SANDWATCH MANUAL

Adapting to Climate Changes and Educating for Sustainable Development

August, 2009

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UNESCO
United Nations
Educational, Scientific and
Cultural Organization

Ministry of Foreign Affairs of Denmark

Foreword

This manual updates an earlier version written by Gillian Cambers and Fathimath Ghina, published by the United Nations Educational, Scientific and Cultural Organization in 2005 (UNESCO, 2005. Introduction to Sandwatch: An educational tool for sustainable development, Coastal region and small island papers 19, UNESCO, Paris, 91pp), and integrates the climate change dimension into all the chapters and activities.

Acknowledgements

The authors would like to especially thank the following persons for substantive input and critical review of this manual: Pascale Gabriel, Karen Eckert, Nicole Garofano, Hans D. Thulstrup, Elda Varela Acevedo.

Photo Credits: Araura College, Aitutaki, Cook Islands; Herman Belmar; Ruperto Chaparro; CORALINA, San Andres, Colombia; Pascale Gabriel; Candace Key; Hans Thulstrup; Elda Varela Acevedo.

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Chapter 1 Introduction

Summary

Sandwatch provides the framework for children, youth and adults, with the help of teachers and local communities, to work together to critically evaluate the problems and conflicts facing their beach environments and to develop sustainable approaches to address these issues, whilst at the same time helping beaches become more resilient to climate change. Preliminary chapters focus on how to get started with Sandwatch activities and climate change. Documenting the Sandwatch methodology: *Monitoring, Analysing, Sharing, and Taking action* is the major focus of this publication. An activities-orientated approach is used to provide step-by-step instructions to cover monitoring methods and data analysis, including observation and recording, erosion and accretion, beach composition, human activities, beach debris, water quality, waves, longshore currents, plants and animals. The activities are related to (a) sustainable development issues including: beach ownership; mining beaches for construction material; conflict resolution between different beach users; pollution; conservation of endangered species and (b) climate change adaptation issues: sea level rise, rising temperatures, ocean acidification and increased extreme events. Ways to share the findings and create a Sandwatch network are described and methods include the use of local media, websites, social networking and video production. Finally, ways are discussed to design, plan and implement a Sandwatch project that fulfils one or all of the following criteria: (a) addresses a particular beach-related issue; (b) enhances the beach; and (c) promotes climate change adaptation.

Background

Sandwatch is a programme whereby children, youth and adults work together to scientifically monitor and critically evaluate the problems and conflicts facing their beach environments and then design and implement activities and projects to address some of those issues, whilst also enhancing the beach environment and building ecosystem resilience to climate change. Founded on a series of very simple protocols, Sandwatch appeals to persons of all ages and all backgrounds.

Sandwatch can trace its early beginnings to an environmental education workshop held in Trinidad and Tobago in July 1998, organized by the United Nations Educational, Scientific and Cultural Organization (UNESCO). Participants saw firsthand many of the problems facing the coastal zone – problems related to erosion, pollution and poorly-planned development – and resolved to do something about these issues themselves. This was the beginning of what has become known as Sandwatch.

Starting as a Caribbean regional initiative, Sandwatch is now a vibrant, international programme implemented by schools, youth and community groups in Africa, Asia, Europe, and islands in the Caribbean, Pacific and Indian Oceans. Networked via the Internet, Sandwatch is now on its way to becoming a worldwide movement.

At the mid-point of the United Nations Decade of Education for Sustainable Development (2005-2014) Sandwatch presents an example of Education for Sustainable Development in action, and is being targeted as one of several flagship projects for the Decade.

As the world confronts the growing threat of climate change, Sandwatch presents an opportunity to help people and ecosystems respond to present and future changes in a practical manner. Beaches are among the ecosystems most at risk from climate change as they face rising sea levels and increased storms. By contributing to ecosystem health and resilience, Sandwatch can help people from all walks of life learn about climate change and how their actions can contribute to the adaptation process.

Short history and scope of Sandwatch

Sandwatch is also about sharing information. Here a group of students in San Andres discuss how to measure beaches with a representative from CORALINA.

Other representatives from CORALINA talk with a beach user on how to best protect an eroding beach. (CORALINA is the Corporation for the Sustainable Development of the Corporation of San Andres, Old Providence and Santa Catalina)

Sandwatch has been supported from its conceptualisation by UNESCO, primarily through its education and science sectors, and its national commissions. Many other partners are also involved. Sandwatch formally began in 2001 with a regional training workshop held in Saint Lucia with teachers and students from 18 Caribbean countries. Participants were trained to use standardised methods for the measurement of beach changes including erosion and accretion, wave and current action, water quality, and human activities that impact the beach. A manual was prepared prior to the workshop, with the assistance of the University of Puerto Rico Sea Grant College Program.

Following the training workshop, teachers worked with their students to monitor their beach environments and record their results. A follow-up workshop was held in Dominica in 2003, with the added participation of representatives from the Pacific and Indian Ocean islands. In 2004-2005 Sandwatch groups were invited to enter an international “Community Sandwatch” competition, with the goal of having students plan, design, implement and evaluate community-based beach enhancement projects based on the beach monitoring methods that are an integral part of Sandwatch. The 30 entries, documented on the Sandwatch website (www.sandwatch.org), illustrated the effectiveness of the approach both from a learning perspective and a practical application. Entrants worked with different beach users, ranging from interested tourists to sceptical developers, to preserve the beach environment and displayed their knowledge and communication skills as they utilised the media to their advantage. Selected highlights are shown in Box 1.

