Fire Island

National Park Service
U.S. Department of the Interior

Fire Island National Seashore
Long Island, New York

Shape-Shifting Shoreline

A Beach Dynamics Activity

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Program Outline: *Shape-Shifting Shoreline*

Program Theme:

The beach is ever changing. The wind and the waves sculpt the sand on many different time scales, from the daily tides to seasonal storms. While the beach may not be the same from one day to the next, there are patterns of change to be discovered.

Tangible resources:

- **Marine habitat**
- **Ocean**
- **Sand**
- **Waves**
- **Wind**
- **Tide**

Intangible/universal concepts:

- ***Power:* The power of wind and water to move sand along a beach**
- ***Protection:* The protection of the mainland from storms**
- ***Cycles:* The enduring cycle of erosion and accretion**
- ***Change:* The shore is dynamic and ever-changing**
- ***Peace:* The peacefulness of the beach**
- ***Clean*: The cleansing power of water**

Park Interpretive themes:

1. **Nature's rhythms of change and renewal**
2. **Island resources from ocean to bay**

Program Goal:

To enhance understanding of how barrier beaches change through time, to cultivate an appreciation for the varied benefits of a healthy barrier island and to foster sustainable interactions with this ever-changing environment.

Program Objectives:

At the end of this program, participants will be able to:

- **Identify the major features of the beach and dune system**
- **List two factors that change the shape of the beach**
- **Draw a typical beach profile**

Program Content:

Target Age Group: Grades 8-12, Adult.

Program Overview: This activity explores the slope and shape of the beach using surveyor's profiling equipment. Understanding these parameters and how they change through time is important to defining our roles living and recreating in a coastal area. Students will work in teams of 4 with individual roles to measure the elevation of the beach along a transect.

Materials:

Instructions & Data Sheets [at end of packet]
Pencils
1-Sighting Level*
1-Tripod*
1-Graded Rod*
1-Tape Measure*
1-Compass*
5-Field Guide to Beach Features + Surveying Manual*

* Equipment may be available for your field study at Fire Island National Seashore. Inquire at 631-687-4780 for availability and terms.

Student Roles: Divide the class into groups of 5. Each member of the group will be assigned different roles and responsibilities.

Navigator:	Use the compass to determine the heading and lay out the Tape Measure, help Rod Holder determine when Graded Rod is vertical
Surveyor:	Look through the Sighting Level and read out the elevation values from the Graded Rod
Data Recorder:	Record elevation values and distances on Data Sheets
Graded Rod Handler:	Hold the Graded Rod vertical and very still, move along the tape measure, read out distance values for Data Recorder
Naturalist:	Record the distances at which interesting features occur, sketch interesting features. Examples of interesting features: end of swash zone, wrack line (proxy for high water), scarp, change in sediment color

Methods:

Data sheets with team instructions are located at the end of this packet.

Once students have arrived at the study site, have been placed in groups and assigned roles, the activity takes approximately 30-45 minutes to complete.

1. **Follow the boardwalk to the ocean dune (see map) and walk down the stairs. The marker is on the ocean side of the western corner of the staircase.**
2. **Using the Tape Measure, the Navigator should measure the height of the marker above the sand surface. The Data Recorder should note this on the data sheet.**
3. **The Navigator should attach the Tape Measure to the hook on the marker and extend the Tape Measure down to the water line following a course of 175° (generally perpendicular to the shoreline).**
4. **Set up the Tripod near the 50 ft mark on the Tape Measure – make sure the Tripod is about 6 ft to the east/west of the Tape Measure (see diagram). The Tripod should be set up so that the top is at a comfortable level - at or just below eye level - for the Surveyor, taking into account the additional height of the Sighting Level.**
5. **Attach the Sighting Level to the Tripod, adjusting the leveling knobs to center the bubble in the bull's-eye level. Once level, take care to not disturb the legs of the Tripod which could change the level of the set-up.**
6. **The Surveyor should test the movement of the Sighting Level; it should swivel smoothly and remain level. Adjust leveling knobs as necessary; this is the final opportunity for level adjustment.**
7. **Graded Rod Handler should set up for the first data point at the marker (distance 0 ft), making sure to keep the Graded Rod vertical. Read out the distance to the Data Recorder to write on the Data Sheet.**
8. **The Surveyor should swivel the Sighting Level to bring the Graded Rod into the field of view, adjusting the focus knob so the numbers are sharply in focus. Read out the value located at the cross-hair in the field of view (see diagram) for the Data Recorder to write on the Data Sheet.**
9. **Repeat steps 7 & 8, with the Graded Rod Handler moving 5 feet further along the Tape Measure for each data point. The Graded Rod Handler and the Naturalist should consult on any topographic features (like a scarp) that do not fall on a 5 foot interval, taking extra points as needed.**
10. **Continue at 5 foot intervals down to the top of the swash zone. If the beach is protected by life guards, adventurous students may continue further into the water, using caution with regard to wave and rip current activity and water temperature. Data Recorder should note the distance and elevation at which the top of the swash zone occurs as well as the time and day the survey was conducted.**
11. **Follow the instructions on the Data Sheet to process and graph the raw data.**

Putting it all together:

Complete calculations and graph data to see beach profile and compare to previous survey data/graphs if available. Discuss the shape of and changes in the beach profile.

Questions that can be explored:

- What features on the beach can be seen in the data?
- How has the beach changed over time? (if previous data is available)
- How do different parts of the beach change?
- Why might different areas of the beach change over different time scales?
- What would you expect to change if a storm came by overnight?
- How do you imagine the barrier island or beach would change if sea level rose? What if it dropped?
- Why might it be important for builders, coastal residents, fisherman, and people recreating on beaches to know about how different parts of the beach change over time?

