Sorting Sand

A Beach Dynamics Activity

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Program Outline: *Sorting Sand*

Program Theme:

Changing levels of energy from wind and waves over the tidal cycle affect the distribution of the sizes of sand grains which can be discovered by exploring the sand in different locations on the beach.

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 a sustainable interaction with this ever-changing environment.

Program Objectives:

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

- Identify the major structural features of the beach
- List three different minerals found in the sand on Fire Island
- Describe the differences in grain size along the beach profile

Program Content:

Target Age Group: Grades 8-12, Adult. Modifications may be made to reach a younger audience.

Program Overview: The program consists of two activities examining sand properties to be conducted simultaneously on the beach. Students work together in sets of two teams of three to study sand grain composition and distribution at different locations on the beach. After the activities, the teams come together to share and synthesize data and to discuss the relevance of the data collected. An understanding of sand composition and distribution is fundamental to understanding the overarching barrier island dynamics, and how it shapes wildlife and human development on the island.

Materials:

Instructions & Data Sheets - 1 for Sand Size Team, 3 for Naturalists [at end of packet]
Pencils
1-Sieve Set*
1-Graduated Pitcher*
3-Hand Lenses*
3-Grain Size Cards*
3-Plastic Dishes*
3-Magnets*
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 sets of 2 groups of three (one Sieve team, and one group of naturalists), each group will have individuals in different roles.

Sieve Team:

Measurer:	Measure sand using graduated pitcher
Shaker:	Put the Sieves in the proper order, shake sample when called for
Data Recorder:	Record data, assist Shaker and Measurer as necessary
Naturalists:	Use Hand Lens, Grain Size Card, Plastic Dish and Magnet to explore sand properties (3 sets of tools)

Methods: There are two different activities in this program; the instructions for both are below. The activity is written for two teams of students working simultaneously, but can be adapted to be done consecutively. Data sheets with team instructions are located at the end of this packet.

The Sand Size Distribution activity should be conducted twice at two different locations on the beach (i.e. once close to the water line and again closer to the dune toe), switching teams when changing location.

Activity 1: Sand Size Distribution (*Measurer, Shaker, Data Recorder*)

Once students have arrived at the study site, and have been placed in the Sieve Team and assigned roles, the approximate time to conduct the activity is 20-30 minutes

1. The Team works together to find a location on the beach to take a sample
2. The Data Recorder draws a sketch of the field location and indicates the general location of the sample
3. The Measurer uses the Graduated Pitcher to measure out 250 mL of sand
4. The Shaker puts the Sieve Set in the proper order with the largest mesh at the top of the stack and mesh sizes gradually decreasing below with the catch pan below the smallest mesh.
5. The Measurer pours the sand into the top of the stack of Sieves.
6. The Shaker puts the cap on the Sieves and using a side to side or back and forth motion, shakes the Sieves and sand sample. Do NOT shake the Sieve up and down. Shake for 1-2 minutes. Check the top sieve (largest mesh), if sand grains that are smaller than the mesh size are still present, continue shaking for another 1-2 minutes.
7. The Team measures the volume of sand that is present in each Sieve; the Data Recorder notes the volumes and Sieve mesh size.
8. The Team draws a histogram representing the sand distribution for their location (see bottom for example histogram; this step may be done in the classroom)

Activity 2: Sand Composition (*3 Naturalists, working individually*)

Once students have arrived at the study site, and have been assigned naturalist roles, the approximate time to conduct the activity is 15-30 minutes

1. Each Naturalist picks a different spot on the beach (ex. one by the water, one by the wrack line, one by the dune toe).
2. Draw a sketch of the field location, noting the general location of the sample
3. Take a small handful of sand and sprinkle some on the Grain Size Card. A thin layer will work best. Also pour some into the Plastic Dish to be used in step 5.
4. Using the Hand Lens, view the sand sample and the Grain Size Card and estimate the average size of the sand grains, record this data on the data sheet.

5. Use the Field Guide to identify the major minerals that are in your sand sample. The Field Guide will also include instructions on using the sand in the Plastic Dish with the magnet. Record all identified minerals on your data sheet.
6. Visually estimate how much of your sample is light colored and how much is dark colored; record this information on your data sheet.

