty construction, the beach at Camp Ellis initially grew seaward. The sand added to the beach was a combination of material dredged from the river channel plus the wave-washed remains of its tidal delta (Figure 3b). Although the beach grew for only a brief period, the north jetty was extended repeatedly to 1,280 meters in 1897, 1,768 meters in 1930, and 2,030 meters in 1938. A jetty also was built on the south bank of the river mouth in 1890, and expanded in stages to 1,463 meters. Each of the structures was built low and, later was repeatedly raised; in 1969 the north jetty was elevated to 5.2 meters for the first 259 meters from land, and the north wall of the structure was made more reflective to waves by carefully re-orienting the stones. Each change in the jetties required a study to determine its need and to determine whether the cost of the activity was justified by the benefit (benefit/cost ratio). New constructions require the benefit/cost ratio to equal or exceed 1.0.

The purpose of this last action, and the intent of all the additions to each jetty, was to keep sand out of the navigational channel, which continued to fill following each dredge event. The army, although lacking observational data, had determined that there was "a constant movement of sand from north to south along the ocean beach...which has deposited material in front of the original entrance channel" (USACOE, 1910). Later, again without benefit of any study, the army inferred that "the beach material is of glacial deposit origin…due to the topography of the coast, there is apparently no natural source of material other than

Figure 2:

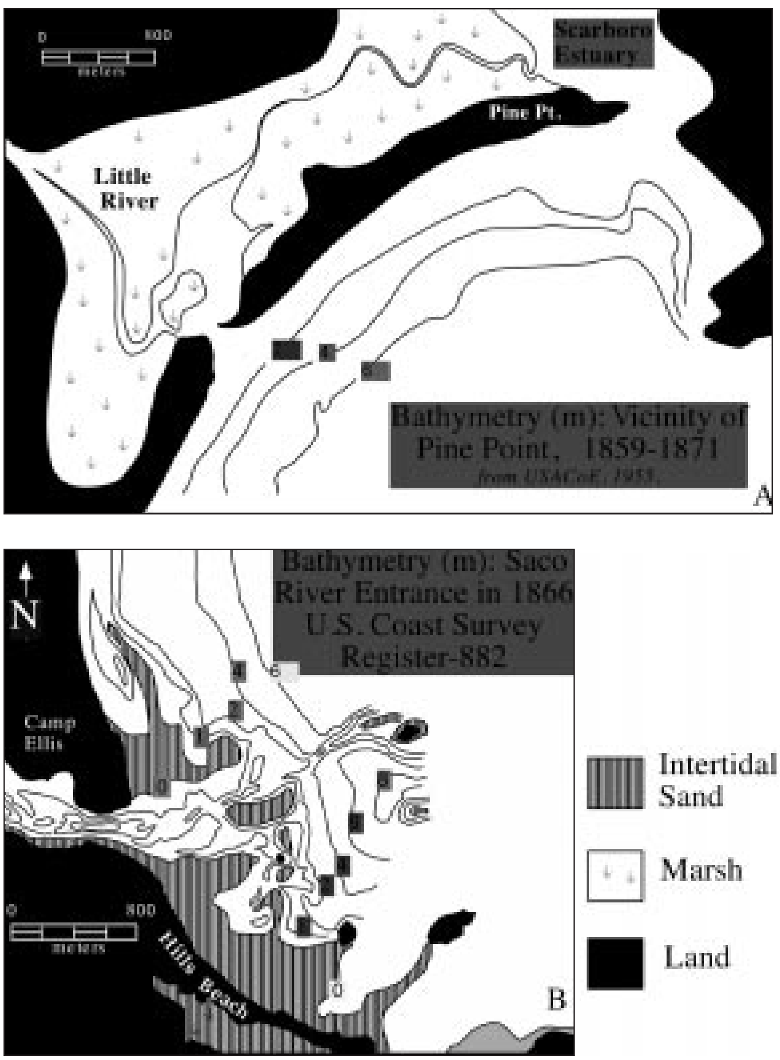
Location map of Camp Ellis in Saco Bay, and historical dislocation of sand resulting from construction of the Saco River jetties. The checkerboard pattern on Pine Point indicates a region of new beach (after Barber, 1995; Kelley et al., 1995).



by local erosion within the confines of Saco Bay" (USACOE, 1955). These observations by the army spawned a theory that an unseen deposit of Ice Age material was eroding beneath Saco Bay and relentlessly pouring sand onto Old Orchard Beach, from whence it was moved by waves and currents to the south and into the navigation channel. All enlargements and additions to the jetties were predicated on this theory—the assumption that sand was coming from the north and moving either through the jetty, or out along it and into the channel. Despite numerous objections by geologists, this theory was never examined by the army with direct observations in Saco Bay.