Background Information:

We use beach profile surveys to track the way the beach changes through time. By starting a survey at the same point every time and conducting the survey along the same compass bearing, we can directly compare surveys and quantify changes in the beach. Regular beach survey programs are designed to track long-term changes in beach shape and volume and help land managers and homeowners decide how best to protect the shoreline. Beach surveys can also show the effects of storms on the beach and the time-scale of beach recovery.

Beaches are most dynamic where the waves wash up over the course of a daily tidal cycle, constantly moving sand up and down the beach and along the shoreline through the actions of the crashing waves and longshore transport. Further up the beach, the berm, which is generally above the daily reach of the tides, will change during conditions where waves are more energetic and reach a higher elevation on the beach. The storms that change the berm do not necessarily need to pass directly over the beach. Even storms that remain far offshore can increase the wave energy enough to move sand temporarily offshore. Sand that is removed from the beach is stored offshore, usually in a structure called an offshore bar. At low tide, you may be able to see evidence of an offshore bar by the presence of a secondary line of breaking or choppy waves past where the waves are breaking and washing up on shore. A picture of this is included in the Beach Dynamics Field Guide.

The equipment we use to conduct beach profile surveys today has its roots in ancient cultures. The Egyptians used land surveys for taxation as well as to build impressive architecture like the pyramids. The Greeks developed sophisticated precursors to modern equipment, and the surveys we conduct today depend on the advancements made in geometry, astronomy, geophysics and technology in the last four thousand years. For example, the sighting level we use in this exercise is a close cousin to equipment used during the exploration of North America and the rest of the globe.

Figure 1: Surveying Level being used in Glen Canyon in 1921 (NOAA image).

To compare elevations between locations or through time, we need to create a standard to which we can compare all other elevations. In other words, we need a *datum*, or a common reference point. Most elevations on Earth are measured in reference to sea level. There is a long history of surveying, done both by people and satellites, that has gone into determining sea level, which is challenging because sea level changes daily because of tides, monthly over the lunar cycle, and over much longer time scales relating to global temperatures and global ice cover. When we talk about sea level, we usually are talking about *Mean Sea Level* which is defined as the "still water level", or the level the water would be if we stopped having tides and waves. (See Web Resources Understanding Tides chapter 10)

Sea level is a complex phenomenon that changes over a wide range of time scales. One of the concerns we have today is the link between rising sea level and global climate change. Sea level rise is a particular concern for coastal communities and habitats, like Fire Island National Seashore. The shape, location and movement of barrier islands is linked to sea level, even though it isn't obvious, barrier islands are moving towards the main land as the sea rises. The rising sea over the last 18 thousand years is an integral part of Fire Island's story. Prevailing research suggests that the barrier islands on the south shore of Long Island formed as sea level rose after the last ice age, gradually shifting to their current location. See the next section for a brief description of the recent geologic history of Long Island and the formation of Fire Island.

Beach profiling, like that done in this activity, will document future changes in the beach and larger barrier island with regard to sea level rise and any changes in storm energy. With beach profiling data, managers can decide on the best course of action for living and recreating sustainably on a barrier island like Fire Island.

The Recent Geologic History of Long Island:

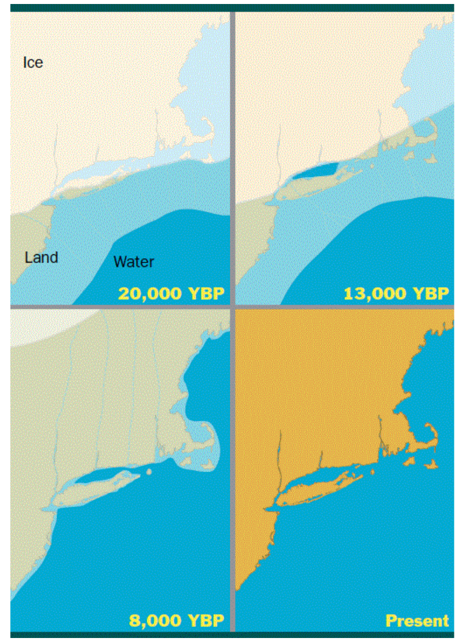


Figure 2: Sea level changes since the last ice age (Sea Grant Publication).

A series of four time points in Long Island's recent geologic past. The coloring shows the extent of ice in the lightest shading, what was land in the medium blue shading, and the location of liquid water in the dark blue shading.

20,000 years before present (YBP) was the height of the last ice age. The ice is shown at its furthest extent, reaching down to the middle portion of Long Island, and in fact, this ice is responsible for the present form of Long Island. The ice, as it was growing, pushed everything, sand, rocks, trees, in its path forward, much like a bulldozer.

13,000 YBP the climate is warming and the ice begins to retreat. When the ice began receding, the debris transported in front of the ice was left in place. This is known as a glacial moraine. There are two of these that form the highest points of Long Island, the Harbor Hill moraine forms the north shore and the Ronkonkoma moraine runs through the center of the island. The Long Island Expressway (I-495) roughly follows the crest of the Ronkonkoma moraine. This time period we also see what will be the Long Island Sound on the north filling with fresh melt water.

