The Ocean's Sand,
A Natural Resource

Minerals Management Service

U.S. DEPARTMENT OF THE INTERIOR

Table of Contents

WHAT IS THE DEPARTMENT OF THE INTERIOR AND THE MINERALS MANAGEMENT SERVICE?...... 1

WHAT IS INTERMAR AND WHY IS ITS WORK IMPORTANT? 1

WHAT IS SAND AND GRAVEL?........ 2

WHY DO WE NEED SAND AND GRAVEL? 3

WHAT IS A BEACH?........ 5

WHAT IS EROSION? 7

TYPES OF EROSION:........ 7
- Water Erosion 7
- Glacial Erosion........ 8
- Wind Erosion........ 8
- Coastal Erosion........ 8

WHAT CAUSES COASTAL EROSION? 9

WHAT CAN BE DONE TO RESTORE BEACHES AND CONTROL EROSION 9

STUDENT ACTIVITIES: BEACH PROFILING AND BEACH EROSION 11

EXAMINE SAMPLES OF BEACH SAND - PRIMARY........ 11
MAKE A BEACH PROFILE - PRIMARY........ 11
ANALYZE GRAIN TYPES - PRIMARY 12
DO A SAND SIZE ANALYSIS - PRIMARY 12
EXERCISE: ANALYZING SEDIMENT SIZE DISTRIBUTION - SECONDARY 13

WHAT ENVIRONMENTAL CHALLENGES DOES MMS FACE IN DEALING WITH SAND AND GRAVEL/BEACH EROSION?........ 16

SHIPWRECKS 16
SEAFLOOR CREATURES........ 16
FISH 17
EFFECTS TO WAVES........ 17

RECOMMENDED INTERNET SITES........ 18

20 Years of Service to America
MMS
Minerals Management Service
1982-2002

www.mms.gov

What is the Department of the Interior, and the Minerals Management Service?

The Department of the Interior is the Nation's principal conservation agency and has responsibility for most of our nationally owned public lands and natural resources. This includes ensuring good use of our land and water resources; protecting our fish, wildlife, and biological diversity; preserving the environmental and cultural values of our national parks; and historical places, and providing for the enjoyment of life through outdoor recreation. The Department assesses our energy and mineral resources and works to ensure that their development is in the best interests of all our people. The Department also has a major responsibility to Native Americans and for people who live in island territories under U.S. administration.

The Minerals Management Service (MMS) is part of the Department of the Interior. The MMS manages the mineral resources located offshore and collects revenue from the minerals developed from offshore and onshore Federal and Indian lands and distributes those revenues to states, Native Americans and to the U.S. treasury.

What is Intermar and Why is its Work Important?

Intermar (International Activities and Marine Minerals) is a program within the MMS that helps states who need sand for their coasts. Intermar's job is to help the states find the sand on the ocean floor to place on beaches when storms and hurricanes destroy them. We call this *beach nourishment.* The sand along the state's coastlines out to 3 miles is state property and can be used by the states to put sand on the beach.

When there is not enough sand in state waters, then the state comes to Intermar to get sand for their beaches. The MMS has responsibility for the sand beyond 3 miles from a state's coast and this is known as the Outer Continental Shelf (OCS). As more sand is needed, we will use more OCS sand. Most beaches need 1 to 2 million cubic yards for one beach nourishment project. The MMS has provided over 14,600,000 cubic yards of OCS sand to coastal states.

The communities whose beaches have been destroyed by erosion or storms write to Intermar to start a sand project. Intermar makes sure the environment is protected when states receive sand for their beaches. Intermar has done dozens of scientific studies to find sand in federal waters beyond 3 miles in the ocean.

This is Surfside Beach, South Carolina **before** it was nourished with sand.

