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Co-Measurement of Beaches in Maine, USA: Volunteer Profiling of Beaches and Annual Meetings

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ABSTRACT

Maine's tourist beaches have experienced chronic erosion for a long time. Efforts by scientists and government planners to regulate development have run into conflict with property owners. To reconcile the two groups, a beach profiling project was begun to better understand the behavior of beaches as well as to bring the regulators and regulated together. Early results have demonstrated that southwest storms lead to beach accretion; northeast storms lead to erosion. A web site and an annual meeting where the data are presented have each proven very popular. This program of involving volunteers to gather otherwise-hard-to-collect data has been very successful and would work in many other locations.

ADDITIONALINDEXWORDS: *New England, storms, currents, waves, beach volume*

INTRODUCTION

During summer months, tourists and residents flock to the sandy beaches in southern Maine (Figure 1) with little awareness that these natural resources are eroding. The most rapid rate of sea level rise in millennia (KELLEY *et al*., 1995), combined with widespread development of beaches following World War 2 (KELLEY *et al*., 1989, and a proliferation of shoreline engineering structures (KELLEYand ANDERSON, 2000) all are at the root of the erosion problem. Those who closely follow the erosion problem, often property owners, seldom understand the mechanisms behind the erosion. It is becoming increasingly difficult for scientists to determine whether the contemporary erosional behavior of the beaches results from anthropogenic activity or natural processes, or is a combination of the two (KELLEYand ANDERSON, 2000).

Regular topographic monitoring of Maine's beaches, and relating this information to simultaneous records of meteorological and oceanographic conditions as well as human construction is necessary to develop a complete database that will track shoreline change over time. However, because the beaches are widely spaced and 250 km from scientists at the University of Maine, it is not possible for us to gather topographic data on a regular basis

In addition to geologic problems on Maine's beaches, there are social, legal and political challenges as well. Currently, Maine's 1979 Sand Dune Law (MSRA, 1979) serves as a guideline for development along the State's coast. This pioneering legislation seeks to minimize property losses and, at the same time, protect public beaches. To this end, the law precludes construction of new seawalls and other engineering structures, and requires the removal of buildings that are 50% or more destroyed by a storm (MAINE DEPARTMENT OF ENVIRONMENTAL PROTECTION, 1993). Building relocation and beach nourishment, therefore, are the only options for property at risk. Despite the apparent success of the law in promoting development in safe locations, legislative and legal suits continue, with three Maine State Supreme Court cases active in the past two years. Arguments often boil down to homeowners' anecdotes of shoreline behavior, storm and seawall effects and scientists' measurements/predictions based on long-term, often remote data. There has been little cooperation between technical experts on coastal processes and the impacted communities of property owners (PILKEY and DIXON, 1996). What is needed is a mechanism to bring together scientists and homeowners to develop a collective understanding of the beaches and appreciation for the opinions and emotions of others.

To involve and educate the public in the scientific measurement of Maine's beaches, we initiated the Maine Beach Profiling Project. This project, funded by the Maine Sea Grant Program, involves a mixture of scientific observation, data synthesis and public outreach. Collaboration between coastal citizens and scientists/government regulators is the core of the idea. In this report we describe the organization of the program and our preliminary results.

