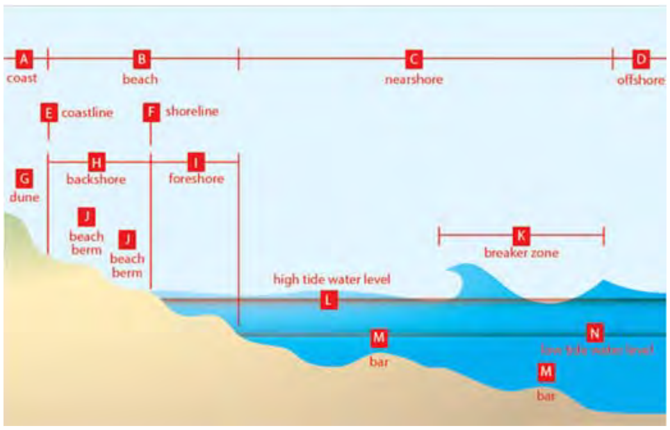
Alaska Seas and Watersheds
An Alaska Sea Grant K–12 Education Program

Erosion Project
High School Unit
Beach/Shoreline Erosion Monitoring
Surveying a Beach Profile



Acknowledgements: Unit developed by Marilyn Sigman, Alaska Sea Grant and Anne Garland, ARIES, Inc. 2019. with grant support from the Gulf Research Program for the Alaska CoastWatch for Action Project.

Instructor Preparation:
Review the data collection procedures for this field trip activity, select your field trip site and beach profiling methods and assemble or arrange for loans of equipment.

Selecting Your Field Trip Monitoring Site. Select the beach location for the profile that will run from the top of the beach on a transect perpendicular to the water's edge. Consider the following selecting your site:

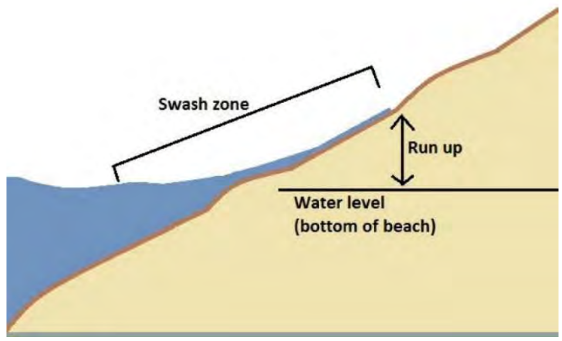
1. Are the features regular or irregular across the beach? For example, where does the vegetation start? Are there sand dunes or berms?

2. Are the boundaries between coast, beach, and water (the shoreline and coastline) clear? Are there landmarks or human structures landward of the beach that are unlikely to be affected by erosion for several years that can be used so the transect measurements can be repeated?

3. Is there evidence that the land above the beach is actively eroding (e.g., slab erosion of permafrost areas, movement of sediments and vegetation onto the beach)?

4. Can students easily observe high and low tide water levels? Look for evidence of wrack materials deposited at the high tide line and flotsam (debris, or concentrated gravel/shells) deposited at the top of the swash zone, the highest "run up" of water. The swash zone - between the highest run-up by waves on the beach and the lowest "run-down" at the bottom of the beach - delineates the most slope of the transect from wave action. Measurements within this zone are the most valuable measures for the transect profile and should be taken consistently. Will it be possible to safely station a student or adult in the approximate middle of the swash zone?

5. Is there a chance students could get cut off from returning to the site during a storm tide?



Preparing for the field trip.

Give students (and other teachers or adults who will assist with different types of data collection) an opportunity to practice using the equipment, particularly using the GPS (or the mapping function on a cell phone) and the compass to find and read a bearing, using the sighting/level device to sight in on the horizon and on the measurements on the rod or rods in the same line of sight along the transect.

Tell students to dress for the weather which may include gloves and mittens to keep hands warm when not using the equipment. Waterproof boots are essential for keeping feet warm and dry after students go into the water (which they will do even they're not wearing waterproof boots!).

Make copies of data sheets for the different stations onto Rite-in-the-Rain® paper if available or create them in pencil on pages from a rite-in-the-rain notebook. Place the equipment, data sheets, and pencils for each station into a separate zip-loc bag and attach each bag to a clipboard.

Please Note: Safety first! Data collection can be hazardous during storms that push storm surges higher on beaches than anticipated and even inland. Also, if you will be using the horizon for your line of sight for the beach profile, you need to be able to see it, and poor weather conditions can limit visibility, and measurement of elevations along the transect. Re-schedule the field trip if a severe storm is forecast or if you encounter these types of conditions when you didn't anticipate them. If you can return to the beach soon after a major storm event and surge flooding, however, and repeat the transect, your students may be able to document dramatic changes in the beach profile.

