## ADAPTATION PROJECT

# INCREASING BEACH RESILIENCE TO CLIMATE CHANGE [1]

**MAIN SUBJECTS**
Natural sciences

**GRADE**
K4-9

**TARGET**
Schools in coastal areas

**OVERVIEW**
Beaches with healthy ecosystems are more resilient to climate change. With this project, students help their beach become more resilient. They monitor “their” beach, decide on a particular problem to address and design and implement solutions. Depending on the local context, three versions of this project are proposed: one aimed at implementing solutions to reduce beach erosion, a second to address the issue of coral bleaching, and the last one focusing on helping recover coastal ecosystems.

### STEP LIST

Step 1 is common to the 3 examples

| | |
|---|---|
| **STEP 1** – Selecting a beach and identifying potential problems (applies to all examples) | The students select a beach case study according to several criteria and gather information for identifying potential threats to that beach that may be related to climate change. Then, they choose one problem to focus on. In this project, three examples of coastal threats (“problems”) are described, with the corresponding steps 2, 3 and 4. |

Steps 2 to 4 are different for each of the 3 examples

| | |
|---|---|
| **STEP 2** – Monitoring the beach | Students monitor the beach and gather data on what is happening to the beach with respect to the problem they have defined. |
| **STEP 3** – Analysing the data | Students analyse the data to evaluate precisely how the problem they chose to focus on is affecting the beach. |
| **STEP 4** – Implementing solutions | Once the students have established how climate change is affecting a particular aspect of the beach, they set up a mitigation plan. |

1 This project is a short version adapted from the larger project proposed by Sandwatch in the Sandwatch manual on “Adapting to climate change and educating for sustainable development”. Many parts of it are directly taken from this manual. For a more extensive project on beaches and coastal ecosystems, the OCE encourages you to refer directly to the original Sandwatch manual UNESCO (2010). Sandwatch: Adapting to climate change and educating for sustainable development. Paris: UNESCO), which is available for download: http://www.sandwatch.ca/images/stories/food/SW%20Docs/Sandwatch%20Manual.pdf
Depending on the project you choose to carry out with your students, your beach monitoring data may fit for inclusion in the Sandwatch Climate Change Database. Get informed about it and participate!
Sandwatch is also a network that allows Sandwatchers from all over the world to keep in contact and learn about each others’ activities. So if you are new to Sandwatch and want to get involved, please consider becoming part of the network.

## STARTING POINT

Start the project by debating with the students on the possible impacts the climate has on the beaches they know. *What kind of changes are to be expected?* Depending on the region, different answers are possible:

- Rising sea levels and subsequent coastal erosion. Coastal erosion can threaten human settlements (buildings, roads, etc.) and ecosystems. Loss of ecosystems, such as mangroves, coral reefs, seagrass meadows and saltmarshes, has many consequences on people's livelihoods. Shrinking beaches may have an impact on tourism.
- Ocean acidification can affect marine and coastal ecosystems, with consequences for biodiversity, food security, etc.
- Ocean temperature increase will affect marine and coastal ecosystems, contributing, for example, to coral bleaching.
- An increased air temperature in already very warm regions may make the beach too hot for tourism.

## STEP 1
## SELECTING A BEACH AND IDENTIFYING POTENTIAL PROBLEMS

### SELECTING A BEACH

In order to carry out this project, start by selecting a beach. To do so, some key factors should be considered:

- **Safety**: The beach should provide a safe environment for the students. If there are very strong currents and/or very high waves, for example, there is a risk. Safety must always be the prime concern.

- **Size of the beach**: In some areas, beaches are small (less than 1 km in length) and enclosed by rocky headlands. These "bayhead" beaches, as they are known, are an ideal site for a monitoring project. If a long beach is selected for monitoring, we recommend students focus on one section only (about 1 km).

- **Importance of the beach to the community**: Try to choose a beach which is used by the residents of the area and therefore important to the local community. This will help ensure local interest in the monitoring activities and will also be an important factor during the design and implementation of beach enhancement projects.

- **Issues of interest**: Particular issues such as heavy use during weekends, preferred destination for local residents or tourists, and history of erosion during storms, may influence selection of a particular beach location.

**Consider gathering information from the local community!**

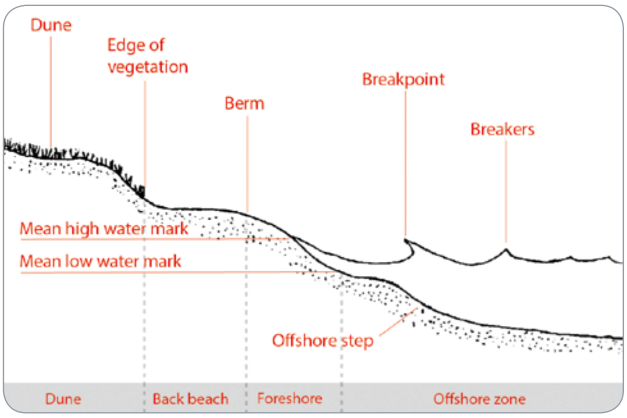
You can contact local scientists, environmental organisations or local authorities to gather further information on which beach to select. Very often, beaches that are known to be affected by climate change (or other) impacts are already being monitored, and existing data can provide a useful comparison to the data you and your students will collect, and give you an idea of how your beach has changed up to the present day. In some cases, your measurements may even be an important contribution for local scientists!