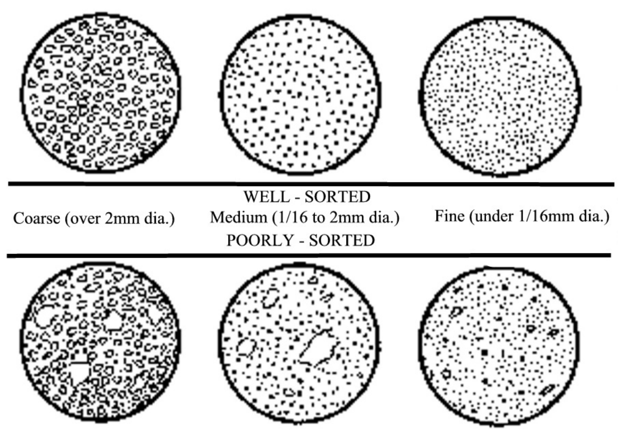
This is Surfside Beach, South Carolina **after** it was nourished with sand.

WHAT IS SAND AND GRAVEL?

Sand is a small rock fragment commonly made up of quartz (beach sand). Sand comes from the weathering of rock fragments by wind and water.

Silt is a fine rock fragment smaller than sand and larger than clay. This is the smallest sand size visible to the human eye.

Gravel consists of loose rock fragments that are generally larger than sand fragments - usually ½ inch in length.



The upper 3 circles show coarse, medium, and fine grains that are well sorted (most sand grains are about the same size). The lower circles show poorly sorted grains (a mixture of grain sizes and types including grains of gravel).

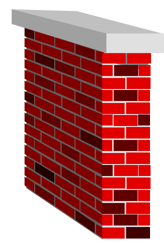
WHY DO WE NEED SAND AND GRAVEL?

Sand and gravel play an important role in the quality of life for all Americans. In the early years of our country, sand was used to make plaster, bricks, and mortar - the cement that holds bricks in place. Gravel was used for making concrete and as a pavement for early roads and streets. Sand is highly resistant to weathering and is the main ingredient used in mixing concrete for the construction of our nation's buildings and highway system as well as for nourishing our beaches.

Before the middle 1800's, all mining and construction work was done with hand tools and animal power. With the advent of steam engines, construction progressed more quickly. Moving construction materials to building sites was difficult at first, limiting the amount of construction that could be done.

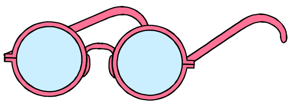
Prior to use in construction, sand and gravel must be processed. Machines are also needed to haul sand and gravel from a pit or quarry to a processing plant where the material is crushed, washed, and sorted into various sizes. In some cases, sand and gravel are dredged from the bottom of lakes and rivers and moved by barge to a processing plant and storage site. Once the materials are processed, they must be delivered to a construction site or factory where they will be used. Today, about 85 percent of all sand and gravel moves by truck; the rest goes by railroad or barge.

As technical methods for mining improved and more sand and gravel became available, more materials could be made from sand and gravel. The development of high-strength concrete and asphalt enabled us to make bridges, highways, and buildings bigger than ever. These new structures use large amounts of sand and gravel.

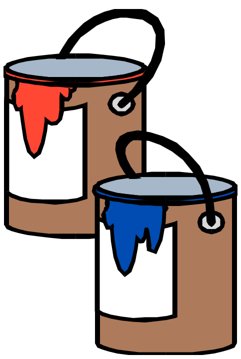


Asphalt pavement is made up of more than 90 percent of sand and gravel and concrete is over 80 percent sand and gravel. Nearly 20,000 tons of sand, gravel, and crushed rock are needed to build 1 mile of a four-lane highway, and an average of 120 tons are required to build a new house in the United States. Most of this goes into concrete for foundations; basement walls and floors; bricks; blocks; and pavement for driveways, sidewalks, and parking areas.

Sand and gravel is in other things too - paint, paper, vinyl, plastics, roofing materials, glass, wallboard,



linoleum flooring, and carpeting. All of these things require significant amounts of sand and/or gravel. Most indoor plumbing and wiring products contain vinyl, which also contains sand. Sand and *silt* (material smaller than sand grains) are also used as fillers in many products we use everyday such as toothpaste, medicines, rubber, and cardboard.