Sand Mineral Identification:

Light Color / Low Density Minerals

Quartz: clear to tan, translucent

Feldspar: white to tan, opaque

Shell: can be any color found in shells, may retain some characteristics of the shell (ridges, thinness, color on one side)

Dark Color / High Density Minerals

Garnet: light pink to red, translucent (Garnet is the New York State mineral)

Staurolite: dark orange to red, translucent (can be confused with Garnet)

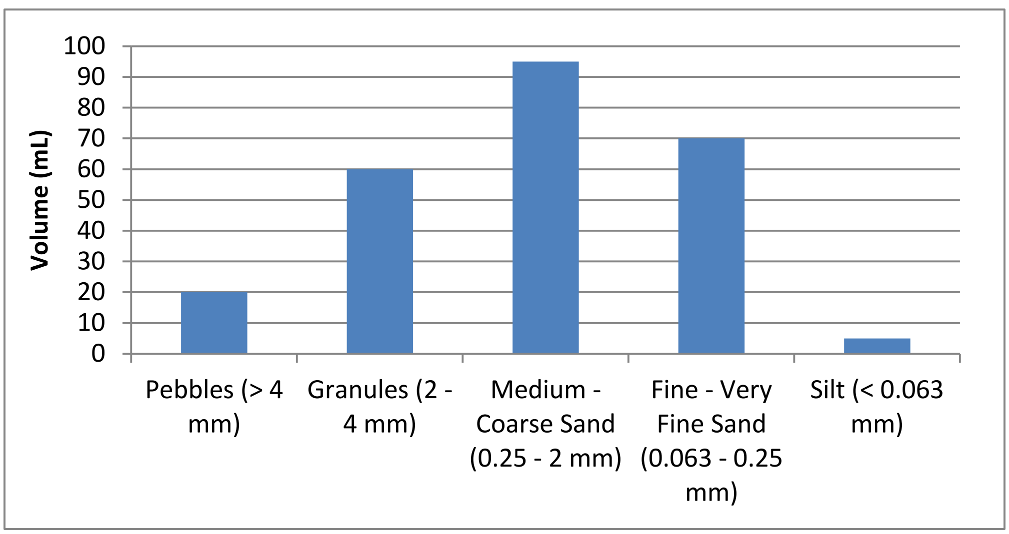
Magnetite: dark metallic, strongly magnetic

Ilmenite: iron-black to steel-grey, weakly magnetic

Hornblende: black, opaque

Epidote: yellow-green (the color of pistachios), translucent

Example Histogram:



Putting it all together:

After the completion of the two activities, each Sand Size Distribution team should give a report to the rest of the group on their part of the beach. This can then be compared with the data collected by the Naturalists. This may be done in the classroom.

Questions that can be explored:

- **How does the Sieve data compare with the Naturalist data?**
- **What are some differences in the kind of data each method provides?**
- **Why might you want to use both methods?**
- **How does the sand near the water compare with the sand higher up on the beach?**
- **What might cause those differences?**
    - **Watch the waves crashing on the beach for some insight.**
- **What do you think the estimated percent dark mineral content tells you?**
- **Why is it important to know about mineral composition of the beach?**
- **What might the mineral composition of the beach indicate about the geologic history of the island?**
- **What would you expect to change if a storm came by overnight?**

Background Information:

Beaches are shaped by many things, among them, the rising and falling of the tides, the crashing waves and the wind blowing along the shore. Changes in sand grain size distribution on the Fire Island National Seashore ocean coastline are a result of the wave-energy levels on the beach. The general trend is to find coarser sand as you move from the waterline up onto the beach. This is because waves have more power as they move forward, up the beach, even though this power is short-lived. In contrast, the return of the water seaward had less power and, therefore, can only carry smaller grains. Larger grains are moved forward by the crashing waves and left there as the weaker return flow cannot carry them back to the sea.

We see this phenomenon happening on a longer time scale too. Below the berm (in the swash zone), the sediments are moved by waves crashing and the movement of the water over a normal tidal cycle. But only the high energy waves produced by storms can carry sediment above the berm, where normal tides do not reach. The berm is also more susceptible to having the finer sediments blown away by the wind. This is because it spends more time as dry, loose sand. The sand in the swash zone, on the other hand, is more frequently wet. The water's cohesiveness holds the sand grains together, so the finer grains are less able to be moved by the wind. So even on a small scale, the wind and waves control changes in shoreline shape.

The distribution of the grain size is called sorting. Well-sorted sand will have sand grains that are all close to the same size. Poorly-sorted sand will have a wide variety of grain sizes together. The degree of sorting is determined by how far the grains are from the sources and how long they have been there- the older and the further they are from the source, the more well-sorted they will be.

