# The Wind, the Waves, and the Wide Open Sea

## A Beach Dynamics Activity

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## Program Outline: *The Wind, the Waves and the Wide Open Sea*

**Program Theme:**

**Energy from wind and waves shape the beach, changing its form from day to day and season to season; investigating the properties of these forces illuminate the way the shoreline changes through time.**

**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 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:**

- **Use appropriate tools (e.g. anemometer, drogue, compass) to collect field data for measuring wind, waves and sand movement**
- **List two processes that move sand along the beach**
- **List two ways that human development on a barrier island is affected by wind and wave action**

## Program Content:

*Target Age Group:* Grades 8-12, Adult.

*Program Overview:* This activity measures wind and wave conditions which are the fundamental forces that shape the beach. These parameters allow us to monitor and predict shoreline change and to understand the dynamic nature of barrier islands. Students work in groups of four and are assigned specific roles to collect and record data and observations and come together to synthesize the data and discuss the relevance of the data collected.

Please note: background information included in lesson plan should be reviewed and discussed in class prior to site visit.

*Materials:*

Instructions & Data Sheets [at end of packet]
Pencils
2-Drogues (apples, oranges, pieces of driftwood, other small floatable items; not supplied by NPS)
1-Anemometer*
1-Compass*
1-Stopwatch*
4-Field Guides to Beach Features*

* 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 3 or 4. Each group with have individuals assigned different roles and responsibilities.

| | |
|---|---|
| *Wind Master:* | Use the Anemometer according to the printed directions; work with Navigator to determine the direction of maximum wind strength |
| *Navigator:* | Work with Wind Master and use the Compass to determine the direction of maximum wind strength; work with Wave Spotter to determine direction of incident waves |
| *Drogue Thrower:* | Deploy the drogue to determine longshore drift direction;, work with Wave Spotter to determine speed of longshore drift |
| *Wave Spotter:* | Identify beach features using the field guide; determine presence of offshore bar or rip currents along the beach; work with Navigator to determine the direction of incident waves; work with Drogue Thrower to determine longshore drift speed |

*Methods: Divide the class into groups of 4. Each of the 4 individuals in each group will be assigned a different role.*

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

*Approximate time to complete: Once students have arrived at the study site, and are assembled in groups and assigned roles, the activity takes approximately 15-20 minutes to complete*

Wind Master: *Using the Anemometer*

1. Stand at a high point on the dune on top of the boardwalk[1] – do not walk on unprotected dunes.
2. Draw a sketch of the field location from your position
3. Describe in your own words the field conditions (weather, general sense of wind and wave activity, this provides context for the data you collect and helps you remember the day more clearly when looking at your notes).
4. Press the button on the Anemometer to turn it on.
5. Hold the Anemometer at eye level with the screen facing towards you. The wind will turn the small turbine at the top of the Anemometer. A speed reading will appear on the screen.
6. Rotate in position while facing into the wind, holding the Anemometer and note when the wind speed reading reaches a maximum.
7. Work with Navigator to determine the compass bearing for the maximum wind speed. Record this bearing on the data sheet.
8. Press and hold the button on the Anemometer to reset the max speed value to zero.
9. Watch the wind speed for about 1 minute, determine and record the sustained wind speed (the wind speed for most of the time, not including sudden gusts or short periods of calm)
10. Record the highest gust speed during this time (listed at the bottom of the Anemometer screen).

Navigator: *Wind and Wave Direction*

1. Stand at a high point on the dune on top of the boardwalk[1] – do not walk on unprotected dunes.
2. Draw a sketch of the field location from your position
3. Describe in your own words the field conditions (weather, general sense of wind and wave activity, this provides context for the data you collect and helps you remember the day more clearly when looking at your notes).
4. Working with the Wind Master:
    a. Both the Navigator and the Wind Master should be facing in the same direction, facing into the wind.