Box 1
Selected Highlights from the “Community Sandwatch” Competition 2004-2005

- In Cuba, a Sandwatch group worked with hotel developers and construction workers to raise their awareness about beach flora and fauna and convinced the developers to help move a community of threatened iguanas to a neighbouring more protected site.
- In St. Vincent and the Grenadines, the Sandwatch group restored a degraded coastal area and used the power of the media to help local fishermen change their attitudes and stop polluting the beach and nearshore area.
- In The Bahamas the Sandwatch group worked with hoteliers and tourists to ensure visitors adopted safe and environmentally sensitive practices when snorkelling over a nearshore reef that provides protection to their beach.
- In the Cook Islands, Sandwatch groups saw their beach ravaged by several cyclones, but vowed to replant the vegetation and help the beaches recover after the cyclone season.
- In Cuba, another Sandwatch group included students with special needs in their beach enhancement project, thereby illustrating the contribution that can be made by all members of society.

Following the establishment of the Sandwatch website in 2006, the programme has expanded worldwide as networking has become an important component of the programme. In 2006, Trinidad and Tobago organised a Sandwatch fair, inviting more than 13 countries to share their Sandwatch experiences. In 2008 the non-profit Sandwatch Foundation was established to coordinate and promote Sandwatch.

In 2007 the Fourth Assessment Report of the Intergovernmental Panel on Climate Change (IPCC) compiled overwhelming evidence to show that the earth's climate is changing mainly as a result of greenhouse gases caused by human activities. Partly as a result of this report and the award of the 2007 Nobel Peace Prize to the IPCC and former US Vice-President, Al Gore, climate change became a worldwide concern. Sandwatch, which already had the objective of building ecosystem resilience, was identified as a programme ideally suited to building capacity in climate change adaptation. In 2008, a "Sandwatch and Climate Change" video competition was held, a training workshop was conducted to provide Caribbean Sandwatch groups with the communication skills to effectively convey information on climate change to a general audience, and a dedicated climate change section was established on the website.

The original Sandwatch manual, prepared in 2001, was revised and published in 2005. As a result of the growth and expansion of the programme, new emphasis on networking and communications, and the particular success of the applied approach and its contribution to beach enhancement worldwide, it was decided in 2009 to revise the manual. This new edition includes new information and activities related directly and indirectly to climate change, and new methods that have been developed by Sandwatch groups. It therefore represents a useful tool for both new and established Sandwatch groups.

Objectives of Sandwatch

Through Sandwatch, children, youth and adults work with their local communities, and get involved in the enhancement and wise management of their beach environments.

The objectives of Sandwatch are to:

(a) involve children, youth and adults in the scientific observation, measurement and analysis of changes in the beach environment utilizing an inter-disciplinary approach;

(b) assist Sandwatch groups, with the help of local communities, to apply their information and knowledge to the wise management and enhancement of their beaches;

(c) integrate the Sandwatch approach into the formal and informal education system and contribute to the Decade of Education for Sustainable Development;

(d) contribute to the understanding of how climate change affects beach systems; and

(e) build ecosystem resilience and contribute to climate change adaptation.

Sandwatch vision statement

Sandwatch seeks to change the lifestyle and habits of children, youth and adults on a community wide basis, to adapt to climate change by building ecosystem resilience, and to develop awareness of the fragile nature of the marine and coastal environment and the need to use it wisely.

Sandwatch methodology

Taking action based on sound science is the basis of the Sandwatch methodology. The Sandwatch methodology has four main steps: **M**onitoring, **A**nalysing, **S**haring, **T**aking Action (MAST):

(a) Monitoring the beach: Selection of a specific beach where various parameters are regularly measured, including:

- observing the beach and preparing a sketch map;
- people's use of the beach;
- debris on the beach;
- water quality;
- erosion and accretion;
- beach composition;
- waves;
- longshore currents; and
- plants and animals.

(b) Analysing the results: Compiling the information into tables, graphs and charts and determining trends as to how a particular parameter changes over time, including:

- compiling data tables;
- using graphs and charts to display the data;
- designing artwork and physical models illustrating the findings; and
- conducting simple statistical analysis (where appropriate and depending on the group's background).

(c) Sharing the findings: Communicating the results in the local context, such as with other classes, schools and youth groups, parents, community members and government officials; as well as with other Sandwatch groups worldwide, through the following:

- meetings and presentations;
- story-telling and drama;
- written publications such as newsletters, flyers, pamphlets, stories, cartoons;
- visual media: posters, photographs, videos;
- networking via the Internet; and
- websites.

(d) Taking action: Planning, implementing and evaluating a beach-related activity that fulfils one or all of the following:

- addresses a particular beach-related issue;
- enhances the beach; and
- promotes climate change adaptation.

With a strong field monitoring component, Sandwatch tries to 'make science live', yet remains inter-disciplinary with applications ranging from ecology to woodwork and from poetry to mathematics. Sandwatch activities relate directly to topics already included in the primary and secondary school curricula. Sandwatch also provides an approach that can be used by non-school groups such as youth groups, environmental and community groups.

Outline of this publication

Documenting the Sandwatch methodology is the major focus of this publication. Chapter 2 provides some background on climate change and projected beach impacts and discusses how Sandwatch contributes to Education for Sustainable Development. Chapter 3 provides information for new groups on how to get started with Sandwatch. Chapters 4 - 12 outline methods for measurement and analysis of specific components of the beach system:

4. observation and recording;
5. erosion and accretion;
6. beach composition;
7. human activities;
8. beach debris;
9. water quality;
10. waves;
11. longshore currents; and
12. plants and animals.

Chapter 13 discusses the third component of the Sandwatch methodology: how to communicate and share the information with other groups. Finally, Chapter 14 describes the fourth step of the Sandwatch methodology: taking action through the planning, implementation and evaluation of beach-related projects. A glossary at the end of this publication defines the terms used in this publication.

