BRINGING THE COAST TO THE CLASSROOM

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Document Contents:

VISTA TOPIC: COASTAL ZONE

MODULE TOPIC

Coastal Zone: Waves, coastal processes, beach-profile analysis, and much more.

VISTA OVERVIEW

The coastal zone is constantly changing. Wind, waves, tide, and currents are processes that have a daily effect on the beach and shoreline. Storms can have a dramatic and instantaneous effect on the coast that may take years to recover from. An understanding of the changes to the beach and shoreline helps understanding of the processes that form them.

The objectives of these activities are for students to

- explore coastal processes, beach morphology, and shoreline change along the Texas coast through analysis of data collected by high school students involved in the Texas High School Coastal Monitoring Program;
- learn how to plot topographic profiles from XZ (horizontal and vertical) data, to recognize the significant features of the beach, and to gain understanding of how a beach may change through time; and
- become familiar with basic terminology used in reference to periodic waves and to understand how wind energy is transferred into wave energy. This activity also introduces the effects of water depth on waves.

ABOUT THE VISTA

Correlation to Texas Essential Knowledge and Skills (TEKS). We recommend that teachers select one or two of the TEKS listed to emphasize during learning activities and not attempt to teach all the TEKS listed. The high school science TEKS are available on the Texas Education Agency Website at http://www.tea.state.tx.us/rules/tac/chapter112/ch112c.html.

	TEKS										
Discipline	1	2	3	4	5	6	7	8	9	10	11
IPC	A	A,B,C,D	A,C		B						
Environmental Systems	A	A,B,C,D	A,C		A,E		D	A			
Aquatic Science	A	A,B,E	A,C		A,D			B,C			
Physics	A	A,B,C,D E,F	A,C	A,C		A		A			
Astronomy	A	A,B,C,D	A,C	A				C		C	
GMO	A	A,B,C,D	A,C							B	B

Correlation to National Science Education Standards Grades 9–12

Content Area	Standard	Correlation
Unifying Concepts and Processes	Evidence, models, and explanation	Learners make observations, manipulate data, and propose explanations.
Science as Inquiry	Abilities and understanding of scientific inquiry	Learners analyze beach morphology data collected over time to examine the influence of wave energy, currents and tides on the ever changing shoreline.
Earth and Space Sciences	Energy in the Earth system and the origin and evolution of the Earth system	Learners develop an understanding of the dynamic processes responsible for shaping shorelines. They also realize that interactions between the coast and the ocean produce changes evident on a human time scale. .
Science and Technology	Understanding about science and technology	Learners develop an understanding of the technology involved in monitoring shoreline change (i.e. GPS) and manipulating data.
Science in Personal and Social Perspectives	Natural hazards, natural resources and environmental quality	Learners develop an understanding of the power of storms, including hurricanes—a serious natural hazard along the Texas Gulf Coast—to alter the morphology of coastal areas. They also become aware of the Texas coast as a valuable natural resource vulnerable to degradation as a consequence of increasing pressure from population growth and recreational use.
History and Nature of Science	Science as a human endeavor	Learners work with real data to draw conclusions in a similar manner to that of real scientists.

Correlation to Benchmarks for Science Literacy

Benchmarks specify how students should progress toward science literacy, recommending what they should know and be able to do by the time they reach certain grade levels. *Benchmarks* can be found at American Association for the Advancement of Science Webpage: http://www.project2061.org/tools/benchol/bolintro.htm.

	BENCHMARK											
MODULE	1	2	3	4	5	6	7	8	9	10	11	12
Coastal Zone	A,B, C	A, B	A,C	B,C, E,F, G					B,C		C	A,B,C

BACKGROUND INFORMATION FOR TEACHERS

DID YOU KNOW?

Did you know that Texas has 600 kilometers of shoreline? Ever-increasing numbers of visitors travel to the Texas Gulf Coast for recreation; they also travel on business and in search of employment opportunities to our coastal cities and towns. This rapidly expanding population is straining the capabilities of land and natural resources, and development is threatening critical habitats and species. The Gulf Coast is subject to the episodic occurrence of violent tropical storms as well as the less dramatic, but more constant, impacts of wind and waves. For the coastal zone to be managed and developed wisely, it is vitally important that measurements be taken on a regular basis to determine what is there, document natural processes at work, and monitor the impacts of our choices in how we develop the coastal zone.

Texas High School Coastal Monitoring Program

The Bureau of Economic Geology at The University of Texas at Austin is responsible for monitoring shoreline change in Texas. Since 1997 the Bureau has run a highly successful program in three coastal high schools—Galveston, Port Aransas, and Port Isabel (Fig. 1)—called the Texas High School Coastal Monitoring Program (THSCMP). This program engages high school students, teachers, and scientists in a long-term research project to investigate dune and beach dynamics on the Texas coast. Valuable data are collected and analyzed, and participants see the science that explains this ever-changing environment. The high school program contributes to many decades of coastwide research on the effects of storms, shoreline change, gain and loss of wetlands, coastal hazards, and many other coastal issues that are important to Texas.

The Texas High School Coastal Monitoring Program has three major goals. First, it provides high school students with an inquiry-based learning experience. Working in teams, the students conduct scientific research involving data collection, analysis, and hypothesis testing. Through their collaboration with working scientists on an actual research project, students gain an unparalleled educational experience. Second, the program increases public awareness and understanding of coastal processes and hazards through the students. Community outreach is an important part of the program. Finally, the project monitors seasonal changes at several beaches on Galveston, Follets, Mustang, and South Padre Islands. Monitoring these beaches helps us understand the relationship between coastal processes and beach morphology, providing critical information for coastal management.

As part of their course work, science students monitor selected beaches over the academic year they are involved in the program. They measure shore-normal beach and dune topographic profiles and make observations on weather conditions, sea state, longshore current, and dune vegetation. These data are analyzed by scientists at The University of Texas at Austin and the students themselves and compared with earlier data. The students share their observations with students from other high schools in the program and with the coastal community. Data and observations collected by the students are posted on the program's Worldwide Website (http://txcoast.beg.utexas.edu/thscmp/). Each year the Coastal Monitoring Program reaches a new group of science students. Field trips to the beach are a very popular part of the students' learning.