[1] Please see the section titled Hurricane Sandy and the Dunes of Fire Island (page 11)

b. Hold compass level in your hand with the big arrow in the direction that the maximum wind is coming from.
c. Move the dial so that the North icon is lined up with the north side of the pointing dial.
d. Read the degree value that lines up with the big arrow, record this on your data sheet.
e. Record the wind speeds from the Wind Master on your data sheet

5. Working with the Wave Spotter:
    a. Both the Navigator and the Wave Spotter should be facing in the same direction – towards the direction the waves are moving in from.
    b. Imagine a straight line stretches from your belly button to the waves – rotate yourself so that that line is perpendicular to the line of wave crests.
    c. Hold compass level in your hand with the big arrow lined up with your imaginary line.
    d. Move the dial so that the North icon is lined up with the north side of the pointing dial.
    e. Read the degree value that lines up with the big arrow.
    f. Record the wave direction on your data sheet

Drogue Thrower: *Longshore Transport Direction*

1. Draw a sketch of the field location from your position
2. Describe in your own words the field (weather, general sense of wind and wave activity, this provides context for the data you collect and helps you remember the day more clearly when looking at your notes)..
3. Stand at the waterline; make a mark in the sand for the starting point.
4. Take the drogue (apple, orange, piece of driftwood) and toss it into the water just beyond the surf.
5. Note which direction the drogue moves in (ex. from east to west).
6. From the starting mark, pace[2] out 10 meters in the direction of longshore transport and make another mark in the sand. The Wave Spotter should stand at this second mark, ready to time the travel of the drogue [see Wave Spotter directions for more detail].
7. Retrieve the drogue (or use another) and return to the starting mark.
8. Coordinating with the Wave Spotter, throw the drogue in the water again to determine the travel time. Record this on the data sheet.
9. Convert the travel time to speed following the directions on the data sheet.

[2] Prior to your visit, have your students determine their pace – instructions are included at the end of the packet.

Wave Spotter: *Wave qualities*

1. Stand at a high point on the dune on top of the boardwalk[3] with the Navigator– do not walk on unprotected dunes.
2. Draw a sketch of the field location from your position
3. Scan the waterline taking note of wave qualities – general wave direction, presence of rip currents or waves breaking on an offshore bar.
4. With the Navigator, determine a compass bearing for the direction the waves are traveling from. Focus on a point beyond the surf zone where the waves are just beginning to break. Take a bearing directly perpendicular to the line of the wave crest.
5. Move down to the waterline, where the Drogue Thrower is.
6. Use the Stopwatch to determine the speed of longshore transport.
    a. Stand at the 10 m mark made by the Drogue Thrower
    b. Start the Stopwatch when the Drogue hits the water.
    c. Stop the Stopwatch when the Drogue passes the 10 m mark.
    d. Record this travel time on the data sheet.
7. Use the Stopwatch to determine the wave period.
    a. Pick an imaginary point within the surf zone
    b. Start the stopwatch and begin counting wave crests that pass your imaginary point
    c. Stop the stopwatch when the 10th crest passes your point.
    d. Record this time on your data sheet.
    e. Follow the instructions on the data sheet to convert the recorded time into the wave period.
8. Estimate the height of the breaking waves where they are just beginning to break, record this on the data sheet.

[3] Please see the section titled Hurricane Sandy and the Dunes of Fire Island (page 11)

**Putting it all together:**

**After the completion of activity, all team members should prepare a report for the group. This may be done in the classroom.**

**Questions that can be explored:**

- **How do the wind direction, wave direction and longshore transport direction compare to each other?**
- **Why might the wind, wave and longshore transport directions be different?**
- **Why is it important to measure the direction and speed of the wind, the waves and longshore transport?**
- **What factors might affect the direction and speed of the wind, the waves and the longshore transport?**
- **How might hard structures[4] built on the beach affect each of the three parameters?**
- **How might hard structures be affected by the wind, waves and longshore transport?**
- **Longshore transport is usually in one predominant direction, however periodic changes in wave direction may shift transport to the opposite direction – what changes on the beach would you expect to see? What changes in hard structure interaction would you expect?**

[4] see terminology section for a list of common shoreline structures

## Background Information:

The shape of the beach and the patterns of sand movement are defined, in a large part, by the qualities of the incident, or on-coming, wave conditions. Waves, in turn, are defined by the wind conditions at sea and at the shoreline, with a few notable exceptions. Understanding the wind and the waves allows us to understand how the beach and the barrier island are shaped and allows us to predict how the patterns in beach shape are affected by changes in conditions over a variety of time scales.