Chapter 2 Climate change adaptation and education for sustainable development

> *"Many Small Island Developing States (SIDS) comprise small, low-lying islands with limited land and freshwater resources. They are likely to be severely impacted by the projected rise in sea levels and the increase in extreme weather events caused by global warming. SIDS are also likely to be among the first countries confronted by the devastating social and human consequences of climate change – such as the forced migration of entire populations away from islands as they become uninhabitable. Faced with these risks, there is an urgent need to develop appropriate educational materials on climate change for SIDS. This means helping small island communities learn to manage their natural resources and ecosystems in a more sustainable way. The flagship UNESCO Sandwatch project is an excellent example of what can be achieved in this regard."*
>
> Address by Mr Koïchiro Matsuura, Director-General of UNESCO, International Seminar on Climate Change Education, UNESCO Paris, 27 July 2009

This chapter explores climate change and ways in which Sandwatch can contribute to adaptation through education for sustainable development.

Weather and climate

People talk a lot about the weather, which is not surprising when you consider the impact it has on our mood, how we dress, what we eat and what we do. Weather is a term that describes the current atmospheric condition at a given place and time and includes temperature, moisture, wind speed, and barometric pressure, among other things. Climate is not the same as weather. Rather it is the **average pattern** of weather for a particular region over a long period of time, usually at least 30 years. So while weather changes from day to day and the changes are easy to see, it is not so easy to detect climate changes, which instead requires long periods of careful measurement. It is impossible to look at short term weather changes for any given area and make valid statements about long-term climate change.

Climate change

Climate on earth has changed continually as the planet has evolved geologically. Natural causes include changes in the amount of the sun's solar radiation reaching the earth, and volcanic eruptions that can shroud the earth in dust thereby reflecting the heat from the sun back into space. Most of the historical changes in climate have occurred on time scales far longer than a human life – centuries, millennia or millions of years.

Natural causes, however, can explain only a small part of the present warming trend that has been observed during the second half of the 20th century. There is now unequivocal evidence that the earth's climate is changing as a result of human activities, principally increased carbon dioxide emissions, since pre-industrial times (1700s). The overwhelming majority of scientists agree that rising concentrations of heat-trapping greenhouse gases in the atmosphere are causing the climate to change.

Energy from the sun warms the earth's surface and, as the temperature increases, heat is radiated back into the atmosphere as infra-red energy. Some of the energy is absorbed within the atmosphere by 'greenhouse gases'. The atmosphere acts in a similar way to the walls of a greenhouse, letting in the visible light and absorbing the outgoing infra-red energy, keeping it warm inside. However, human activities are adding greenhouse gases, particularly carbon dioxide, methane and nitrous oxide, to the atmosphere, which enhances the natural greenhouse effect and makes the world warmer.

> Climate change is defined as a change in climate which is attributed directly or indirectly to human activity that alters the composition of the global atmosphere and is observed over long time-periods (many decades).

Climate change predictions

There is a large body of information about climate change in published literature and on the Internet, some of it is sensational, some contradictory and some based on sound science. However, it is very difficult for the lay person to distinguish sound knowledge from misleading information.

The Intergovernmental Panel on Climate Change (IPCC) is one of the most accurate sources of information on climate change. The IPCC was established in 1988 to provide decision-makers and others interested in climate change with an objective source of information. The IPCC does not conduct any research nor does it monitor climate related data or parameters. Its role is to assess on a comprehensive, objective, open and transparent basis the latest scientific, technical and socio-economic literature relating to climate change. The IPCC consists of thousands of scientists from different disciplines, who work together to produce assessment reports at approximately five year intervals. The IPCC supports the United Nations Framework Convention on Climate Change (UNFCCC), which entered into force in 1994 and provides the overall policy framework for addressing climate change. Whilst the IPCC reports are very technical, they do contain supporting material such as 'frequently asked questions' which help the general reader understand the contents. The IPCC reports are available on the website www.ipcc.ch

Projections for climate change vary regionally and readers are advised to contact local sources such as national meteorological offices and national reports on climate change (see each country's national communication available on the UNFCCC website www.unfccc.org) for country-specific information. Table 1 provides global projected changes up to 2099 based on the IPCC Fourth Assessment Report (2007).

Table 1 Projected Global Climate Changes by 2099 (Source IPCC, 2007)

Parameter	Projected Change
Temperature	Increase of between 1.1 and 6.4^{o}C
Sea level rise	Increase of between 0.18 and 0.59 m
Ocean acidification	Decrease in pH of 0.14 – 0.35 pH units (resulting in increased acidity)
Snow and ice extent	Decrease in areal extent of ice and snow
Extremes: heat waves and heavy precipitation	More extreme events
Tropical cyclones	Stronger tropical cyclones
Precipitation	Changes vary regionally, some areas getting drier, some wetter.

Activity 2.1 Conduct your own weather measurements

What to measure → Depending on the age of the group, simple or more complex weather characteristics can be observed and/or measured on a daily basis to show how weather changes. Simple weather measurement kits are available, however there are several weather measurements that require no special equipment and are described below.

How to measure→Observe, measure and record the following:

- Cloud cover: clear, partly cloudy (less than half of the sky is covered with cloud), mainly cloudy (more than half the sky is covered with cloud) and completely cloudy;
- Cloud type: descriptors included high and low clouds; cloud colour; cloud type e.g. cumulus, cirrus, stratus clouds;

Simple cloud observations

Partly cloudy, high cirrus clouds;

Completely cloudy, mid-level cumulus clouds.

- Temperature: use a simple thermometer (although be sure to keep it out of direct sunlight);
- Rainfall: collect rainfall in a simple container and then pour the rainfall collected into a graduated cylinder or measuring cup;
- Wind speed and direction: direction from which the wind blows can be estimated by looking at smoke from a chimney or a flag and using a compass to determine the direction; a simple wind meter is required to measure wind speed (see Annex 1).

Compile the data into tables and prepare graphs showing how the weather changes (or does not change) from day to day.

When to measure→Conduct the weather observations and measurements daily at the same time of day for a week. Repeat the measurements at a different season, e.g. wet and dry seasons, winter and summer.

What the measurements show→The measurements will show how the weather changes from day to day and there are likely to be quite significant changes between one day and the next. Comparisons of the data taken at different seasons of the year will also show further differences.