Figure 3:

A) 1871 map of Pine Point region. Note that the Little River inlet is now closed and the Scarborough River inlet is 550 meters narrower today; B) 1866 map of Saco River mouth. Note the large sandy tidal delta that is gone today (after Kelley et al., 1995).



Although sand continued to clog the navigation channel at a regular rate, Camp Ellis beach ceased to grow seaward shortly after the turn of the nineteenth century. Many houses and roads were claimed by the sea at considerable cost to both public and private sectors. All later USACOE studies of beach erosion at the mouth of the Saco River (1920, 1939, 1955, 1961, 1969, 1976, 1987) denied a harmful influence of the jetty on the adjacent eroding beach, and invoked storms as the cause of that problem. In a 1992 report, however, the army, for the first time, acknowledged that "a lack of natural nourishment material (i.e., sand) in the area" (USACOE, 1992) was compounding the problem at Camp Ellis. Although some of the early USACOE reports discerned a correlation between lengthening and raising the jetty and beach erosion, the 1992 report found "no conclusive links…between construction of the navigation project and shoreline changes" (USACOE, 1992).

By the 1990s, complaints of erosion by Camp Ellis property owners had increased in number. In 1991, in response to these complaints, the Maine Geological Survey, in cooperation with the University of Maine and Boston University, initiated a study of Saco Bay. Sponsored by the Maine-New Hampshire Sea Grant Program (Barber, 1995; Kelley et al., 1995), the study concluded that there was no source of sand within Saco Bay, and that sand for the beach was derived from the river on annual floods. An estimated 10,000 to 16,000 cubic meters of sand per year washes down the Saco, enough to account for the 8,500 cubic meters per year that historically has been dredged from the harbor (Normandeau Associates, 1994). Far from keeping beach sand out of the harbor at Camp Ellis, lengthening the jetty may trap river-bourne material in the harbor. Other sand coming down the river goes to sea more than a mile seaward of Camp Ellis.

Contrary to the army's contention, sand generally travels to the north from the river (Figure 2). Local people knew this from watching the dredged material placed on Camp Ellis beach migrate to the north and block Goosefare Brook. Using documents from the army, scientists became convinced that north was the net direction of sand. In the appendices of a 1955 study of beach erosion at Camp Ellis, the Corps estimated that between 1859 and 1955, almost six million cubic meters of sand disappeared from Camp Ellis beach and shallow offshore, or 61,933 cubic meters per year during that time interval (Figures 2, 4, 5). Although the army never questioned where this extraordinary volume of sand went, historic maps revealed what happened. The introduction of a large volume of sand between 1871 and 1877 closed the Little River tidal inlet on the Scarborough-Old Orchard border (Figure 2). By 1955, so much sand had transferred from the Camp Ellis area to Pine Point that the Scarborough River inlet narrowed from 762 meters to 207 meters (Farrell, 1972) (Figure 4). As a result, the army proposed constructing a jetty at the Scarborough River inlet to keep it open. In more than a century of working at Camp Ellis, the army has never associated their activities at one end of the bay with their work at the other end. Indeed, when the Maine Geological Survey repeatedly suggested that sand from the planned dredge of the Scarborough River be barged back to Camp Ellis, the army initially resisted, citing cost as a prohibitive factor.

To resolve the chronic erosion and property loss problem and to maintain a viable anchorage at Camp Ellis, representatives of the state met with representatives from the city of Saco, the Federal Emergency Management Agency and the army to consider a buy-out of houses in imminent danger of collapse. The Corps refused to participate in discussion of a buyout, prompting a letter from Governor McKernan. "I think it is inappropriate for the Corps to walk away from this problem," wrote Governor McKernan (letter from Gov. McKernan to Lt. General Hatch, 5-28-92), "particularly in light of the impact of the navigation project on the adjacent shoreline."

When confronted with these objections, along with renewed complaints by Camp Ellis residents for action, the army finally proposed a $500,000 physical model study at Waterways Experimental Station in Mississippi. Here, a football field-sized, scaled-down model of Camp Ellis was constructed to "answer the question" of the army's role in Camp Ellis erosion, and to propose solutions. Significantly, the concrete model lacked a river to bring in sand, and no information on waves and storms in Saco Bay were collected to develop it. When it was suggested by the Maine Geological Survey that instead of a physical model, spoils being dredged from the anchorage and placed on Camp Ellis should be monitored to understand the

Figure 4:

Shoreline change at Pine Point, 1877-1991. A) The photo shows shoreline positions from historic maps. All of this newly developed land was added to Pine Point as a result of beach erosion at Camp Ellis. B) The beach profiles show that the beach continued to grow between 1976 and 1991 (after Kelley et al., 1995).