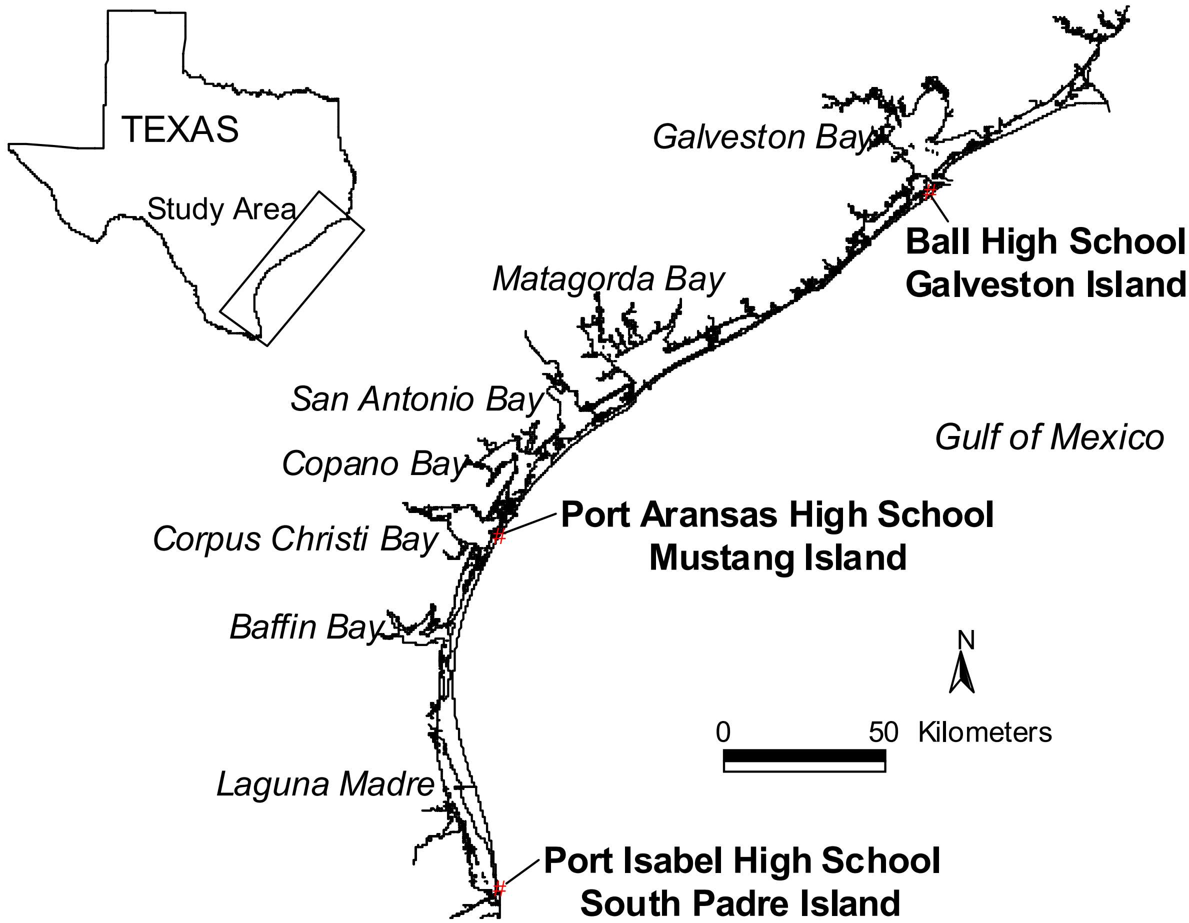

Figure 1. Location of schools participating in the Texas High School Coastal Monitoring Program.

<u>Beach Environment</u>

The beach is a dynamic environment. This narrow strip of real estate is constantly being rearranged by the daily forces of waves, tides, and weather. Figure 2 is a schematic map of a *barrier island* system. A barrier island is a narrow, long, coastal island composed of an accumulation of sediments that rises above sea level, typically extending parallel to the mainland but separated from it by a body of water. A barrier island has several environments, including dunes, tidal flats, marshes, washover fans, and, of course, the beach. Although all these environments are important, we are going to focus our attention on the beach and dunes. Figure 3 is a cross section along A-A′ in Figure 2. We will be interested in the bottom half of this diagram, the beach cross section.

At first glance a beach seems like such a simple environment. However a lot of terminology is used to describe this narrow interface between land and sea. Berm, berm crest, vegetation line, wet/dry line, foredune, foredune crest, wrack line, coppice mound, and scarp are all terms students involved in THSCMP use to describe different features encountered on the beach. In the definitions provided in Table 1, the terms *backshore* and *foreshore* are used frequently. Teachers may wish to define these zones before starting the activity. **An alternate approach would be to allow students to develop their own terminology to describe these features.**

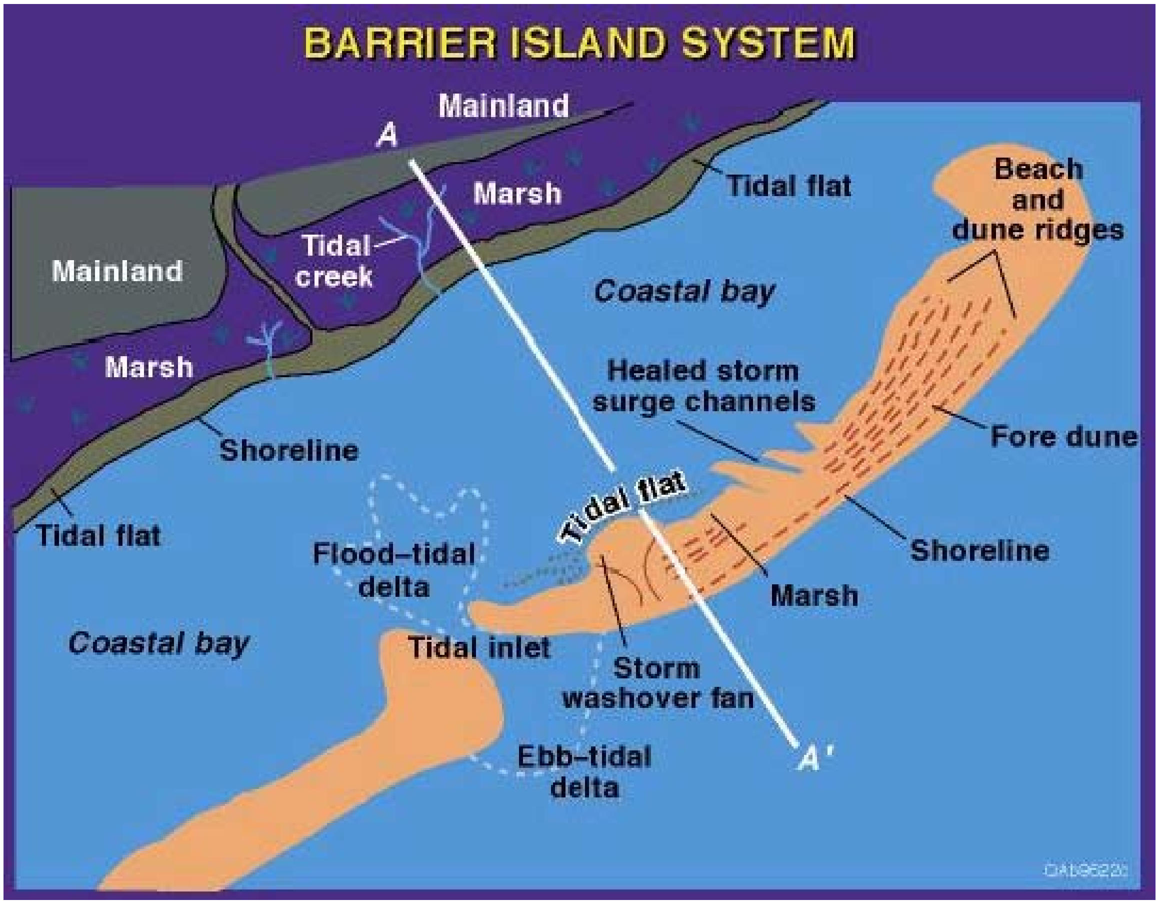

Figure 2. Schematic map of geologic environments in a barrier island system.