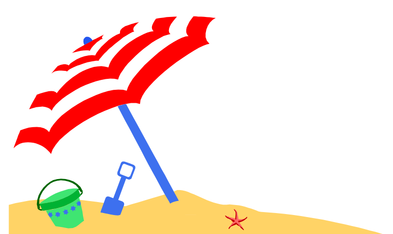


Each American uses about 21,000 pounds or 10.5 tons of sand, gravel, and crushed rock each year. At an average weight of 3,000 pounds per cubic yard, this amount of material would equal a cube 6 feet square at the base and 6 feet tall.

Another big use of sand is to restore beaches. Parts of many beaches are lost each year as severe storms cause waves to pull the sand out so far into the sea that it cannot return to the beach. When beaches lose large amounts of their sand, they become prone to *breaching* (when the sea creates an inlet across the beach) and are then unable to protect the land and property behind the beach. To fix this situation, beaches must be *nourished* with new sand to maintain their proper width.

Here is a list of things from our everyday life that contain sand and gravel to give you an idea of how important they are:

1. water glass or glass bottle
2. piece of asphalt pavement (look for a pothole in a street - with parent - there are usually small pieces of pavement)
3. piece of asphalt shingle (hardware store)
4. piece of concrete
5. piece of vinyl plastic or carpeting
6. Tums or a Rolaids pill
7. toothpaste
8. bottle of acrylic paint



WHAT IS A BEACH?

Beaches are made up of sand at the edge of a body of water. Beach sand comes from streams and rivers that bring eroded materials to the shore and from waves that constantly hit the shoreline. Beaches range in length from small ones on lakes and rivers to ones hundreds of miles long, like on the Atlantic coast of the U.S. The width of beaches ranges from a few feet on rocky coasts to hundreds of feet on some flat, low-lying coastlines.

Beach length and width depend upon *sediment* (mineral grains deposited by water or air), its supply (where its coming from), and its stability (ability of the coast to withstand erosion). If large amounts of sediment are available and *wave energy* (power of the waves) remains low, a wide beach will form. The beach will maintain its shape and size if sediment supply and wave energy remain about equal.

The sediment that makes up a beach can vary from large pebbles and rocks to fine sand and even mud. Many beaches in warm climates are made from pieces of coral and shell from nearby reefs. If sediments are rapidly brought to the beach, such as from the collapse of cliffs, the beach will consist mainly of rock and gravel. When sediments are brought slowly to the shore and have more time to break down into smaller pieces, a sandy or muddy beach will form.

Goat Island beach near Leigh, New Zealand. The sand on this beach is made up of rock and shell fragments.

The color of a beach also depends on the sediment supply. White sand beaches are usually made of coral and shell. Tan, brown, and gray beaches are made from river-transported sand or the erosion of sandy cliffs. Beaches can even have unusual colors such as the black and green beaches in Hawaii (from volcano sediments), orange and yellow (from colored quartz and clays), and pink (from pink coral). There are also beaches with gold (Nome, Alaska), tin ore (Indonesia), and diamonds (Namibia and South Africa) sediments.

Pakiri Beach near Hahei, New Zealand. The sand consists of coarse quartz, with a few shell fragments.

This is a famous surfing beach at Raglan, New Zealand. The beach consists of rocks and boulders.

This is a picture of a beach that has many shells. This occurs in sheltered places, bordered by muddy bottoms. The shells can be washed up easily.

WHAT IS EROSION?

Erosion is a natural process by which rock and soil are broken loose from the earth's surface at one location and moved to another. Erosion changes land by wearing down mountains, moving shorelines, filling in valleys, and making rivers appear and disappear. It is usually a slow process occurring over thousands or millions of years. But unusually large storms and human activities such as farming, mining and construction can speed up erosion.

Erosion begins with a process called *weathering.* The causes of weathering include chemicals; living organisms; the movement of air, ice, and water; and heat from the sun. These are called *environmental factors.* In this process, environmental factors break rock and soil into smaller pieces and loosen them from the earth's surface. The biggest cause of erosion is the formation of ice. As water freezes, it expands with great force. So when water freezes inside tiny cracks in a rock, it can break the rock apart.