The size of a sand grain is one component that determines how easily sand will be moved by wind and/or waves. Smaller grains can be moved with less energy than larger grains, but the density of the material that makes up the grain is also an important factor. The lighter colored grains are less dense minerals – quartz and feldspar. The darker grains are more dense, iron bearing minerals – garnet, magnetite, ilmenite, epidote and hornblende. After a windy or stormy day, you'll see the darker sands in a thin layer on the beach. Many people may mistake these dark grains for an oil spill, but these dark, dense grains are what is left behind when the lighter, less dense grains were moved away by the wind and waves.

The shape of the sand grains helps us determine how old the grains are and how much wind and wave energy they have been exposed to. Newly eroded grains that have not been exposed to much energy in the environment will have sharp angles. As the grains are exposed to energy over time, those angles are worn away and the grains become more round in appearance.

The two different methods explored in this activity generate different types of data. The sieving provides a quantitative measure of sand grain size distribution and allows for direct numerical comparison between different samples. This method easily determines the mode of the sample (i.e. which size class has the most volume), and the mean can be

calculated. The naturalist data is more qualitative; naturalists estimate the sorting and average size of the sample visually, however they also identify the composition of the sample and estimate the percentage of the two primary groups of minerals (dark and light).

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 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.

[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.

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Instructions: *Sand Size Distribution Team* (*Measurer, Shaker, Data Recorder*)

Check off each step as it is completed.

1. _____ *Team*: Work together to find a location on the beach to take a sample
2. _____ *Data Recorder*: draw a sketch of the field location and indicate the general location of the sample
3. _____ *Measurer*: use the Graduated Pitcher to measure out 250 mL of sand
4. _____ *Shaker*: put the Sieve Set in the proper order with the largest mesh (#5) at the top of the stack and mesh sizes gradually decreasing below with the catch pan below the smallest mesh
5. _____ *Measurer*: pour the sand into the top of the stack of Sieves
6. _____ *Shaker*: put the cap on the Sieves and using a side to side or back and forth motion, shake the Sieves and sand sample. Do NOT shake the Sieve up and down. Shake for 1-2 minutes. Check the top sieve (largest mesh), if sand grains that are smaller than the mesh size are still present, continue shaking for another 1-2 minutes.
7. _____ *Data Recorder:* record the volumes and Sieve mesh size from step 8
8. _____ *Team*: measure the volume of sand that is present in each Sieve
9. _____ *Team*: draw a histogram representing the sand distribution for your location

Data Sheet: *Sand Size Distribution Team* (*Measurer, Shaker, Data Recorder*)

Name: ______________________________

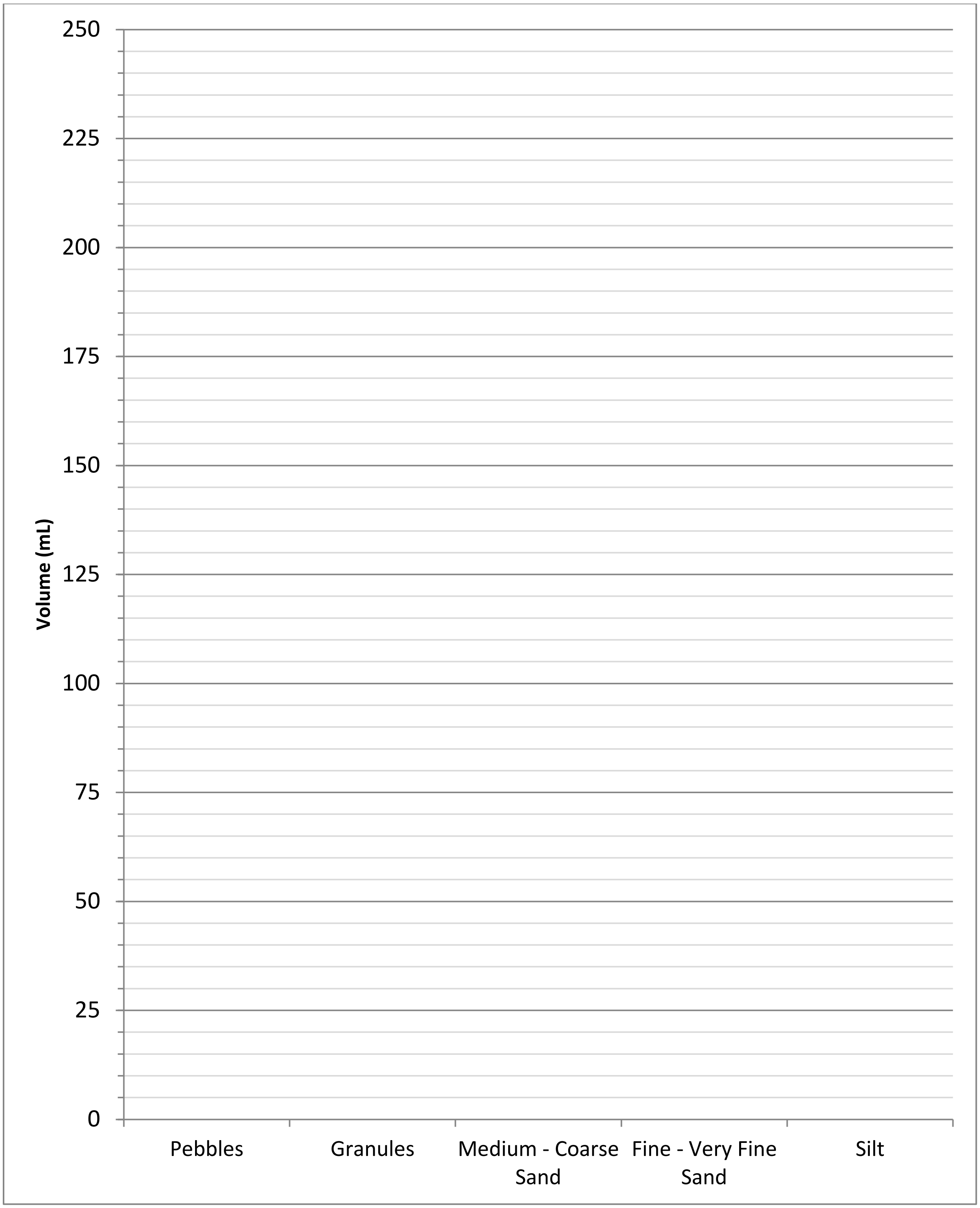
Date: ______________________________ **Time:** ________________________

