



The exposed tree roots and leaning palm tree are indicators of erosion at this beach in the Rock Islands, Palau.

Chapter 5 Erosion and accretion

Background

Beaches change their shape and size from day to day, month to month and year to year, mainly as a response to waves, currents and tides. Sometimes human activities also play a role in this process, such as when sand is extracted from the beach for construction, or when jetties or other structures are built on the beach.

Erosion takes place when sand or other sediment is lost from the beach and the beach gets smaller, and the opposite process – **accretion** – takes place when sand or other material is added to the beach, which as a result gets bigger.

ACTIVITY 5.1 Measuring erosion and accretion over time

What to measure → One very simple way to see how the beach changes over time, and whether it has eroded or accreted, is to measure the distance from a fixed object behind the beach, such as a tree or a building, to the high water mark.

The *high water mark* is the highest point to which the waves reached on that particular day. It is usually easy to identify on a beach, by a line of debris such as seaweed, shells or pieces of wood, or by differences in the colour of the sand between the part of the beach that has recently been wetted by the water and the part that remains dry.

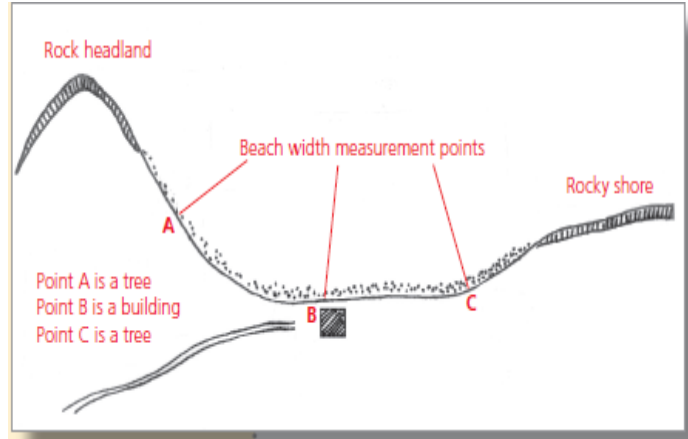


Figure 5 (Left) Determining the high water mark, Savannah Bay, Anguilla. (The arrow shows the position of the high water mark on that date.)

Figure 6 (Right) Plan view of a sample beach showing suggested points for measuring beach width.

Figure 5 shows a photograph of a beach in Anguilla; the arrow shows the high water mark which, in this case, is the landward-most edge of the band of seaweed.

Alternatively, in countries where tide tables are published in the local newspapers, the visit to the beach can be timed to coincide with high tide, in which case the measurement is made to the water's edge. One note of caution, in the Caribbean the tidal range is very small, approximately 0.3 m (1 ft), so the state of the tide – whether high, mid or low tide – does not matter very much. But in many parts of the world the tidal range is greater, 1 m+ (3 ft+), so in such cases it will be necessary to always repeat these measurements at the same tidal state, e.g. if the first measurement is done at high tide, then subsequent measurements should also be done at high tide.

Sometimes there may appear to be more than one line of debris on a beach. In such cases, take the line closest to the sea; the other debris line may well be the result of a previous storm some weeks or months ago.

Most beaches show variation in erosion and accretion, for instance, sand may move from one end to the other. So if monitoring the physical changes in the beach, it is recommended to carry out these measurements at a minimum of three sites on the beach, one near each end and one in the middle (see Figure 6).

How to measure→At the first point, select the building or tree that you are going to use as the starting point for the measurement. Write down a description of the tree or building and take a photo. This will help you to return to the same point to re-measure. With two people, one standing at the building and one at the high water mark, lay the tape measure on the ground and pull the tape measure tight.

Note the distance either in metres and centimetres, or feet and inches, whichever system the group is familiar with, record the measurement together with the date and the time of measurement. Then proceed to the next point and repeat the measurement. Label your three points either with physical names or a notation system (A, B, C or 1, 2, 3).



Taking a photo of your reference tree or building is always advisable, Magazin Beach, Grenada.



Measuring the beach width, Sandy Beach, Puerto Rico

If your beach or beach section is about 1.6 km (1 mile) long then a minimum of three points is recommended. However, you can always add additional points.