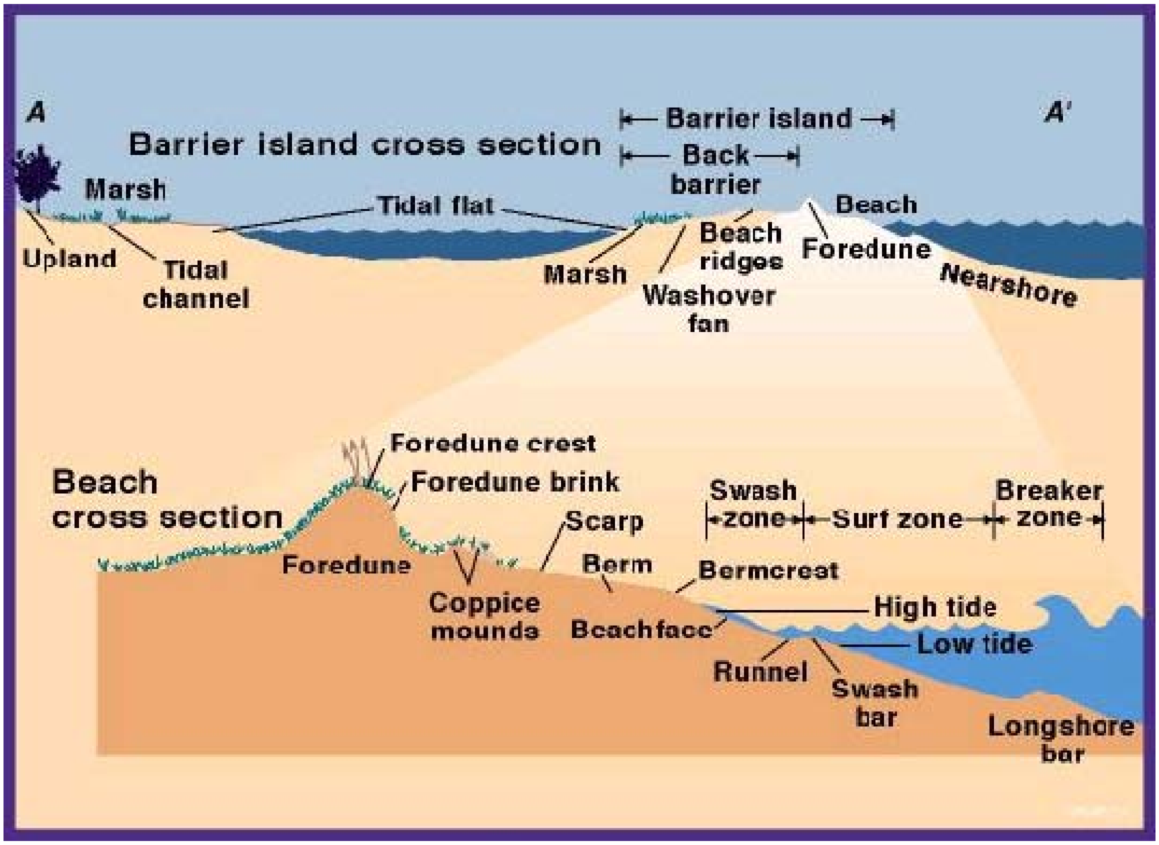

Figure 3. Cross section view along the line A to A' from Figure 2 above. At least three times during the school year, students collect quantitative geomorphic and sedimentologic data that describe the seaward beach (a point behind the foredune crest to the waterline). The *backshore* or *backbeach* is the upper zone of the beach lying between the berm crest, or the high water line, to the point of development of vegetation or change in physiography (i.e., sea cliff, dunes, seawall, etc.). This region is nearly horizontal or slopes down slightly landward. The backshore is commonly under the influence of the wind. Only during high-water events are waves a factor in this zone. The backshore is where most beach goers like to leave their blankets, umbrellas, and coolers. The *foreshore*, or *forebeach*, is the sloping part of the beach profile lying between a berm crest (or upper limit of high tide) to the low-water mark of the run-down of the wave swash at low tide. This area is constantly under the influence of waves and is exposed, then unexposed, by the rise and fall of tides.

Table 1. List of features typically found on a beach.

Beachface:	The sloping, nearly planar section of the beach profile below the berm, which is normally exposed to the swash of waves.
Berm:	The nearly horizontal part of the beach or backshore formed by deposition of sediments by waves. Some beaches may have more then one berm at slightly different levels, other beaches may have none.
Berm Crest:	The seaward limit and generally the highest point of a berm on a beach. The crest of seaward most berm separates the foreshore from the backshore.
Scarp:	A nearly vertical escarpment cut into the beach profile by wave erosion. It is generally less than 1 meter high.
Coppice Mound:	Small mounds formed by the accumulation of windblown sand on the backshore just seaward of the foredunes and anchored by vegetation. With an adequate sediment supply, these mounds could grow larger, become continuous, and form a new foredune system.
Vegetation Line:	Farthest extent seaward of vegetation. Commonly somewhere seaward of the foredunes. Some beaches have many vegetation lines (i.e., one line marking extent of continuous landward vegetation; another marking boundary of a sparsely vegetated area).
Foredune:	Accumulation of windblown sand and sediment that forms a ridge at the landward margin of the beach. Can be stabilized with vegetation. First line of defense for structures behind dunes in case of high water due to storms.
Foredune Crest:	Top of the foredune.
Wet/Dry Line:	Line between wet sand and dry sand on the beachface. Marks highest level of wave swash.
Wrack Line:	Line of debris left on the backshore following an extremely high water level.

Now that we have an understanding of some of the terminology used to describe features on the beach, let's move on to some of the processes that shape the Texas Coast.

Tropical Storms–One of Nature's Safety Valves

Storms are generated in warm, tropical ocean waters. In order for heat to be dissipatedinto the upper atmosphere, the energy in these warm waters gets transferred into thunderstorms. The thunderstorms may merge and begin to spin around a central axis. This spinning structure forms a spiral pattern, the central axis having calm winds called an *eye*. This structure is known as a *tropical depression*. If wind speeds exceed 39 mph (62.8 km/h), then the storm is classified as a *tropical storm* and given a name. If wind speeds increase even more, up to 74 mph (119 km/h), the storm is reclassified as a *hurricane*. Although wind speeds in tropical storms are not as powerful as in hurricanes, tropical storms can still produce damaging winds and rain, just as hurricanes can. Hurricanes and tropical storms, as well as the typhoons that occur in the Pacific, move heat away from the tropics to higher latitudes.