On some Alaska beaches (e.g. Arctic Ocean beaches in the fall), bear patrols and/or a plan for handling encounters with bears are necessary.

Plan to assign each of the four stations to teacher or other adult who will have the datasheets.
1. Site documentation (GPS locations, photos, sediment classification)
2. Weather (air temperature, water temperature, wind speed and direction, precipitation, etc.)
3. Ocean conditions (wave direction and estimate height, wave period)
4. Beach Profiling

If students who are not involved in the beach profiling finish collecting their data, they can join the beach profiling group along the transect or you can set up a station rotation schedule if you have enough time at the beach.

Divide students into groups before you leave the school for the field trip.

Choosing a Beach Profiling Method

There are several community-based methods in use for beach profiling by Alaska coastal community members to collect and contributed scientific data about local rates of coastal erosion. These are described below so that you can choose the one that is most feasible for you and your students, which will likely depend on the availability of scientific equipment (or time to make inexpensive substitutes) and the nature of the beach site you select for monitoring.

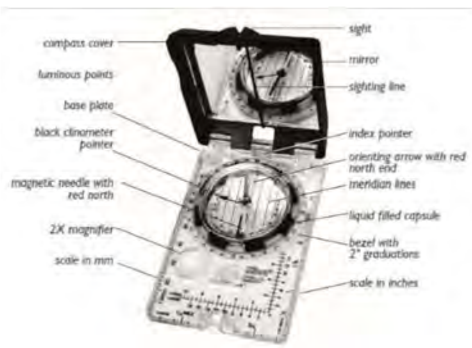
Community Observers of Barrow Community-Based Monitoring (COBCOM) program
This program uses a stadia rod method (described below). In Utqiaġvik, the program coordinators and trained volunteers can assist you with equipment loans (including use of a high-precision sighting level and tripod) or providing training opportunities in the methods.
Contacts: Anne Garland (awhgarland@yahoo.com) or the NSB Emergency Manager Heather Seemann, heather.seemann@north-slope.org.

Kaktovik Oceanography Program Coastal Monitoring Field Trip
The Harold Kaveeoluk School in Kaktovik has a coastal monitoring equipment kit with a stadia rod and other equipment for documenting site, weather, and ocean conditions. Scientists and educators from the Beaufort Lagoons LTER Project assist teachers on a coastal erosion monitoring field trip at the beginning of the school year.
Contacts: Christina Bonsell (cbonsell@utexas.edu) or Nathan McTigue (mctigue@utexas.edu)

"Stakes for Stakeholders" Coastal Erosion Monitoring Program
Community volunteers in several communities in the Bristol Bay region use the Emery board

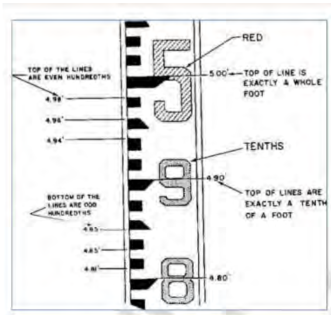
method (described below) for beach profiling. They use two other methods: 1) installing two or more stakes on the land above the shoreline, and 2) affixing a time-lapse camera to a stake for beaches that are difficult to access or dangerous during storms and storm surges. (A time-lapse camera will be installed at a site in Utqiaġvik for the latter reason.) The stake method can provide a repeatable method for measuring bluff or cliff erosion landward. Considerations for site selection and methods are described in Community-Based Methods for Monitoring Coastal Erosion. Time-lapse cameras are expensive but have been set up in several Alaska communities you may be able to look at images and data about the highest water levels during storm surges.
Contacts: Gabe Dunham, Alaska Sea Grant, gabe.dunham@alaska.edu or Chris Maio, UAF, cvmaio@alaska.edu

Alaska Statewide Coastal Erosion and Flood Monitoring Program: For information about community-based efforts in other Alaska communities, see the Alaska Division of Geological and Geophysical Services (DGGS) Coastal Monitoring website. For equipment loans, more information and volunteer training opportunities, contact Jacquelyn Overbeck, Alaska DGGS Coastal Hazards Program Manager, jacquelyn.overbeck@alaska.gov.



Stadia rods vs. Emery Rods

A 16-foot collapsible stadia rod can be purchased commercially or may be available for loan to schools in North Slope communities. (These come with metric and standard measurements and some may have them both on opposite sides. The COBCBM program records data in feet and inches, and tenths of inches, and the width of the beach to the nearest foot.) Or you can substitute a rod made from yardsticks or boards, marked visibly in intervals of feet and inches or tenths of inches. The marked distances need to be visible at a considerable distance which is an advantage of the white stadia rods with red and black numbers and markings.)