8,000 YBP sea level continues to rise as the last of the ice recedes and melts, and the coast begins to approach the current form of the shoreline. Long Island Sound is connected with the ocean, but the bays, like Great South Bay, are still dry. There is evidence of sand waves as far out as 4 miles offshore of the present coastline that may have contributed to ancestral barrier islands that gradually migrated closer to their present location. Barrier islands move as sea level rises by a process of overwash and inlet formation. Sediment is moved from the ocean side of the island to the bay side during storms that either bring water and sediment over the top of the dunes or break through the dune and form a temporary inlet. This process, over hundreds to thousands of years, move the barrier island to keep up with the rise of sea level.

Present Long Island retains the impact of the last ice age; from the moraines that shaped the island, the barrier island chain that is now close to the mainland, kettle lakes formed from ice water (Lake Ronkonkoma and Lake Success). The melting ice also created an outwash plain south of the moraine, which explains the present day differences in coastline between the north shore (rocky, cliffs), and the south shore (sandy, gentle slope). Fire Island is part of a chain of barrier islands formed from the outwash from the glacier that began forming 8,000 years ago.

How To Process Your Data

In order to compare surveys over time, especially when different groups are conducting them, there needs to be a standard reference point. In this case, we have defined the distance (or x-axis) zero point as the western corner of the staircase in the Wilderness Area. The elevation of the starting marker has been determined using a high resolution GPS unit. By using the elevation of a permanent feature, we can then do a little processing of the raw data collected and determine the real elevation of the beach profile and compare it to other processed survey data.

The raw data collected is relative to the height of the Sighting Level above the sand surface and the elevation of the sand surface itself. We don't need to measure the height of the Sighting Level, since we are not changing the position of the level over the course of the survey, and we are using a fixed reference point.

Point #	Distance (ft)	Rod Reading (ft)	Elevation (ft)
1	0	2.31	4.69
2	5	2.52	4.48
3	10	2.62	4.38
4	15	2.84	4.16
5	20	2.84	4.16
6	25	2.94	4.07
7	30	3.03	3.97

Figure 3: Example data sheet.

An example data sheet can be seen to the right. The rod readings (in blue) are measured by reading the value on the rod that is in the center of the Sighting Level's crosshairs (shown below). The field guide has a more comprehensive explanation of how to read the values off of the rod. The values read off the rod indicate the height of the rod relative to the height of the Sighting Level. In our example, the first point at a distance of 0 feet, the Sighting Level was 2.31 feet above the base of the rod. The marker in the example has an elevation of 5.19 feet above sea level. Since the marker is above the sand, we need to account for that change in elevation. The sand was measured as being 0.5 feet below the marker, so the sand surface is at an elevation of 4.69 feet above sea level. The mark read at that first point, which was taken at the marker (0 feet in distance), was 2.31 feet. The Sighting Level reads a value for the height above the sand surface. We can convert this to an elevation by adding the 2.31 foot reading to the sand surface elevation of 4.69 feet – the Sighting Level was reading a value that was 7.00 feet above sea level. This value is what we use calculate the rest of the elevations. Subtracting each rod reading from the 7.00 foot value, we get the elevations (in red) in figure 3 above.

Figure 4: Rod through the Sighting Level. The value shown here is 2.31 ft, the first reading in the example data sheet.

By graphing the Distance (in grey) versus the Elevations (in red), we can see the shape of the beach. We can also add the data collected by the Naturalist, most importantly, the distance of the high water mark. We use the position of the daily wrack line as a proxy for high water. Find the point on the graph where the line of elevations hits the distance recorded for the wrack line and draw a horizontal line at that elevation as a visual marker for high water. Figure 5 shows a graph of the example data (the solid grey line) and the high water mark (the dashed red line).

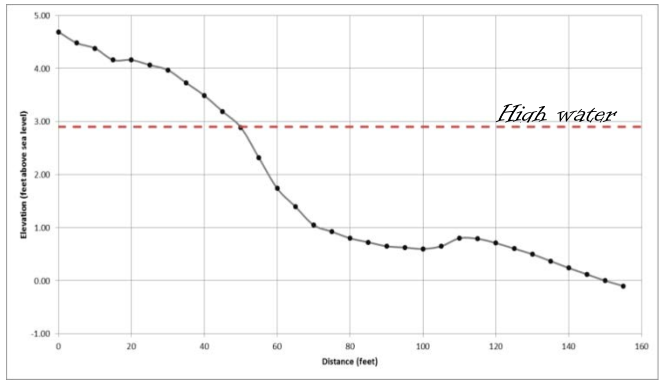


Figure 6: A graph showing beach elevation (solid grey dots) and high water mark (dashed red).

One survey gives you the state of the beach at one point in time. By plotting two different surveys on the same graph, we can investigate changes in the beach over time. Figure 6 plots a second, previous, survey alongside the survey we just processed. Comparing these two profiles, we can see some trends in this data. The area of the beach that is above the high water mark hasn't changed much between these two surveys, but the area of the beach below high water has changed markedly. Since the grey dot survey was performed after the green triangle survey, we can see that sand has moved onto the beach. In fact, the shape of the grey dot line shows a ridge below the high water line that is indicative of an offshore bar reattaching to the shore. Because the two surveys were processed relative to the same datum (the marker installed on the boardwalk), we can quantify these changes and look for longer trends through time.

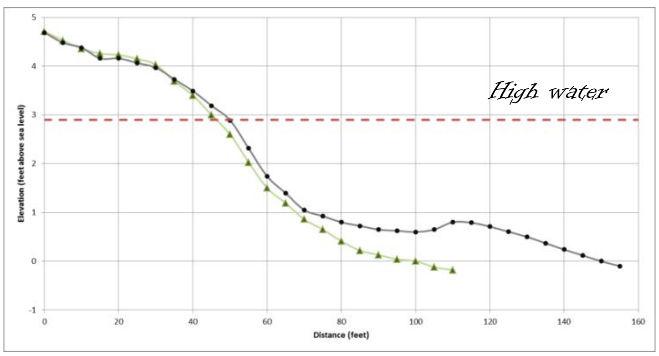


Figure 5: The same data as figure 5 with a previous survey added (solid green triangles).