Tropical Storm Frances hit the Texas coastline in September of 1998. One life was lost because of the storm. Thankfully the death toll was minimal, but the National Hurricane Center reports that the damage due to Frances totaled about $500 million. Storm surges 6 to 8 feet (1.8–2.4 meters) high were recorded, and as much as 16 inches (40.64 centimeters) of rain fell along the Texas and Louisiana coast. The storm caused inland flooding, which lasted for 48 hours and significant erosion of beaches. Using real data collected by high school students before and after Tropical Storm Frances, Exercise 1 evaluates the volume of sand eroded and changes in the beach topography caused by this storm.

<u>Waves</u>

Ocean waves are described using the same terminology that is used in physics to describe periodic waves (propagating disturbance in a medium, for example, wind on the surface of water). In the case of ocean waves the disturbance is wind and the medium is the water surface. The *crest* is the highest part of the wave, and the *trough* is the lowest part of the wave. *Wave height* is the vertical distance between the crest and nearest trough. *Wavelength* (L) is the lateral distance between a point on one wave and the corresponding point on the neighboring wave; for example, the top of two crests. See Figure 3 for a diagram of these wave features. *Wave period* is the amount of time that it takes for two successive wave crests or troughs to pass a fixed point. *Frequency* is the number of waves per second, which is the inverse of the period (frequency = 1/period). Velocity of the waveform, or *celerity,* is calculated by dividing the wavelength by the wave period (celerity = wavelength/period in seconds). For more on characterizing waves, see Exercise 2a in *Earthquakes: Shake, Rattle, and Roll* module and Exercise 2 in *Tsunamis: Walls of Water* module.

Crests of waves are visible at the surface. Just as a rock thrown into a puddle will produce waves moving outward, wind will produce linear wave crests moving across a body of water. Crests of waves can also be *refracted* or bent by irregularities of the ocean floor or offshore structures. In Exercise 3 later, waves are *reflected* back from the sides of the pan.

Most ocean waves are generated by wind blowing over the surface of the water. The size of waves depends on wind speed, the length of time that the wind blows in a consistent direction, and the *fetch*, which is the distance over which the wind blows. Essentially, the stronger the wind and the longer it blows, the larger the waves become. Through this process, a tremendous amount of energy is imparted to waves. The ultimate source of this energy is the sun, and it is this energy that moves tremendous volumes of sediment. Then waves transfer the energy through the water without moving the water from one location to another.

As waves pass over deep water, individual water molecules move in nearly stationary circular patterns. At the surface, the diameter of the orbit is approximately equal to the wave height. At the wave's crest, the molecule is moving with the direction of the wave, but at the wave's trough, the molecule is moving in the opposite direction. Below the surface, the size of the orbit of a given water molecule decreases downward through the water column to a depth of L/2, below which there is no motion of water related to the wave. This concept is illustrated in Figure 4. In water less than L/2 deep, the bottom distorts the orbits of the water molecules. These waves are known as shallow-water waves. Tsunamis are shallow-water waves because their wavelengths are so long that even the deep ocean is less than L/2 deep. Find out more about tsunamis in

Tsunamis: Walls of Water module. Waves in water more than L/2 deep are known as deep-water waves.

When a wave approaches shallow water, such as a shoreline, the form of the wave begins to change. The waves begin to “feel” the bottom (depth is less then L/2) and the waves will steepen and slow down. Waves will begin to break when a wave crest is less than 120˚ or the steepness (wave height/wavelength) is greater then 1/7.

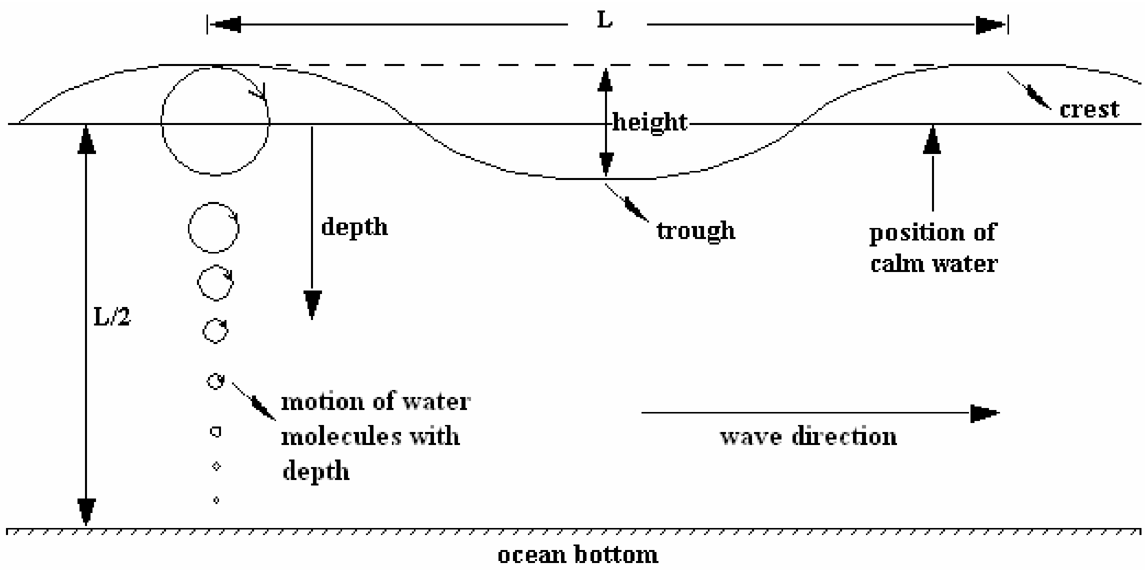

Figure 4. Wave diagram including the motion of individual water molecules with depth.

<u>Tides</u>

Tides are actually waves caused by the gravitational forces of the Earth, moon, and sun. The relationship between masses of the celestial objects, as well as their distance from Earth, generates the gravity waves we refer to as tides. Even though the moon’s mass is much smaller than sun’s, the distance between the Earth and the moon is significantly smaller than the distance between the Earth and the sun; therefore, it has a larger effect on the tides. High tide is actually a bulge of water generated by the pull of the moon on global waters. There is an equal bulge on the opposite side of the Earth from the moon. *Tidal range* is the water-level difference between high and low tide. *Spring tides* are tides of the largest tidal range. They occur twice during a lunar month when the Earth, sun, and moon are in alignment (new and full moons). Spring tides are the highest high and the lowest low tides. *Neap tides*, lowest tidal ranges of the tidal cycle, occur when the moon is in the first and third quarters.

The moon orbits the Earth once every 27 days and 8 hours; therefore, the tides will move forward 50 minutes every day. Tides can be described as either *diurnal* or *semidiurnal*. During a diurnal tide there is one high and one low tide every 24.8 hours, or lunar day. Semidiurnal tides are two highs and two lows during the same period of time.