"Emery rods" are two straight pieces of wood with measured intervals and a connecting rope. You can make themselves with two straight pieces of wood, 2 meters long, and a black marker and a meter stick or you can use two meter sticks. You will also need a piece of string just longer than 5 meters. (The Stakes for Stakeholders" program is currently using metric measurements.) Use the meter stick to mark off every centimeter of the rod, making larger marks every 10 centimeters. Number the large marks (0, 10, 20, …), starting with zero at the top and 200 at the bottom (200 cm = 2 m). Wooden rods can be painted to increase the contrast between the marks.

To make them with four meter sticks and two support boards:

1. Saw one of the meter sticks in half
2. Affix meter sticks to support boards using wood glue
3. Align full meter stick to top left of support board, with lowest numbers at top
4. Put glue on the front of the support board and back of the meter stick
5. Align top half of sawed meter stick to left of support board
6. Values where the two meter sticks meet should appear as such: 90, (blank), 10, 20, so on.
7. Put glue on the front of the support board and the back of the meter stick
8. Repeat process with second set of meter sticks and support boards
9. Values where the two meter sticks meet should appear as such: 90, (blank), 60, 70
10. If desired, use white out and a sharpie to amend the values.
    For example, the 60 cm mark should be changed to 110, 70 cm should be changed to 120, so on and so forth…
11. Wipe off excess glue from sides of board

12. Place weight on top of emery boards and allow 24 hours to dry completely
13. To increase the visibility of the increments, color every other 5 cm interval along the edge with a red marker.

Selecting the starting point of the transect:
The stadia rod and Emery rod methods both use a GPS (or cell phone GPS mapping app) and either stakes and inland landmarks to establish a baseline line of sight that can be re-established for subsequent beach transects at the same location. The alternative is a line along a compass bearing from a landmark and a GPS location.

In choosing a landmark or permanent object, be sure it can be easily found later (like next month or next year) some distance (several hundred feet) from the landward point on the transect and unlikely to change or erode for several years. If possible and if you have necessary permissions from the landowner, mark the start point location with a rebar stake and flagging that is likely to stay in place for some time. If it isn't possible to mark an inland location in this way, be sure the landward start of the transect is in line with a more inland landmark (e.g., large shrub, tree, or rock or in a more developed area, a utility poles or corners of a structure).

A compass bearing may be the only option where a line of sight is not possible due to high bluffs or cliffs landward of the beach, if there are no suitable landmarks, or restrictions on land access will not permit the establishment of fixed point stakes or other markers. Be sure to note whether the compass bearing involved an adjustment to the declination.

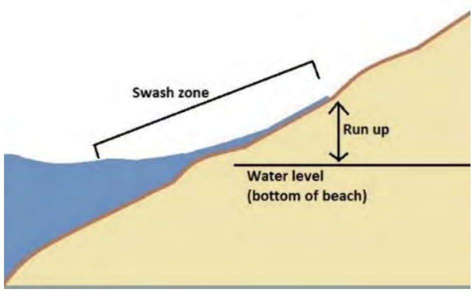
The line of sight aligned along at least two landmarks or a landmark and a compass bearing provide an imaginary transect line, but stretching out an open-reel fiberglass tape or a rope marked in foot- or meter-increments (100-300' long depending on the width of the beach; yellow polyethylene rope is best) will involve more students in setting up and participating in the transect activity. They can stand at the intervals selected for measurement and hold the transect line taut as the profile measurements are being taken.

Select the Starting Point for the Transect. Record what you are using as the "top of the beach" below any vegetation and slumping of permafrost soils. If the start point could change in elevation, however, (such as sand at a sea wall), record the height between the sand and some permanent part of the starting object (e.g., a bolt in the sea wall).

Select the Intervals for Measurement to Characterize Significant Features of the Beach Profile.
The Emery rod method will provide measurements at 5-foot intervals, the length of the string between the two rods. The stadia rod method requires that you choose intervals along the transect to measure elevations (e.g., every 5 feet or10 feet) depending on the width of the beach and variation in slope or other features. After determining your intervals, look for other beach points

to measure that might miss changes in the beach profile. As examples, wave action can deposit cobbles close to the water line and create a bench/ridge higher in elevation than smaller beach materials deposited higher up the beach. Active erosion of shorelines, underlain by permafrost slump from thawing, can result in finer-grained materials that are deposited landward along the beach.