Use the data to show how difficult it is to make any statement about climate based on the daily weather pattern, and emphasises the important work of climatologists collecting daily data for decades in order to compile climate records.

Use the global climate change projections in Table 1 to discuss how the projected global changes might change your weather.

As a further activity, ask the students to interview parents and older members of the community about their memories of weather 20, 40, 60 years ago, and compare these findings with the climate records for your area.

Extension of this activity→ set up a permanent weather station at your school.

Responding to climate change

Two main ways to respond to global climate change are through mitigation and adaptation. Mitigation involves attempting to slow the process of global climate change by lowering the amount of greenhouse gases in the atmosphere. Within the framework of the UNFCCC, countries around the world are working to reduce their carbon emissions. There are also many actions that individuals can take, e.g. reducing their own energy consumption, using renewable sources of energy, reducing their use of excess packaging, and planting trees that absorb carbon dioxide from the air and store it in the soil or in their trunks and roots. However, it is necessary to appreciate the inevitable nature of climate change, some aspects of which (e.g. sea level rise) will continue for centuries even if greenhouse gas concentrations were stabilized now.

Adaptation relates to how to live with the degree of global warming that cannot be stopped. It involves developing ways to protect people and places by reducing their vulnerability to climate impacts. Examples of adaptation include building seawalls or relocating buildings to higher ground to protect communities against increased sea flooding. Other adaptation measures may simply be an extension of sound development practices such as keeping beaches and coastal waters clean.

Activity 2.2 Learning about climate change adaptation and mitigation

What to do→Divide the class/persons into small groups and ask each group to list adaptation and mitigation measures for different levels:

- national level – the country or island, e.g. building sea walls to protect the coastline from rising sea levels (this contributes to adaptation by coping with rising sea levels);
- community level, e.g. starting a recycling programme (this contributes to mitigation by reducing energy usage, and to adaptation by reducing the solid waste dumped in rivers and on beaches, thereby keeping ecosystems more healthy and resilient); and
- individual level, e.g. conserving energy by turning out the lights when no one is in the room (this contributes to mitigation through reducing energy use and greenhouse gases).

After the groups have shared and discussed their lists, ask each person to select one activity from the individual level list, and implement that activity in their home life for a week.

After the week, persons report on their implementation success, problems encountered, and how their family members responded to the activity.

What the activity shows→Participants will learn about mitigation and adaptation actions for different levels of governance and will find that many appropriate actions contribute to both mitigation and adaptation. They can also discuss whether it was easy or difficult to implement the one activity over the course of a week, and whether they intend to continue and involve more of their family members in the activity.

Climate change and beaches

As key recreational sites, beaches are of prime social, cultural, environmental and economic importance and dominate the world's coastlines. They are important ecosystems and also fulfil protective functions safeguarding coastal lands from flooding. Furthermore, beaches are among the most dynamic and fast changing environmental systems.

Climate change is already affecting beaches in a number of different ways. These changes are likely to intensify over time and include:

- rising sea levels, resulting in increased beach erosion, reducing the area of beaches and impacting coastal habitats;
- extreme weather events and changes in cyclone and storm behaviour, producing higher and more powerful waves, increasing beach erosion;
- changing precipitation patterns with more floods and altered freshwater flow to the oceans, affecting beach ecology, sediment budgets and the formation of beachrock;
- rising temperatures, affecting the animals and plants living on and near the beach, e.g. bleaching of coral reefs; and
- acidification of the oceans, negatively affecting marine organisms that need calcium carbonate to form skeletons or shells.

Sandwatch and climate change adaptation

One of the ways in which humans can adapt to climate change is by ensuring that ecosystems are more resilient and healthy not just for today but for the long term. A wide beach backed by a coastal forest and protected by a healthy coral reef can better withstand sea level rise and future high wave events than a narrow beach confined by concrete infrastructure on the landward side and a degraded, dying coral reef on the seaward side. Sandwatch, with its focus on the use of scientific monitoring of beach changes to inform effective action to enhance and care for beach ecosystems, is ideally suited to contribute to climate change adaptation.

In November, 2008, Sandwatch joined with Counterpart Caribbean and other partner organizations to work with Caribbean teachers and youth to learn more about climate change and how they could spread the word to other persons and groups in their countries. Thirty teachers and students worked for three days to improve their communication skills including drama and storytelling, video production and web-based tools. In the six months since the event, the participants reached out to more than 30,000 people through news stories, videos, exhibitions and presentations.

Youth will have to lead the way on climate change adaptation (Logo from Youth and Climate Change Workshop, Barbados, November 2008)

Drama is an effective way of portraying information about climate change (Dramatic presentation at a Youth and Climate Change Workshop, Barbados, November 2008)

This revised manual is designed to help new and established Sandwatch groups learn about climate change and how they can contribute to climate change adaptation through Sandwatch.

Education for sustainable development

Education for Sustainable Development (ESD) is an approach to teaching and learning that seeks to empower people of all ages to assume responsibility for creating and enjoying a sustainable future. It prepares people of all walks of life to plan for, cope with, and find solutions for issues that threaten the sustainability of our planet, and encourages changes in behaviour that will create a more sustainable future.

Put simply, ESD promotes five types of learning as the basis for fostering sustainable development. These are:

- learning to know;
- learning to do;
- learning to live together;
- learning to be; and
- learning to transform oneself and one's society.

Education for sustainable development is education for life.

More than just one discipline, ESD requires an understanding of science, economics, mathematics, geography, ethics, politics, and history. Moreover, addressing the interaction between humans and the environment is critical, making it necessary to incorporate subjects such as human ecology, philosophy, psychology and language. It is not necessary to be a scientist or an environmental expert, rather it is a case of facilitating learning, and knowing how and when to get other teaching colleagues and experts involved. ESD involves decision-making, communication and creative skills, in other words, it is education for life. Venturing into unknown areas and learning about new issues are other exciting aspects. For more information on ESD, please see www.unesco.org/education/esd.