You may also consider interviewing members of the local community that have lived or developed their businesses in/near the beach for a long time: they can provide you with important empirical information on the beach changes, as well as on issues of interest of a particular beach. Fishermen, for example, are frequently aware of the changes in the amount of fish over the years, or the importance of a particular beach as a fish nursery, etc.

### DEFINING THE BOUNDARIES OF YOUR BEACH

A beach is a zone of loose material extending from the low water mark to a position landward where either the topography abruptly changes, or permanent vegetation first appears. Applying this definition to the diagram shown in the figure below – which is called a cross-section (or beach profile) – the beach extends from the low water mark to the vegetation's edge. The land behind the beach may consist of a sand dune, as shown in the cross-section represented, or a cliff face, a rocky area, low land with trees and other vegetation, or a built-up area. When monitoring a beach, all its cross-section must be considered.

Beaches are often made up of sand particles, and in many places the term "beach" may be used only for sandy beaches. However, a beach may be made up of clay, silt, gravel, cobbles or boulders, or any combination of these. For instance, the mud/clay deposits along the coastline of Guyana are also beaches.




Beach cross section.

A beach is more than just a zone of loose material found where the water meets the land; it is also a coastal ecosystem. Sometimes, geologists, ecologists and others need to look at the "beach system" from a broader perspective, taking into account the offshore zone out to a water depth of about 12 meters. In tropical areas, this is where seagrass beds and coral reefs are found, and these ecosystems supply sand to the beach. Much of the sand in this offshore area moves back and forth between the beach and the sea. This broader view may also include the land and slopes behind the beach, up into the watershed, since streams and rivers bring sediment and pollutants to the beach and sea.

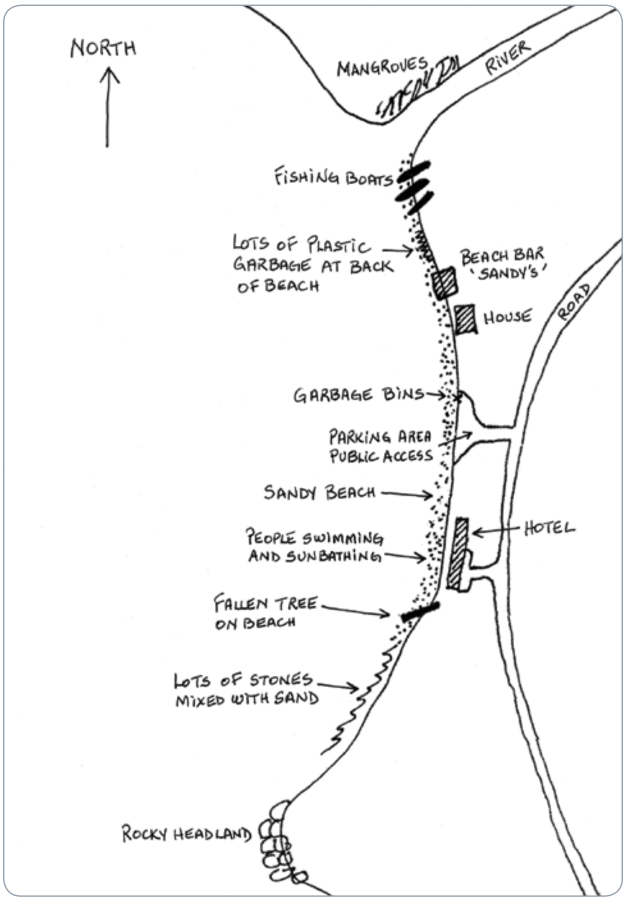
### OBSERVE THE BEACH AND DRAW A MAP

Before starting the detailed monitoring of the beach, it is important to obtain an overall picture of it and gather as much information as possible through simple observations.
Divide the students into groups, and have the students walk the length of the beach, writing down everything they see. If the beach is very varied, the student groups may be given different items to look for, e.g. one group might record buildings and roads, another group vegetation and trees, a third group might record the type of activities in which people are engaged and so on. Since the purpose of this activity is to draw a map, the students should record the various items and where on the beach they are located. Items to look for include:

- Beach material: size (sand, stones, rocks), colour, variation in material along different sections of the beach.
- Animals (e.g. crabs, birds, domestic animals, shells of animals).
- Plants and trees (e.g. seaweeds and seagrasses, grasses, plants, trees behind the beach).
- Debris, litter, pollution (e.g. garbage on the beach or floating in the water.)
- Human activities (e.g. fishing, fishing boats on the beach, sunbathers, walkers, people jogging, sea bathers, swimmers, picnic groups).
- Buildings behind the beach, beach bars and restaurants, houses and hotels, public access.
- Paths to the beach, litter bins, signs, lifeguard towers, jetties etc.
- Sea conditions (e.g. whether the sea is calm or rough).
- Objects in the sea (e.g. mooring buoys, boats at anchor, buoyed swimming areas).