Selecting the End Points of the Transect.
The end points of the transect are the top of the swash zone and the "edge of the water," which may be hard to define with a range in the extent of incoming waves or a rapid tidal change. How wet do you want students (or yourself) to get? You can measure to sea level (sometimes defined as the wet part of the beach when the waves retreat). This varies with wave cycles and run ups, however, so select the edge of water which is the average extent in the approximate mid-point of the swash zone. **When you have laid out the transect and selected the seaward endpoint, record the total width of the beach.** When the profile is complete, record the time to take into account that the water level will be affected by the tidal stage as well as wind-driven waves.



Surveying the Beach Profile

<u>Stadia rod method</u>

This method requires a sighting level. Hand-held sighting levels work fairly well but borrow more precise equipment (surveyor's level on a tripod or laser level) if possible.

1. A student or adult observer stands in a place where they have a view of the entire transect landward and seaward. (This can be at the starting point but the observer should not be responsible for holding the tape taut in addition to being the observer.) When choosing this location, take into account that the numbers on the stadia rod can be difficult to read at longer distances, particularly when weather conditions limit visibility. Consider selecting an adult to be the observer or a student with experience using scopes for hunting or birdwatching. A measurement of this person's height is essential for adjusting elevation measures of the entire extent of the transect.

2. The observer fixes his or her sight on the horizon and then reads the measurement on the stadia rod at each selected interval or additional points along the transect line in the same line of sight with the horizon (i.e., the "bubble" in the level is in center of the field of view). (You can have more than one observer of the same transect, as long as, each person reads the entire profile's elevations.).

3. Another student is responsible for moving the stadia rod to the selected measurement points. This student can assist the observe by moving their hand up and down the rod to point to the location on the rod that is in the line of sight (harder to do while wearing mittens) and also may be in a better position to read the measurement on the stadia rod.

4. One student will measure and record the height of the observer at eye level and then record the elevation data for each point along the transect. He or she also records the total width of the beach (i.e, the reading on the tape at the water level).

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Beach Profile Datasheet
Stadia Rod Method

Transect Name or Location:
GPS Reading of Landmark:
GPS Reading at top of the transect:
Compass Bearing:

Observer at top (landward end) of the transect:
Eye-level of observer:

Feet from the top (landward side) of the transect	Reading in line of sight between the observer and the horizon (to nearest tenth of a foot or inch)

Total Beach Width:

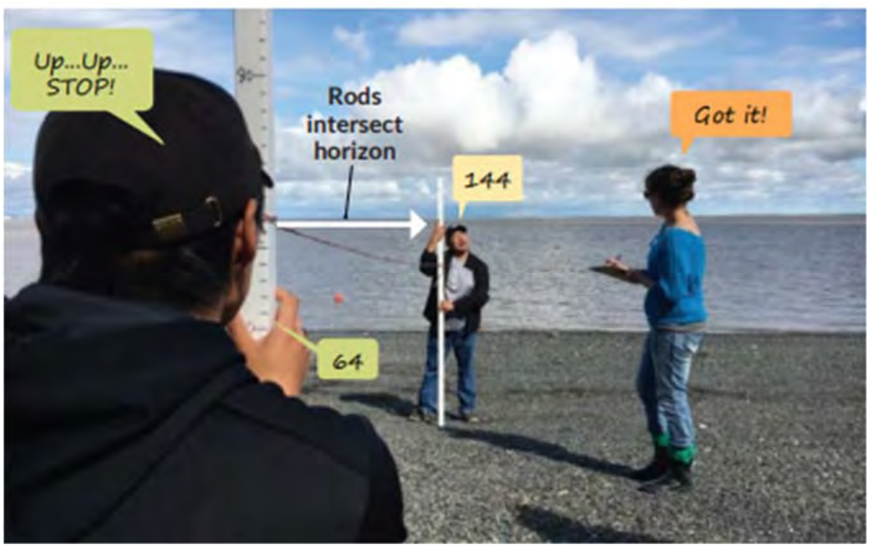
Observations on Factors that May Be Affecting the Rate of Erosion:

Emery Rod System

1. Tie the Emery rods together with 5 meters of string between the two rods. Measure this distance exactly because being off by a small distance can cause large errors in the profile. You will need to adjust the profile measurements by the height of the string above the starting point of the beach. If you tie the string at the base of the Emery rods, this adjustment will be zero.