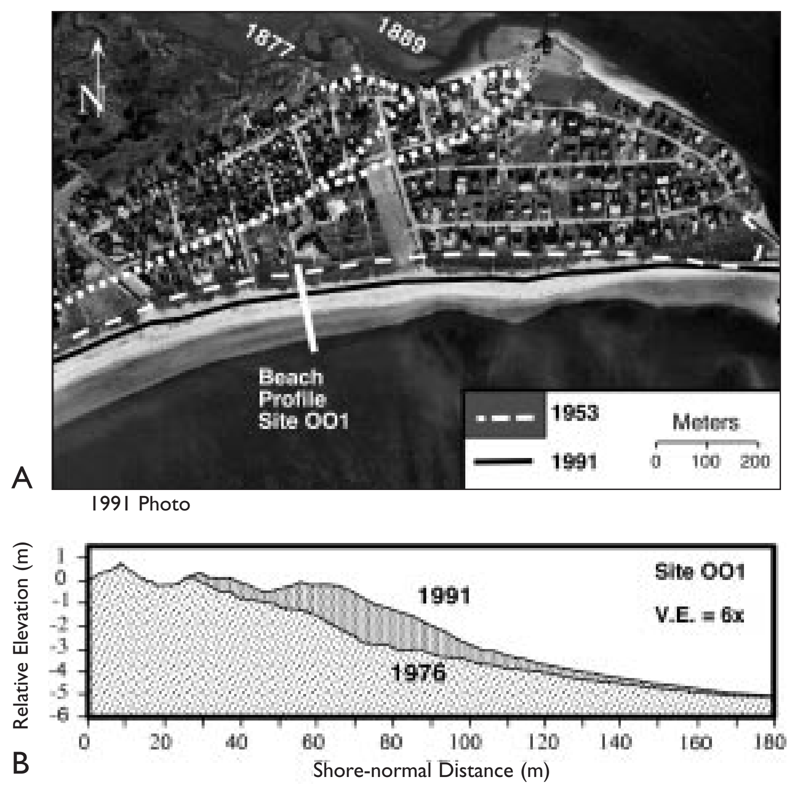
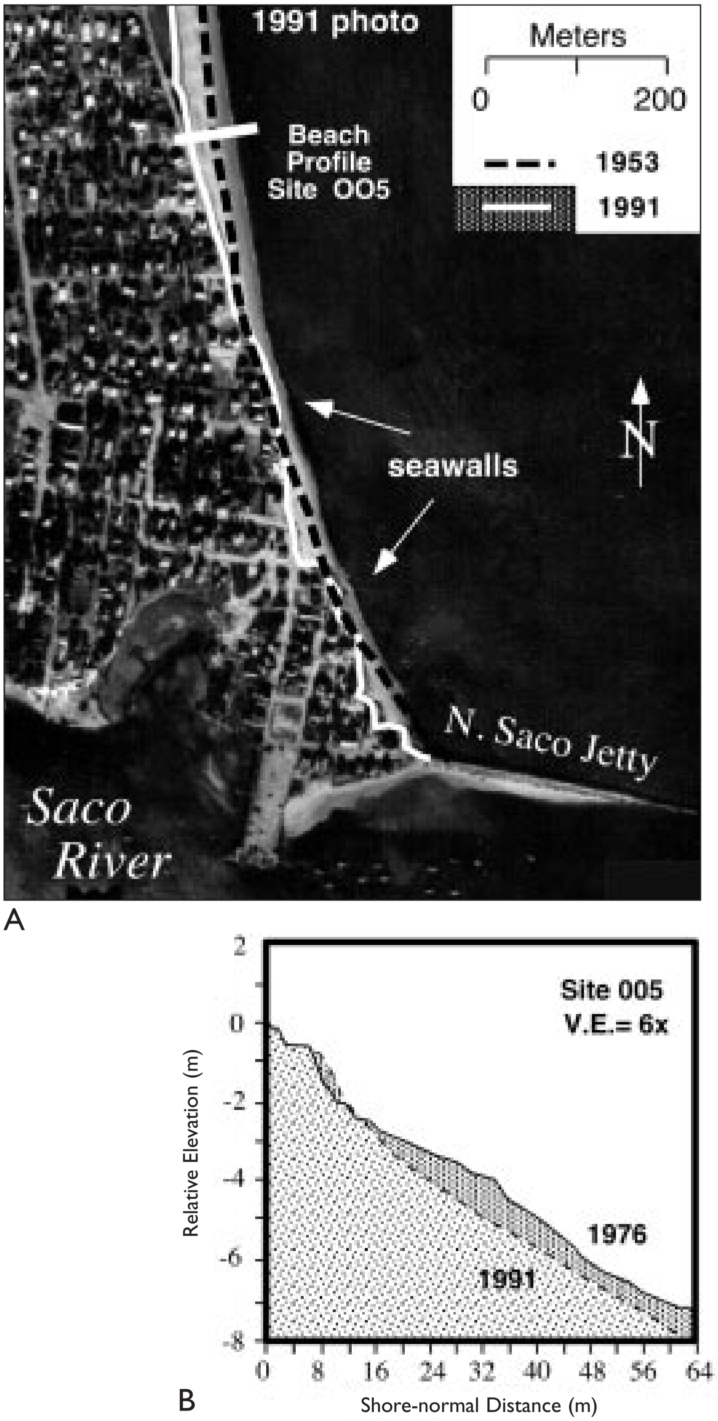