Encourage the students to make detailed observations (e.g. instead of recording three trees, encourage them to try and identify the trees: two palm trees and one sea grape tree).

Make a sketch map of the beach; this can be done as a class exercise, or each student or group can make their own map. An example of a sketch map is shown below. You may wish to prepare a simple map outline on which students can record their observations, or even a copy of a topographic map. The advantage of such a topographic map is that it is accurate, so the scale can be used to determine distances.




Sample beach sketch.


Sample topographic map.

**CHOOSING ONE PROBLEM TO FOCUS ON AT A TIME**

Now that you have drawn a map of the beach you selected, it is time to decide on which problem – related to climate change – to focus on. Here we propose three examples: beach erosion, coral bleaching and endangered beach ecosystems.

# Example 1 – Beach erosion

Beaches change in shape and size from day to day, month to month and year to year, mainly in response to waves, currents and tides. Sometimes human activities also play a role in this process, for example, when sand is extracted from the beach for construction, or when jetties or other structures are built on the beach. In regions with very different wave regimes along the year, associated with seasonal changes (summer-winter weather and wave conditions), the beach profile can vary significantly between winter and summer seasons. The emerged part of the beach is usually much larger in summer than in winter, especially after big storms. Erosion takes place when sand or other sediment is washed away from the beach and the beach gets narrower. The opposite process, accretion, takes place when sand or other material is added to the beach, which as a result gets larger.

Sea level rise, associated with climate change, also contributes to beach changes: as the mean sea level rises, beaches are progressively eroded, and beach morphology has to adapt.

Before you start monitoring the beach, try to gather as much information as possible on what the beach looked like in the past. If you have already talked to local scientists, organizations or authorities, you probably have documents and information that give you an idea of what your beach looked like in the past and how it has changed up to the present day. Aerial photographs and topographic maps are particularly useful.

Aerial photographs are usually kept at government departments responsible for lands and surveys, and sometimes at planning and environmental agencies. Aerial photographs are taken from a plane looking vertically downwards. They show a bird's eye view of the beach. You may be able to find aerial photographs of the beach taken in the 1960s or 1970s. Aerial photographs, like topographic maps, can be used quantitatively to determine the length, width and size of the beach. Compare the aerial photographs with your present-day sketch map and note any changes. Sites such as OpenStreetMap or Google Earth can be viewed for free on the internet and allow you to view and save maps and present-day aerial views of your beach within minutes. These can give you another perspective of your beach.

With the help of the referred documents, discuss:

- How the beach has changed.
- If the changes are good or bad.
- Whether you prefer the beach as it was in the past or as it is now.
- How you think the beach will look in ten years time.
- From what you have learned about climate change, how you think the size of the beach will change.

In order to understand the evolution of your beach, measurements must be taken regularly and over the years. This type of project can be carried out over several years with the same class, or each year you can suggest it to a different class, keeping the data updated so the results can be compared with previous years and older existing data records.

## STEP 2
# MONITORING THE BEACH

### 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 reached by waves on a given 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 wet sand reached by the waves and the dry sand closer to shore (see figure below).

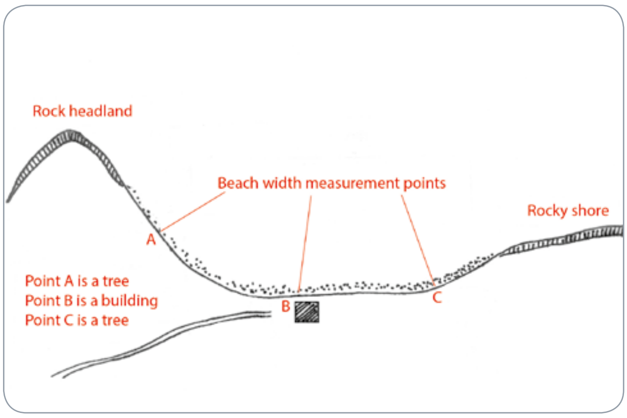
Alternatively, in countries where tide tables are published in the local newspapers (or on the internet, for example on the website of the national hydrographic institute), the visit to the beach can be timed to coincide with high tide, in which case the measurement is made to the water's edge. One note of caution: in some regions of the world, tidal range is very small, 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 more than one meter. In such cases, the measurements must be repeated at the same tidal state (e.g. if the first measurement is taken at high tide, then subsequent measurements should also be taken at high tide). Sometimes there may appear to be more than one line of debris on a beach. If this is the case, take the line closest to the sea; the other debris line may well be the result of a previous storm some weeks or months previously. Most beaches show variation in erosion and accretion, for instance, sand may move from one end to the other. So when monitoring the physical changes to the beach, we recommend carrying out these measurements at a minimum of three sites on the beach, one near each end and one in the middle (see figure below).