2. The method is fairly simple, but complicated to describe as a step-by-step process. Watch the **video Introduction to Beach Profiling (4 minutes)** that demonstrates how volunteers in Maine measure beach profiles using Emery rods to help monitor beach erosion: https://www.youtube.com/watch?v=NaF7Pq2HkxA&feature=c4-overview&list=UU0wajJ67o5YTuxaRjZGX8eA

The manual developed for the Stakes for Stakeholders program includes variations on the methods used on Maine beaches.
- The landward observer picks a number on their rod and places their eye at this number and looks to see where the horizon intersects the other rod (rather than lining up the top of the seaward rod and horizon). Both numbers are recorded, but the recorder also needs to keep track of whether the second number is higher (+) or lower (-) than the previous number. The landward observer and the seaward observer leap-frog each other down the beach.
- The observer may use a sight level if needed.



The distance between the measurements can be shorter than 5 meters to record changes in the beach profile in shorter intervals. Just shorten the string, measure the length, and record it.

Alaska Seas and Watersheds
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Beach Profile Datasheet
Emery Rod Method

Transect Name or Location:

GPS Reading of Landmark:

GPS Reading at top of the transect:

Compass Bearing:

Observers:

Fixed Spacing (Length of Rope) (e.g., 5 meters)

Start Time:

Segment #	Spacing if Other than Length of Rope	Change in Elevation (differences between the two readings)	Up (+) or Down (-)	Notes
Examples: 1	2 m.	92-5	-	Base of berm
2		10-36	+	

Total Beach Width:

End Time:

Equipment, procedures, and datasheets for documenting site, weather, and ocean conditions at the time of the beach profiling

Equipment:

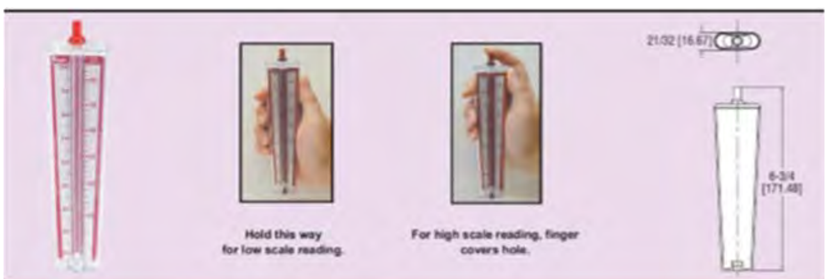
- A hand-held wind gauge and thermometer to measure air temperature **AND/OR** a Kestrel digital (air) temperature and wind speed gauge
- A small bucket and a submersible thermometer for measuring water temperature
- A stopwatch (The timer on a cell phone can be used instead.)
- A Range-finder compass
- A small ruler to measure sediment size in mm OR a McCullough Sand Gauge to categorize sediments by grain size, color, and texture. (These can be ordered from CGS Mule: http://www.cgsmule.com/Products/Geology-Rock-and-Sand-Identification-Supplies/Sand-Gauge.html
- A GPS or a cell phone with a mapping app that provides GPS information.
- A cell phone or camera to take pictures

Weather Stati

One student will be the data recorder while the other students take turns:

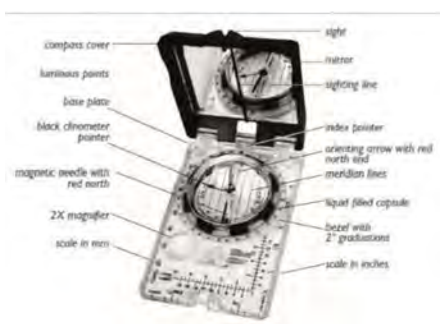
a) collecting air temperature data (in degrees Fahrenheit) and the wind direction and speed (in miles/hour) using the digital weather station and/or
b) measuring wind speed and direction using a hand-held wind gauge and a compass.
c) using the small bucket to collect a water sample and measure the water temperature, waiting for at least three mines before taking the reading.

Follow the directions for use of the Kestel weather station, setting the wind read-out to mph and the temperature to F.



Wind Gauge

1. Hold the gauge vertically and adjust orientation for maximum wind speed.
2. If wind speed exceeds 10 mph, hold finger over top hole and repeat.



Several students should look at the readings on the equipment and reach consensus on the measurement to be recorded. If the wind is variable in terms of direction and speed, they should take several wind measurements a few minutes apart and either record a range or distinguish between the prevailing wind speed and higher gusts. This is a good opportunity to discuss prevailing weather conditions (e.g., prevailing wind direction and wind-driven surface currents) and storm surges and changes in patterns that students, teachers, and other adults in the group may have noticed over several years.

