

Marine Extension Bulletin

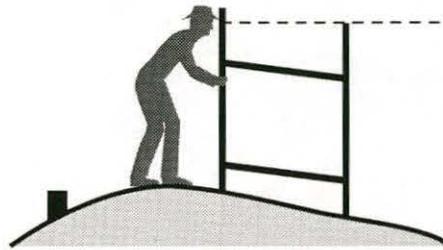
From the Woods Hole Oceanographic Institution Sea Grant Program

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Beach and Dune Profiles:

An Educational Tool for Observing and Comparing Dynamic Coastal Environments

Beaches and dunes are in constant motion, continually changing shape and shifting position in response to winds, waves, tides, relative sea level, and human activities. The most significant changes occur seasonally and following storms. During summer, beaches are generally higher and sandier than they are in winter. During the winter, the 'missing' sand moves from the beach to nearshore areas to form sandbars. This happens as a result of changing wave shape due to more intense storm activity. During spring and early summer, or following a storm, the sand in the nearshore region moves back toward—and eventually attaches to—the beach. Once on the beach, the finer sand grains are moved by wind action to form higher, wider sand dunes. These seasonal and storm-related interactions and changes in the form, volume, and position of beaches, dunes, and nearshore areas produce what is known as 'dynamic equilibrium' (Figure A).



Emery Rod Method for obtaining beach and dune profiles.

Beach and dune profiling is one way to obtain information about seasonal and storm-induced beach and dune shapes. Comparing season-to-season profiles and profiles taken before and after a significant storm clearly illustrates the important changes taking place along the shoreline and how quickly coastal landforms change.

There are several methods for obtaining beach and dune profiles, and each has its advantages and disadvantages. The U.S. Army Corps of Engineers has published descriptions of each method

(see references). One of the simplest, rapid, and inexpensive methods is known as the Emery Rod Method, named for a former Woods Hole Oceanographic Institution (WHOI) geologist, Kenneth "K.O." Emery.

Emery Rod Construction

Emery Rod construction is quite simple. Necessary components include four wooden rods, each 1-inch square and 5 feet in length. Two rods are painted one side only with alternating bright colors (such as red and white), with each block painted in increments of tenths of feet, or in inches or centimeters, beginning at the top. The remaining two rods are connected to the painted rods (with bolts and wingnuts) to form a parallelogram (Figure B, p. 2).

NOTE: To prevent the rods from sinking into the sand and thus giving inaccurate elevation readings, it is recommended that 'foot pads,' made of small discs of wood or large bottle caps, be attached to the bottom of the two vertical rods.

Beach and Dune Profiling How-tos

Setting the Permanent Monument and Profile Stake

The most active and changing part of the dry beach system is the area slightly landward of the foredune crest and seaward to the surf zone (Figure C, p. 4). As

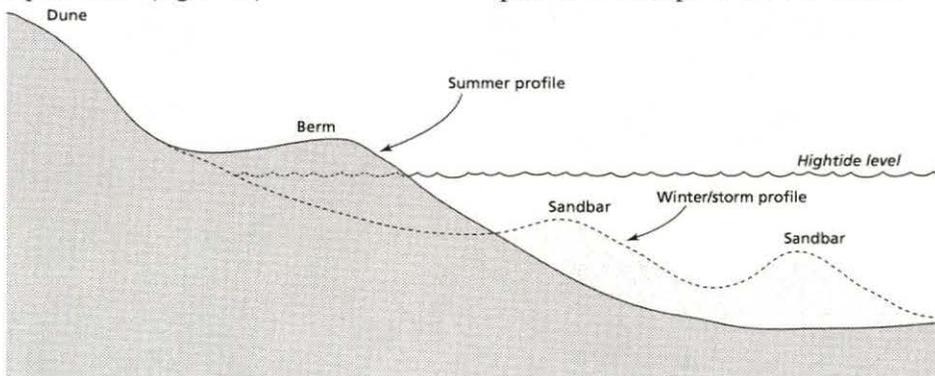


Figure A: Typical summer and winter beach and dune profiles.