The measurements can be supplemented with photographs of the beach taken from the same position and angle on different dates.

When to measure → Ideally these measurements could be repeated monthly, but even if only repeated every few months, they will still yield some interesting information.

What the measurements will show → The data will show how the beach has changed over the monitoring period, whether it has gained or lost sand, possibly one part of the beach has increased in size while another section has decreased in size. Figure 7 shows line graphs from three points on a sample beach, the beach at Site A accreted (it gained sand), at Site B there was very little change and at Site C the beach eroded (it became smaller).

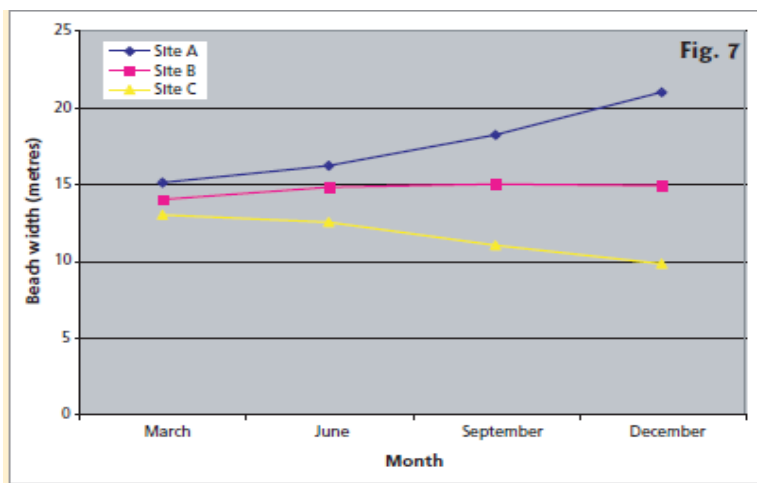


Figure 7 Line graph showing erosion and accretion changes over time

The data may show seasonal changes in the measurements, e.g. the beach may be wider in summer than in winter. Figure 8 shows this type of seasonal pattern in a bar graph.

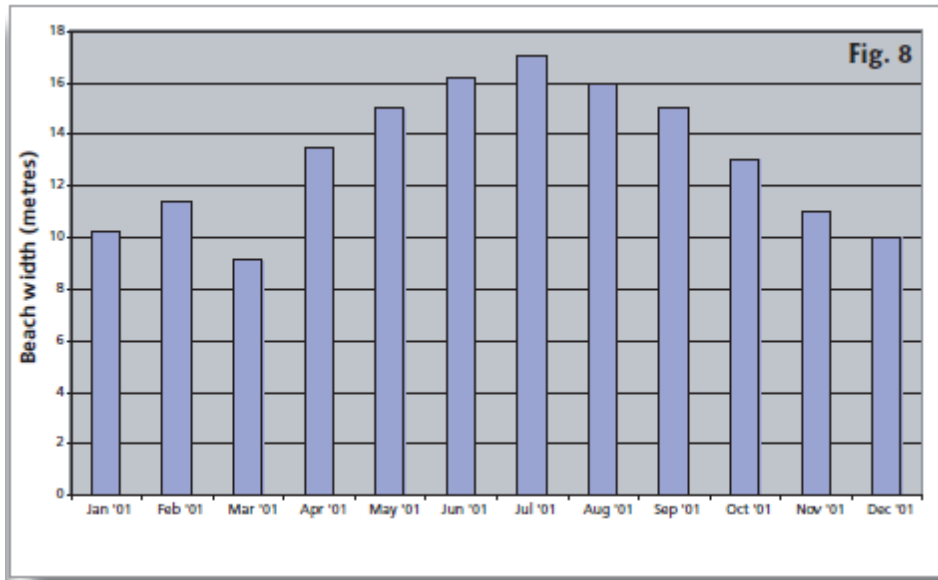


Figure 8 Bar graph showing beach width changes over time

If the students are also measuring waves (see Chapter 10), then these measurements may be related to the changes in beach width. Figure 9 shows beach width and wave height recorded on the same graph. In this case the beach width was greatest in August and September when the wave height was lowest.