Sandwatch and education for sustainable development

Sandwatch brings together different aspects of education for sustainable development. It focuses on taking education outside the classroom and learning about real problems and issues and what can be done to find solutions. This is not done by youth in isolation, but in collaboration with their peers, communities and other focus groups. Thus young people learn inter-personal communication skills, such as how to communicate with others having different levels of understanding and different priorities, and this is an important skill for life after school.

Sandwatch takes a holistic view of the environment, involving natural, human, economic and political components. The activities or projects designed by the students are based on the principles of science: data collection, data analysis and critical thinking. Students learn to organize and prioritize their information, and how to critically select the salient points and key issues. The process also provides for self-discipline whilst providing scope for lateral thinking and creativity. Virtually every subject in the school curriculum can be integrated into Sandwatch, from drama to language skills and from mathematics to woodwork. Of particular importance is the teaching of many life skills in a practical learning-by-doing framework. Sandwatch provides opportunities for students to learn to share information and even more importantly to listen to others. They learn to appreciate the principles of environmental stewardship and responsible citizenship by working for the benefit of the community rather than their own personal advantage. They also learn to understand the benefits that can be derived from sound scientific monitoring which can often be rather repetitious. Finally, Sandwatch also develops a sense of caring for the environment and the world about us.

Beaches are places to be treasured, Pigeon Island, Jamaica.

Chapter 3 Getting started

Finding out more about Sandwatch

One of the best sources of information about Sandwatch is the website (www.sandwatch.org) which is updated regularly and provides a wealth of hands-on information. You can download and read the manual, various country reports on Sandwatch activities, and the Sandwatcher Newsletter, which is published in English, French and Spanish several times a year and contains articles written by Sandwatchers from around the world.

You might also like to partner with another Sandwatch school in your country or in a different country. This way you can direct your questions to other, more experienced persons. To find a suitable partner Sandwatch group, just email any of the persons on the Contacts page of the website and they will be happy to help you link up with another Sandwatch group.

Forming a Sandwatch committee

While many Sandwatch groups have one innovative leader and champion of Sandwatch activities, it is always helpful to adopt a team approach. This makes the activity more sustainable should the innovator leave, and since Sandwatch is such a multi-disciplinary activity it is helpful to involve other persons with different backgrounds and skills. However, organizing a large committee involves a lot of extra work, so a small committee is a good starting point. The Sandwatch team can always be expanded later.

In some countries national Sandwatch committees have been established. For example, the Dominican Republic in the Caribbean has a very active Sandwatch programme involving more than 13 educational centres along the south coast of the island. The programme is organised by a national committee comprising the Associated Schools Project Coordinator of the UNESCO National Commission, Department of Environment and Natural Resources, Department of Education and the National Aquarium.

Get advice from professionals

While the activities described in this manual are quite simple and straightforward, it often helps to get other teachers, environmental professionals, and climate experts involved in your programme. They can usually provide additional information and may be able to provide some assistance with interpreting your results. For example there may be a community college or university in your country who, as part of their outreach activities, may be willing to help. Similarly, government-run environment and planning departments often have education programmes and may be able to provide additional support. Climate change focal points and experts from local and national meteorological offices are good sources of information on climate change. Sandwatch teams in other countries are another possible source of assistance.

Select the beach to monitor

The key factors to consider here are:

Safety: the beach should provide a safe environment for the students, e.g. if there are very strong currents and/or very high waves, there is always the risk a student will go bathing with disastrous consequences. Safety must always be the prime concern.

Accessibility: choose a beach that is easy to get to, preferably near the school and within walking distance. In some countries private beaches exist, so make sure the beach is a public beach.

Small beaches enclosed by headlands, also known as bayhead beaches, and seen here at Anse Ger in Saint Lucia (left), are ideal for Sandwatch monitoring. Some beaches like at Byera on the east coast of St Vincent and the Grenadines (right) are very long, and in these cases a particular stretch should be selected for Sandwatch monitoring.

Size of the beach: this is another important issue. In some areas, beaches are small (less than 1.6 km (1 mile) in length) and enclosed by rocky headlands. These ‘bayhead’ beaches, as they are called, represent an ideal size for a monitoring project. However, in many countries there are also long beaches, which extend for several kilometres (or several miles). If one of these very long beaches has been selected as the beach to be monitored, it is recommended to determine a particular section (about 1.6 km or 1 mile) for the monitoring.

Importance of the beach to the community: try and choose a beach which is used by the residents of the area and therefore important to the local community. This will provide for 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 at weekends, favourite destination for local residents, history of erosion during storms, may be other reasons to select one beach location.

Define the boundaries of your beach

What is a 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 Figure 1, which is called a cross-section, the beach extends from the low water mark to the vegetation edge.