RESOURCES

Books

1. *The Evolving Coast* by Richard A. Davis, Jr., 1994, Scientific American Library. Good book for general audiences. Introduces the reader to processes that affect and form the world's coastlines.
2. *Dictionary of Geological Terms Third Edition* by the American Geological Institute
3. *Exploring Tropical Cyclones: GIS Investigations for the Earth Sciences* by Michelle K. Hall-Wallace, C. Scott Walker, Larry P. Kendall, and Christian Schaller, Brooks Cole, Pacific Grove, CA, 2003. This book contains a number of excellent learning activities that are relevant to this module.

Websites
4. The University of Texas at Austin, Bureau of Economic Geology's (BEG), Texas High School Coastal Monitoring Program including data associated with Tropical Storm Frances (http://txcoast.beg.utexas.edu/thscmp/).
5. National Oceanic and Atmospheric Association's (NOAA) National Data Buoy Center's (NDBC) Science Education Pages (http://www.ndbc.noaa.gov/educate/educate.shtml).
6. National Oceanic and Atmospheric Association's (NOAA) National Hurricane Center's page on storm surges (http://www.nhc.noaa.gov/HAW2/english/storm_surge.shtml).
7. National Oceanic and Atmospheric Association's (NOAA) National Hurricane Center's preliminary report on Tropical Storm Frances (http://www.nhc.noaa.gov/1998frances.html).
8. Satellite images and storm-track map of Tropical Storm Frances (http://www.atmos.umd.edu/~stevenb/hurr/98/frances/).
9. Oceans Alive on-line exhibit from the Museum of Science in Boston, Massachusetts (http://www.mos.org/oceans/motion/index.html).
10. Office of Naval Research on-line ocean information, including tutorials (with quizzes) about currents, waves, tides, and beaches (http://www.onr.navy.mil/focus/ocean/default.htm).
11. Texas Coastal Ocean Observation Network, Conrad Blucher Institute for Surveying and Science, Texas A&M University, Corpus Christi (http://dnr.cbi.tamucc.edu/wiki/TCOON/HomePage).
12. National Oceanic and Atmospheric Association's (NOAA), National Ocean Service's (NOS), Center for Operational Oceanographic Products and Services (CO-OPS) National Ocean Service's (http://co-ops.nos.noaa.gov/).

<u>Learning Experience</u> - 1: Tropical Storm Frances analysis

Time Frame – 50 minutes

Materials

- Several sheets of graph paper
- Internet access (**http://txcoast.beg.utexas.edu/thscmp/**)
- Ruler
- Colored pencils

Objectives

Tropical Storm Frances struck the southeast (upper) Texas coast September 7 through 13, 1998, and caused extensive beach and dune erosion and damage to structures. The storm surge peaked at only 1.4 m above mean sea level, but extreme water levels (> 0.78 m) lasted for 64 hours. Although peak wave height was 4.09 m during the storm, extreme wave heights (>2.30 m) lasted for 73 hours.

You are a coastal scientist hired by the Texas General Land Office to document the effects of Tropical Storm Frances. To do so you will need to construct beach profiles before and after the storm at different locations along the Texas coast. You will use data that have been collected by students at Ball High School and scientists at the Bureau of Economic Geology (BEG) at The University of Texas at Austin.

One of the goals of this section is to help you understand the importance of the Texas High School Coastal Monitoring Program. Through data collection conducted by schools in the program, BEG scientists are able to better comprehend coastal processes, beach morphology, and shoreline change along the Texas coast.

Procedure/Guided Inquiry Activity

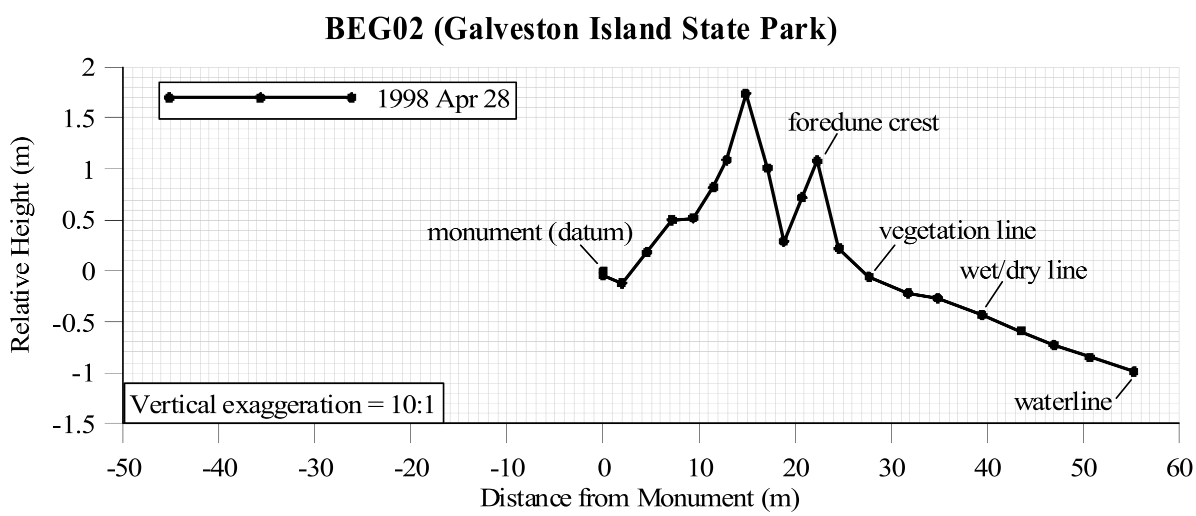

Figure 5. Sample plot.

Plot data downloaded from the Texas High School Coastal Monitoring Program Website (http://txcoast.beg.utexas.edu/thscmp/). You will need the following profile information to answer the questions in Part A: BEG02-980428-1020 and BEG02-980916-0830. For Part B, you will need BEG02-981022-0852 and another BEG02 profile from 2003 or 2004 (your choice).

Plot the two profiles for Part A first and answer questions using the counting rectangles technique described by your teacher. Use a different colored pencil for each profile. Be sure to add a legend so you can identify the different profiles. Label the features of the beach profile (provided with dataset).

Critical Thinking Questions for Students

Part A

1. Dune: What volume of sand has been lost in the dunes? How was the dune system affected following Tropical Storm Frances?
2. Beach: What volume of sand has been lost on the beach? Approximately how far landward has the beach moved?
3. What is the total (dune + beach) volume of sand lost during Tropical Storm Frances?

Part B

1. Add the 981022 profile to your plot. After Tropical Storm Frances, *washover* sand in the picnic area at Galveston Island State Park (BEG02) was bulldozed seaward to form an artificial *foredune* (981022 plot). Without considering the new dune system–consider the beach portion of the profile–how much has BEG02 recovered in 1 month (September to October)?
2. Add the final BEG02 profile. How much recovery (beach and dune system) has occurred since October 1998? In other words, what volume of sand has been returned to the beach and dune system?