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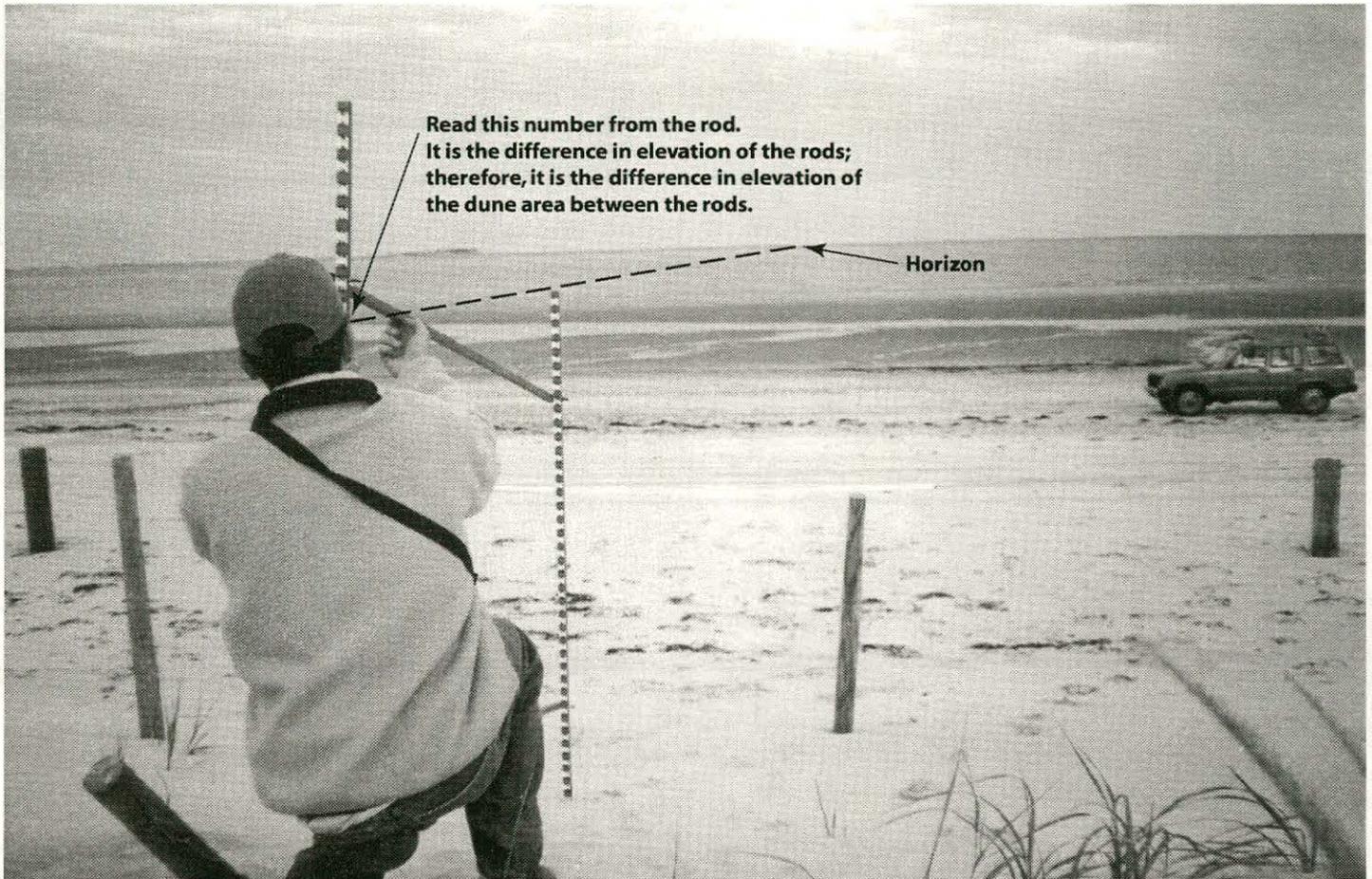


Photo by Jim O'Connell, WHOI Sea Grant

Figure B: Dune and beach profiling using modified Emery Rods.

such, it is a good place to conduct profiles. It is very important to establish a point of reference—a fixed point that can be easily relocated during future visits—in order to record seasonal and storm-related changes.

NOTE: To ensure a reliable reference point, we recommend installing a permanent monument in the back, stable area of the dune (*Figure C*). A 6-foot long wooden stake, measuring 4 inches square, would serve as an inexpensive and simple permanent monument.

The next step in conducting an Emery Rod profile is to install a profiling stake. Using this profiling method requires that the horizon be visible. With the horizon in view, install a profiling stake just landward of the foredune crest (*Figures B & C*). A wooden stake or copper pipe can

serve as a profiling stake; it should be at least 5 feet long and driven into the dune with approximately 1 foot of the stake exposed. This is the point from which most profiles will begin.