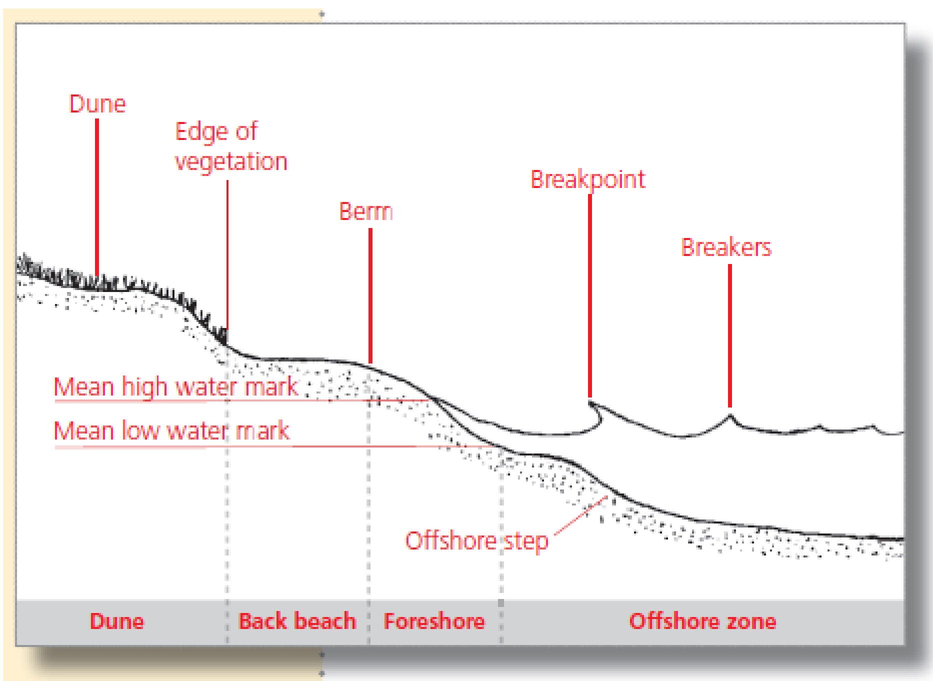


Figure 1 *Cross-section of a typical beach.*

Beaches are often made up of sand particles, and in many islands 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.

Sandwatch focuses on the beach, the offshore zone and also the land behind the beach; this may consist of a sand dune, as shown in the cross-section, or a cliff face, a rocky area, low land with trees and other vegetation, or a built-up area.

A beach is more than just a zone of loose material found where the water meets the land; it is also a coastal ecosystem. An ecosystem is the basic unit of study of ecology and represents a community of plants, animals, and micro-organisms, linked by energy and nutrient flows, that interact with each other and with the physical environment. Ecology is the study of the relationship of living and non-living things.

Sometimes, geologists, ecologists and others look at the beach from a broader perspective, taking into account the offshore zone out to a water depth of about 12 m (40 ft). 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. Thus, often there is a need to look at the wider perspective of the '*beach system*'.

Deciding which beach characteristics to monitor

A Sandwatch group can select which of the beach characteristics described in Chapters 4 – 12 they want to measure, they can elect to do all the measurements, or just one or two. However, there is one activity that is so important that it is really the starting point for every Sandwatch activity and that is observing the beach, recording the observations and making a sketch map (see Chapter 4). This helps to provide an overall perspective of the beach and its potential problems.

Deciding how frequently to monitor

The frequency of monitoring can be decided by the Sandwatch group and also depends on the characteristic that is being monitored. If measuring beach width, this could be done every week, every month or just twice a year, although if a big storm takes place, there might be some interesting results if the beach could be re-measured after the storm. Similarly, interesting changes in water quality may be measured after a heavy rainfall event. The environment changes all the time both naturally and as a result of man's actions, so it is always important to have a flexible approach when it comes to Sandwatch.

Entering your data in the Sandwatch Climate Change Database

The information collected in Sandwatch is very important and represents a useful record of beach conditions at a particular time. Collected regularly over long time spans (several years) the data provides important information about beach changes and how these are being affected by climate change. For any one particular beach it may represent the **only** quantitative information available. It is therefore very important that you always enter your data in the Sandwatch Climate Change Database (presently being established) where it is stored permanently and available for others - Sandwatch groups, scientists, government planners, environmentalists, and other interested groups - to view.

Who to involve in Sandwatch

Anyone can get involved in Sandwatch: primary and secondary schools (Sandwatch can be adapted for students of any age from between 7-18 years), youth groups, religious organizations and community groups. Any interested group of persons can start Sandwatch.

There is no need to make a special application or request. Most of the people involved in Sandwatch do so as volunteers.

However, Sandwatch is not just an approach, it is 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 a part of the network.

Sandwatch cannot be done in a classroom alone, it is essential that students go outside the classroom and experience the beach environment. In many countries taking students outside the classroom during class time represents a major hurdle due to government regulations. Many teachers and schools overcome this hurdle by holding the field sessions on the beach during weekends or after school hours. Most of the activities described in this manual involve work on the beach followed by work in the classroom; in most cases the work in the classroom will take considerably more time than the work on the beach (two to four times as much).

Primary schools participation in Sandwatch

Primary schools in several countries are successfully implementing Sandwatch and informally adapting it into different parts of the curriculum, e.g. observing the beach and making a sketch map can be integrated into social studies; counting beach users and drawing a graph can reinforce mathematical concepts; understanding and using a compass can help in understanding the earth and magnetism; and writing a story or poem about the beach can utilize language and creative skills. A student, Alana Stanley, who was involved in Sandwatch at Mayaro Government Primary School in Trinidad wrote:

> *'One of the activities that I am involved in is collecting data on wave intervals. When my teacher first told me about it, I said to myself, That's boring. Was I in for a rude awakening? Boring? Ha! It was the first time I got to use a stopwatch. Since my first experience, many mathematical problems have become clearer to me and I now have begun to enjoy maths, simply due to my experiences in Sandwatch. Sandwatch has not only helped me in mathematics, but I have a better appreciation for and a greater understanding in geography and science.'*

Secondary schools participation in Sandwatch

Many secondary schools are also involved in Sandwatch, using the different activities to strengthen and reinforce the curriculum. Some examples are shown below:

- in *science*, Sandwatch provides the opportunity to apply the scientific method to explain the changes in the natural environment (developing a hypothesis, making measurements, analyzing the results, discussing the findings and testing the hypothesis); it is directly applicable to environmental studies and basic sciences (biology, chemistry and physics); it helps students learn to use simple instruments to make accurate measurements;
- in *mathematics* it can help reinforce concepts of trigonometry and in applications of statistics;
- in *social studies* students learn how people interact and change their environment; Sandwatch develops map-making skills and the concept of place; it facilitates interaction with people from other countries and learning about their culture and lifestyles;

- in *information technology* it strengthens computer skills such as word processing and database management. Sandwatch can also introduce students to the world of information sharing through video production and webcasts;
- the use of language skills come into all aspects of Sandwatch through *creative writing*, reports, storytelling, keeping journals, spelling, newspaper articles as well as through drama, poetry, dance and music. Sandwatch can also be used to teach foreign languages, see the example from Mayotte in Box 2; and
- *creative arts and crafts* can translate a table of data into a visual picture thereby developing artistic and imaginative skills that also help in sharing the information with other groups; designing and making signs, pamphlets and reports also provides artistic opportunities.