**→ How to measure**

At the first point, select the building or tree that you are going to use as a reference point. Write down a description (and / or take a picture). 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 tight. Record the measurement together with the date and time. Then proceed to the next point and repeat the measurement. If your beach or beach section is about 1 km long, then a minimum of three points is recommended. However, you can always add additional points.

**→ When to measure**

Ideally, these measurements could be repeated monthly, but even if only repeated every two or three months, they will still yield interesting information.




Beach width measurement points.

High-water mark on the landward edge of the band of seaweed.

## 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. Instead of simply measuring the width of the beach, a beach profile also includes the beach slope. The figure below bottom right corner bottom right corner shows how a beach profile has eroded as a result of a tropical storm.

### → How to measure

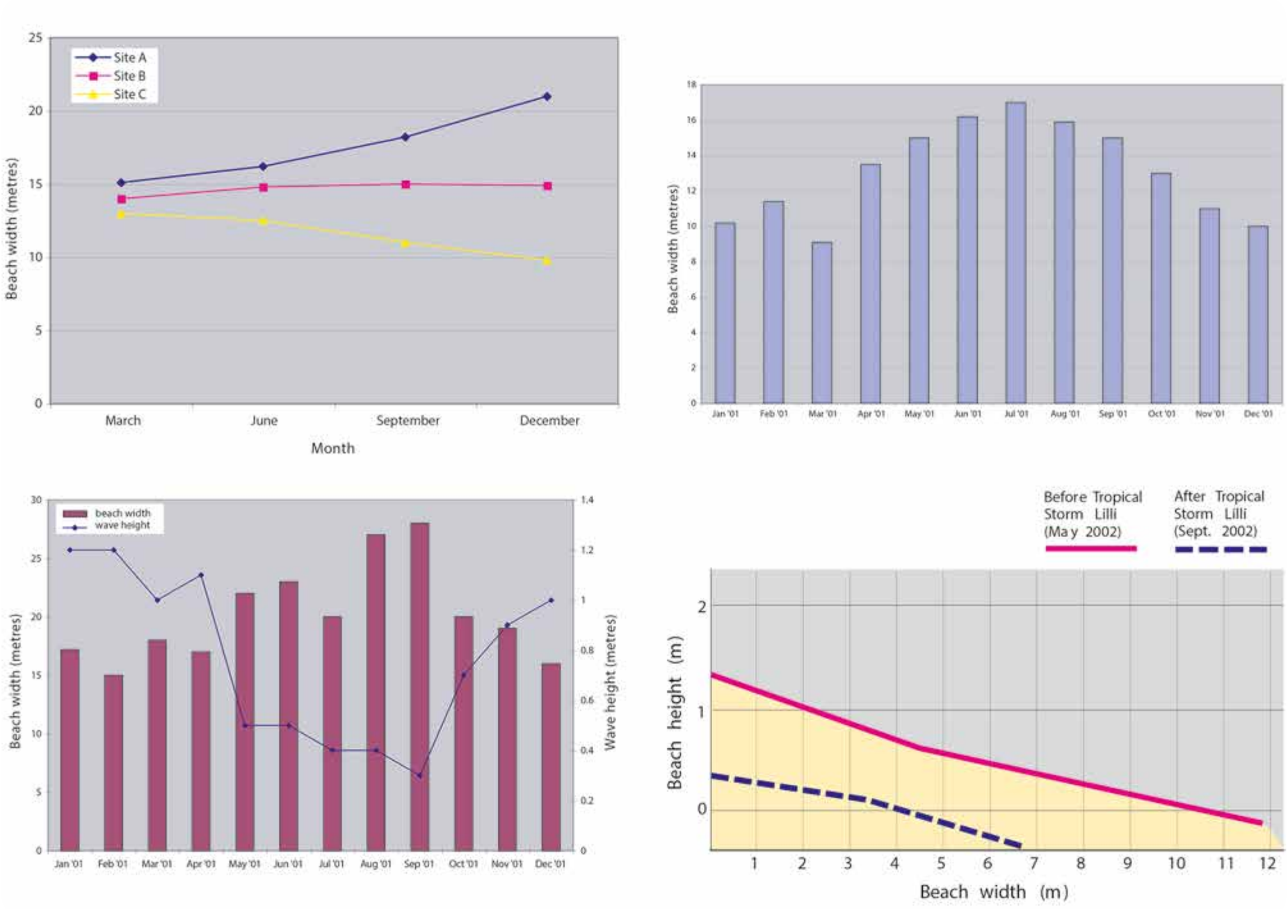
There are many different ways of measuring beach profiles: the method described in Appendix 2 of the SANDWATCH manual is one of the simpler methods. If an accurate GPS is available, it can also be used.

### → When to measure

Beach profiles should be repeated at three-month intervals or more frequently, if time permits and preferentially at low tide (to have access to a longer profile of the beach).

## STEP 3
# ANALYSING THE DATA

The data will show how the beach has changed over the monitoring period, and whether it has gained or lost sand – it is possible that one part of the beach will have increased in size while another section will have decreased in size. The figures below are examples of graphs that can be obtained from the data collected on the beach width and slope.




Examples of the type of graphs that can be obtained from the data on the beach width and slope.