Part C (optional)

Repeat Part A for BEG08 on Follets Island (BEG08-980428-0850 and BEG08-980915-1141). After answering those questions, add BEG08-981022-1104 and a 2003 or 2004 BEG08 profile of your choice.

1. BEG08 on Follets Island is in a natural setting. After Tropical Storm Frances, this area was not manipulated to return *washover* sand to the beach and dune system. How much did the beach and dune recover in 1 month? At the end of your monitoring period?
2. Excluding the artificial dune at BEG02, how do these two sites compare with one another during this recovery period?

*Remember, Frances was only a Tropical Storm. Imagine what would occur during a Category 3 Hurricane (wind speeds from 111 to 130 mph)!

Formative Assessment/Authentic Assessment

Teachers should check that students are plotting beach profiles correctly.

Learning Experience - 2: Introduction to ocean waves showing the transfer of energy from wind to waves

Time Frame - 50 minutes

Materials

- Hand-held hair dryer, block of wood and string, or thin wooden board to act as a paddle
- 9×13 inch clear glass Pyrex pan, a large cookie sheet at least 1/4 inch deep, an aquarium, or any other clear container. Students should be able to observe wave properties. (HINT: A clear underbed plastic storage box works really well. It is very shallow, but your wave field will be much longer.)
- Pitcher of water
- Construction paper
- Ruler
- Stopwatch
- Modeling clay (anything that can be placed in the water as an obstruction)
- Cork (or something that will float)
- Towels for cleaning up
- A water-soluble overhead projector marker (optional)

Advanced Preparation

1. Teacher needs to review wave section of PowerPoint presentation
2. Set up experiment.

NOTE: Because electricity is involved, students should observe the experiment as it is carried out by the teacher. Students can become actively involved once the electrical portion of the experiment is completed.

Procedure/Guided Inquiry Activity

1. Introduction to basic terminology used to describe waves (included in the Did You Know? section earlier). The presenter/teacher should introduce the terms/concepts shown in italics. This portion of the lesson should take about 10 minutes and should give students a greater appreciation of what they will see in the experiment.
2. The experiment portion of the lesson takes about 30 minutes and allows students to use the vocabulary terms they have just learned and to discover for themselves the processes that create waves.
3. Fill Pyrex pan, large cookie sheet, aquarium, or other container with water until the water comes about halfway up the sides of the container.
4. Create waves by one of the following processes: (a) blow across the surface of the water; (b) use a hair dryer set at a low setting (harder to vary the velocity) to blow across the surface of the water; (c) use a block of wood tied to a piece of string, and raise it up and down in the water; or (d) insert a thin board into the water and move it back and forth like a paddle. If using the hair dryer method, the teacher should conduct the experiment with the students observing. Also be extra careful because of the risk of electric shock.

5. Place your float (cork) in the middle of the pan. Observe how the float responds to the waves you are creating. Try to keep the wave period consistent.
6. A student volunteer should measure the wave period with a stopwatch. Make a mark on the side of the pan with the marker or a piece of tape. As the crest of a wave passes your point, count that as zero and start your stopwatch. The next wave is wave number one. When the 10^{th} wave passes your point, stop the watch. Divide the number of seconds by 10 to get the wave period. Because these are waves with small wavelengths, this task may be difficult to do.
7. Take a piece of construction paper. Dip it into the water along the side of the pan and remove immediately. You have created a snapshot of the wavefield. Lay the paper on the desk and with a marker trace the contact between the wet and dry paper. Either now, or once the paper dries, measure wave height and wavelength.
8. Vary the speed of your "wind." Again measure wave height, wavelength, and wave period.
9. Remove the water from the pan. Now mold some clay to represent depth changes in the ocean floor. Try something simple like a wedge to represent the continental margin. Place the clay into one end of the pan. If you have access to sand, dirt, or gravel, you may want to use that instead. Create a beach face at one end of the pan. Repeat steps 3–5.

Critical Thinking Questions for Students

1. Were the waves shorter or taller as the wind speed increased?
2. Were your waves shallow- or deep-water waves before you added the wedge/margin?
3. What effect did the wedge/margin have on the waves' height and wavelength?
4. What effect do tropical storms and hurricanes have on waves? Imagine that a hurricane is making landfall on the Texas coast. Would the effect of the wind be different on one side of the storm's eye versus the other? You may have to do additional research on hurricanes.

Authentic/Formative Assessment

A. Ask students to prepare a diagram labeling wavelength, wave height, amplitude, crest, and trough based on their measurements and observations, before adding the obstruction to represent the seafloor.
B. Ask students to draw a model of their observations of the waves both with and without the clay in the pan.
C. For extra credit, have students prepare diagrams to illustrate frequency and period.
D. For additional extra credit, have students research the three types of *breakers*. There are plenty of Websites available with sketches and explanations. Have students explain each type, draw examples, and list a place or instance where/when each of these breakers might be present.

LEARNING EXPERIENCE - 3: Introduction to tides

Time Frame - 50 minutes

Materials

- Internet access
- Microsoft Excel
- Lunar calendar

Advanced Preparation

1. Introduction to terminology used to describe tides (included in the Did You Know? section earlier). The presenter/teacher will need to introduce the terms/concepts shown in italics. This portion of the lesson should take about 10 minutes and should give students a greater appreciation of what they will be looking for.

Procedure/Guided Inquiry Activity

Students can work in teams or by themselves.

1. Launch Internet Explorer or Netscape. Type in the following address: http://co-ops.nos.noaa.gov/. Add this page to your favorites. We will be coming back to the main page later in the exercise.
2. You have now entered the Center for Operational Oceanographic Products and Services (CO-OPS) Website. Click on the word "Predictions."
3. Click on "Here for 2004 Tidal Predictions."
4. Click on the state of Texas. You will find a list of stations in Texas where tides are predicted. The sites are listed from the Louisiana border to the US/Mexico border.
5. Select the predictions for Galveston Pleasure Pier. You will find a page with Galveston Pleasure Pier tidal predictions for the entire year. All heights are in feet referenced to Mean Lower Low Water (MLLW) and are listed in Local Standard Time or Local Daylight Time (for Texans, this is Central Standard or Central Daylight Time). Below is an example of data from this site. The time of each tide is followed by the height of the tide (H=High Tide, L=Low Tide).

Date	Day	Time	Height	Time	Height	Time	Height	Time	Height
1/1/03	Wed	07:35AM LST	-1.5 L	04:27PM LST	2.1 H				
1/2/03	Thu	08:24AM LST	-1.5 L	05:16PM LST	2.0 H				
1/3/03	Fri	09:12AM LST	-1.5 L	06:01PM LST	2.0 H				
1/4/03	Sat	10:00AM LST	-1.4 L	06:41PM LST	1.8 H	11:16PM LST	1.4 L		
1/5/03	Sun	01:41AM LST	1.5 H	10:45AM LST	-1.0 L	07:15PM LST	1.7 H		
1/6/03	Mon	12:05AM LST	1.2 L	02:46AM LST	1.4 H	11:28AM LST	-0.8 L	07:43PM LST	1.5 H
1/7/03	Tue	01:12AM LST	1.0 L	04:06AM LST	1.2 H	12:08PM LST	-0.4 L	08:05PM LST	1.4 H

6. Look at the current month. Can you determine when neap and spring tides occur? What is the maximum and minimum tidal range?