NOTE: Only on the rare occasion that a portion of the backdune has changed or if the profiling stake has been lost (perhaps due to a major storm), will it be necessary to repeat the profile from the permanent monument to the profiling stake location.

Obtaining Dune and Beach Elevations

Once the permanent monument and profiling stakes have been established, it is time to record various elevations and measurements. Recording this information is best done on a data sheet. An example of a beach profile data sheet is

included in *Attachment 1*. Some examples of measurements to be recorded include:

- the distance from the top of the permanent monument or profiling stake to the sand surface
- the geographic coordinates of the monument and stake (using a compass for triangulation* or GPS), and
- the compass bearing of the desired transect

*Triangulation is obtained by taking compass bearings from your stake to three easily observable objects, such as a water tank, transmission tower, or roof chimney, etc.

NOTE: Triangulation or GPS data will allow you to easily relocate your markers and will allow you to plot your

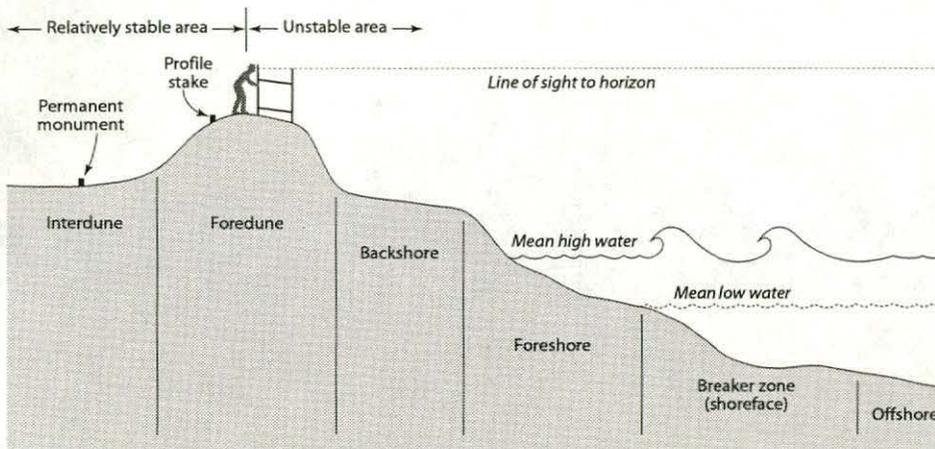


Figure C: Terms describing a typical dune and beach profile. Note the location of the permanent monument and profile stake.

transect locations on a topographic map, nautical chart, or orthophotograph.

Most likely, the horizon will not be visible from the permanent monument. To obtain the backdune profile for the area between the permanent monument and profile stake (*Figure D, p. 4*), a standard surveying technique is required. One simple option is to attach a sighting level to the top of the back rod. Looking through the sighting level to the front rod, read the number on the front rod. This number represents the dune elevation change between the rods. An inexpensive sighting level can be purchased at most hardware stores for approximately \$20. Another simple method is to string a taut line between the two vertical poles and suspend a line level from the string. When the line is taut and level, read the numbers from each rod where the line intersects the poles. The difference in elevation between the rods, and thus the dune elevation change between the poles, is the difference between the numbers read from each rod.

Once the initial elevations have been recorded, it is time to record data for the area seaward of the profiling stake, where the horizon is visible (*Figure B*). For the first reading, place the back Emery Rod against the profiling stake, making sure the rods do not sink into the sand and that the rods are vertical. A

one-ounce fishing weight or plum-bob can be hung from the side of the back stake with a cup hook to ensure that they are vertical. Standing behind the landward rod, line up your eye with the top of the lower of the two rods and the horizon (*Figures B and C*). This imaginary line-of-sight will intersect one of the two rods. Note the elevation number where the line-of-sight intersects the rod. The difference represents the elevation change of the dune or beach between the two rods. If the number came from the front rod, the slope went up and should be recorded as a positive number. If the number came from the back rod, the slope went down and should be recorded as a negative (*see example, Figure C*). Always make sure a plus or minus sign is recorded. (This technique is prone to cumulative error. If one number is recorded incorrectly, then all subsequent numbers for the profile will be affected.)

To obtain the next reading, move seaward and place the back rod in the same location previously occupied by the front rod, and repeat the line-of-sight step outlined in the previous paragraph. Continue this sequence all the way to low water, or preferably to wading depth to obtain as much of the profile as possible. (To capture the profile of the winter or storm-derived sandbars, one would have to go into the

breaker zone or farther.)