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. Only by carefully measuring beach profiles before and after each storm is it possible to give an accurate description of 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. 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.

Analyze your data and try to understand what is happening to your beach.

- *Is it eroding everywhere?*
- *Is it eroding in a particular part and accreting in another part?*
- *Are there buildings, plants, animals or users of the beach that are threatened by this erosion?*

When evaluating the effects of climate change in the potential erosion of your beach, you must bear two important things in mind:

- Climate change effects are only measurable over multiyear timescales.
- There are other causes besides climate change that contribute to beach erosion, and with this kind of measurements you will not be able to tell the difference between those causes.

Nevertheless, if you bear in mind both aspects mentioned, your data can still be very useful. Consider, for example, that you observe (comparing to past measurements or data provided by other institutions) that your beach is eroding every year: even if you are not sure of the causes of that erosion, the important thing is to try slowing/stopping it! The accurate data you gathered, such as beach profiles, are the basis for developing a plan to increase the resilience of your beach to future climate change.

## STEP 4
## IMPLEMENTING SOLUTIONS

If after analysing your data, you concluded that your beach is effectively eroding, it is time to do some research on what kind of actions can help mitigate coastal erosion. Do not forget that we are talking here about actions that students can carry out, so building seawalls, and beach nourishment by adding sand are solutions that are not within your reach. Nevertheless, there are several examples of things you can do to reduce coastal erosion.

Healthy dunes are essential to control coastal erosion. Protecting the dunes is one way of reducing coastal erosion. You can:

- Plant/care for dune vegetation.
- Build small fences to (i) avoid people stepping on the dunes (access control fences) and (ii) avoid aeolian erosion of sand (sand trap fences).
- Employ dune thatching (dune thatching consists in covering the sand with dead branches that act as a wind barrier and/or protect newly planted vegetation).
- Draw posters and place them near the sensitive zones to let people know what is happening and the best way to behave (e.g.: "Do not walk on the dunes, we need them to protect us from coastal erosion").


Dune plants planted by students as part of a Sandwatch project.

Dune thatching on the Atlantic coast of France.

# Example 2 – Coral bleaching

Changes in conditions, such as water temperature, light or nutrients, can stress corals. When they are stressed, they expel from their tissues the symbiotic algae that give them their beautiful colours, and they turn white. This phenomenon is known as coral bleaching. Coral bleaching does not imply the death of the coral: if the coral is strong and healthy, and the stressing condition does not last too long, it can recover.

Rising water temperatures, associated with climate change, are endangering corals worldwide. Between 2014 and 2017, a global coral bleach event has affected 75% of the world's reefs. This is set to continue, with 75% of coral reefs expected to be lost if global temperature rises by only a further 0.5ºC, and if local stressors due to human activities, which can also influence coral mortality, are not minimised.

## STEP 2
## MONITORING THE BEACH

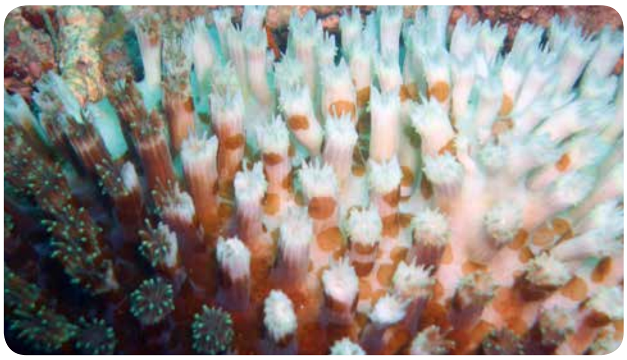
In order to understand what is causing coral bleaching, you will have to monitor your beach. However, before doing so, conduct some research into past bleaching incidents. Find out from some of the local beach users (e.g. fishermen and divers), or your national fisheries department, when the last coral bleaching incident occurred. If, for instance, it occurred in mid-August two years ago, obtain the daily temperature record from your nearest weather station, for 1 July – 30 September for the last three years. Plot the daily temperatures on a graph for each of the three years and determine whether the temperatures were higher during the year of the bleaching, and/or whether there was a prolonged period of high temperatures. This data collection and analysis will give you an overview of the evolution of your coral reef along the years.

### MEASURING PRESENT DAY BLEACHING

→ **What to measure**
Sea surface temperature and occurrence of coral bleaching.

→ **How to measure**
Measure sea surface temperatures daily, or as frequently as possible, during the three hottest months of the year; remember to always measure at the same time of the day. (Sea surface temperatures often lag behind air temperatures by at least a month, so if July is the month when the highest air temperatures occur, August may be the month when sea surface temperatures are highest). If it is safe to walk out to a reef, or swim and snorkel over your reef, then do so and observe whether any white patches develop on the corals. If they do, then record and photograph your observations (the figure below shows an example of a partially bleached coral). Compare the occurrences of bleaching with the measured sea surface temperatures.