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

Step 7: Record the data in the table below

Sieve #	Grain Classification	Grain Size	Volume (mL)	Notes (if any)
# 5	Pebbles	> 4 mm		
# 10	Granules	2 - 4 mm		
# 60	Medium - Coarse Sand	0.25 - 2 mm		
# 230	Fine - Very Fine Sand	0.063 - 0.25 mm		
Catch pan	Silt	< 0.063 mm		

Step 8: Fill in the histogram below with your data from step 7



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Instructions: *Naturalist*

Check off each step as it is completed.

1. _____ Pick a spot on the beach (Naturalists should be spread out; ex. one by the water, one by the wrack line, one by the dune toe).
2. _____ Draw a sketch of the field location, noting the general location of the sample
3. _____ Take a small handful of sand and sprinkle some on the Grain Size Card. A thin layer will work best. Also pour some into the Plastic Dish to be used in step 5.
4. _____ Using the Hand Lens, view the sand sample and the Grain Size Card and estimate the average size of the sand grains, rounding and sorting, record this data on the data sheet.
5. _____ Use the Field Guide to identify the major minerals that are in your sand sample. The Field Guide will also include instructions on using the sand in the Plastic Dish with the magnet. Record all identified minerals on the data sheet.
6. _____ Visually estimate how much of your sample is light colored and how much is dark colored; record this information on the data sheet.

Sand Mineral Identification:

Light Color / Low Density Minerals

Quartz: clear to tan, translucent (most common)
Feldspar: white to tan, opaque (less common than Quartz)
Shell: can be any color found in shells, may retain some characteristics of the shell (ridges, thinness, color on one side)

Dark Color / High Density Minerals

Garnet: light pink to red, translucent (Garnet is the New York State mineral)
Staurolite: dark orange to red, translucent (can be confused with Garnet)
Epidote: yellow-green (the color of pistachios), translucent
*Magnetite**: dark metallic, strongly magnetic
*Ilmenite**: iron-black to steel-grey, weakly magnetic
*Hornblende**: black, opaque

* *A note about identifying the black/metallic minerals:*
These can often be difficult to identify visually, but the differing levels of magnetism helps to distinguish between Magnetite, Ilmenite and Hornblende. See Field Guide for instructions.

Data Sheet: *Naturalist*

Name: ______________________________

Date: ______________________________ **Time:** ________________________

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

Steps 4-6: Record the data in the table below

Average Grain Size (letter code and μm range)	
Rounding	
Sorting	
Minerals identified	
Estimate % dark mineral content	

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)