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Beach Erosion Monitoring Transect
Datasheet to Record Weather Conditions

Date: **Time:**

Transect Name or Location ____

Observers:

Air Temperature (°F.) _______, _______, ______ Average Temperature ______
Method(s):

Water Temperature (°F.) ______, ______, ______ *Average Temperature* ______

Wind Speed (mph) _____ Method _________________(wind gauge or digital)
_____ Method _________________

Wind Direction ______

Precipitation ____

Other Observations (fog, storm conditions, storm surge, etc.)

Site Documentation Station

One student will be the recorder while other students take turns doing the following:

1. Take GPS readings: of an inland landmark or reference point, at the beginning point of the transect, along the beach transect at the top of the swash zone and at the water's edge, and at any significant changes in slope along the transect.
2. Classify the sediments in the swash zone.
3. Take pictures along the transect - seaward from the starting point and landward from the water's edge. If there is storm surge, take a longshore picture to show the run up.

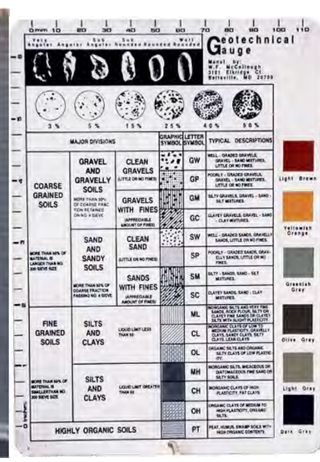
Sediment Classification

Students make sediment observations to determine the dominant (most abundant) type of sediment and 2nd dominant type of sediment in the swash zone.

Using a Sand Card

1. Hold a handful of representative surface beach material in one hand beside the sand card in the other hand.
2. Observe the dominant size of beach sand by matching alternative sizes on the card.
3. Record the gradation, for example "coarse sand."
4. For gravel, observe the longer dimension of a representative (average-sized) piece, using the scale on the card, recording the material as "gravel," and recording the size in mm.
5. Observe the presence or lack of edges on the beach material grains, compare to samples on the card, and record the shape of the grains as "angular," "sub-angular," "sub-rounded," or "well-rounded."

Using a Metric Ruler (in mm) to Classify Sediments. If sand cards are not available, students can use a ruler to measure the most abundant average-sized sediments, using the classifications on the datasheet (sand – very coarse, coarse, medium or fine; silt, clay, pebble, cobble, boulder). If beach material is clearly composed of two dominant materials, e.g., sand mixed with a nearly equal amount of gravel; record the gradation of the secondary beach material. Otherwise, do not record any secondary beach material.

This station provides a good opportunity to discuss the different processes that cause weathering of rocks and the deposition land and marine sediments, including calcareous shells, on the beach as interactions of the lithosphere, hydrosphere, and biosphere.

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Beach Erosion Monitoring Transect
Site Information Datasheet

Date: **Time:**

Transect Name or Location ____

Observers:

GPS readings:
Inland landmark/reference point ______________________________________
Landward transect starting point ______________________________________
Water's edge on transect line ____
Other way points and distance from landward end of transect:
____

Observers:

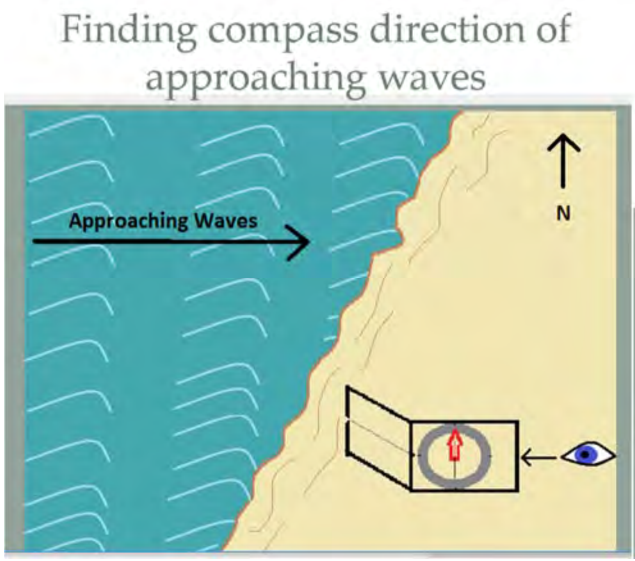
<u>Beach Materials</u>
Dominant (most abundant on beach):
Secondary (second most abundant):

Classify by size: Boulders >256 mm, Cobbles, 64–255 mm, Pebbles 4-63 mm, Granules 2-4 mm, Very Coarse Sand 1-2 mm, Coarse/Medium/Fine/Very Fine Sand < 1mm.
Classify by appearance and texture: Silt (very fine, dark), Clay (soft texture)

Evidence of deposition of materials from the land onto the upper beach? Describe:

Beach Erosion MonitoringTransect
Ocean Conditions Station

Students:
Use a compass to determine the ordinal direction (e.g., SW, N, etc.) and bearing of the wave direction and the direction that the waves are coming from.