Figure 5:

Shoreline change at Camp Ellis between 1953 and 1991. A) The photo shows shoreline positions from historic aerial photographs. The area of apparent beach growth is a location where a rock seawall was built seaward of Surf St.
B) The beach profiles show that erosion continued between 1976 to 1991 (from Kelley et al., 1995).



direction and rate of sand movement during storms, the army declined, noting "it is quite possible that no significant storm events will occur (during the year of measurement)" (Col. Miller to Mr. Philip Donovon, letter of 9-24-93).

In April of 1995, the Army presented the results of their physical model study to the public at a hearing in Saco. The only solution they developed which would protect both property and the navigation channel was a 914 meters long, 4.5 meters high rock breakwater parallel to the beach in three meters of water. However, the cost was estimated at $14 million, which yielded only a 0.2 benefit/cost ratio. This ratio was too low to permit federal construction of the breakwater, which is prohibited by Maine law in any case because of the damage it would cause on adjacent beaches to the north. A member of the public then asked the army if that was the end of the whole study and was told, "That's about it" (Mr. Paul Provonost, Deputy Director of Planning, New England Division).

Wells Harbor and Wells and Drakes Island Beaches, Wells, Maine

Wells Beach and Drakes Island are relatively large beaches separated by the Webhannet River tidal inlet (Figure 6). Because the Webhannet River has a very small discharge and its estuary is choked with salt marshes and tidal flats, the inlet has always been shallow (Figure 7). On flooding tides, water—carrying sand from both beaches—used to accelerate through the narrow inlet, and slow down upon entering the estuary behind the beaches. Here, sand was deposited, which formed a flood-tidal delta. On the seaward side of the inlet an ebb-tidal delta existed as well (Figure 7). All of the sand on the beaches, including the submerged part of the beaches out to a 30-meter water depth, was in a balance or equilibrium with the tidal delta sands. During storms, sand might be swept from the beaches and enlarge the tidal delta for a time, but it would return when "normal" conditions ensued again. Sand freely moved from the offshore, submerged part of the beach, to beach and dune, to inlet, depending on conditions.

For centuries people lived in Wells and used the estuary as a harbor (as well as a source of salt hay, shellfish and fish, and waterfowl), but could only enter or exit the inlet at high tide. Similarly, the beaches were either used to repair boats or for vacation visits, but no permanent structures existed in the dunes. However, around the turn of the nineteenth century, changes began to occur. By the end of World War II, houses were built on top of almost all the most seaward sand dunes. As fishing boats became larger—with deeper drafts—to haul more lobster traps or to travel farther to catch fish, people began to clamor for an expanded anchorage and an "improved" inlet.

In 1953 the town requested that the United States Army Corps of Engineers create a small boat anchorage (partly for safety reasons) and, at the same time, reconstruct the seawalls that were collapsing onto the beaches (USACOE, 1994). Although the army could not do work on the private seawalls near the inlet, on the basis of a benefit/cost ratio of 1.0, they agreed by 1961 to construct an anchorage.

Work began with the construction of rock jetties 145 meters apart at the end of Drakes Island and Wells Beach. The purpose of the jetties, 200 meters long on Drakes Island and 290 meters on Wells Beach, was to prevent sand from moving into the navigation channel from the beaches. During jetty construction, a northeaster eroded the northern tip of Wells Beach, requiring the placement of rocks to prevent further erosion by 1963. The army also determined that it was necessary to extend the north jetty sixty meters to prevent waves from entering the channel.

Initial dredging began in July 1962, but progress was slow due to rapid shoaling in the navigation channel and anchorage, frequent mechanical breakdowns and occasional storms. By November 1963, the project was stopped when the dredger left without completing the work to the army's design specifications (Byrne and Ziegler, 1977). A second attempt to dredge the project began in August 1964, but ended in May 1965 when the dredger quit because of rapid shoaling and equipment losses (Byrne and Ziegler, 1977). To fix this situation, between 1965 and 1967, the army: 1) extended the north jetty 373 meters; 2) extended the south jetty 396 meters; 3) dug a 91 meters by 122 meters by 3 meters basin south of the anchorage to collect material eroding from the salt marsh; and 4) re-dredged the entire project.