After weathering has loosened materials, they are moved to new locations. For example, winds lift particles from the earth's surface and can carry them over great distances. Glaciers transport materials trapped inside their ice. Raindrops splash against sloping land and move small pieces of soil downhill. Water currents carry materials down a riverbed and out to sea. Ocean waves crashing on the beach move sand from one beach to another beach, even those that are great distances apart.

Types of Erosion:

There are many different types of erosion that occur in many different places.

Water Erosion: Water plays an important role in erosion by carrying away material that has been weathered and broken down. When an area receives more water (in the form of rain, melting snow, or ice) than the ground can absorb, the excess water flows to the lowest level, carrying loose material with it. Gentle slopes are subject to *sheet erosion* (when rain washes away a thin layer of top soil) and *rill erosion*, (small closely spaced cracks caused by running water cutting into surface soil). In dry desert areas that have little vegetation to absorb water, runoff can leave a pattern of small valleys and long narrow cracks called gullies.

Water can erode solid rock, especially along streambeds when the stones that are carried by the water rub against other stones and cause them to break apart. Every year, rivers deposit about 3.5 million tons of eroded land material into the oceans.

Glacial Erosion: Glaciers are an important part of erosion. Although a glacier moves slowly, it does remove all the loose material from the surface over which it travels, leaving bare rock surfaces when the ice melts. Besides removing loose material, glaciers actively erode the solid rock over which they travel. Rock fragments that become embedded in the bottom and sides of the moving ice mass act like giant teeth grinding and scouring the *bedrock* (solid rock usually underlying soft sediment above) that forms the walls and floors of mountain valleys.

Wind Erosion: Wind is another active agent of erosion, especially in dry climates with little vegetation. Wind blowing across bare land lifts particles of sand and silt but leaves behind larger pebbles and rocks. Eventually, a surface layer of closely packed stones, called a *desert pavement*, is formed as the sand and silt are removed. The removal of large quantities of loose material is called *deflation*. Deflation lowers the landscape slowly, usually less than a meter (3 ft) in a thousand years. However, deflation can occur more rapidly, as it did during the 1930's in the southern parts of the Great Plains of the United States. This was called the Dust Bowl. Winds may sometimes deposit sand in large piles known as sand dunes.

Home threatened by coastal erosion.

Coastal Erosion: When sand moves away from beaches it is called coastal erosion. Coastal erosion of rocky cliffs and sandy beaches results from the action of ocean waves and currents. The constant removal and replacement of sand permanently changes the size and shape of beaches. Sand may be moved to dunes on the beach, carried out to sea, or moved to other beaches. This is especially true during severe storms. In many parts of the world, the loss of land due to coastal erosion is a serious problem because many buildings and homes are built along the beach.

WHAT CAUSES COASTAL EROSION?

Coastal erosion results from the beach interacting with the ocean. The beach system is one that is considered to be in *dynamic equilibrium*. This means that sand is moved from one location to another but it does not leave the beach areas. For example, winter storms, which generate large waves, may remove significant amounts of sand, creating steep, narrow beaches. In the summer, gentle waves return the sand, widening beaches and creating gentle slopes.

It is the energy in the wave that determines the size and the amount of sand that will move and how far it will go. The energy in the wave depends on the speed of the wind, how long the wave travels, and if there is anything to block the wave as it moves toward shore. Gentle waves move fine sand, but storm-generated waves can move rocks and boulders. Materials picked up from shoreline areas are deposited wherever the water is slowed down. Because there are so many things that can affect coastal erosion (including human activity, sea-level rise, weather conditions and climate change), sand movement will not be consistent year after year.

Coastal erosion poses many problems to coastal communities because valuable property such as businesses and homes can be destroyed by waves if too much sand is removed from the beach. Beach erosion can also destroy the nesting habitat of many threatened or endangered sea turtles and birds.

A deck collapsing as a result of coastal erosion.

Many coastal communities must make decisions about whether to and how to control erosion and restore their beaches.

What Can Be Done to Restore Beaches and Control Erosion

When beaches shrink in size, it is called the *starving* of sediment. This happens when manmade features like dams have been built to prevent floods on rivers or other bodies of water that stop new sand from naturally *nourishing* the beach.