Average Wave Period
1. Observe a place where waves most regularly break or where crests pass a fixed object (like a boulder or piling) out in the water
2. Start timing when a crest passes the point of observation
3. Count eleven crests and stop the timing when the eleventh crest passes the observation point
4. Record the average wave period as that elapsed time divided by 10, in seconds

Example, if the elapsed time from the first to the eleventh crest passing the observation point is 60 seconds, the average wave period is recorded as 60 ÷ 10 = 6 seconds

Wave Height: Estimate the height of the breaking waves in feet.

These observations provides the opportunity to discuss the relationship between wave action (and longshore currents and tides along Alaska coasts), deposition of sediments of different sizes and types, and the sometimes-opposing effect of wind and tide-driven wave directions.

<u>Extension</u>: The sighting level, rigid folding rod, a stadia rod, and a 100’ tape or line can be used to estimate the height of the wave more accurately. The contact people listed at the beginning of the lesson plan can train you and your students in the procedure to do this.

Beach Erosion Monitoring Transect
Ocean Conditions Datasheet

Date: **Time:**

Site #__ OR Location _______

Location: Transect # ____

Observers:

Wave Direction:

Estimated Wave Height in feet ________________

Wave period:
Time for 11 waves to pass a fixed point or crest in seconds: ____, ____, ____
Average wave period ___________

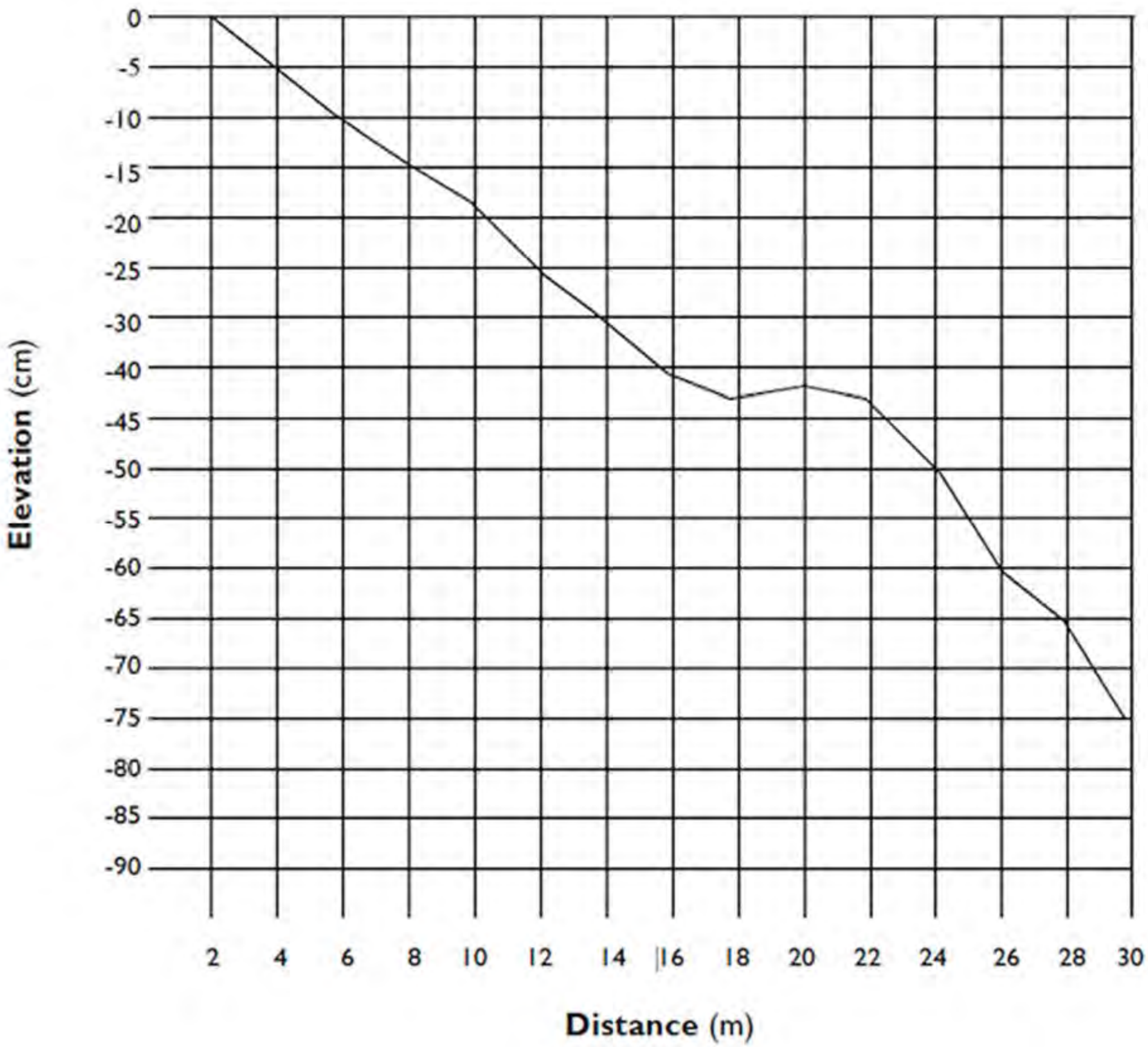
Additional observations (tidal stage, surf conditions, storm surge, wildlife, etc.)