Figure 6:

Map of Wells, showing historic shoreline positions. Sand accumulated near the jetties following their construction (after Kelley et al., 1989).

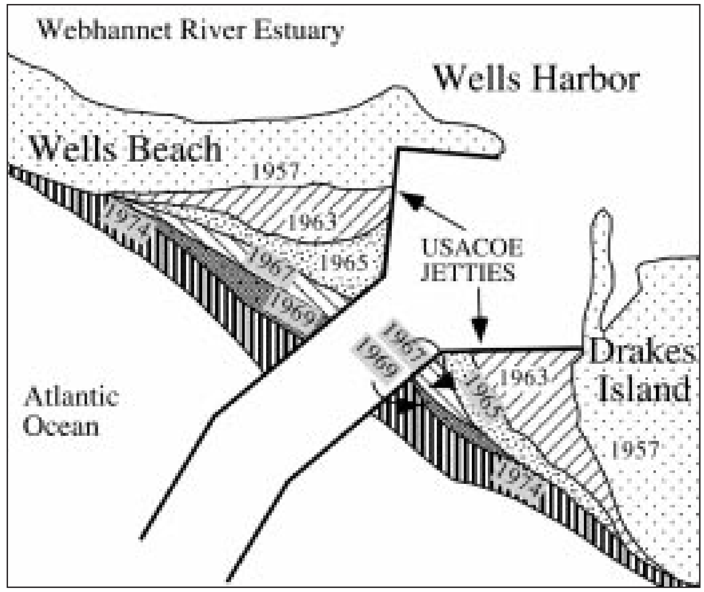


Figure 7:

Aerial photograph of Wells Inlet in 1953. Note the narrow low-tide channel prior to dredging, and the large quantity of sand in the flood and ebb tidal deltas on the landward and seaward sides of the inlet, respectively.

Nevertheless, shoaling continued relentlessly, and the project was dredged in 1970, 1971 and finally in 1974. More than 382,000 cubic meters were dredged from the project, with virtually all of it dumped on the adjacent salt marsh (USACOE, 1994) (Figure 8), removing it from the sand beach system (Figure 1). By 1980, it was clear that things were not going as planned. Rather than fill in at the anticipated rate of 3,057 cubic meters per year, the anchorage filled at a rate of 15,286 cubic meters per year; rather than the 186 moorings secured in 1974, now, in 1980, there was only space for forty vessels (USACOE, 1980; Humm, 1985). Despite realignment, the jetties still faced directly into the prevailing waves, bringing sand into the anchorage and making boat passage through the jetties hazardous. No discussion of how these events altered the original benefit/cost ratio was apparently undertaken because the harbor no longer represented the most pressing problem. Now, attention was focused on the eroding beaches (Figure 9).

Since the first day the jetties blocked the free passage of beach sand into and out of the tidal inlet, sand began to collect adjacent to the jetties (Figure 6). Waves and currents drove the sand next to the jetties, but the shadow effect of the structures prevented waves from other directions from returning sand to the ends of the beaches. Wind blew the deposited sand into high dunes, trapping more than 76,430 cubic meters of sand (Figure 6). Loss of their beaches angered the beachfront property owners and led to a cessation of dredging after 1974. By 1980, the New England Environmental Mediation Center was brought in to help resolve the dispute between the army, one faction within the town wanting a dredged harbor, and another desiring a return of the lost beach sand (Humm, 1985).

Almost a decade of inaction ensued before a proposal to again attempt to dredge the harbor emerged in the late 1980s. However, this effort proposed to place the sand on the beach instead of the salt marsh. However, times and laws had changed, the salt marsh, formerly a dump for dredged material, was now the Rachel Carson Wildlife Refuge and governed by several agencies. Federal, state and private organizations opposed renewed dredging because of its destructive impact on the marsh. Salt marsh peat erodes into the deep anchorage when it is dredged. After unanimous denials for a permit to dredge the harbor from the State Board of Environmental Protection, the Maine State Legislature also refused to alter the law to accommodate a dredge.

The town regrouped by 1994, and sought only to move the sand next to the jetties back along the beach. However, this sand was now incorporated into well-vegetated dunes and protected from removal by the state's Natural Resource Protection Act. Furthermore, similar to the sand that moved from Camp Ellis to build up Pine Point, the sand next to the jetties at Wells was claimed by new owners as private property and partly developed. Its "owners" expressed disapproval with the potential loss of their sand, even if it could temporarily save their neighbors.