One way to restore eroded beaches is through beach nourishment. In a typical beach nourishment project, sand is collected from the ocean bottom several miles from the shore by a *dredge*, a large floating machine used for scooping up sand and gravel from the ocean floor. The dredge then pipes the sand and gravel to the beach. A mixture of sand and water exits the pipe on the beach, and as water drains away, sand is left behind. Bulldozers move this new sand on the beach until the nourished beach matches the beach before erosion.

Offshore Dredge used to pump sand to the Patrick Air Force Base, Florida 2001.

Beach Nourishment Project at Patrick Air Force Base, Florida 2001.

The rate at which new sand must be added depends on how large the grains of sand are compared to that of the original beach sand. The new sand should be perfectly matched, but this is almost impossible. If the sand size is larger than the original sand, the beach erodes more slowly. If it is smaller, it erodes more quickly.

Beach nourishment is a temporary solution to the problem. If any buildings and homes along the beach are not moved out of the way of the eroding beach, the beach will have to be nourished again. The amount of time between nourishments depends on how fast the beach is eroding.

Nourishment sand provides three important beneficial effects.

1. Beach nourishment sand directly protects the natural *dune-bluffs (a* hill or ridge of windblown sand) from wave attack by acting as a buffer or protective zone between the waves and the eroding natural coast.

2. Beach nourishment reduces erosion on nearby properties by supplying sand to the regional beach and sand bar system. Both the beach nourishment site and the shoreline benefit from the added sand.

3. Beach nourishment restores beaches that continue to be used for recreation and tourism.

Student Activities: Beach Profiling and Beach Erosion

Before nourishing a beach, a number of things must be checked to see if the project can be done correctly. You need to find sand that matches the size and color of the beach and see if the shape of the original beach can be maintained. You also need to make sure that the environment on the beach and the offshore *shoals* (a mound of sediment on the ocean floor that is higher than the area around it) are protected. One of the ways to study beach sand is to do a grain size analysis (measuring grains with a set of sieves with different sized holes), to decide whether the sand you want to use to nourish the beach is about the same size as the beach's original sand. Finally, you look at the grains under a microscope to see the shape and color. Once new sand is placed on the beach, the beach is watched or *monitored* to see if it is holding its correct shape and if most of the sand is staying on the beach.

Examine Samples of Beach Sand – Primary

1. Using a magnifying glass, look at the different sizes of sand grains. Can you tell the difference in the grain sizes?
2. Look at the color of the sand grains. Grains that are clear and glassy-looking grains are quartz. Usually most yellowish-looking grains are quartz also. Black and dark brown grains are mostly iron minerals or bits of other metals. Light brown, tan, and pinkish grains are usually a mineral called Feldspar, which comes from granite. Gray colored grains are quartz or flint. See if there are pieces of solid whiter grains, which are parts of seashells or other marine organisms.
3. Place a handful of sand on a sheet of white paper and make the grains move around the paper by tilting it from side to side. Note how some of the similar colored and similar sized grains seem to stick together, such as the largest grains and the darkest colored grains. This is similar to what happens when a wave hits the beach and moves the sand around.

Make a Beach Profile - Primary

To make a beach *profile* (a "picture" of the area starting at the sand dunes, moving across the beach, ending at the sea floor) you will need a string, a yardstick, and a small level.

1. Start at the water's edge and go to where you see the vegetation or the dune edge.

2. Using a cup or jar, gather sediment samples from several different sites in each of these areas.

Analyze Grain Types - Primary
(This can also be done with sand collected from a lake shore or riverbed)

1. Use a magnifying glass to analyze grain types for several small samples of beach sand you collected.

2. Separate and count the number of clear grains, light colored grains, dark colored grains and pieces of shell. These different colors represent different types of minerals in the grains.

Do a Sand Size Analysis - Primary

The various sizes of grains that make up a sand deposit can be separated into groups of grains that are about the same size. In this way, sand can be described as being of a certain average grain size, which determines whether or not it can be used for a given purpose.