Wind is caused by differences in atmospheric pressure between two locations (for more information about wind generation, see the Web Resources section). We use an anemometer to measure the speed of the wind. Wind speeds can vary greatly from a calm day with no hint of air movement to hurricanes with wind speeds that exceed the highway speed limit. The scale that we use to describe wind speed is called the Beaufort scale.

We use a compass to measure the wind direction. Wind direction influences the wave direction which can have a variety of effects on the shoreline. Different groups of scientists use different conventions for naming winds. Meteorologists name winds for the direction the wind is coming from (wind coming from the north east, moving towards the south west would be called a *North Easterly* wind) while Oceanographers name winds for the direction the wind is going towards (wind coming from the north east, moving towards the south west would be called a *South Westerly* wind). In this exercise, we are taking wind readings facing into the wind and, like meteorologists, will name winds for the direction they originate from.

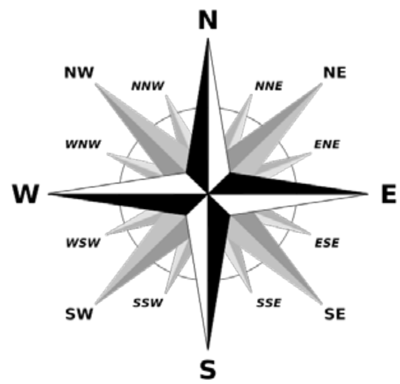


Figure 1: Compass rose shows the 4 Cardinal directions, 4 Ordinal directions and 8 further subdivisions (Wikimedia Commons).

The friction of the wind moving across the surface of the ocean causes water to build up and form waves. This can easily be demonstrated at home by blowing across a cup or bowl of water.

The size of waves is defined by three parameters: the strength of the wind, the duration of the wind and the uninterrupted length of the body of water the wind acts upon (also known as *fetch*). In your bowl, the waves you can generate are small compared to the waves you see in the beach, in part, because the wind you can generate cannot be sustained very strong or for very long. But even if you could blow as strong or for as long as you could imagine, the size of the waves would still be small because the fetch of a bowl is so much smaller than the ocean.

You might expect water particles to move in the same direction as the wave, but the individual water particles moved by the waves we see actually move in circular paths, or orbitals. The next time you see a gull floating in the ocean, spend some time watching the way it moves as waves pass. The gull does not ride on top of the wave the way a surfer rides a breaking wave. Instead, it stays in the same spot, appearing to move up and down as the wave passes under it. See the Web Resources section for access to an animated demonstration of this principle.

Friction between the wind and the surface generates waves by transferring the wind energy to the water, and friction within the water column carries that energy below the surface. Try to imagine a deck of cards placed on a desk; the cards will not move unless a force is applied to them. If you place your finger on the top card, gently pushing so the top card slides across the rest of the deck, you are transferring your energy to the card. If you push harder on the deck, more cards will start to move, but the upper cards begin to fan out, with the lower cards moving less than the upper cards. Each card moves the one below it, but some of that energy is converted through friction into heat energy and is lost from the system. The wind is your finger and each card is like another layer of orbitals in the water. The stronger the wind, the deeper the movement of the orbitals penetrates in the water column.

Friction comes into play again as waves approach the shore. As the water shallows, the orbitals begin to interact with the seafloor. Friction causes the orbitals to flatten and elongate, and also causes the bottom of the water column to slow more than the top of the water. On the surface, you will notice the front, or leading, edge of the wave begin to steepen. The leading edge steepens until it collapses into a breaking wave. Waves, as they begin to interact with the seafloor also begin to move sand grains. Changes in energy while waves break and wash on the shore have a discernible effect on sand grain distribution, which can be explored in the Sorting Sands activity.