Figure 8:

Aerial photograph of Wells during 1974 dredging operation (after Kelley et al., 1989). The dredge spoils pile is in the foreground. As much of this sand as possible should go back to the beach.

Faced with owning a harbor or a beach, Wells spokespersons began to indicate they would prefer a beach, and have discussed asking the army to remove the jetties and let the sand be redistributed along the beach by waves. In response to all the local outcries, the army commissioned a study that reached one conclusion (among others) that stated, "A hydraulic model study is required for the determination the optimum (sic) jetty configuration to reduce inlet shoaling and beach erosion" (USACOE, 1994). One study concludes that more studies are needed. The history of Wells begins to appear disturbingly similar to Camp Ellis at an earlier stage.

RECENT ACTIONS

Responding, in part, to the problems at Camp Ellis and Wells Harbor, the state sponsored a series of "stakeholder" meetings where citizen groups could discuss beach problems with state agencies (Maine State Planning Office, 1998). The problem at Camp Ellis was an important focus of that group because it is assumed that the area will be lost if nothing is done (Marine Law Institute et al., 1994). One result of this effort was the creation of a Saco Bay Beach Management Committee, which identified erosion at Camp Ellis as a high priority. A major difficulty this committee or any state or local group faces when considering action at Camp Ellis, is that federal action is required to alter the jetty.

In Wells, the state brokered a compromise among organizations in favor of and opposed to the dredging of the harbor. With participation from the army, a plan was developed that will allow a reduced dredge to occur in 2000-2001, with the sandy dredge spoils placed on the adjacent beaches. Monitoring of the tidal delta and adjacent marshes will then determine if further dredging can occur. While this addresses the immediate need of a dredged harbor and sandy beaches, it is probable that the harbor will fill very quickly and that the new beach sand will move near the jetties as it did in the past (Figure 6). Most observers agree this is only a short-term solution.

DISCUSSION

In both Wells and Camp Ellis, the army was brought in to construct a harbor at no local cost to a community. Initially the army resisted, citing high costs and low benefits, but later began construction when (presumably) more benefits were discovered or political pressure mounted. In each case, engineering problems were addressed with engineering solutions; one technical study followed and often repeated its predecessors. Beach erosion, a non-issue in the beginning, began to drive all discussion around the harbors. The technical resolution of the problems will require more than engineering expertise. A major concerted effort on the part of federal, as well as Maine state, university and private organizations is called for.

Figure 9:

A 1997 photograph of Wells Beach, Wells, which shows the lack of sand in this beach system today. At high tide there is little or no recreational beach. The large rocks were added to prevent the seawall from becoming undermined, owing to a lack of sand.

PURELY ECONOMIC CONSIDERATIONS

In a state renowned for its natural, deep-draft harbors, we have unsuccessfully expended enormous effort to turn two tidal deltas into anchorages. In the case of Camp Ellis, this was possibly justified initially because of the commerce associated with industries in Biddeford and Saco. In Wells, the harbor was constructed largely for recreational boating, with commercial fishing vessels comprising only 10% of the fleet (U.S. Army Corps of Engineers, 1997). However, despite significant changes in the local economic situation, no reanalyses have occurred. This is particularly distressing in light of the unanticipated loss of a large number of properties and beach area at Camp Ellis. In the case of Wells no serious reconsideration of the value of the harbor has been undertaken despite the costly history which followed an initial (almost miraculous) benefit/cost ratio of 1.0. Instead, to create benefits equal to the incurred costs, "a projected rate of fleet growth was factored into the analysis...This growth was assumed to occur until a total fleet of small craft sufficient to justify the project would be reached in about the year 2016" (U.S. Army Corps of Engineers, 1997). Recently, even though it is extremely unlikely that Wells Harbor will experience the projected growth, the army announced that the dredging planned for 2000 was going ahead despite a cost more than double the previous estimate (Cohen, 2000).

If the cost of these projects was borne by private interests, or even by the local communities themselves, it is probable that economic analyses would have been made decades ago. Apparently since the costs are absorbed by the federal government, no one has ever challenged the projects on the basis of their economic value.

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ENVIRONMENTAL-ECONOMIC CONSIDERATIONS

In both Wells and Camp Ellis, the true cost of the harbors has involved more than simply the dollar value invested in anchorages. In each instance there has also been an environmental-economic cost. Some of Maine's greatest summer tourist attractions are its few small, but beautiful, sandy ocean beaches. Camp Ellis, Wells and Drakes Island beaches have been lost or severely degraded because of the existence of nearby harbors. How many tourist dollars never came to Maine because of this? In addition, there have been substantial private property losses ($1.5 million in federal flood insurance payments to Wells since 1978; $1.1 million to Saco (L. Sidell, State Floodplain Coordinator, personal communication, 11-94)), not to mention the loss of the local property tax base and the cost of repairing public roads. Although it is difficult to place a dollar value on wildlife and its habitat; this too has been sacrificed for harbors, but never factored into their cost. What is truly alarming with regard to all of these hidden costs to the anchorages is that the beach erosion continues to worsen. Relatively undeveloped beaches at least as far north of Camp Ellis as Ferry Beach State Park, and as far north of Wells Inlet as Laudholm Beach State Park, are eroding, possibly as a result of the engineering structures.