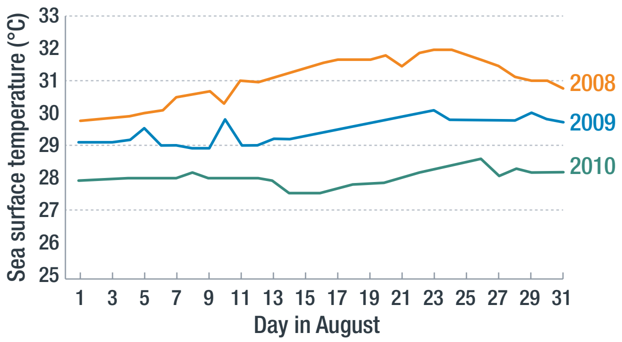
→ **When to measure**
During the three hottest months of the year.



Bleached coral.

## STEP 3
## ANALYSING THE DATA

The measurements will show that bleaching occurs during periods of very high and prolonged sea surface temperatures, probably over 30ºC, although this temperature may vary in different parts of the world. Discuss with the students what happens when the corals bleach, whether there is any recovery after the bleaching event, and what effects this might have on the beach.




Example of sea surface temperature measurements in the tropics.

## STEP 4
# IMPLEMENTING SOLUTIONS

If after analysing your data, you concluded that the corals of your beach have suffered one or multiple bleaching events, it is time to do research on what kind of actions can help reducing coral bleaching. Bleaching events are timed with warmer surface water temperatures: unfortunately, cooling the water is not something you can do. However, healthier corals will be more resilient to incidences of warmer water. As long as the conditions causing bleaching are sporadic, improving coral health, or replanting new healthy corals, are two measures that will help increase the resilience of the coral ecosystem.

**SAMPLE SANDWATCH PROJECT: BAHAMAS STUDENTS BUILD A BEACH MURAL TO PROTECT REEF FROM TOURIST DAMAGE**

After plotting data on a graph and analysing it, they concluded that one of the main issues was that visiting tourists were damaging a small reef located about 20 m from the beach. They had observed visitors standing on top of the coral reef to adjust their masks, breaking off pieces of coral to take as souvenirs and even spear-fishing close to the beach. The table below shows the action plan of this project.

| ACTION | TIME SCHEDULE | PERSONS INVOLVED | ACTIVITIES AND RESOURCES NEEDED | EXPECTED OUTCOME |
|---|---|---|---|---|
| **1.** Plan and design the content of the mural. | January to February | Class 4 students and teachers for science, art, language, woodwork. | Visit to beach to assess potential sites. | **a.** Storyboard showing what the mural will display and the message it intends to convey; **b.** Sketch map and photos of beach showing where the mural will be placed; **c.** List of materials needed to construct the mural. |
| **2.** Consult with land owners, beach managers and other persons in authority to obtain permission to place the mural. | March to April | Teachers for class 4 and school principal arrange meetings with: **a.** Government departments responsible for beaches, planning and environment; **b.** Leaders from communities using the beach. | Discuss the project and obtain permission for the mural. | Written permission from relevant authorities to prepare and construct the mural. |
| **3.** Prepare and place the mural. | May to June | **a.** Identify funding and sources for materials to construct the mural; **b.** Students prepare the mural itself. | Materials to make the mural and paint. | Hold an official “opening” and related public awareness activity. |
| **4.** Sandwatch students assess the impact of the mural. | July to August | Class 4 students conduct a questionnaire survey among beach users to determine the impact of the mural, and based on the results design further awareness or follow-up activities. | Research, consultation with local experts. | Evaluation of the project and lessons learnt. |

Replanting corals is another way of increasing coral resilience.

However, to be sure you do it right, try to find local scientists or organisations that can help you with setting up a project.