The angle at which waves approach the shoreline also has a strong effect on sand movement. If the wave crests approach directly parallel to the shoreline, sand would move up and down the beach, and there would not be any lateral, or along-shore, movement. When waves approach at an angle, however, sand moves along the shore as well as up and down the beach face. Crashing waves convert the energy stored in the wave into kinetic energy. The momentum of the wave energy keeps the water traveling up the beach in the same direction as the waves. Once this kinetic energy has been used to move water up on the beach, the water is pulled by gravity downslope back to the ocean. Gravity causes the water to take the steepest path down the beach, which is a line perpendicular to the shoreline. This creates a zig-zag pattern of water movement – up the beach at an angle, and back straight down – which creates a net movement along the shore that we call *longshore transport*. This phenomenon occurs in the water, the sand grains, and any other item that is carried by the water untethered. You have probably experienced longshore transport the last time you swam in the ocean – you entered the water for a swim directly in front of your towel, only to discover that you've moved away from it when you exit the water.

The lateral movement of sand is an important part of how barrier islands move and change. On the ocean shore of Fire Island, (and in general, on the south shore of Long Island), longshore transport tends to be from east to west. Storms and other changes in predominant wind patterns can reverse the direction, but the reversal tends to be a short-term change. The growth of the spit at the Fire Island Lighthouse shows how important

**longshore transport is to the shape of Fire Island – when the first lighthouse was completed in 1826, it was located at the western end of Fire Island, close to the inlet. The island grew westward through longshore transport of sand at an average rate of 68 meters (223 feet) per year – this translates to a growth of 7 inches a day. In 1941 the Army Corps stabilized the inlet with a jetty and Fire Island Inlet is still dredged to maintain a safe passage, so longshore transport has been altered from its natural pattern. Today, the Fire Island Lighthouse is 9 kilometers (6 miles) away from the inlet.**

**Natural patterns of longshore transport can be disrupted by a variety of manmade structures built on the beach. Rivetments and Break Waters built parallel to the beach will not disrupt longshore transport, but may have effects on wave conditions and movement of sand during storms. Bulkheads sequester land behind the structure and change wave conditions such that sand will not be deposited in front of the structure. Structures built perpendicular to the beach, like groins and jetties, will build up on the up-drift side and will erode on the down-drift side.**

## 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[5].**

**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 24, 2013), 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.**

<u>Impact on Activity</u>

**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*. In taking wind measurements, either stand in an overwash area where there is no dune to shelter you from measuring northerly winds, or stand at the top of the stairs of the Wilderness Visitor Center, choosing which side of the building to stand on to make sure you are not sheltered from the wind.**

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[5] *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.

## Terminology and Resources:

**The Beaufort Scale[6]: also called the Beaufort wind force scale is a measure of wind speed that relates to conditions at sea or on land. For a more thorough description of the development of the Beaufort scale and photographs of each force, please visit the United Kingdom's National Meteorological Library and Archive Fact sheet 6[7]**

**(Table of modern description of Beaufort Scale from NOAA[8])**

| Force | Classification | Wind Speed (knots[9]) | Sea Conditions | Land Conditions |
|---|---|---|---|---|
| 0 | Calm | <1 kn | Sea surface smooth and mirror-like | Calm, smoke rises vertically |
| 1 | Light Air | 1-3 kn | Scaly ripples, no foam crests | Smoke drift indicates wind direction, still wind vanes |
| 2 | Light Breeze | 4-6 kn | Small wavelets, crests glassy, no breaking | Wind felt on face, leaves rustle, vanes begin to move |
| 3 | Gentle Breeze | 7-10 kn | Large wavelets, crests begin to break, scattered whitecaps | Leaves and small twigs constantly moving, light flags extended |
| 4 | Moderate Breeze | 11-16 kn | Small waves 1-4 ft becoming longer, numerous whitecaps | Dust, leaves and loose paper lifted, small tree branches move |
| 5 | Fresh Breeze | 17-21 kn | Moderate waves 4-8 ft taking longer form, many whitecaps, some spray | Small trees in leaf begin to sway |
| 6 | Strong Breeze | 22-27 kn | Larger waves 8-13 ft, whitecaps common, more spray | Larger tree branches moving, whistling in wires |
| 7 | Near Gale | 28-33 kn | Sea heaps up, waves 13-19 ft, white foam streaks off breakers | Whole trees moving, resistance felt walking against wind |
| 8 | Gale | 34-40 kn | Moderately high (18-25 ft) waves of greater length, edges of crests begin to break into spindrift, foam blown in streaks | Twigs breaking off trees, generally impedes progress |
| 9 | Strong Gale | 41-47 kn | High waves (23-32 ft), sea begins to roll, dense streaks of foam, spray may reduce visibility | Slight structural damage occurs, slate blows off roofs |
| 10 | Storm | 48-55 kn | Very high waves (29-41 ft) with overhanging crests, sea white with densely blown foam, heavy rolling, lowered visibility | Seldom experienced on land, trees broken or uprooted, "considerable structural damage" |
| 11 | Violent Storm | 56-63 kn | Exceptionally high (37-52 ft) waves, foam patches cover sea, visibility more reduced | |
| 12 | Hurricane | >64 kn | Air filled with foam, waves over 45 ft, sea completely white with driving spray, visibility greatly reduced | |