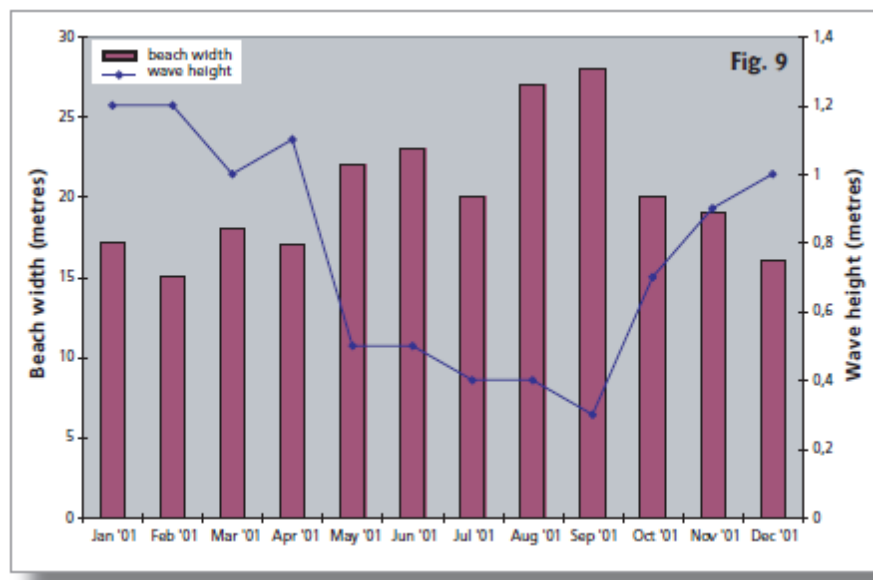


Figure 9 Mixed graph showing changes in beach width and wave height

ACTIVITY 5.2 Determining the effects of man-made structures on erosion and accretion

What to measure→ Look for any man-made structures on the beach (also called sea defences) such as jetties, groynes, seawalls on or behind the beach. Note their numbers and where they are positioned.

If the structure is a jetty or a groyne, select a measurement point on each side of the structure, and measure the distance from a fixed object behind the beach to the high water mark, as in the previous activity (5.1).



Measuring the beach width in front of this wall at Grand Mal, Grenada, as well as in front of the grassy area to the left, could yield interesting results.

Alternatively if there is a seawall at the back of the beach, you may wish to set up a measurement point in front of the seawall as well as one on an adjacent part of the beach where there is no seawall.

How to measure→ Use the same techniques as described above in the activity dealing with erosion and accretion (Activity 5.1).

What the measurements will show→ Again the measurements will show how the beach changes over time. In the case of the measurements on either side of the jetty, the data may show that the beach on one side of the structure gets bigger, while the beach on the other side gets smaller. These changes can also be related to measurements in waves and longshore currents (see Chapters 10 and 11).

Beaches in front of seawalls may also react differently to beaches where there are no seawalls. Often the beaches in front of seawalls may change very dramatically, e.g. a beach in front of a seawall may completely disappear one week, only to re-appear the following week.

ACTIVITY 5.3 Measuring beach profiles

What to measure→ This activity is better suited to older students in secondary school. A beach profile or cross section is an accurate measurement of the slope and width of the beach, which when repeated over time, shows how the beach is eroding or accreting. It builds on 'Activity 5.1 Measuring erosion and accretion' and includes measurement of the slope of the beach. Figure 10 shows how a beach profile eroded as a result of a tropical storm.

There are many different ways of measuring beach profiles, the method described in Annex 2 is one of the simpler methods, and is currently used in many small islands to determine beach changes over time. The Annex describes how to measure beach profiles and also provides information on the use of a simple computer programme available to analyse the data. The program is available free on request from persons listed on the contact list of the Sandwatch website (www.sandwatch.org).