1. Start with as many different sizes of kitchen strainers from coarse size (largest openings) to fine strainers (smallest). You can also make paper sieves from cones rolled by making pin pricks in a large circle of printer paper. Make large and small holes for different size grains.

2. Weigh one of the samples you took from one part of the beach, or estimate volume with a measuring cup.

3. Pass your sample through the coarsest strainer, saving the material that does not go through in one jar.

4. Take the material that does go through and put it through the next smallest size strainer and so on.

5. Save the last or final sample that passes through the smallest size strainer.

6. Weigh each of the separate grain size groups or measure each in the cup and then determine the percentage of each size vs. the whole sample. This is called a sediment particle size distribution.

Exercise: Analyzing Sediment Size Distribution - Secondary

Required Materials:

Set of sieves (available from scientific supply stores)
Ruler
Scales (for weighing sediment)
Collecting pan (plastic tray or baking pan)
Magnifying glass
Paper Plates
Pencil and graph paper
Several sediment samples (collected from the beach, river, sandbox, etc.)

1. Stack the sieves inside the collecting pan from fine (smallest mesh) to coarse (largest mesh). If done correctly, the sieve with the largest mesh size should be on top and the sieve with the smallest mesh size should be on the bottom sitting inside the collecting pan. The collecting pan is used to catch the very fine sizes of sediment including any silts and clays.

2. Using a scale or mass balance, measure and record the weight of the sediment sample in table 1. Next, weight and record weight of an empty paper plate. Then pour the sample into the top of the stacked sieves. Cover with a paper plate and shake the sieves gently for several minutes. Be sure to hold the sieves snug as they may try to come apart during shaking.

3. Take the nest of sieves apart and place them in order from coarsest to finest. Repeat the following process for each sieve. Gently tilt one side of the sieve and tap the sides until all the sediment moves to the bottom of the sieve. Carefully pour the sediment onto a paper plate by flipping the sieve over and tapping the sides gently. Weigh the sediment. Record the weight of the sediment in the box that matches the sieve size in table 1.

4. Use the following to construct a chart that will show the percentage of each of the grain sizes to the whole sample. This is called a Histogram.

   An example of a sand histogram is shown on page 15.

Table 1. Weight percent of grain sizes.

Grain size (mm)	**Weight of sample and paper plate**		**Weight of paper plate**		**Weight of total sample (this number will be the same for all)**			**Percentage of total**
0.05		-		÷		x 100	=	
0.10		-		÷		x 100	=	
0.25		-		÷		x 100	=	
0.50		-		÷		x 100	=	
1.0		-		÷		x 100	=	
2.0		-		÷		*100	=	

Construct a block diagram, or histogram on the graph below using the information you obtained from sieving the sediment. The “x” axis represents the various sizes of the sediment, ranging form very fine to very coarse. The “y” axis represents the weight in percent that you calculated above. For example, if no sediment as found in the 0.10 mm sieve, then the percent of fine sediment in the entire sample would be 0. If half the weight of the entire sample were found to be in the 0.25 mm sieve, then the weight percent for medium sand would be 50%.

Table 2. Sediment Size Distribution Histogram

	Wgt %						
	100						
	90						
	80						
	70						
	60						
Y-Axis	50						
	40						
	30						
	20						
	10						
	00						
		0.05 mm	0.10 mm	0.25 mm	0.50 mm	1.0 mm	2.0 mm
		Very Fine	Fine	Medium	Coarse		Very Coarse
	X-Axis						

Topics for discussion:

Which sample shows the most sorting (more similar grain sizes)?