7. Now find a lunar calendar. Did the dates you selected for neap and spring tides correspond with the appropriate phases of the moon?
8. Choose another month. Using Excel or graph paper plot high and low tides. Can you determine when neap and spring tides occur?
9. Let's look at actual water-level data compared with predicted values. Return to the main CO-OPS Webpage. Click on Tides OnLine.
10. On the left-hand side of the screen click on "State Maps" under "Select Stations By." Again select the state of Texas. Let's continue looking at Galveston Pleasure Pier. Place your cursor over the words Galveston Pleasure Pier, and click the left mouse button.
11. The red x's on the top graph represent actual water-level observations and the blue line represents predicted values. Write down the time of the latest water-level observation, the observed height, and the predicted height. There are other graphs with meteorological observations from this location. If the observed and predicted values are not the same, what other factors do you think can affect the level of the tides?

Critical Thinking Question for Students

Thinking back to the previous learning experiences about tropical cyclone effects on beaches and waves, what effect do you think tide level at landfall of a tropical storm or hurricane has?

Authentic/Formative Assessment

- Have student's draw a diagram with the positions of moon, Earth, and sun and their effects on tidal cycles (what is the alignment of the moon, Earth, and sun during spring tides?).
- Extra credit. This assignment will take you to the following Website: http://dnr.cbi.tamucc.edu/wiki/TCOON/HomePage. This site is the Texas Coastal Ocean Observation Network (TCOON) run by the Conrad Blucher Institute for Surveying and Science (CBI) at Texas A&M University at Corpus Christi. CBI installed and manages more than 40 water-level measurement systems along the Texas Gulf Coast. In the Corpus Christi and Galveston areas there are tide gauges on both the open Gulf Coast (Bob Hall Pier and Galveston Pleasure Pier, respectively) and in the Bay systems. Have students follow the directions below for retrieving data from the TCOON site.
    1. Launch Internet Explorer and Netscape and enter the following address: http://dnr.cbi.tamucc.edu/wiki/TCOON/HomePage.
    2. At the bottom of the page you will find a map of the Texas coast with flags marking the location of water-level measurement sites (tide gauges). Select either the Corpus Christi Bay Inset or the Galveston Bay Inset.
    3. By positioning your mouse over the blue flags, you can determine the name for each station. Decide on two stations for which you are going to get data. DON'T click on the flag yet; just make a decision. One gauge needs to be the open coast gauge (Galveston Pleasure Pier in Galveston Bay Inset and Bob Hall Pier in Corpus Christi Bay Inset). The other gauge can be from anywhere in the bay.

4. Make a sketch of the bay system you choose. Label islands, major towns, and bodies of water. Draw flags and label tide gauge stations. Designate the two you have chosen from which to retrieve data.
5. Now click on the flag of the bay station you chose. You will find a page with basic station information about the site. Look through the information.
6. At the top of the screen, click on the tab that says "Datums." You will find the page that has listed the tidal datums for the site. Scroll down until you see a list called "Elevations of datums above station datums." You should see a list that includes Mean High Water, Mean Sea Level, Mean Lower Low Water, etc. If this list is not present, return to the map of the Bay system (hit "Back" button twice), and choose a different bay station.
7. Once you have confirmed that there is a list of tidal datums, click on the "Data Query" tab. Here you will select the information you want to retrieve.
8. Select the following parameters:
   - Stations—there should be a number already in the box on this section. That is your bay tide gauge's designation. You need to select the open coast gauge from the scroll box. The text to the right says that the stations are listed by latitude from north to south. Not so; they are alphabetical. Select either Bob Hall Pier or Galveston Pleasure Pier from this list.
   - Series—select Primary Water Level.
   - Dates—you can change these, but leave them as they are for now. If you do change the dates, select an entire week's worth of data.
   - Format—GIF under Graph should be marked.
   - Units—please select metric.
   - Elevation—from the drop-down list select Mean Sea Level
   - Date Format—either leave as default or select a style you are most comfortable with.
   - Time Zone—U.S. Central Time.
   - Now click the button "Click here to retrieve data".
   - Print the graph you have created.
9. Answer the following questions.
   A. Compare and contrast the two plots on your graph.
   B. Look at the sketch map of the bay system you selected. Rationalize why you think the two tide gauges are different or the same. You may have to do some more research on tides in bays vs. the open coast.

Appendix 1. Correlation to the Texas Essential Knowledge and Skills (Integrated Physics and Chemistry (IPC), Environmental Systems; Aquatic Science; Physics; Astronomy; and Geology, Meteorology, and Oceanography (GMO))
http://www.tea.state.tx.us/rules/tac/chapter112/ch112c.html.

	TEKS										
Discipline	1	2	3	4	5	6	7	8	9	10	11
IPC	A	A,B,C,D	A,C		B						
Environmental Systems	A	A,B,C,D	A,C		A,E		D	A			
Aquatic Science	A	A,B,D,E	A,C		A,D			B,C			
Physics	A	A,B,C,D E,F	A,C	A,C		A		A			
Astronomy	A	A,B,C,D	A,C	A				C		C	
GMO	A	A,B,C,D	A,C							B	B

Chapter 112. Texas Essential Knowledge and Skills for Science
Subchapter C. High School

§112.42. Integrated Physics and Chemistry.

(c) Knowledge and skills.

(1) Scientific process. The student, for at least 40% of instructional time, conducts field and laboratory investigations using safe, environmentally appropriate, and ethical practices. The student is expected to:

(A) demonstrate safe practices during field and laboratory investigations.

(2) Scientific processes. The student uses scientific methods during field and laboratory investigations. The student is expected to:

(A) plan and implement investigative procedures including asking questions, formulating testable hypotheses, and selecting equipment and technology;

(B) collect data and make measurements with precision;

(C) organize, analyze, evaluate, make inferences, and predict trends from data; and

(D) communicate valid conclusions.

(3) Scientific processes. The student uses critical thinking and scientific problem solving to make informed decisions. The student is expected to:

(A) analyze, review, and critique scientific explanations, including hypotheses and theories, as to their strengths and weaknesses using scientific evidence and information; and

(C) evaluate the impact of research on scientific thought, society, and the environment.

(5) Science concepts. The student knows the effects of waves on everyday life. The student is expected to:

(B) demonstrate wave interactions including interference, polarization, reflection, refraction, and resonance within various materials.

§112.44. Environmental Systems.

(c) Knowledge and skills.

(1) Scientific processes. The student, for at least 40% of instructional time, conducts field and laboratory investigations using safe, environmentally appropriate, and ethical practices. The student is expected to:

(A) demonstrate safe practices during field and laboratory investigations.