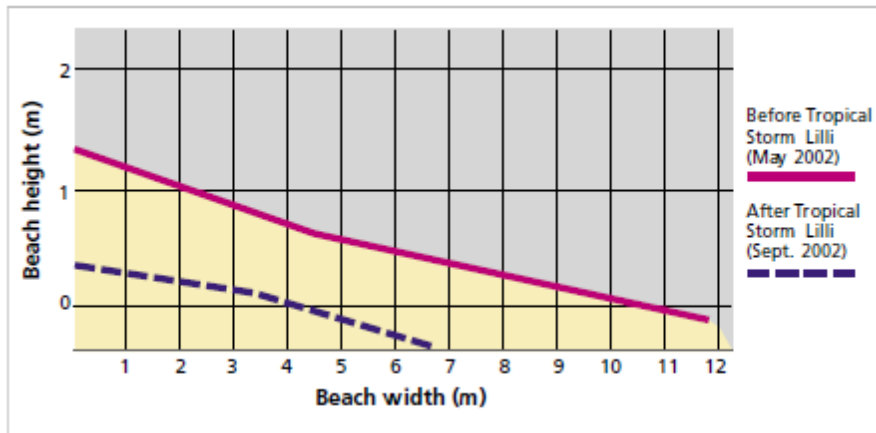


Figure 10 Changes in a beach profile before and after Tropical Storm Lilli (2002), Port Elizabeth, Bequia, St Vincent and the Grenadines.



Left: Group of students measuring a beach profile at Hamilton, Bequia, St Vincent and the Grenadines. Right: Group learning how to measure slope with an Abney level at Beau Vallon, Mahe, Seychelles.

When to measure → Beach profiles should be repeated at three month intervals or more frequently if time permits.

What the measurements show → The measurements show how the beach profile changes over time. For instance, Figure 10 shows how the beach profile became steeper and the beach width narrower after a tropical storm. The computer programme allows successive profiles to be plotted on the same graph to see the changes.

Regular measurements of profiles can show not only how a beach responds to a storm or hurricane, but also how/if it recovers afterwards and the extent of that recovery. Removing sand for construction or building a seawall also impacts a beach, and only by carefully measuring beach profiles before and after the activity is it possible to say accurately how the beach has

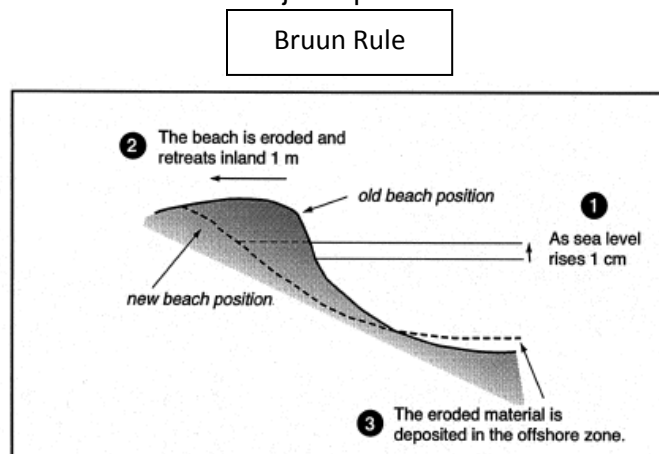
changed. Government authorities, as well as beachfront house and hotel owners may also be interested in the information collected from beach profiles. Designing a successful tree planting project requires knowledge of how the beach changes over time. The applications are numerous. Many people think they can tell how a beach has changed simply by looking at it, but it is much more complex than that, and often people's memories are not as accurate as they like to think. Accurate data, such as beach profiles, are the basis for sound development planning.

Beach erosion and sea level rise

Chapter 2 discussed climate change and how it will impact beaches. As the temperature rises, the ocean water expands, and this change combined with the melting of the polar ice caps and glaciers, results in a rise in sea level rise. Rising sea levels result in increased beach erosion, reducing the area of beaches and impacting coastal habitats. Of particular concern is the fact that sea level will continue to rise for centuries, regardless of mankind's efforts to stabilise greenhouse gases. This is because the temperature of deep ocean water changes very slowly, so the process of expansion that has already started cannot be stopped in just a few decades.

Table 1 (Chapter 2) shows that global sea level is predicted to rise between 0.18 and 0.59 m by 2099. As new information is coming to light since the IPCC report was published in 2007, it appears that these sea level rise projections are on the low side so higher rates of sea level rise can be expected.