As you record the profile numbers along your transect, it is useful to record other interesting beach and dune features on the profile data sheet. Things worth noting include the seaward edge of dune vegetation, wrack lines, wet/dry interface, and low water line. Also record vegetation type and density and noticeable grain size changes (sand, pebble, cobble) along the beach and dune.

NOTE: Whenever possible, arrange to take profiles at low tide, preferably at the lowest tides of the month, to get the maximum profile distance. Also note the time of high tide and its published elevation on the data sheet, and record the time you reach low water. (Tide charts are available from most marine supply stores or bait shops.)

Graphing the Profile

Once you have documented the elevation changes along your transect on the profile data sheet, you are ready to graph the profile. This can be done manually (on graph paper) or by using computer software. *Figure D* and the accompanying *Sample Profile Data Sheet* in *Attachment 1* represent an actual beach and dune profile taken at Rexhame Beach in Marshfield, Mass., and graphed using Microsoft Excel. Note that the profile begins at elevation 13.4 NGVD. This is because the top of the permanent monument was surveyed at elevation 14.4 NGVD and the sand surface was 12 inches down from the top of the monument making the beginning sand surface elevation at 13.4 NGVD. Knowing the beginning elevation of your profile enables you to compare your results with published tide and storm wave heights.

Comparing Dune and Beach Profile Changes

While obtaining dune and beach profiles at the peak of each season is optimal, at least two are needed for comparison: one in winter and one in summer. This allows for the observation

of dynamic seasonal changes in the beach and dune. Conducting a profile following significant storms is also recommended to get a sense of the dynamic response of the beach and dune to storm waves, winds, and currents. Be quick in obtaining post-storm profiles, however. Research has revealed that beaches can recover quickly following a storm. Geologists at the U.S. Geological Survey, for example, discovered that beaches at the Cape Cod National Seashore recovered to pre-storm conditions within approximately one week.

While conducting profiles from the same transects helps yield both a visual and quantitative understanding of the dynamic nature of beaches and dunes, obtaining profiles from different areas will reveal interesting relationships, such as slope variation based on sediment grain size. For example, cobble or coarse-grained sandy beaches are generally much steeper than fine-grained sandy beaches. Reasons for this include shape differences of the beach material and the unique interlocking characteristics of large vs. small grain sizes. In one study, for example, the slope of cobble beaches with a grain size of 65-256 mm measured between 19-23 degrees, while the slope of a sandy beach with a grain size of .25-.5 mm measured approximately 5 degrees. To test this hypothesis, conduct profiles at both cobbled beaches and sandy beaches and compare your results.

In-depth Investigation

Dune and beach profiling can be an essential part of a dune rebuilding or dune and beach restoration project. By taking one additional profiling measure—surveying the top elevation of your permanent monument—a dune and beach can be designed or engineered to a specific known elevation. Often, this is done in an attempt to prevent or minimize storm wave and surge overtopping, or to provide profiles

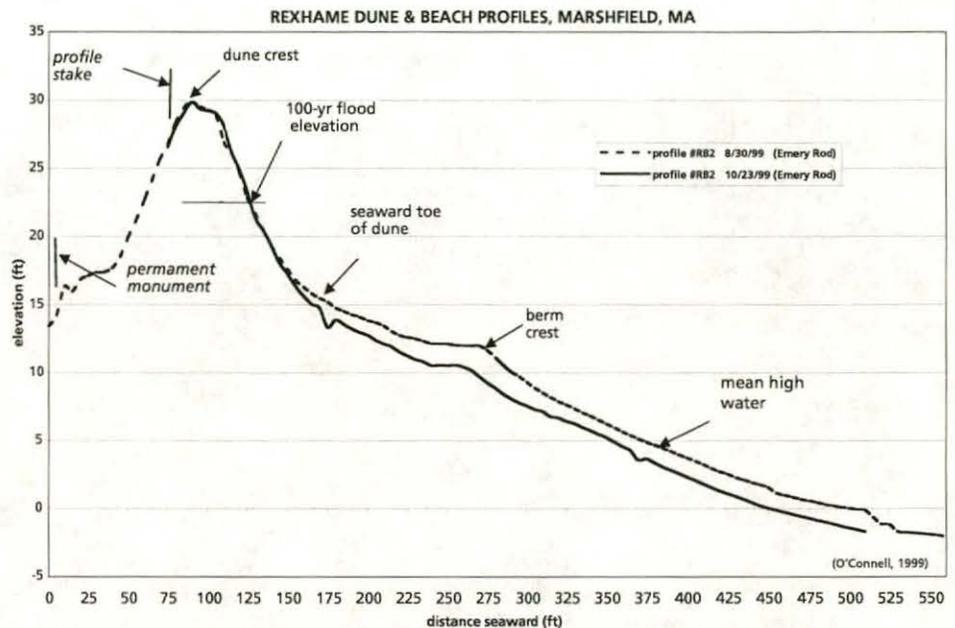


Figure D: REXHAME dune and beach profiles measured by modified Emery Rods.