[6] Wikipedia article on Beaufort scale (http://en.wikipedia.org/wiki/Beaufort_scale)
[7] National Meteorological Library and Archive Fact Sheet 6 – The Beaufort Scale (http://www.metoffice.gov.uk/media/pdf/4/4/Fact_Sheet_No._6_-_Beaufort_Scale.pdf)
[8] NOAA Beaufort Wind Scale (http://www.spc.noaa.gov/faq/tornado/beaufort.html)
[9] A Knot is a unit of speed equal to one nautical mile per hour. To convert between knots and other useful metrics (meters per second or miles per hour) use the following relationships:

- 1 nautical mile = 1.15 statute miles
- 1 nautical mile = 1852 meters
- 1 statute mile = 1609 meters
- 1 hour = 60 seconds

### *Common Shoreline Structures*

**Bulkhead: a close to vertical wall built to stabilize the shoreline and protect property upland from the structure. Bulkheads convert the shore from a gentle slope that absorbs wave energy to a steep, close to vertical, slope that reflects wave energy.**

**Revetment: a collection of large boulders or other hard structure placed parallel to shore, usually at the toe of the dune, to prevent undercutting of the dune by storm waves. During calm periods, revetments may be completely covered by sand. Revetments are built to protect property on or behind the dune.**

**Breakwater: a hard structure built in the water parallel to the coastline. It is meant to protect the coast from the waves by causing them to break before reaching the shore.**

**Groin: a hard structure built perpendicular to the coastline. Groins are usually built in fields with groins installed regularly down a stretch of the beach. They are intended to take advantage of the predominant longshore transport direction and build the beach wider.**

**Jetty: a hard structure built perpendicular to the coastline, similar in structure to a Groin. Jetties are built to stabilize inlets to maintain a permanent navigable passage.**

### *Other Vocabulary Terms*

| | | |
|---|---|---|
| Anemometer | Fetch | Offshore Bar |
| Beach | Friction | Orbitals |
| Compass | Gravity | Rip Current |
| Drogue | Longshore Transport | Swash Zone |
| Dune | Meteorologist | Wave Crest |
| Energy (kinetic, heat) | Oceanographer | Wind |

### *Web Resources*

Fire Island National Seashore:

[Barrier Island Dynamics Presentation: includes animation of wave orbitals]
*http://www.nps.gov/fiis/naturescience/shoreline-dynamics.htm*

Exploring Earth:

[Wave orbital animation only]
http://www.classzone.com/books/earth_science/terc/content/visualizations/es1604/es1604page01.cfm?chapter_no=visualization

Wikimedia Commons:

[Image of compass rose] *http://en.wikipedia.org/wiki/File:Brosen_windrose.svg*

National Weather Service:

[Origins of Wind] http://www.srh.noaa.gov/jetstream//synoptic/wind.htm

Long Island's Dynamic South Shore

[PDF of a book on the dynamic forces shaping the south shore]
http://www.seagrant.sunysb.edu/cprocesses/pdfs/LIDynamicSouthShore.pdf

## Instructions: *Wind Master*

Check off each step as it is completed.