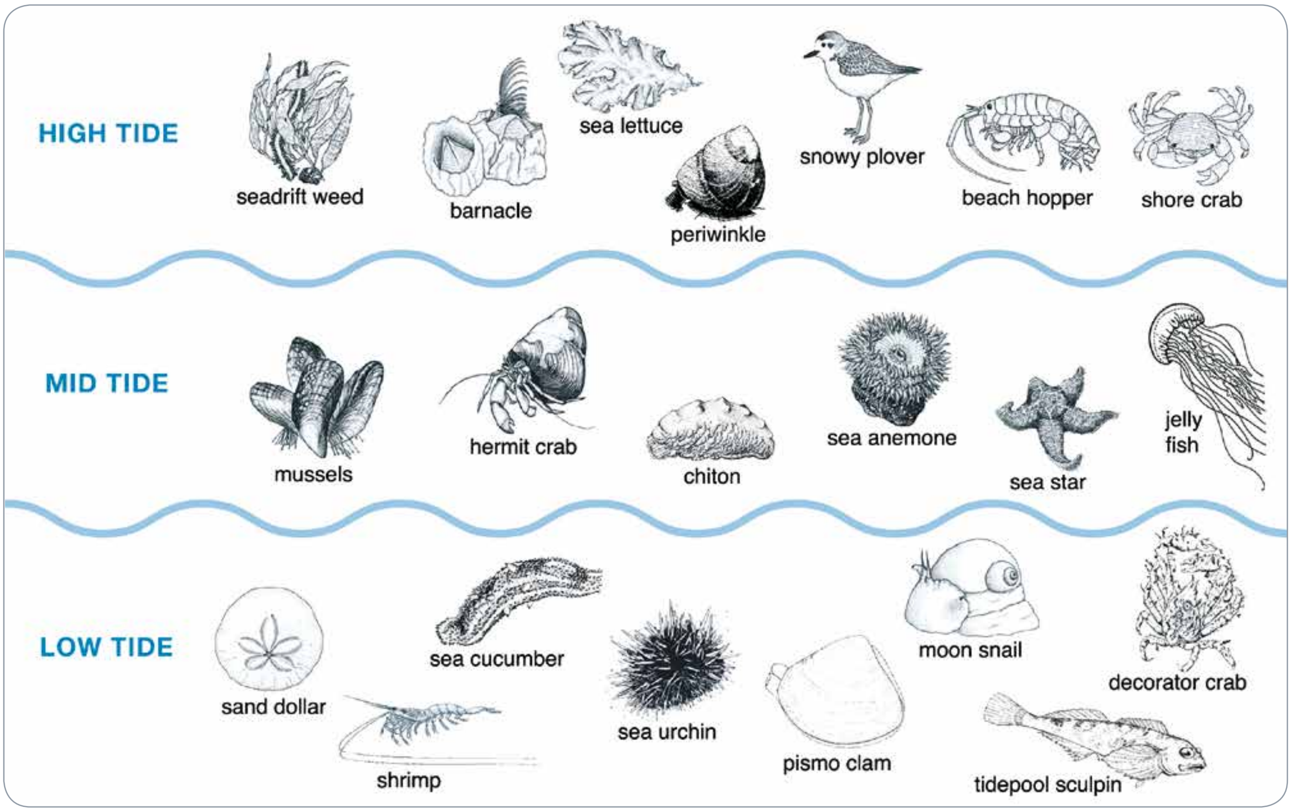
Coral plantation in Malaysia

# Example 3 – Endangered beach ecosystems

While at a glance beaches may appear as barren stretches of sand, in reality they are diverse and productive transitional ecosystems – called “ecotones” – that serve as a critical link between marine and terrestrial environments. The sandy beach is an unstable environment for plants and animals, largely because the surface layers of the beach are in constant motion as a result of waves and wind. This also means that organisms that live there are specially adapted to survive well in this type of environment. Many burrow in the sand for protection from waves and predators or to prevent drying out during low tide. Others are just visitors, such as birds and fish. While different animals are found in different zones, they often move up and down the beach with the tides. Zonation patterns along sandy shores are therefore not as clearly defined as on rocky shores (see figure below).

The beach ecosystem encompasses the interaction between the biological organisms and the physical environment in the beach area. The birds and crabs are as much a part of the ecosystem as the sand and the waves.
The vegetation on the beach and behind the beach also plays an important role: it helps stabilize the beach and prevent erosion. Landward of the highest high-water mark, vines and grasses predominate, which then give way to small salt-resistant shrubs, which in turn give way to trees. In tropical environments the sand runner or goat-foot (*Ipomoea pes-caprae*), a long trailing vine, is often found colonising the sand surface. Other species of vines, herbs and shrubs may also occur depending on the location of the beach. Further inland there are coastal trees, which in tropical areas might include seagrape (*Cocoloba uvifera*), seaside mahoe (*Thespesia populnea*), coconut palms (*Cocos nucifera*), manchineel (*Hippomane mancinella*) and the West Indian almond (*Terminalia catappa*). The change from low vines and grasses to mature trees is known as a vegetation succession.

Many of the projected impacts of climate change will adversely affect beach ecosystems, in particular sea level rise, ocean acidification and temperature increase. Resident and visiting species (e.g. sea turtles and migrating birds) will be affected. Beach erosion will tend to reduce the area of beach habitat for plants and animals. The most extreme effect would be the total loss of the beach, while alternatively in some areas the beach will be able to retreat inland thereby maintaining the beach ecosystem intact.




Common plants and animals found between the high and low water mark (illustration compiled by Aurèle Clemencin).

## STEP 2
## MONITORING THE BEACH

In order to assess how the ecosystem of your beach is being affected by climate change, you will have to monitor your beach. However, before doing so, carry out some research about how the ecosystem was in the past. Local beach users (e.g. fishermen and divers) or local organizations may have relevant information.