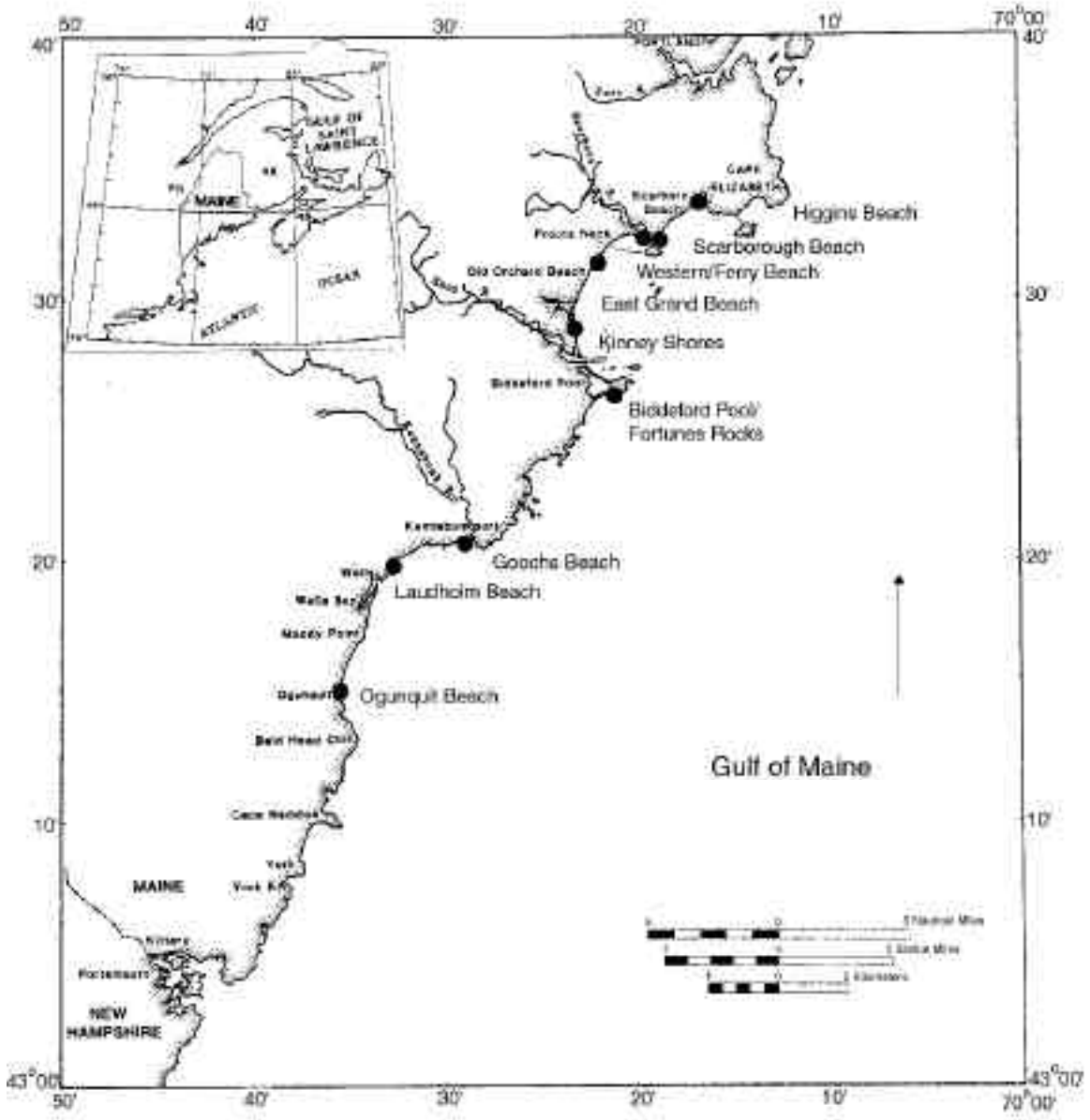

Figure1. Location of beaches monitored in this project. Filled circles indicate the location of the beaches studied. Current/wave meter deployment sites were located in 20 m of water off central Saco and Wells Embayments (from Heinze, 2001).

PHYSICAL SETTING

Four coastal compartments, based on bedrock structure and geomorphology, comprise the paraglacial coast of Maine (KELLEY, 1987). Arcuate embayments with intervening bedrock headlands characterize the southwest compartment, the area with most of the region's sand beaches (Figure 1). Sand is delivered to the Saco Embayment by the Saco River (KELLEY *et al.*, under review; KELLEY *et al.*, 1995; BARBER, 1995). Beaches in the Wells Embayment apparently derived their sediment supply from erosion of glacial deposits (KELLEY *et al.*, under review; MILLER, 1998), although all bluffs of glacial sand and gravel are protected by engineering structures today (KELLEY *et al.*, 1989).

Maine has a mixed energy, tide-dominated shoreline (FITZGERALD and VAN HETEREN, 1999). The tides are semidiurnal and increase along the coast from 2 m in the southwest, to greater than 6.5 m in the northeast (KELLEY, 1987). The mean tidal range in the southwestern Gulf of

Maine is 2.7 m. The dominant wave approach is from the south-southeast, and the yearly significant wave height is 0.3 m-1.13 m (BELKNAP *et al*., 1988).