1. _____ Stand at a high point on the dune on top of the boardwalk– do not walk on unprotected dunes.
2. _____ Draw a sketch of the field location from your position
3. _____ Describe in your own words the field conditions (weather, general sense of wind and wave activity, this provides context for the data you collect and helps you remember the day more clearly when looking at your notes).
4. _____ Press the button on the Anemometer to turn it on.
5. _____ Hold the Anemometer at eye level with the screen facing towards you. The wind will turn the small turbine at the top of the Anemometer. A speed reading will appear on the screen.
6. _____ Rotate in position while facing *into* the wind, holding the Anemometer and note when the wind speed reading reaches a maximum.
7. _____ Work with Navigator to determine the compass bearing for the maximum wind speed. Record this bearing on the data sheet.
8. _____ Press and hold the button on the Anemometer to reset the max speed value to zero.
9. _____ Watch the wind speed for about 1 minute, determine and record the sustained wind speed (the wind speed for most of the time, not including sudden gusts or short periods of calm). Determine where this reading fits into the Beaufort Scale.
10. _____ Record the highest gust speed during this time (listed at the bottom of the Anemometer screen).

## Data Sheet: *Wind Master*

**Name: ______________________________**
**Date: _______________________________** **Time: ________________________**

**Step 2: Draw a sketch of the field site (map view)**

**Step 3: Field Conditions (ex: windy or calm, sunny or cloudy, large or small waves)**

**Step 7: Wind direction (compass bearing): _________**

**Step 9: Sustained wind speed: _________ meters/second**

**Beaufort Scale Category: ________________________**

**Step 10: Maximum wind speed (gust): _________ meters/second**

Instructions: *Navigator (working with both Wind Master and Wave Spotter)*

Check off each step as it is completed.

1. _____ Stand at a high point on the dune on top of the boardwalk– do not walk on unprotected dunes.
2. _____ Draw a sketch of the field location from your position

3. _____ Describe in your own words the field conditions (weather, general sense of wind and wave activity, this provides context for the data you collect and helps you remember the day more clearly when looking at your notes).

4. Working with the *Wind Master:*
   a. _____ Both the Navigator and the Wind Master should be facing in the same direction, facing into the wind.
   b. _____ Hold compass level in your hand with the big arrow in the direction that the maximum wind is coming from.
   c. _____ Move the dial so that the North icon is lined up with the north side of the pointing dial.
   d. _____ Read the degree value that lines up with the big arrow, record this on your data sheet.
   e. _____Record the wind speeds from the Wind Master on your data sheet
5. Working with the *Wave Spotter:*
   a. _____ Both the Navigator and the Wave Spotter should be facing in the same direction – towards the direction the waves are moving in from.
   b. _____Imagine a straight line stretches from your belly button to the waves – rotate yourself so that that line is perpendicular to the line of wave crests.
   c. _____ Hold compass level in your hand with the big arrow lined up with your imaginary line.
   d. _____ Move the dial so that the North icon is lined up with the north side of the pointing dial.
   e. _____ Read the degree value that lines up with the big arrow.
   f. _____Record the wave direction on your data sheet

Data Sheet: *Navigator*

**Name: ______________________________**
**Date: _______________________________** **Time: _________________________**

**Step 2: Draw a sketch of the field site (map view)**

**Step 3: Field Conditions (ex: windy or calm, sunny or cloudy, large or small waves)**

**Step 4d: Wind direction (compass bearing): _________**

**Step 4e: Sustained wind speed: _________ meters/second**

**Beaufort Scale Category: ________________________**

**Maximum wind speed (gust): _________ meters/second**

**Step 5f: Wave direction (compass bearing): _________**

Instructions: *Drogue Thrower*

Check off each step as it is completed.

1. ______ Draw a sketch of the field location from your position
2. ______ Describe in your own words the field conditions (weather, general sense of wind and wave activity, this provides context for the data you collect and helps you remember the day more clearly when looking at your notes).
3. ______ Stand at the waterline; make a mark in the sand for the starting point.
4. ______ Take the drogue (apple, orange, piece of driftwood) and toss it into the water just beyond the surf.
5. ______ Note which direction the drogue moves in (ex. From east to west).
6. ______ From the starting mark, pace out 10 meters in the direction of longshore transport and make another mark in the sand. The Wave Spotter should stand at this second mark, ready to time the travel of the drogue [see Wave Spotter directions for more detail].
7. ______ Retrieve the drogue (or use another) and return to the starting mark.
8. ______ Coordinating with the Wave Spotter, throw the drogue in the water again to determine the travel time. Record this on the data sheet.
9. ______ Convert the travel time to speed following the directions on the data sheet.