### OBSERVING AND RECORDING PLANTS AND ANIMALS ON THE BEACH

**→ What to measure**

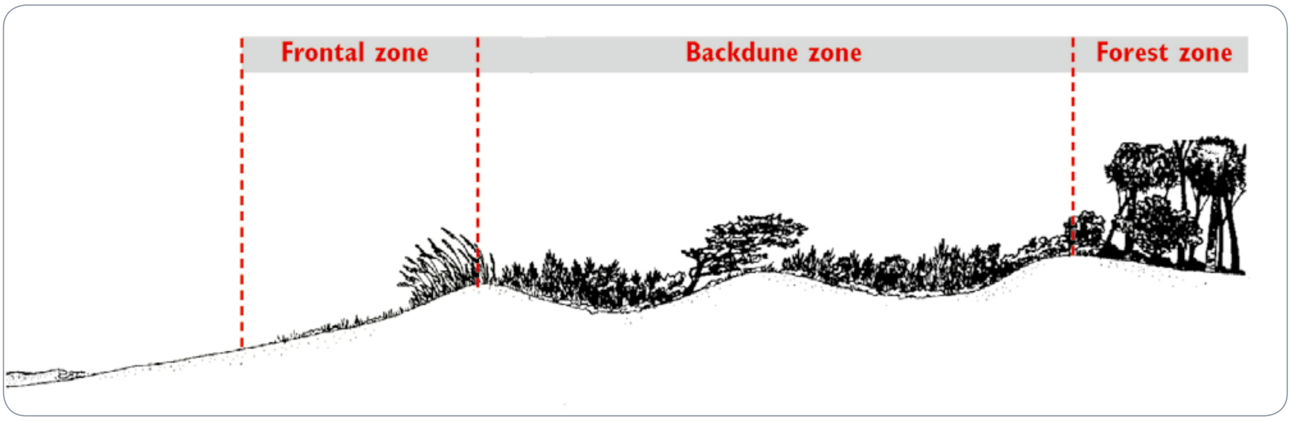
The distribution of plants and animals along the different regions of the beach, and also in the backdune zone (until the forest zone).

**→ How to measure**

For this activity, take containers and collect ten different objects from the beach and record where on the beach each object was found. The easiest way is to define a profile (cross-section, perpendicular to the shoreline) that stretches from the low-water shoreline to the forest zone (encompassing foreshore, backbeach, dune and backdune zones – see figure in "Step 1" in the top of page 156).
Remember not to collect live animals, and if you select a live plant, then take a small piece or leaf from the plant or – better – take a picture. The idea is to observe and conserve the flora and fauna. To better identify the zone where each specimen was collected, you can also lay out a tape measure from the most seaward edge of the beach until the forest zone, and note the distances.

**→ When to measure**

At low tide, in order to gather information not only on animals and plants living in the emerged part of the beach, but also in the intertidal zone (figure below).




**Vegetation succession:** the frontal zone is covered with grasses and vines, which gives way to shrubs and herbaceous plants and eventually the coastal woodland (adapted from Craig, 1984).

## STEP 3
## ANALYSING THE DATA

Separate biological from non-biological items, and plants from animals, and identify the items you collected (you can go further into detail on the identification, providing a full description with pictures, and investigating the habits – diet, movement, reproduction, protection – of each specimen). Discuss the ways in which the different species of animals and plants will be affected by climate change and how they might be protected. When discussing these different issues, make a connection between them and the environmental conditions in the different zones (e.g. the beach may be subject to wave action during storms and will receive the full force of the salt spray, while the backdune and forest zones may be more protected from the salt spray and the wind, and the soil and nutrient conditions may be better there).

Once you have finished the detailed description of the distribution of the animals and plants found in your coastal ecosystem, you need to compare it with analogous data you have gathered from previous years. When doing so, try to find out what has changed since then, and which changes can be attributed to climate change. You may find out, for example, that:

→ The distribution and/or abundance of the species along the different zones of your profile has changed.
If your beach is narrower than before, because coastal buildings have hindered the landward retreat of the beach and the dune system that naturally follows sea level rise, there will probably be at least partially eroded dunes. Hence, the animals and plants living in this zone of the beach are probably no longer present, or are less numerous or have been replaced by other species.
For rocky beaches, changes in the abundance and distribution of rocky shore animals and algae may be observed (mussel beds, for example, may be reduced by an over-abundance of predators). Ocean acidification may also be responsible for changes in the kind of species that thrive on a rocky beach.
The range limits of many intertidal species may have been shifted upwards on the beach.

→ If your coastal ecosystem has saltmarshes, or mangroves, you may observe a landward migration and/or disappearance of those vegetated zones, and the animals that inhabit those ecosystems.

If local organisations or scientists are working on your beach, they may help you identify other changes to your coastal ecosystem.

## STEP 4
## IMPLEMENTING SOLUTIONS

Once you have identified which species of plants and/or animals are most at risk on your beach you can draw up a plan to help those habitats recover. Consult with the owners or managers of the land as to whether they agree to the idea of planting more trees on the land, or mangroves, or other dune vegetation. You will have to explain to them that the vegetation will help the beach ecosystem cope with climate change. Be sure to plant native species that correspond to species that previously existed in the region or still exist today but are struggling to thrive. These will be more resilient to climate change than species imported from other regions. Look for partners to help with your project (e.g. Agriculture Department, community group, environmental non-governmental organisations) and:

- Design your planting plan (native tree species, numbers of seedlings, space between seedlings, ecological fertilizer requirements). This must include a follow-up plan to care for the plants while they are young.
- Plant the trees and publicise the activity.
- Carefully monitor the number of seedlings that survive over the first six months, and care for the trees, in particular by providing them with water since the beach is a very harsh environment for new plants.

Students planting mangrove trees in Cambodia.