The prevailing winds affecting the Gulf of Maine vary seasonally (BELKNAP *et al*., 1988; NELSON and FINK, 1980). South-southwest winds dominate in the summer, producing low-energy wave conditions and swells. In comparison, the beaches experience northwest winds during the fall and winter. The strongest winds produce winter storms, such as Nor'easters, that create heavy surf conditions from the east and northeast. These storm winds are historically responsible for significant erosional events in the Gulf of Maine (FITZGERALD *et al*, 1994).

METHODS

Volunteer Selection

In June 1999, a press release announced the need for volunteers to help study the eroding beaches in southern Maine. Following the press release, an organizational meeting was held for approximately 150 people, who were divided into teams, based on their geographic location, as well as interest. Each team was assigned a beach and team leaders were designated to every group. The team leaders serve as the contact person for the group, and are responsible for supervising their team and managing supplies and data. Communication between leaders and University of Maine scientists is maintained by email. The initial groups of volunteers were a mixture of homeowners, school-teachers and beach-loving members of the public, especially retirees.

Beach Profiling/Data Collection

The volunteer training began with a general discussion of beach processes and the importance of gathering long-term data. At this time, the volunteers were shown a training video (Kelley *et al*., 1999), showing the steps that should be followed in the field. The scientists then met with each group individually to determine specific transect locations on their beach, as well as to demonstrate the proper way to take topographic profiles. Along each beach, four transects were established approximately 50-m apart, although the distances vary slightly from beach to beach. Each profile line has two control stakes, that were surveyed to a permanent benchmark.

The volunteers use the Emery Method (EMERY, 1961) of beach profiling to make near-simultaneous monthly measurements at the time of spring tide. This method utilizes a set of 1.5-m poles, graduated to 1-cm intervals, and attached by a 3 m graduated rope (Figure 2). The volunteers start by taking a vertical reading at the front stake, and continue making horizontal and vertical measurements along the length of the transect to the water's

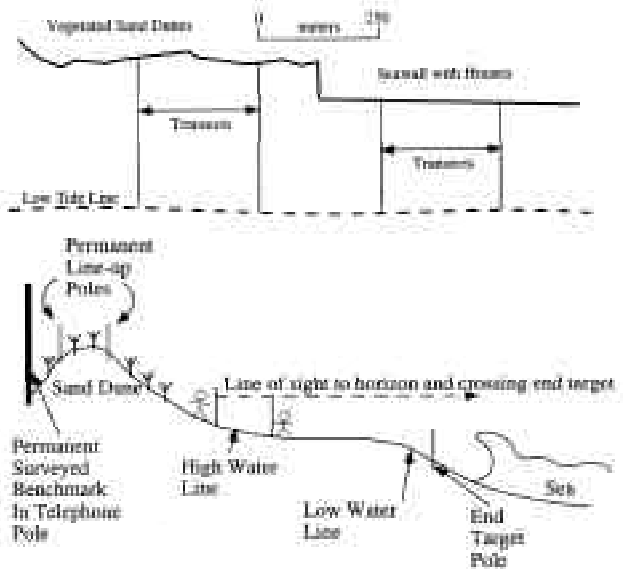

Figure 2. Schematic drawing of A) a typical beach-profile transect layout, and B) a volunteer team surveying a beach by the Emery method (from HEINZE, 2001).

edge. The person holding the rod on the landward side sights to the horizon and records the elevation loss or gain. Measurements are taken every 3-m horizontally, or wherever a significant change in topography occurs. The record from each transect consists of a series of horizontal distances, vertical distances and appropriate annotations (end of dune grass, last high tide line, etc.) where warranted. Volunteers also take photos with disposable cameras that we provide.

Project Website

Following collection, the data is sent to us via mail where it is put into a spreadsheet and graphed. The graphs are displayed on a website (http://www.geology.um.maine.edu/beach), along with additional information and pictures of the project and the beaches that were monitored. The graphs display every month of profile data from the beginning of the project, and also show a comparison between months with the greatest and least profiles. We plan on developing an interactive website soon to allow volunteers to directly enter data.

Wave and Current Observations

Two current meters (Falmouth Scientific model 3D-ACM) were deployed in shoreface locations of Saco Bay and Wells Embayment during the winter months (Figure 2). The instruments gathered current direction and wave height at programmed times for up to two months. Cross-

correlating these measurements with meteorological data from the NOAA Portland Buoy 44007 (located in 20 m of water 10km northeast of Saco Bay) allow us to observe how the beach profiles respond to different meteorological/oceanographic events.