Research shows that for every 1 cm of sea level rise the shoreline will retreat inland 100 times that amount. This is known as the Bruun Rule and is essentially an approximation that varies according to the physical characteristics of the particular beach and the offshore slope. However, it is a useful rule of thumb that can be used to illustrate how the predicted global sea level rise of less than a metre will have a major impact on beaches around the world.



The Bruun Rule, as shown above, shows that as sea level rises by 1 cm, the position of the beach retreats inland by 1 metre, as sand is transported from the beach to the offshore bottom.

On lowland coasts where the land behind the beach is not developed, it is likely that the beach will reposition itself further inland over time as a response to climate change. However, where the land behind the beach is developed with houses, hotels, roads and other infrastructure, then the beach will not be able to retreat inland, and in these cases it is likely that the beaches will get narrower and eventually disappear over time, unless other measures are taken such as building groynes and offshore breakwaters, and replenishing the beach with sand from another source, either offshore or land based.



As sea level rise, the beach on the left (Culebra, Puerto Rico) will likely reposition itself further inland, while the beach on the right (Barbados) will narrow and eventually disappear unless specific measures are taken to replenish the beach.

ACTIVITY 5.4 Measuring beach changes resulting from sea level rise

What to measure→ Before going out to the beach, find out from your national climate change focal point or meteorological office whether measurements of sea level are conducted in your country, and whether national data relating to sea level rise is available.

Have the students do some simple research and calculations:

- Determine the annual rate of sea level rise in your country; if no data is available use the uppermost figure in Table 1, Chapter 2 (0.59 m over 100 years = 0.0059 m/year);
- Using this figure calculate the retreat of the high water mark over the next 10 years:
 $0.0059 \text{ m/yr} \times 10 \text{ years} \times 100 = 5.9 \text{ m}$
- Repeat the calculation for the next 20 years and next 30 years:
 $0.0059 \text{ m/yr} \times 20 \text{ years} \times 100 = 11.8 \text{ m}$
 $0.0059 \text{ m/yr} \times 30 \text{ years} \times 100 = 17.7 \text{ m}$

Using these figures, let the students determine where the high water mark is today, then using a tape measure, measure 5.9 m landward of that point and make a line in the sand, repeat for the 20 year and 30 year distances.

When to measure→ This measurement can be done at any time. It may be useful to take photos with the students pointing out where the new average position of high water mark will be in the future.

What the measurements show→ The measurements show the average position of high water mark in 10/20/30 years time and they indicate how the sea will reach further into the land than it does today. If your beach is very narrow and is perhaps backed by a seawall, then you may run

out of space for the 20 or 30 year measurements, in which case it is likely your beach will disappear altogether in the future. Alternatively if the beach is backed by a coastal forest, then all that may happen is that the seaward line of trees will disappear.



Teachers stand where the average high water mark will be in 10, 20 and 30 years time, Hope Town, The Bahamas

Additional activity → Have the students role play a development scenario, with some students playing the role of the developers, and other students representing government officers from planning and environmental agencies, other beach users, owners of neighbouring properties, and environmental organizations.

The following scenario is an example. The developers are planning a resort comprising a large hotel, condominiums, swimming pools and golf course.

Factors the development group might put forward are:

- the new development will bring in more tourists, new jobs and more revenue to the country;
- during the building phase the construction sector will benefit;
- local residents will continue to have use of the beach;

- the development is a real benefit for island X, and if they are not interested the developers will go to island Y.

Points that might be raised by the government officers include:

- a development such as this would need an environmental impact assessment (this is a detailed study of how the development will affect the environment and specific planning measures that can be taken to reduce any adverse impacts);
- the proposed site has experienced erosion problems in past storms, and how do the developers propose to cope with future erosion, including the impacts of climate change;
- beaches are public in this island, so how does the developer propose to maintain free access to and along the beach.

Points that may concern beach users, neighbouring property owners and environmental organizations might include:

- the beach is important for hawksbill turtle nesting, so how will the developers ensure that this activity is not impacted;
- the beach is used during carnival time for an annual sailing race, so will this activity continue?
- neighbouring residents might be concerned about increases in noise and crime;
- will local residents will be able to use the beach at all times of day and night for fishing, picnicking and other activities?