There are two measures we can use to quantify changes in the beach through time. The first is the width of the beach. Because all surveys may not go down to the same elevation, we use the zero sea level mark as a reference point. If a survey does not reach zero, draw a straight line with the same slope as the last few points in your survey until it crosses the axis. You can then compare the distances at which the beach reaches sea level. The green triangle survey has a width of 100 feet while the grey dot survey has a width of 150 feet.

We can also compare the volume of sand above sea level. To calculate the volume of the beach, we take the area under profile and multiply it by a width of one foot – this gives us the cubic feet of sand in a slice of beach one foot wide. On the graph paper you plotted your data on, count the boxes that are under the profile, cutting off at the zero elevation line (see figure 7). Each box represents 5 feet in distance and

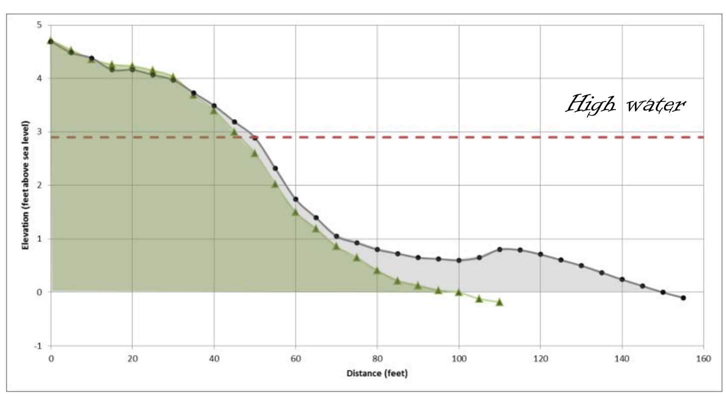


Figure 7: Profiles with area for calculating beach sand volume shaded.

0.2 feet in elevation, so each box represents 1 square foot of area. The grey dot survey has a volume of 263 ft^3 and the green triangle survey has a volume of 229 ft^3.

Hurricane Sandy and the Dunes on Fire Island:

On October 29, 2012, Hurricane Sandy made landfall on the coast of New Jersey. Despite being more than one hundred miles from the center of the storm, Fire Island's landscape was changed by winds gusting over 80 miles an hour and storm surge over ten feet[1].

During the storm, high water and large waves scoured sand from the beach and dunes, moving sand over the top of the dunes and, in some places, through the dunes and across the width of the island. The elevation of the beach and location of the dunes were changed, creating a beach that is lower and wider.

Storms do not cause sand to be lost from the island; instead they move sand in many directions, including offshore and across the island. Much of the sand moved offshore will gradually return and build up the beach. Beachgrass will help stabilize sand and naturally rebuild dunes in a more northerly position. Sand moved across the island during the storm helps make the island more resilient to future storms by increasing the elevation of the island interior and bayside. Sandflats created during the storm can develop into new marshland.

In two locations on Fire Island, storm flow carved out a channel and "breached" the island, allowing a free exchange of water between ocean and bay. One breach, located in Smith Point County Park, silted up naturally and was reinforced by the Army Corps of Engineers. As of the writing of this (September 29, 2014), the National Park Service, along with its partners in the breach contingency management team, is evaluating the other breach, in the Otis Pike Fire Island High Dune Wilderness, to determine if there is a need to intervene.

Storm recovery happens across a variety of timescales. In a few days after the storm, some sand begins making its way back up the beach, you may see rows of ridges reattaching to the beach. Weeks after a storm, sand continues to move back on the beach, building back the berm, dune fronts that had been sheared off begin to slump to a more stable slope and longshore transport fills in small breaches (ex. Smith Point breach). Months after a storm, vegetation recovers or recolonizes overwashes, stabilizing the sand. Years after a storm, dunes slowly continue to rebuild in areas that had been washed through. New storms, though, will set the clock back to an earlier stage.

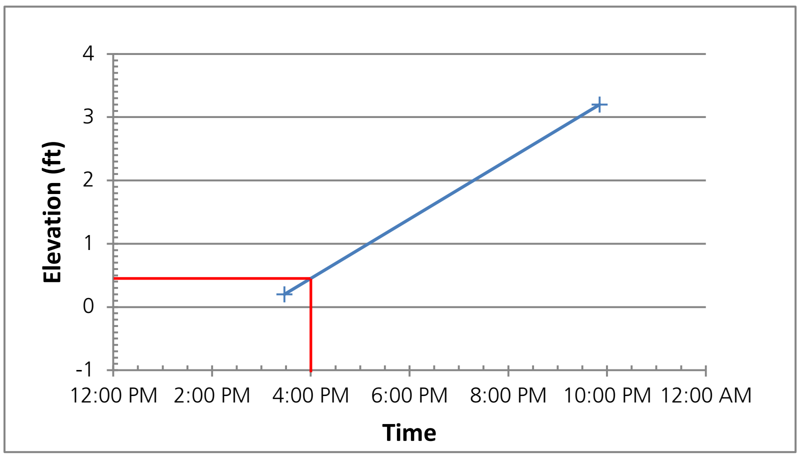
Impact on Activities

Many areas of Fire Island National Seashore, had boardwalk that was lost or damaged by the storm. In areas like the Otis Pike High Dunes Wilderness Area, where boardwalk may take time to rebuild, you will need to adapt the exercises in the *FINS Beach Dynamics Activity Series*.