**Data Sheet**: ***Drogue Thrower***

**Name: ______________________________**
**Date: _______________________________** **Time: ________________________**

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

**Step 2: Field Conditions (ex: windy or calm, sunny or cloudy, large or small waves)**

**Step 5: Longshore Transport Direction: ___________________________**

**Step 8: Longshore Transport Travel Time:**

$Y =$ _________ **(time in seconds for drogue to travel 10 m)**

**Step 9: Longshore Transport Speed:**

$Speed = \frac{10}{Y} =$ _________ **meters/second**

Instructions: *Wave Spotter*

Check off each step as it is completed.

1. _____ Stand at a high point on the dune on top of the boardwalk with the Navigator– do not walk on unprotected dunes.

2. _____ Draw a sketch of the field location from your position

3. _____ Scan the waterline taking note of wave qualities – general wave direction, presence of rip currents or waves breaking on an offshore bar.

4. _____ With the Navigator, determine a compass bearing for the direction the waves are traveling from. Focus on a point beyond the surf zone where the waves are just beginning to break. Take a bearing directly perpendicular to the line of the wave crest.

5. _____ Move down to the waterline, where the Drogue Thrower is.

6. _____ Use the Stopwatch to determine the speed of longshore transport.
   a. Stand at the 10 m mark made by the Drogue Thrower
   b. Start the Stopwatch when the Drogue hits the water.
   c. Stop the Stopwatch when the Drogue passes the 10 m mark.
   d. Record this travel time on the data sheet.

7. _____ Use the Stopwatch to determine the wave period.
   a. Pick an imaginary point within the surf zone
   b. Start the stopwatch and begin counting wave crests that pass your imaginary point
   c. Stop the stopwatch when the $10^{th}$ crest passes your point.
   d. Record this time on your data sheet.
   e. Follow the instructions on the data sheet to convert the recorded time into the wave period.

8. _____ Estimate the height of the breaking waves where they are just beginning to break, record this on the data sheet.

## Data Sheet: *Wave Spotter*

**Name:** ______________________________

**Date:** ______________________________ **Time:** __________________________

**Step 2: Draw a sketch of the field site (map view)**

**Step 3: Wave Qualities**

**Step 4: Wave direction (compass bearing):** _________

**Step 6: Travel Time:** _________ **(time in seconds to travel 10 meters)**

**Step 7: Wave Period:**

$X =$ _________ **(time in seconds for 10 wave crests to pass your point)**

$Period = \frac{X}{10} =$ _________ **seconds**

**Step 8: Estimated Wave Height:** _________ **(in meters)**

## How to Measure Distance with Your Pace:

When we need to measure something but don't have access to a ruler or tape measure, what do we do?

In these situations, we use the resources we have readily available. In the case of measuring distance, we can use our walking steps to track how far we've gone – this method is called *pacing*. To do this with any accuracy, we need to know how big our steps are and we need to keep track of the number of steps we take. To calibrate your pace, follow the steps below using a ruler or tape measure. Everyone will have a different pace because we are all different heights and walk differently, so it's important for everyone to try this and to remember their own numbers.

1. With a ruler or tape measure, mark out a 10 meter straight distance.
2. Walking naturally, count the number of steps you take to travel the distance.
3. Do this a couple of times and take the average.

Things to keep in mind – the terrain influences how we walk, our steps will be bigger going downhill and smaller going uphill, and we may walk differently on loose sand than we do on hard pavement. Ideally, we would know our pace for each type of terrain, but we can use one terrain's pace as a ballpark estimate for another terrain.

You can test how close you come to your estimate by bringing a tape measure with you, pacing out 10 meters and measuring the distance you walked.

Something to think about:

How might you try to improve your accuracy in pacing?

## Science Standards

*Next Generation Science Standards*

- **ESS2.A Earth Materials and Systems**
- **ESS2.C The Roles of Water on Earth's Surface Processes**
- **ESS2.D Weather and Climate**
- **ESS3.D Global Climate Change**

*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)