Summer Conference

Meetings were planned as annual events ("State-of-Maine's Beaches" meeting) at a site near the study area. Although we planned to focus initially on the results of the profiling, we plan to expand the program over time to maintain public interest. Evaluations completed by the attendees will be used to improve the event from year-to-year. In this informal setting, scientists, government regulators and property owners will be free to mingle and discuss the co-generated data.

RESULTS AND DISCUSSION

Scientific Gains

The monthly topographic data were internally consistent (within a beach), and suggest there is no significant "operator error". The results have confirmed earlier inferences regarding the seasonality of Maine's beach volumes (Figure 3), although the onset of winter erosion and summer accretion is offset from the calendar year (Figure 3; HEINZE, 2001). Overall, most of the beaches displayed unexpected net accretion during the first 2 years of study (Figure 4), but this appears due to the relative frequency of the three major types of meteorological/oceanographic

events observed (HEINZE, 2001). Frontal passages and southwest storms lead to upwelling and sand movement onto beaches (northward) (Figure 5); only northeasters consistently remove sand from beaches through downwelling. A disproportionate number of southwest storms and frontal passages lead to beach accretion (HEINZE, 2001).

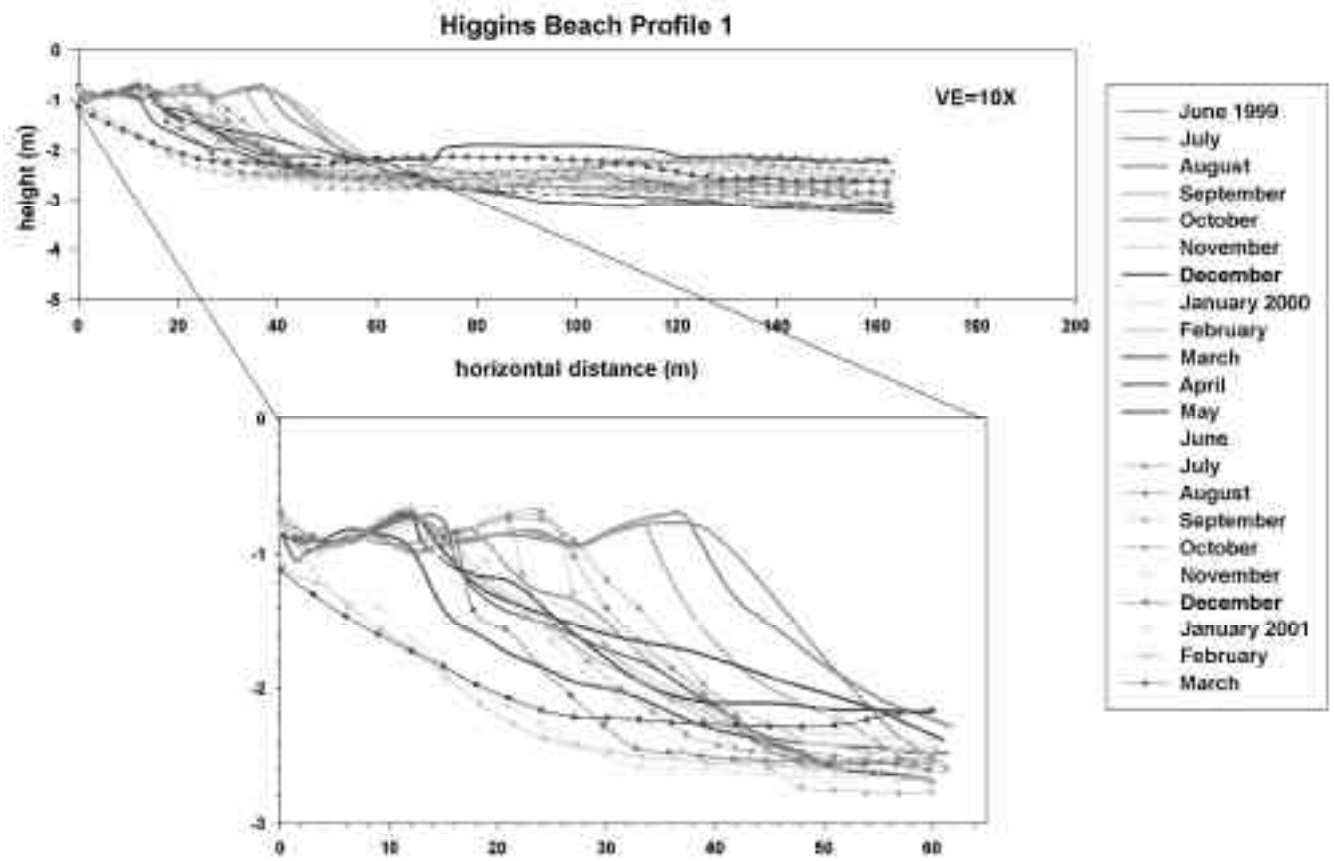

Figure 3. Beach-profile data from Higgins Beach, Maine (from Heinze, 2001). Separate box provides legend for volume changes.

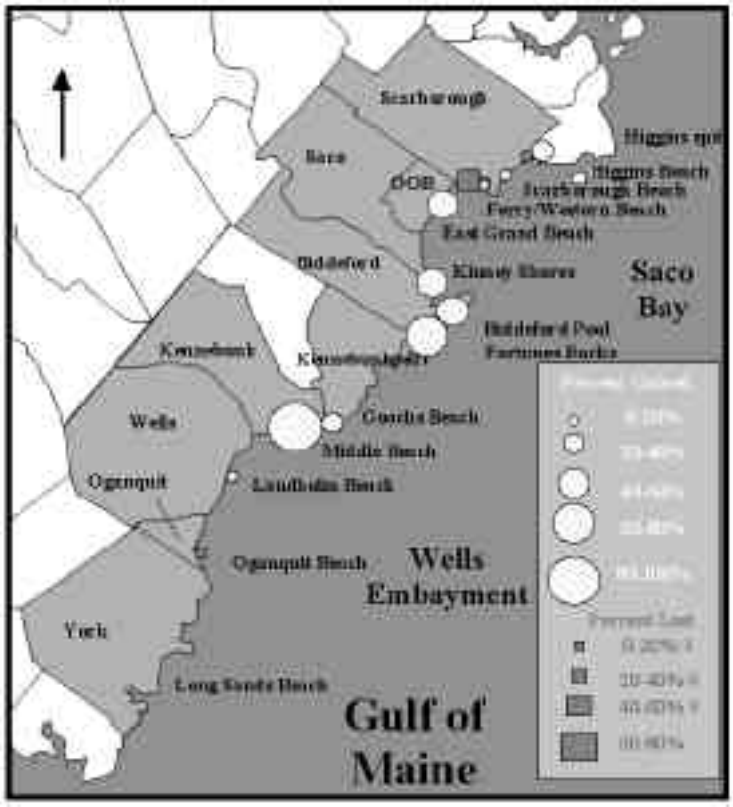

Figure 4. Volume change during the first year of beach profiling in southern Maine. Gain or loss is with respect to the initial profile line that was assigned a width of 1 m for calculation purposes (from Heinze, 2001). These beaches have generally experienced erosion and retreat since the early 1900's (Nelson, 1979).