[1] *Storm Surge* is the water height above normal astronomical tidal height, caused by a combination of lower atmospheric pressure from a storm system and water pile-up from wind action.

The *Shape-Shifting Shoreline* activity is the most storm-impacted activity in this series. The boardwalk that was the original "fixed" starting position is no longer in place and as of the writing of this addendum (September 29, 2014), the remaining boardwalk that could potentially be transformed into a starting position has not been made accessible yet. In the event that a "fixed" starting position cannot be set, choose a location near the toe of the dune (if present) to be the first data point. Processing the collected data to be meaningful elevations requires a little more effort than starting from a "fixed" location with a known elevation. There are two versions of the Data Recorder data sheet in this packet: the original version (#1) and an adjusted version (#2). The adjustments to processing involve these steps:

1. Note the time that the data point at the top of the swash zone is collected.
2. Using a tide table (available as a booklet from the Visitor Centers) determine the time and elevation of the high and low tides that are around your data point.
    a. Example: Saturday April 13 2013, low tide is at 3:28 pm with an elevation of 0.2 ft and high tide is at 9:51 pm with an elevation of 3.2 ft.
3. Plot these two tide points on a line graph and connect the two points with a straight line.
4. Draw a line up from the time recorded in step 1 and read the y-axis value where that intersects the line between the two data points
    a. Example: If the swash zone was measured at 4:00 pm, the elevation read off the chart indicates the swash zone was 0.45 ft above sea level.
    b. It is important to keep in mind that this method is only an approximate measure of sea level; tidal elevation does not change linearly with time and is too complex to model more accurately for this level of activity.



5. In the data calculations on the record sheet disregard existing steps for determining values A-D. Instead use the following steps:

X =	Elevation of swash zone	= _________ feet
Y =	Rod reading at swash zone	= _________ feet
Z =	X + Y	= _________ feet

To calculate the elevations from the rod readings, use the equation:

Z-Rod Reading=Elevation

Determining beach elevation in this manner, while only loosely related to actual sea level, you should still be able to compare different surveys, providing you can reliably start in the same location (ex. as determined by GPS).

Terminology and Resources:

Vocabulary Terms

Area
Berm
Compass
Datum
Elevation
Heading
Offshore Bar
Profile
Scarp
Sea Level
Tidal Range
Tide
Volume
Wrack Line

Web Resources

National Oceanic and Atmospheric Administration:
[Understanding Tides] *http://tidesandcurrents.noaa.gov/publications/Understanding_Tides_by_Steacy_finalFINAL11_30.pdf*
Intergovernmental Panel on Climate Change:
[Is sea level rising?] *http://www.ipcc.ch/publications_and_data/ar4/wg1/en/faq-5-1.html*
Coastal Ocean Action Strategies Institute (COAST Institute) at Stony Brook University:
[Active beach survey research] *http://www.msrc.sunysb.edu/~coast/*
Museo Galileo – Institute and Museum of the History of Science:
[General site] *http://catalogue.museogalileo.it/index.html*
[Greek surveying equipment] *http://catalogue.museogalileo.it/indepth/Diopter.html*
National Geodetic Survey:
[History of the NGS] *http://celebrating200years.noaa.gov/foundations/leveling/welcome.html*
[Image of surveying level] *http://celebrating200years.noaa.gov/foundations/leveling/image1.html*
National Museum of American History:
[Descriptions of equipment] *http://americanhistory.si.edu/collections/surveying/type.cfm*
Abraham Lincoln's National Museum of Surveying:
[Teachers resources] *http://www.surveyingmuseum.org/teachers-guide-to-surveying.html*

Instructions: *Naturalist*

Check off each step as it is completed.

Your job as a Naturalist is to provide the context for beach profiling survey. Make sure to note as much information that you think could be important for explaining why the beach is shaped the way it is.

1. **_____: Draw a sketch in a map view of the field site; be sure to include stationary features like the stairs as well as the position of the equipment that has been set up.**
2. **_____: Find and record the position of the daily wrack line – this will be used as a proxy for the location of the most recent high water level. Look for a line of seaweed, shells and other floatable debris. The line should still be reasonably intact if you look down both sides of the beach. You may see older wrack lines on the beach, but they will be drier and less complete.**
3. **______: Find and record the position of the end of the swash zone. Look for the furthest extent that the waves are washing up to at the time of the survey.**
4. **______: Record the position (and sketch where appropriate) of other interesting features on the beach. Examples include: older wrack lines, scarps, changes in sediment color.**

Data Sheet: *Naturalist*

Step 1: Draw a sketch of the field site (map view)

Step 2: Distance of the daily wrack line ____________

Step 3: Distance of the end of the swash zone ____________

Step 4: Other interesting features list/sketch below

____

____

____

____

____

____

Instructions: *Data Recorder*

Check off each step as it is completed.

1. _____ *Team*: Follow the boardwalk to the ocean dune (see map) and walk down the stairs. The marker is on the ocean side of the western corner of the staircase.

2. _____*Navigator*: Measure the height of the marker above the sand surface.

   Data Recorder: Record this information on the data sheet.

3. _____*Navigator*: Attach the Tape Measure to the hook and extend the Tape Measure down to the water line following a course of 175° (use the compass, but this heading is generally perpendicular to the shoreline)

4. _____*Surveyor*: Set up the Tripod near the 50 foot mark on the Tape Measure – make sure the Tripod is about 6 feet to the east or west of the Tape Measure (see diagram in manual). The Tripod should be set up so that the top is at a comfortable level – at or just below eye level – for the Surveyor, taking into account the additional height of the Sighting Level.