to a local conservation commission as a condition for seawall or revetment construction. This will allow comparison of your dune profile elevations to published storm surge and wave heights. In *Figure D*, note that the dune crest is higher than the 100-year flood elevation. Thus, the dune may provide some protection to landward areas. Dune volume is also critical for storm protection. Surveying the top of the permanent monument need only be done once. Contact a local engineer to survey the top of the permanent monument, if desired.

In the classroom, students may be interested in learning about high and low water elevations and elevations of various storms, including the so-called 100-year storm elevation. (The 100-year storm elevation is defined as a storm-related ocean elevation having a 1 percent chance of occurring in any given year.) This information can be obtained from community flood insurance rate maps and accompanying flood insurance studies, usually available for viewing at the office of the town building inspector.

References

- Emery, K.O., 1965, A Simple Method of Measuring Beach Profiles, *Limnology & Oceanography*, V.6, No. 1, pps. 90-93.
- Lawlor, E, 1992, *Discover Nature at the Seashore*. (Stackpole Books)
- U.S. Army Corps of Engineers, 1997, *Beach and Nearshore Survey Technology, Coastal Engineering Technical Note, CETN II-38* (available by calling the Corps, (334) 690-3139).

This bulletin should be referenced as follows: WHOI Sea Grant Program, 2001, *Marine Extension Bulletin*, "Beach and Dune Profiles: An Educational Tool for Observing and Comparing Dynamic Coastal Environments," by Jim O'Connell.

For assistance in planning a beach and dune profiling program, or to obtain information about coastal processes, contact the WHOI Sea Grant Program or the Barnstable County Cape Cod Cooperative Extension Service.

BEACH PROFILE DATA SHEET

TOWN/BEACH: Marshfield/Rexhame Town Beach **PAGE:** 1 of 5

Transect # RB2 Date: 8/30/99 Name: Jim O'Connell

Top elevation of permanent monument (optional) 14.4 feet NGVD

Sand surface from top of permanent monument 13.4 feet NGVD

Top elevation of profile stake (optional) 29.29 feet NGVD

Sand surface elevation at profile stake 28.29 feet NGVD

Geographic coordinates: permanent monument _____

Geographic coordinates: profile stake N42o-07'-22.5" / W70o-40'-41.3"

Transect compass bearing N89E

Distance From Perm Monument (ft)	Rod Reading (feet & tenths of feet)	Cumulative Elevation (add previous rod reading)	Remarks: I surveyed the top of my permanent monument at 14.4 NGVD. The sand surface was 12 inches down from the top of the monument. Thus, I began my profile at 13.4 feet NGVD (see Figure D).
XXXX	XXXX	13.4	sand surface elevation at <i>permanent monument</i>
5	+0.8	14.2	
10	+2.1	16.3	
15	-0.35	15.95	
20	+0.85	16.8	
25	-0.25	17.1	
30	+0.25	17.35	
35	+0.3	17.65	
40	+0.85	18.5	
45	+1.4	19.9	
50	+1.25	21.15	
55	+1.35	22.5	100-year flood elevation (obtained from Flood Ins Study)
60	+1.6	24.1	
65	+1.52	25.62	
70	+1.12	26.74	
75	+1.55	28.29	<i>Profile stake</i>
80	+1.1	29.39	
85	+0.45	29.84	Dune crest (top elevation of dune): see Figure D
90	-0.32	29.52	
95	-0.25	29.27	
100	-0.37	28.9	
105	-2.0	26.9	

NOTES: The highest point of the dune ('dune crest') is at 29.84 NGVD. The top is above the 100-year flood elevation. Therefore, my dune may prevent storm wave overtopping and thus some degree of flood protection to landward areas (see Figure D).

(WHOI, Sea Grant, Jim O'Connell)

Attachment 1: Profile Data Sheet' (page 1 of 5) used to Plot Figure D. This page shows the dune elevations for the first 105 feet of the profile from the Permanent Monument.