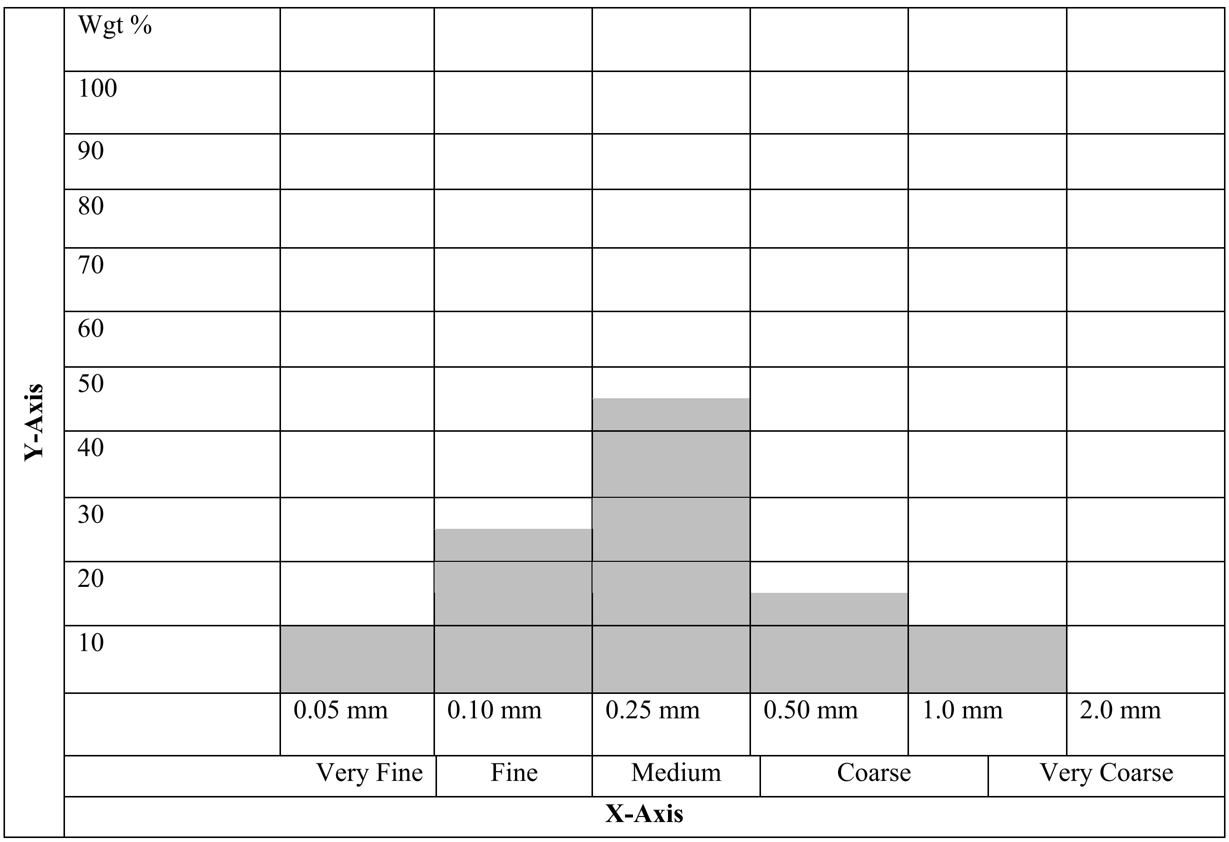
Which sample shows the least sorting (more different size grains)?

Where might you find these types of sediments? Think back to older versus younger sediment discussion (previous page).

Sediment Size Distribution Analysis Example

Grain size (mm)	Weight of sample (in grams)		Weight of paper plate (in grams)	Weight of sample (in grams)		Weight of total sample (in grams)			Percentage of total
0.05	2.2	-	0.2	2.0	÷	22	x 100	=	9.0
0.10	5.2	-	0.2	5.0	÷	22	x 100	=	23.0
0.25	10.2	-	0.2	10.0	÷	22	x 100	=	45.0
0.50	3.2	-	0.2	3.0	÷	22	x 100	=	14.0
1.0	2.2	-	0.2	2.0	÷	22	x 100	=	9.0
2.0	0.2	-	0.2	0	÷	22	x 100	=	0

Table 4. This is an example histogram of very well sorted sediment. This is the type of sediment you might find on beaches such as Virginia Beach, VA, Ocean City, MD, or Huntington Beach, CA.



Remember: Because of the energy generated by ocean waves, beach sands are typically better sorted than river sands.

What Environmental Challenges Does MMS Face in Dealing with Sand and Gravel/Beach Erosion?