5. _____*Surveyor*: Attach the Sighting Level to the Tripod, adjusting the leveling knobs to center the bubble in the bull's-eye level. Once level, take care to not disturb the legs of the Tripod which could change the level of the set-up.

6. _____*Surveyor*: Test the movement of the Sighting Level; it should swivel smoothly and remain level. Adjust leveling knobs as necessary; this is the final opportunity for level adjustment.

7. _____*Graded Rod Handler*: Set up for the first data point at the marker (distance 0 feet), making sure to keep the Graded Rod vertical. Read out the distance to the Data Recorder to write on the Data Sheet.

8. **_____*Surveyor*: Swivel the Sighting Level to bring the Graded Rod into the field of view, adjusting the focus knob so the numbers are sharply in focus. Read out the value located at the cross-hair in the field of view (see figure 4) for the Data Recorder to write on the Data Sheet.**

9. **_____*Team*: Repeat steps 7&8, with the Graded Rod Handler moving 5 feet further along the Tape Measure for each data point. The Graded Rod Handler and the Naturalist should consult on any topographic features (like a scarp) that do not fall on a 5 foot interval, taking extra points as needed.**

10. **_____*Team*: Continue at 5 foot intervals down to the top of the swash zone. If the beach is protected by life guards, adventurous students may continue further into the water, using caution with regard to wave and rip current activity and water temperature. The Naturalist and the Data Recorder should note the distance and elevation at which the top of the swash zone occurs as well as the time and day the survey was conducted.**

11. **_____*Team*: Follow the instructions on the Data Calculations sheet to process and graph the raw data.**

Data Calculations [version 1]: *Data Recorder*

A = Marker Elevation (noted on marker) = __________ feet

B = Height of marker above sand = __________ feet

C = Rod Reading at 0 foot distance = __________ feet

D = *A* - *B* + *C* = __________ feet

To calculate the elevations from the rod readings, use the equation:

$$D - Rod\ Reading = Elevation$$

Once you have calculated your elevations, plot them on the graph paper provided.

E = High water mark distance = __________ feet

F = End of swash zone distance = __________ feet

On your plot of the beach profile, mark the distances for *E* and *F* and draw a horizontal line at the corresponding elevation, clearly indicating which line is for which item. See figure 5 or 6 for an example.

G = Width of the beach = __________ feet

The width of the beach is the distance at which your profile crosses 0 foot elevation. If your profile does not cross, use the last couple of points in your survey and, with a straight edge, draw a straight line through them, extending the line across the 0 foot elevation line.

H = Beach volume = __________ boxes * 1 ft * 1 ft^2
= __________ ft^3

The beach volume is the volume of sand under your profile for a slice of the beach one foot wide. Count the number of boxes, then multiply that number by 1 ft for the width of the slice and 1 ft^2 for the area represented by each box.

Data Calculations [version 2]: *Data Recorder*

Use a tide table to determine the time and elevation of the high and low tides that are around the data point collected at the swash zone. Plot these two tide points on a graph, connecting the two points with a straight line. Draw a line up from the time recorded and read the y-axis value where that intersects the line between the two data points, this is your *X* value below.

X = Elevation of swash zone (calculated) = __________ feet

Y = Rod reading at swash zone = __________ feet

Z = *X* + *Y* = __________ feet

To calculate the elevations from the rod readings, use the equation:

$$Z - Rod\ Reading = Elevation$$

Once you have calculated your elevations, plot them on the graph paper provided.

E = High water mark distance = __________ feet

F = End of swash zone distance = __________ feet

On your plot of the beach profile, mark the distances for *E* and *F* and draw a horizontal line at the corresponding elevation, clearly indicating which line is for which item. See figure 5 or 6 for an example.

G = Width of the beach = __________ feet

The width of the beach is the distance at which your profile crosses 0 foot elevation. If your profile does not cross, use the last couple of points in your survey and, with a straight edge, draw a straight line through them, extending the line across the 0 foot elevation line.