(2) Scientific processes. The student uses scientific methods during field and laboratory investigations. The student is expected to:

(A) plan and implement investigative procedures including asking questions, formulating testable hypotheses, and selecting equipment and technology;

(B) collect data and make measurements with precision;

(C) organize, analyze, evaluate, make inferences, and predict trends from data; and

(D) communicate valid conclusions.

(3) Scientific processes. The student uses critical thinking and scientific problem solving to make informed decisions. The student is expected to:

(A) analyze, review, and critique scientific explanations, including hypotheses and theories, as to their strengths and weaknesses using scientific evidence and information; and

(C) evaluate the impact of research on scientific thought, society, and the environment.

(5) Science concepts. The student knows the interrelationships among the resources within the local environmental system. The student is expected to:

(A) summarize methods of land use and management; and

(E) analyze and evaluate the economic significance and interdependence of components of the environmental system.

(7) Science concepts. The student knows the relationship between carrying capacity and changes in populations and ecosystems. The student is expected to:

(D) analyze and make predictions about the impact on populations of geographic locales, natural events, diseases, and birth and death rates.

(8) Science concepts. The student knows that environments change. The student is expected to:

(A) analyze and describe the effects on environments of events such as fires, hurricanes, deforestation, mining, population growth, and municipal development.

§112.46. Aquatic Science.

(c) Knowledge and skills.

(1) Scientific processes. The student, for at least 40% of instructional time, conducts field and laboratory investigations using safe, environmentally appropriate, and ethical practices. The student is expected to:

(A) demonstrate safe practices during field and laboratory investigations.

(2) Scientific processes. The student uses scientific methods during field and laboratory investigations. The student is expected to:

(A) plan and implement investigative procedures including asking questions, formulating testable hypotheses, and selecting equipment and technology;

(B) collect data and make measurements with precision;

(D) organize, analyze, evaluate, make inferences, and predict trends from data; and

(E) communicate valid conclusions.

(3) Scientific processes. The student uses critical thinking and scientific problem solving to make informed decisions. The student is expected to:

(A) analyze, review, and critique scientific explanations, including hypotheses and theories, as to their strengths and weaknesses using scientific evidence and information; and

(C) evaluate the impact of research on scientific thought, society, and the environment.

(5) Science concepts. The student knows the relationships within and among the aquatic habitats and ecosystems in an aquatic environment. The student is expected to:

(A) observe and compile data over a period of time from an established aquatic habitat documenting seasonal changes and the behavior of organisms; and

(D) evaluate trends in data to determine the factors that impact aquatic ecosystems.

(8) Science concepts. The student knows that aquatic environments change. The student is expected to:

(B) analyze the cumulative impact of natural and human influence on an aquatic system; and

(C) identify and describe a local or global issue affecting an aquatic system.

§112.47. Physics.

(c) Knowledge and skills.

(1) Scientific processes. The student, for at least 40% of instructional time, conducts field and laboratory investigations using safe, environmentally appropriate, and ethical practices. The student is expected to:

(A) demonstrate safe practices during field and laboratory investigations.

(2) Scientific processes. The student uses scientific methods during field and laboratory investigations. The student is expected to:

(A) plan and implement experimental procedures including asking questions, formulating testable hypotheses, and selecting equipment and technology;

(B) make quantitative observations and measurements with precision;

(C) organize, analyze, evaluate, make inferences, and predict trends from data;

(D) communicate valid conclusions;

(E) graph data to observe and identify relationships between variables; and

(F) read the scale on scientific instruments with precision.

(3) Scientific processes. The student uses critical thinking and scientific problem solving to make informed decisions. The student is expected to:

(A) analyze, review, and critique scientific explanations, including hypotheses and theories, as to their strengths and weaknesses using scientific evidence and information; and

(C) evaluate the impact of research on scientific thought, society, and the environment.

(4) Science concepts. The student knows the laws governing motion. The student is expected to:

(A) generate and interpret graphs describing motion including the use of real-time technology; and

(C) demonstrate the effects of forces on the motion of objects.

(6) Science concepts. The student knows forces in nature. The student is expected to:

(A) identify the influence of mass and distance on gravitational forces.

(8) Science concepts. The student knows the characteristics and behavior of waves. The student is expected to:

(A) examine and describe a variety of waves propagated in various types of media and describe wave characteristics such as velocity, frequency, amplitude, and behaviors such as reflection, refraction, and interference.

§112.48. Astronomy.

(c) Knowledge and skills.

(1) Scientific processes. The student, for at least 40% of instructional time, conducts field and laboratory investigations using safe, environmentally appropriate, and ethical practices. The student is expected to:

(A) demonstrate safe practices during field and laboratory investigations.

(2) Scientific processes. The student uses scientific methods during field and laboratory investigations. The student is expected to:

(A) plan and implement investigative procedures including asking questions, formulating testable hypotheses, and selecting equipment and technology;

(B) collect data and make measurements with precision;

(C) organize, analyze, evaluate, make inferences, and predict trends from data; and

(D) communicate valid conclusions.

(3) Scientific processes. The student uses critical thinking and scientific problem solving skills to make informed decisions. The student is expected to:

(A) analyze, review, and critique scientific explanations, including hypotheses and theories, as to their strengths and weaknesses using scientific evidence and information; and

(C) evaluate the impact of research on scientific thought, society, and the environment.

(4) Science concepts. The student knows scientific information about the universe. The student is expected to:

(A) observe and record data about lunar phases and uses that information to model the earth, moon, and sun system.

(8) Science concepts. The student knows the role of the Sun in our solar system. The student is expected to:

(C) describe the Sun's effects on the Earth.

(10) Science concepts. The student knows how life on Earth is affected by its unique placement and orientation in our solar system. The student is expected to:

(C) identify the effects of the moon on tides.

§112.49. Geology, Meteorology, and Oceanography.

(c) Knowledge and skills.

(1) Scientific processes. The student, for at least 40% of instructional time, conducts field and laboratory investigations using safe, environmentally appropriate, and ethical practices. The student is expected to:

(A) demonstrate safe practices during field and laboratory investigations.

(2) Scientific processes. The student uses scientific methods during field and laboratory investigations. The student is expected to:

(A) plan and implement investigative procedures including asking questions, formulating testable hypotheses, and selecting equipment and technology;

(B) collect data and make measurements with precision;

(C) organize, analyze, evaluate, make inferences, and predict trends from data; and

(D) communicate valid conclusions.

(3) Scientific processes. The student uses critical thinking and scientific problem solving to make informed decisions. The student is expected to:

(A) analyze, review, and critique scientific explanations, including hypotheses and theories, as to their strengths and weaknesses using scientific evidence and information; and

(C) evaluate the impact of research on scientific thought, society, and the environment.

(10) Science concepts. The student knows the interactions that occur in a watershed. The student is expected to:

(B) analyze the impact of floods, droughts, irrigation, and industrialization on a watershed.

(11) Science concepts. The student knows characteristics of oceans. The student is expected to:

(B) evaluate the effects of tides, tidal bores, and tsunamis.