Shipwrecks

Some of the sand deposits being considered for beach nourishment contain shipwrecks. Some of these wrecks are historic, others are not but may be used by sport divers for recreation and sport fishing.

In order to make sure that dredging for sand does not damage shipwrecks, the MMS requires that the area be surveyed to see if there are any shipwrecks in the *borrow area*, the area on the sea floor from which the renourishment sand is removed (usually a sand mound). The sand material in the borrow site is similar to the beach that is being renourished.

In order to protect valuable shipwreck areas, the MMS may establish a *buffer zone* in areas where shipwrecks are known to be.

Seafloor Creatures

Creatures that live on and in the sand on the ocean floor are the most directly impacted by beach nourishment activities. Many of these communities rely on *ridges*, long narrow, and low mounds of sand, and *shoals,* shallow areas in the ocean surrounded by deeper water usually made up of sand, as habitat. When dredging occurs on the seafloor, the sandy bottom is pulled through the dredge pipe along with the creatures living there. Most of the creatures either cannot move or move too slowly to escape the path of the dredge. If they don't escape they are destroyed.

The type and size of the sediments on the seafloor is important in determining what creatures can survive there. For instance, small worms called *polycheates* tend to reside in sediment that has fine grains, but a type of shellfish called a *surfclam* tends to like coarser sand.

If dredging changes the types of sediments on the seafloor significantly, the creatures that live in that area will change. Since these creatures are a food source for fish, the types of fish feeding in that area may also change.

The MMS always conducts sand surveys to see what kinds of creatures live in the area and sets limits on how deep a dredge can dig. We do this to help make sure that seafloor creatures that move back into the area will tend to be the same type as those before the dredging, because the area is not significantly changed.

Fish

Another issue that MMS must consider and study is the impact of dredging on fish and fishermen. Sand shoals that are used for beach restoration tend to be favorite feeding places for fish as well. Fish use the shoals as sources of food, feeding on creatures that live on the shoal. They use the shoal for protection and as a place to stay during winter months when water temperatures drop and storms are more frequent. They also use the shoal to lay their eggs. Since dredging removes part of the shoal, fish populations can decrease.

One way to address this problem is to make sure that the dredging leaves the shape of the shoal the same. This helps to make sure that the shoal can still be used by fish as a feeding and resting place, as well as a place to lay eggs.

Effects to Waves

Another important effect of dredging that MMS must study is deciding whether or not dredging an offshore shoal will increase erosion along the shore. If it does, then dredging in that area will only make the erosion

worse. However, for the most part, OCS sand deposits are too far offshore to cause a change in wave patterns that would cause additional erosion at the coastline.

Recommended Internet Sites

The following is a list of internet sites that have information about sand, beaches, and beach-related organizations.

www.mms.gov	The U.S. Department of the Interior Minerals Management Service
www.geology.com	Great site to begin to learn about geology
www.usgs.gov	The U.S Geological Survey
www.fossilguy.com	An interesting site about beaches and fossils in southern Maryland and other areas
www.usace.gov	The U.S. Army Corps of Engineers
www.geosociety.org	The Geological Society of America
www.assg.org	The American Association of State Geologists
www.agiweb.org	American Geological Institute
www.asce.org	American Society of Civil Engineers
www.sme.org	Society of Mining Engineers
www.noaa.gov	National Oceanic and Atmospheric Administration
www.worlddredging.com	World Dredging Magazine
www.esri.com	Environmental System Research Institute (GIS and ArcGIS)
www.csc.noaa.gov	Coastal Services Center
www.coprinstitute.org	Coasts, Oceans, Ports & Rivers Institute of the American Society of Civil Engineers
www.geoinstitute.org	The Geoinstitute of the American Society of Civil Engineers
www.aeg.org	Association of Engineering Geologists
www.asbpa.org	American Shore & Beach Preservation Association

For additional information, visit our website at http://www.mms.gov/intermar/marineac.htm or contact:

International Activities & Marine Minerals Division
Minerals Management Service
381 Elden Street
Herndon, Virginia 20170-4817
Phone (703) 787-1300
Fax (703) 787-1284