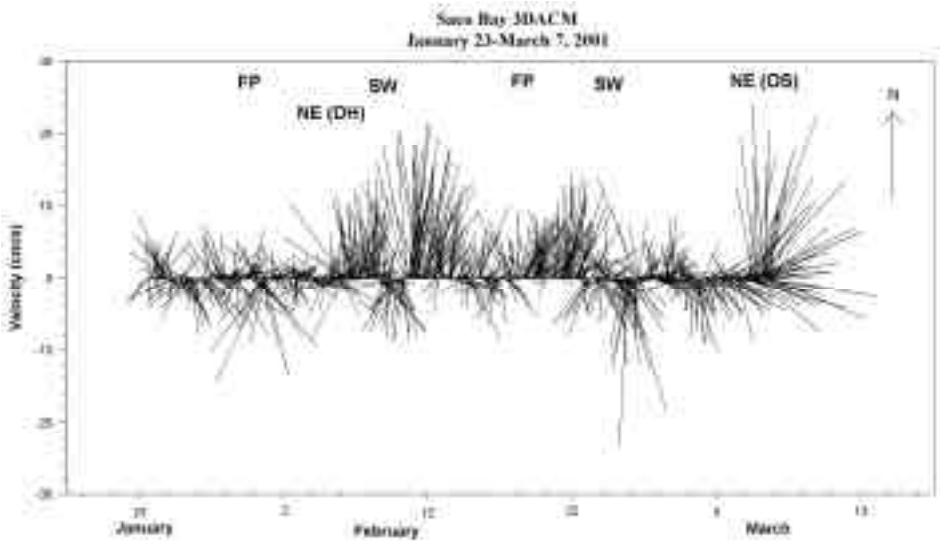

Figure 5. Time series of shoreface currents in Saco Bay. Vectors are hourly 4-minute averages of 15 second averaged burst data a 1 Hz (1 m above the seabed in 21 m depth). FP= frontal passages; NE (DH) = northeast storm, direct hit; SW= southwest storm, NE (OS) = offshore northeast storm. Vectors point in direction water moved. Dominant movement to the north (top) during southwest storms led to beach accretion (from Heinze, 2001).

During the project, a beach replenishment event began in the Wells Embayment. Following the progress of this action through the topographic response of impacted beaches to seasonal storms will provide guidance in the future when the relative merits of such practices are weighed against the costs.

Although it is too early to reach a conclusion, we are also beginning to see consistently different behaviors of beaches with and without seawalls. Undeveloped beaches experience greater volume changes than beaches with seawalls that extend onto the foreshore. We have not yet evaluated a "large" storm, however, and so do not yet fully appreciate the range of volume variability the beaches experience.

Public Outreach/Education

Public education was provided in: 1) formal lectures to the group at the start of the program, 2) private instructions to the individual profile teams, 3) web site interpretations, 4) the annual "State-of-Maine's-Beaches" meeting, and 5) an annual report. Through these mechanisms, we have begun to educate homeowners about how beaches operate, especially during storms, and how scientists utilize field data. We have also begun to see a reduction in the tension between scientists and property owners. For example, no new laws regarding beaches were introduced in the Maine Legislature during the past two years.

More than 150 volunteers have been involved in the project, including property owners, "beach strollers", local high school/junior high teachers and students, and a girl scout group. At the request of the volunteers, we have expanded to 14 beaches, with others in the process of being added. Some volunteers have dropped out, but they were replaced by others; we consistently have more volunteers than we can place on teams.

Information concerning this project has extended beyond Maine's borders. In Massachusetts, teams have begun a similar program of measurement (O'CONNELL, 2001). Plans are presently under discussion to set up a joint web site between the two areas and to coordinate profiling dates (O'CONNELL, personal communication).

The Maine Beach Profiling Project is one of the first such efforts to display results on a web site. The site has been received with much enthusiasm. The volunteers can see the results of their work and make interpretations of what is happening along the beaches they are monitoring. Town officials and state planners can access the site when making decisions concerning coastal property and beach replenishment issues. The data will also serve as a repository for scientific use.

Summer Conference

The summer meeting helped to raise awareness at the State and local level of the need to address management issues on Maine's sand beaches. Over 200 people attended the first conference including beach monitors, state officials, municipal officials, shore residents, teachers, students, scientist and non-profit organization members, in addition to many others. Presentations were given on the geology and beach management practices of Maine. A panel of planners and town officials discussed regional beach management initiatives. In addition, the results of the past year of profiling for each individual beach were displayed in a poster session. Volunteers stood alongside the posters of their beaches to discuss the scientific results, as well as their personal observations. Evaluations filled out by the conference attendees concluded that the beach monitoring efforts should continue in the future. The event received extensive media coverage throughout southern Maine. Since the beginning of the project, more than 12 newspaper articles have been written. At the summer conference, there were three television stations and a radio program airing information. Two newspapers, including the largest in Maine, had front-page articles (MURPHY, 2001). During the conference, interviews given by the principal investigators and a handful of volunteers were later shown on the evening news. In addition to media coverage, numerous public presentations have been made on the profiling project, particularly at the scientific level.

In summary, we believe the Maine Beach profiling Project could be of value in many other locations where long-term profiles are needed, and better relations between scientists and the public are desired.

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