In addition, Sandwatch projects frequently form the subject of school-based assessments for formal regional examinations and science fairs. In some islands extra-curricular clubs and groups have adopted Sandwatch.

Students and teachers work on their data in the classroom after a morning's observations on the beach, Saint Lucia.

Sandwatch in the school curriculum

So far, only the Cook Islands in the Pacific has formally integrated Sandwatch into the national school curriculum. Teachers, and staff from the Curriculum Advisory Unit of the Ministry of Education, worked together to test the Sandwatch activities and identify specific areas of the curriculum where they could be integrated. Now school students in the Cook Islands are learning about Sandwatch in their science curriculum, specifically the Living World Unit and the Earth and Sky Unit, and in their social science curriculum through the People, Place and Environment Unit.

Students with special needs

Sandwatch has scope beyond specific classes and defined age groups. One of the entries to the International Community Sandwatch Competition held in 2005 was a combined effort from Cuba involving students ranging in age from 7-18 years from a secondary school, an art school and a school for children with special needs. A visitor to the latter school wrote: *'A colleague we met mentioned that because the autistic children took part in the Sandwatch project, others could clearly see that these children had lots to offer.' (Hunter, 2007)*

Box 2
Using Sandwatch to teach English as a foreign language
Contributed by Pascale Gabriel

These examples are based on using Sandwatch to teach English to French-speaking students in Mayotte, Indian Ocean, and can be used by teachers of other foreign languages.

Learning to use the words What, Where and How

Before the first visit to the beach prepare a list of titles: date, time, weather, name of beach, shape and size, length and width, wave height, water and air temperature. Ask the students to prepare questions starting with the words: what, when and how, under each title, e.g. What is the date? What is the weather like? What is the name of the beach? How big is the beach? How long is the beach? How wide is the beach? Where do the waves break? What is the colour of the water? The students bring their list of questions to the beach and work in pairs or groups to pose their questions to the others and write down the answers. Back in the classroom the students use the questions and answers to write a description of the beach.

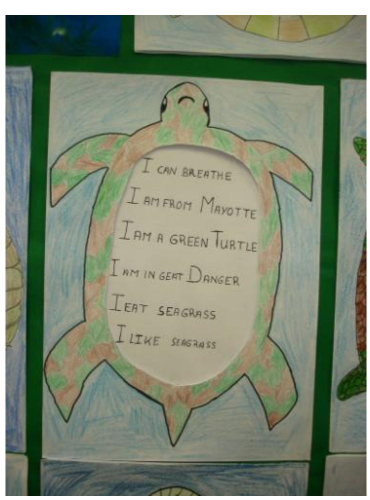
Use the Sandwatcher Newsletter as a teaching tool

In the Sandwatcher Newsletter (December, 2006), there was an article on the reactions of people in Sri Lanka to the Indian Ocean tsunami of December 2004. The article was used a reading and comprehension exercise and different activities included:

- Answering questions on the text;
- Matching beginnings of sentences to the correct ends of sentences;
- Identifying right and wrong sentences;
- Underlining key words and asking questions;
- Writing exercises using topics such as: Where were you on the day of the tsunami? What happened to the sea?

Use beach flora and fauna to practise writing skills

Young students beginning English fold a sheet of paper in two, draw a beach animal on one side, cut out around the animal and on the inside of the paper write some sentences introducing the animal using the present tense. For example in Mayotte, students drew green turtles and after three months tuition in English were able to write simple sentences, e.g.
My name is the Green turtle. I am from Mayotte. I swim in the Indian Ocean, I travel a lot.
I am in great danger from poachers.



Students work from Mayotte

Communities and Sandwatch

School students involve their communities in Sandwatch activities by sharing their findings and implementing projects, but a community can also start a Sandwatch project. For instance in St. Vincent and the Grenadines, mining gravel from the beach at one coastal community provides an economic activity for a women's group but also causes serious beach erosion problems. The Sandwatch group there worked with the women to monitor beach changes and extraction volumes with a view to determining safe and sustainable levels of gravel removal.

Communities wishing to get involved in Sandwatch often start from a particular issue or problem, perhaps water quality or beach erosion. They then elect to monitor beach characteristics relevant to that particular problem, e.g. a community group in the Maldives were concerned about erosion so they decided to monitor beach width and wave and current action as well as the quantities of sand mined by a group from a nearby beach. This is slightly different from the normal school approach, which starts with the monitoring and then identifies issues. Sandwatch is flexible enough to accommodate both approaches.

A community group in the Maldives discusses erosion resulting from sand mining.

Sandwatch equipment

Sandwatch equipment including (from left going clockwise) tape measure, water quality kit, clipboard, hand lens, dye tablets, compass, stopwatch.

It is possible to get started and measure some beach characteristics without any special equipment. So obtaining equipment need not be an obstacle to beginning Sandwatch. Annex 1 lists the basic equipment required for each activity described in this manual, where the equipment can be obtained and approximate cost. In some cases simple household materials can be substituted, see Annex 1. The only activity for which specialised equipment is a necessity is water quality measurement, for which simple kits are available for purchase.

Students and teachers observing and recording at Reduit, Saint Lucia.

Chapter 4 Observing and recording

Background

The first and most important Sandwatch activity is to develop a general picture of the beach and gather as much information as possible based on simple observations. No special equipment is needed for this activity.

ACTIVITY 4.1→Observe the beach and make a map

Observe and record→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 make 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 accesses to the beach, litter bins, signs, lifeguard towers, jetties etc.;
- sea conditions, e.g. is the sea calm or rough; and
- 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, e.g. two palm trees and one sea grape tree.