H = Beach volume = __________ boxes * 1 ft * 1 ft^2
= __________ ft^3

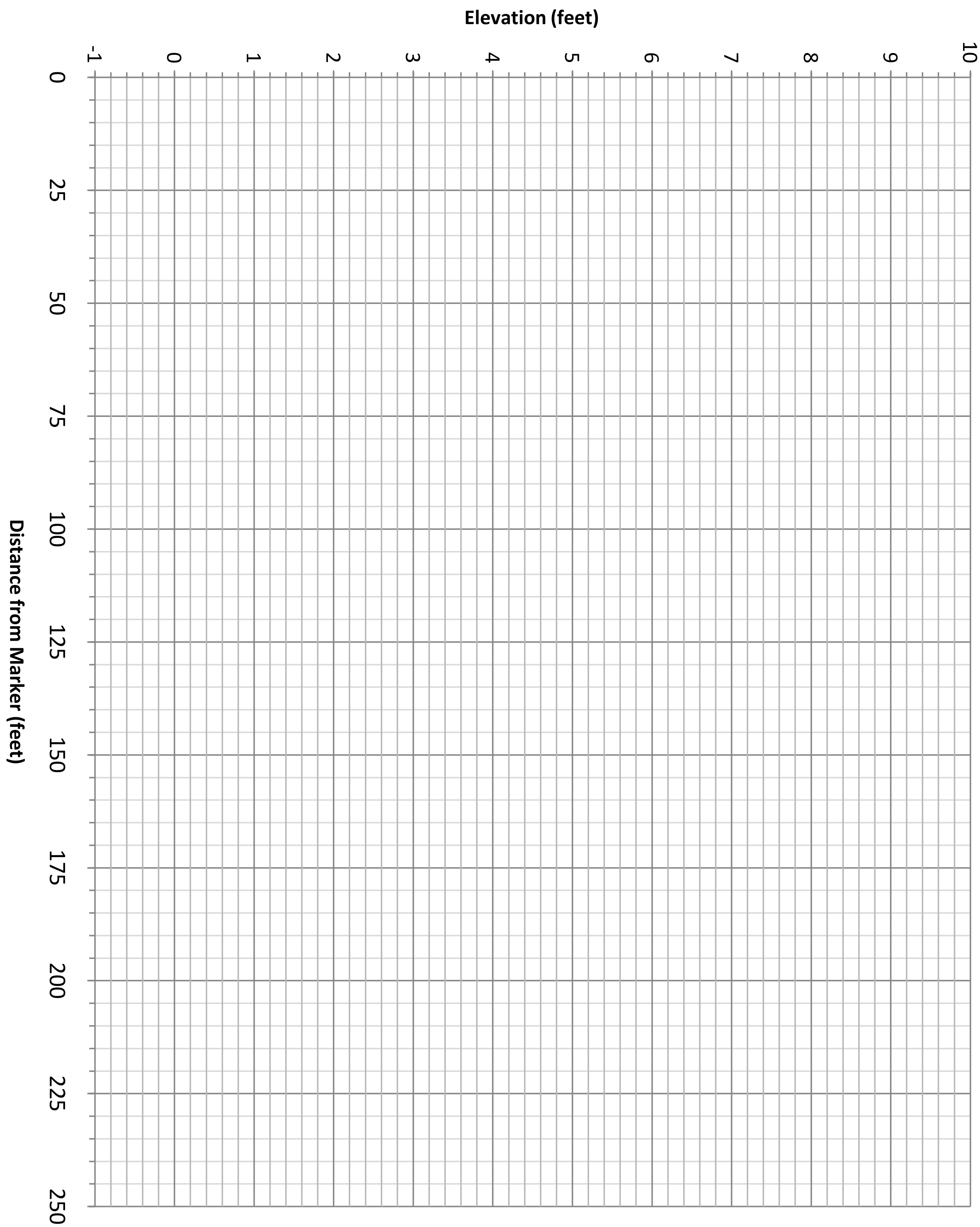
The beach volume is the volume of sand under your profile for a slice of the beach one foot wide. Count the number of boxes, then multiply that number by 1 ft for the width of the slice and 1 ft^2 for the area represented by each box.

Data Sheet: *Data Recorder*

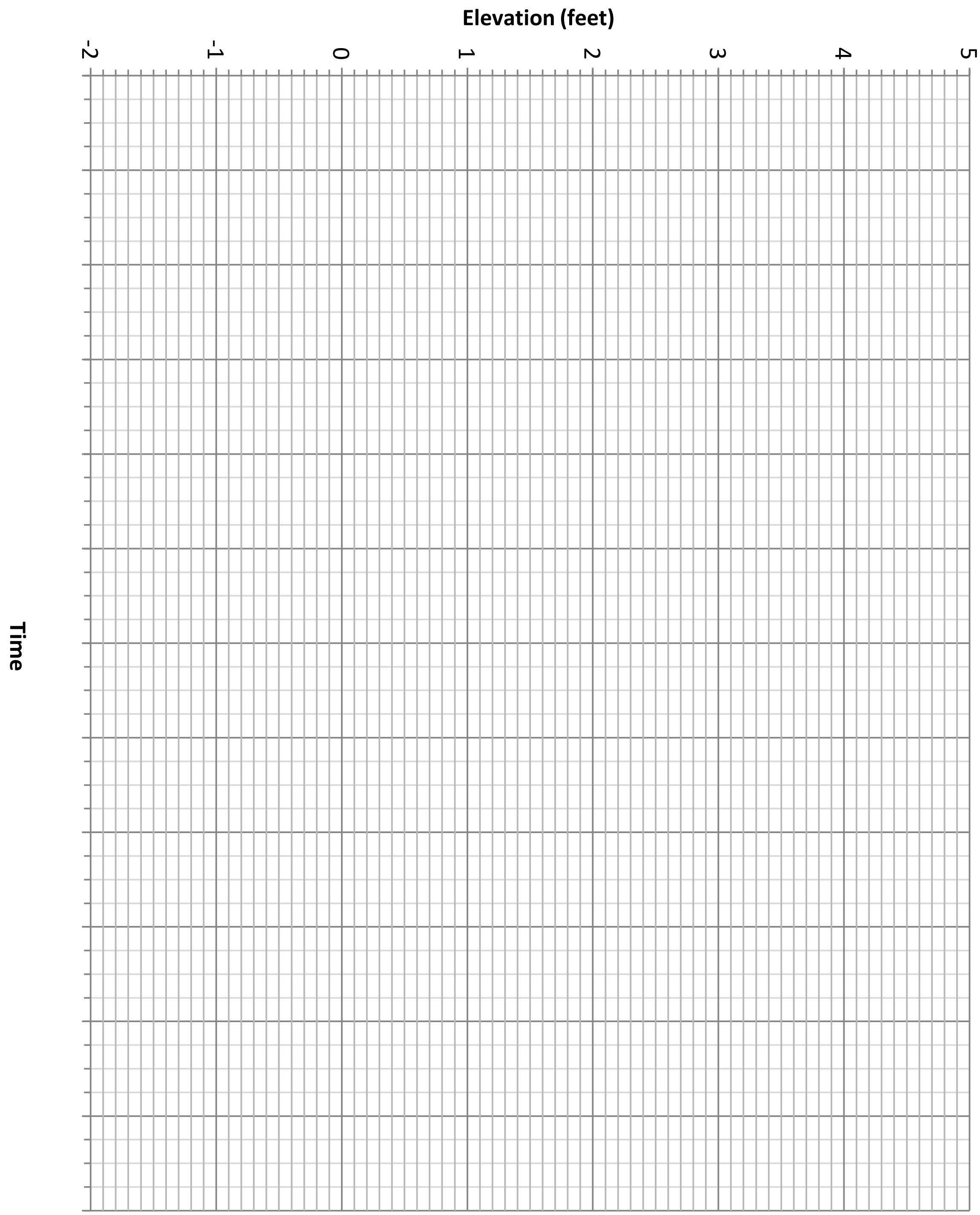
Point #	Distance (ft)	Rod Reading (ft)	Elevation (ft)	Point #	Distance (ft)	Rod Reading (ft)	Elevation (ft)
1				26			
2				27			
3				28			
4				29			
5				30			
6				31			
7				32			
8				33			
9				34			
10				35			
11				36			
12				37			
13				38			
14				39			
15				40			
16				41			
17				42			
18				43			
19				44			
20				45			
21				46			
22				47			