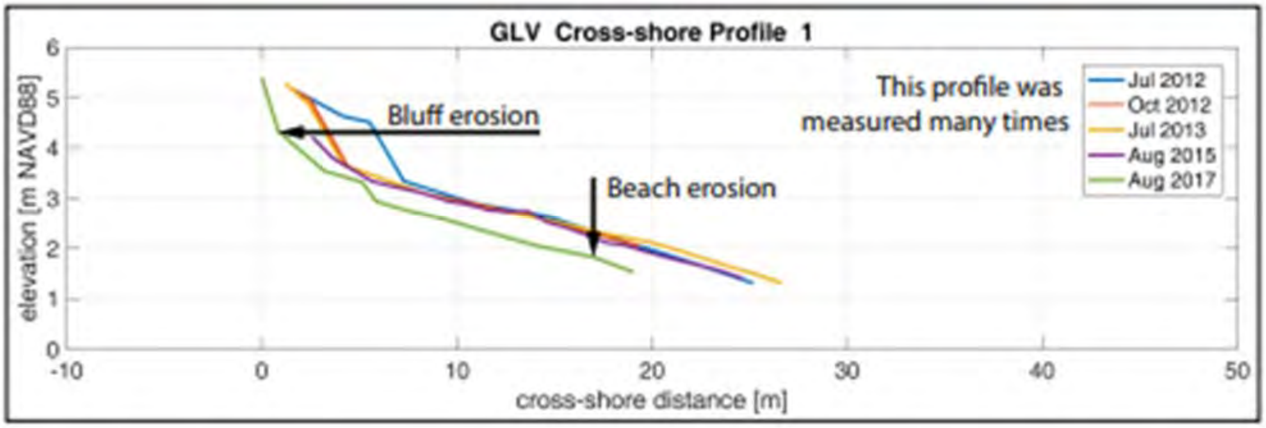
Beach Profile Data Analysis

Stadia Rod Data: Students can use the measurements of changes in elevation to graph the beach profile. They will need to subtract the eye-level height of the observer from each measurement to calculate the change in elevation below "zero" along the transect.

Emery Rod Data: Calculate the change in elevation by taking the difference of the two heights for each segment. Make the number negative if the "down" box is checked, and positive for "up". The horizontal distance will be in meters and the vertical distance of the height will likely be in cm. Draw this line on graph paper. Calculate the next line and have it begin where your last line ended.

If you collect another profile at the same location later, you can draw it from the same starting point and see how much it has changed!


Elevation (cm)
0
-5
-10
-15
-20
-25
-30
-40
-45
-50
-55
-60
-65
-70
-75
-80
-85
-90
2
4
6
8
10
12
14
16
18
20
22
24
26
28
30
Distance (m)



This beach at Golovin has been measured five times over five years. The x-axis is the horizontal distance from the bluff to the water. The y-axis is the height of the ground along this profile. The repeated profile measurements tell us how the beach is changing; the bluff eroded about 5 meters over the time period, but the beach was stable for three years and then eroded about 50 cm in two years.

Figure 5. Rocky Mountain School (Goodnews Bay) high school students and local environmental coordinator, Alice Julius, assist with data collection. A) Students are taught about GPS systems in preparation for a topographic survey. B & C) High school students are trained by Alice Julius to collect coastal profile measurements using the simple Emery rod method.

Graph and photos from *Community-Based Methods for Measuring Shoreline Erosion* by Richard Buzard, Jacquelyn Overbeck, and Christopher Maio. Alaska Division of Geological & Geophysical Surveys Information Circular 84. 2019.