ROLE OF THE ARMY CORPS OF ENGINEERS

At first one could easily conclude that the army is more a pawn than a protagonist in Wells and Camp Ellis. After all, the army was invited into Maine to improve navigation. No one said anything to them about beaches or property; in fact, there was probably little or no beach development at Camp Ellis in 1866. However, the role of the Corps of Engineers has slowly evolved from one of providing federal assistance and specialized expertise where requested to that of an agency with a narrow focus on engineering solutions to geological, economic and environmental issues. The repeated engineering failures at Camp Ellis might be forgiven for nineteenth century ignorance if they did not persist up to the present—and if they were not almost duplicated once again at Wells.

For example, the army's failure to consider the Saco River as the source of sand to the bay's beaches could be ascribed to a general lack of understanding of coastal processes in the 1800s—if such a misunderstanding did not persist in 1994. If one looks critically at the army's decision to erect a $500,000 concrete facsimile of Camp Ellis in Mississippi, in lieu of monitoring the movement of dredged sand just placed on Camp Ellis beach, one might reasonably suspect they are covering up a century of ineptness with a study whose conclusions can neither be replicated nor implemented by others.

As an organization, the army has exhibited a pattern of behavior that involves initial denial of responsibility, followed up (when political pressure is brought to bear) by technical studies that repeat old, untested assumptions and conclusions. As noted by former Maine Department of Environmental Protection Commissioner Dean Marriott: "The recent Corps' reports present no new data; they simply re-examine earlier Corps' reports from a coastal engineering perspective. Erroneous statements and conclusions made in earlier reports are just passed from one study to the next, despite the state's, the city's (Saco) and residents' attempts to have the Corps re-evaluate these conclusions" (letter from Dean Marriott to Col. Harris, 5-21-92).

Historically, Corps' studies result in either more engineering attempts or still more studies until the generation of complaining property owners and their political supporters are gone. Often, the army tries to play off one set of opponents against another by blaming, for example, the state's regulators for their unwillingness to help people. Governor McKernan wrote with obvious frustration: "We have tried to work with the New England Division (of the Corps of Engineers) to find compromises…However, the Division has been of little help in achieving these compromises on numerous occasions. The Corps staff have made many statements to municipalities, the press, legislators, and others, that they want to help the municipalities and carry out projects, but the Department of Environmental Protection is preventing them from doing so. I trust you can agree that it is not productive to have one level of government criticizing and laying blame on another" (letter from Governor McKernan to General Hatch, 5-28-92).

Is it wishful thinking to expect a federal agency to provide high-quality engineering expertise at little or no local cost? Maybe there are few complaints about the army because the federal expenditures seem free to local interests. Imagine the reaction of a town to shoddy engineering work, like the design of the Wells' jetties, if the town had to fully pay for the work out of pocket. Think about how such a community would react to a private company whose poor engineering not only failed to do what it was supposed to, but whose efforts caused the loss of valuable beaches, wetlands and property. Needless to say that company would cease to exist and private competition would provide a new firm that would listen to local interests and educate themselves on the causes of past failures.

CONCLUSIONS

Federal Considerations

At a national level, more public scrutiny of the Army Corps of Engineers' benefit/cost analyses is required. Historic projects should be periodically re-evaluated in light of both changing benefits and costs. The benefits and costs of projects also should include more than construction costs and navigation benefits. Benefits and costs should also encompass the full range of environmental impacts over an extended period of time.

Finally, we need to re-think the role of a military organization, governed by politicians with great pressure from special interest groups, in routine maintenance of our harbors. The army's role in dredging harbors and putting sand on beaches is rooted in nineteenth century history (Shallet, 1994), not in thoughtful governmental planning. Problems with army projects exist all around the United States (Pilkey and Dixon, 1996). Some observers have suggested that the budget of the army for dredging harbors be transferred to either the Department of Commerce or Department

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of Transportation. Other observers suggest that since the army acts largely as an agent between states and dredging companies, the army's dredging budget should be provided directly to the states, leaving the states to assume responsibility for their own mistakes.