23				48			
24				49			
25				50			

Plot your elevation data on the graph below.



If needed, graph the high and low tides surrounding the time that the swash zone data point was taken (determine the scale for the time axis).



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Science Standards

NYS Learning Standards for Mathematics, Science and Technology

- **Students will use mathematical analysis, scientific inquiry, and engineering design, as appropriate, to pose questions, seek answers, and develop solutions (1)**
    - **The central purpose of scientific inquiry is to develop explanations of natural phenomena in a continuing, creative process (1.1)**
    - **The observations made while testing proposed explanations, when analyzed using conventional and invented methods, provide new insights into phenomena (1.3)**
- **Students will understand mathematics and become mathematically confident by communicating and reasoning mathematically, by applying mathematics in real-world settings, and by solving problems through the integrated study of number systems, geometry, algebra, data analysis, probability, and trigonometry (3)**
    - **Students use measurement in both metric and English measure to provide a major link between the abstractions of mathematics and the real world in order to describe and compare objects and data (3.5)**
    - **Students use patterns and functions to develop mathematical power, appreciate the true beauty of mathematics, and construct generalizations that describe patterns simply and efficiently (3.7)**
- **Students will understand and apply scientific concepts, principles, and theories pertaining to the physical setting and living environment and recognize the historical development of ideas in science (4)**
    - **The Earth and celestial phenomena can be described by principles of relative motion and perspective (Physical Setting 1)**
    - **Many of the phenomena that we observe on Earth involve interactions among components of air, water, and land (Physical Setting 2)**
    - **Energy and matter interact through forces that result in changes in motion (Physical Setting 5)**
    - **Plants and animals depend on each other and their physical environment (Living Environment 6)**
    - **Human decisions and activities have had a profound impact on the physical and living environment (Living Environment 7)**
- **Students will understand the relationships and common themes that connect mathematics, science, and technology and apply the themes to these and other areas of learning (6)**
    - **The grouping of magnitudes of size, time, frequency, and pressures or other units of measurement into a series of relative order provides a**

- useful way to deal with the immense range and the changes in scale that affect the behavior and design of systems (6.3)
    - Equilibrium is a state of stability due either to a lack of changes (static equilibrium) or a balance between opposing forces (dynamic equilibrium) (6.4)
    - Identifying patterns of change is necessary for making predictions about future behavior and conditions (6.5)

Ocean Literacy Standards (http://oceanliteracy.wp2.coexploration.org/):

- **The Earth has one big ocean with many features (1)**
    - **Sea level is the average height of the ocean relative to the land, taking into account the differences caused by tides (1d)**
- **The ocean and life in the ocean shape the features of the Earth (2)**
    - **Sea level changes over time have expanded and contracted continental shelves, created and destroyed inland seas, and shaped the surface of land (2b)**
    - **Erosion – the wearing away of rock, soil and other biotic and abiotic earth materials – occurs in coastal areas as wind, waves, and currents in rivers and the ocean move sediments (2c)**
    - **Sand consists of tiny bits of animals, plants, rocks and minerals. Most beach sand is eroded from land sources and carried to the coast by rivers, but sand is also eroded from coastal sources by surf. Sand is redistributed by waves and coastal currents seasonally (2d)**
    - **Tectonic activity, sea level changes, and force of waves influence the physical structure and landforms of the coast (2e)**
- **The oceans and humans are inextricably interconnected (6)**
    - **The ocean is a source of inspiration, recreation, rejuvenation and discovery. It is also an important element in the heritage of many cultures (6b)**
    - **Much of the world's population lives in coastal areas (6d)**
    - **Coastal regions are susceptible to natural hazards (tsunamis, hurricanes, cyclones, sea level change, and storm surges) (6f)**
- **Everyone is responsible for caring for the ocean. The ocean sustains life on Earth and humans must live in ways that sustain the ocean. Individual and collective actions are needed to effectively manage ocean resources for all (6g)**
- **The ocean is largely unexplored (7)**
    - **Understanding the ocean is more than a matter of curiosity. Exploration, inquiry and study are required to better understand ocean systems and processes (7b)**
    - **Over the last 40 years, use of ocean resources has increased significantly, therefore the future sustainability of ocean resources depends on our understanding of those resources and their potential and limitations (7c)**