Regional Considerations

The regional beach management groups in Saco and Wells serve as an important mechanism to develop local interest and support for action on coastal problems. However, these groups are ill equipped to develop a plan that spans engineering, geology, economics, wildlife biology, politics and law. A panel, patterned after National Academy of Sciences' panels, and representing those skills, needs to be convened now to develop realistic plans to deal with beaches and harbors in Wells and Saco. This panel will need to develop a technical and a political consensus before anything can happen on the coast. Money will be needed to support such a panel, probably hundreds of thousand of dollars. The governor is the logical person to convene such a panel. The panel might form the nucleus of a State Academy of Sciences.

Once there is a plan, the congressional delegation must be brought in to assist in implementing it. The support of the delegation is essential because any alteration of federal anchorages requires, literally, an act of Congress. Any successful plan will also require money, probably more money than was used to build the anchorages. Though large, the money spent repairing our coast is actually small compared to the value of the properties on the coast and the tourism dollars beaches attract. It is unlikely that the Corps of Engineers can be left out of Maine's plans. However, Maine must make clear that the army's involvement is limited to doing the state's bidding until the time comes when they can be removed from civilian activities. Of course, if past history is a guide to the future, then once Congress appropriates funds for an Army Corps project the army is in charge of the project. Yet little meaningful public or state involvement occurs under this process. Simply put, turning things over to the Army Corps of Engineers and then stepping back is not a solution.

Local Considerations

In no way should this essay be construed as simply an effort to remove commercial anchorages in southern Maine in favor of recreational beaches. This region needs more anchorages, not fewer. The problem is that the anchorages in Wells and Saco have had a major, deleterious impact on the adjacent beaches because of geological processes that are still poorly understood. Similar impacts might be anticipated in Kennebunkport, York or Scarborough because jetties also abut beaches there, but no such problems have yet been reported. The important local questions to ask are whether we need to: 1) alter the existing structures to permit them to co-exist with healthy beaches; 2) accommodate the existing structures by adding sand to the eroding beaches; or 3) choose between whether we prefer a harbor or a beach because they cannot be made to co-exist. The latter option leads to other considerations, such as where to locate a replacement harbor or how to deal with existing property.

In Camp Ellis, serious thought should be given to altering the north jetty. It could be roughened and lowered on its seaward side to blunt its ability to reflect waves toward Camp Ellis. In addition, sand from the spring freshet of the Saco River might regularly be diverted to Camp Ellis. Every decade when the Scarborough River is dredged, its sand might be added to Camp Ellis. These tasks require some funding, but they are the least expensive options.

In Wells, the least expensive option is an experiment in dredging the tidal inlet/delta (harbor) and putting the sand on the beaches; this is planned to begin in the winter of 2000. This activity will be monitored and we will learn how long it takes for sand to return to the harbor and whether the salt marsh is compromised by the dredging. At the same time, sand dumped on the salt marsh and adjacent to the jetties (Figures 6, 8) might be returned to the beaches. It would be expensive to move much sand from the marsh, but the sand belongs on the beach and should be returned to it. Sand adjacent to the jetties is of uncertain ownership, although some of the "new" land is developed (just as the sand eroded from Camp Ellis is now developed on Pine Point). Ownership must be determined here as well as the practicality of moving large volumes of sand from one end of a beach to the other.

However, making minor structural modifications to the jetties and transferring sand may not halt the erosion of the beaches. In the end, if the jetties threaten the integrity of the beaches of Saco and Wells, a choice must be made between the existing harbors and beaches. The decision may appear simple; the beaches are more valuable than dysfunctional harbors located on tidal deltas. However, the cost of removing the jetties will be substantial, resulting in the loss of considerable commercial infrastructure. Commercial fishing interests will have great difficulty gaining entry to a new port along such a busy stretch of coast. Clearly, new harbor sites will need to be selected. Obtaining money to fund the removal of the jetties and locate new harbor sites will not be an easy task.

The final alternative, to "do nothing," is the present course of action. On sunny days in the summer, with boats in the harbor and people on the beach, it is easy to favor the status quo. Still, the beaches are eroding and year-by-year the problem worsens. The level of the ocean is rising faster than it has in millennia and is unlikely to stop (Kelley et al., 1996). The problem will never correct itself without significant economic loss. Ultimately, we may have to decide between these two choices: investing effort and resources into finding solutions to our coastal problems, or opting to merely absorb the costs of letting nature run its course.

Acknowledgments:
We wish to acknowledge the Maine Sea Grant Program for fostering cooperation between the University of Maine and the Maine Geological Survey and for supporting research along Maine's beaches. We also appreciate the thoughtful reviews by Dr. Daniel Belknap and two anonymous reviewers, as well as the fruitful discussions with Dr. Duncan FitzGerald of Boston University, Dr. Richard Barringer, of the University of Southern Maine, and Dr. Donald Barber of Bryn Mawr College.

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