Draw a map of the beach→ 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 in Figure 2. You may wish to prepare a simple map outline on which students can record their observations, or even a copy of a topographic map, see Figure 3. The advantage of such a topographic map is that it is accurate, so the scale can be used to determine distances. Such maps can be enlarged using a copying machine (although remember to also enlarge the graphical scale).

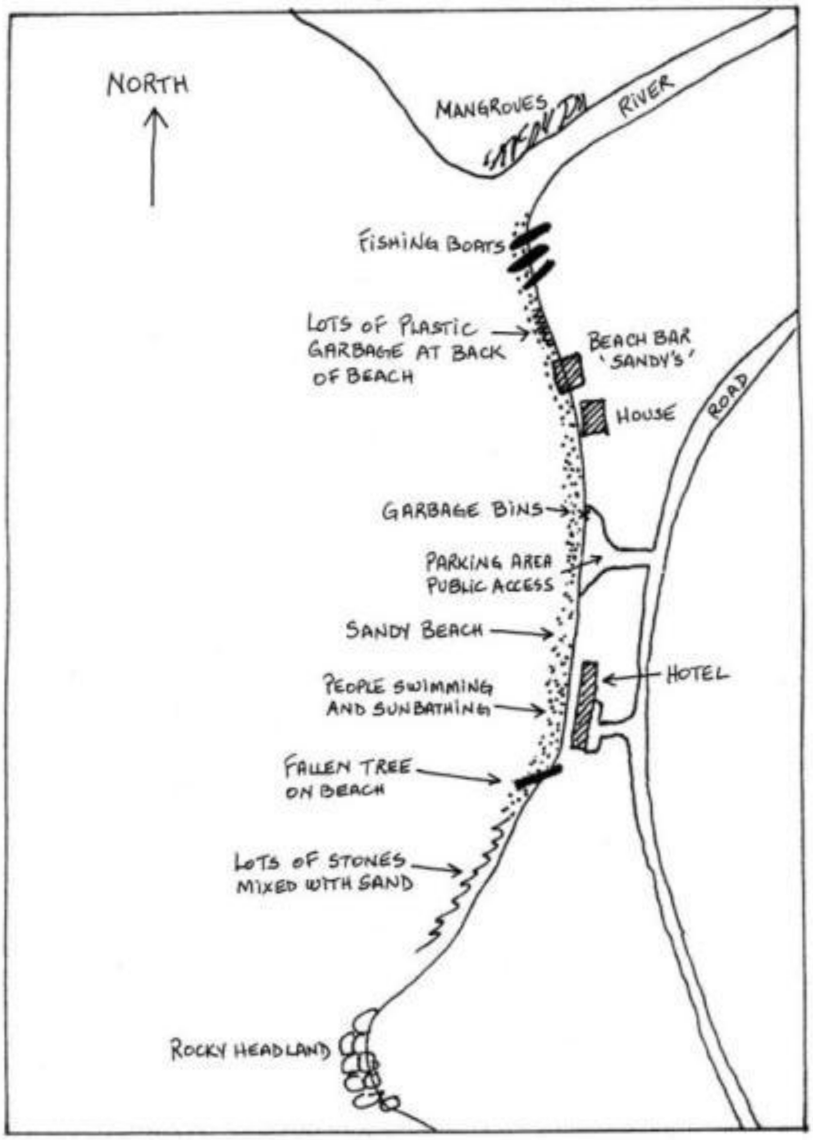
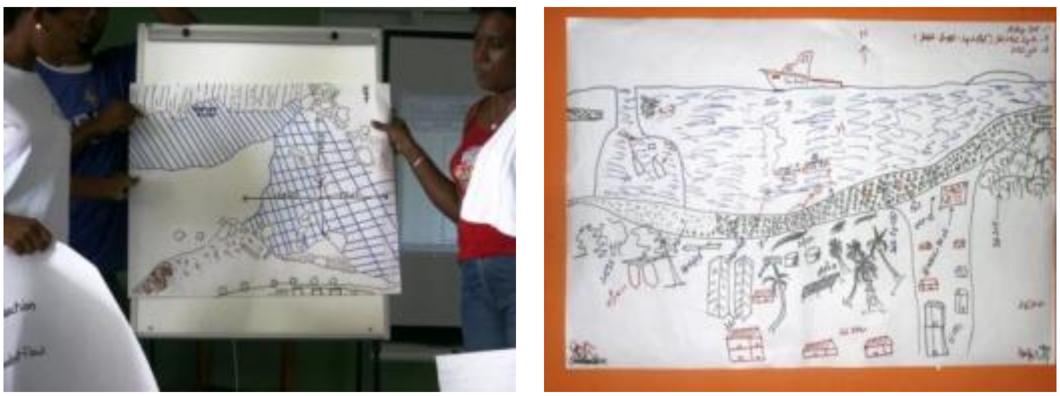


Figure 2 Sample sketch map

Figure 3 Sample topographic map

Discuss the map→ Discuss the map with the class. The map can become the starting point for (a) deciding which characteristics to monitor and where to measure them, and (b) problems facing the beach.



Examples of two sketch maps, on the left, a river section in Dominica, and on the right on the left a beach in the Maldives.

ACTIVITY 4.2→Look and listen, create a photo mural and sound map

Create a photo mural of the good and bad aspects of the beach→Using disposable or digital cameras, ask the students to take ten pictures of things they like about the beach and ten pictures of things they dislike. Print the pictures and use them to create a photo mural.

Discuss the findings→Discuss how the good aspects can be enhanced and whether anything can be done about the bad aspects of the beach. This becomes a starting point for deciding which characteristics to monitor and determining particular issues that might be addressed in projects. The displays are always useful for sharing with other groups and community members.

A photo mural from St. Vincent and the Grenadines shows some of the outstanding issues as well as Sandwatch activities.

Create a sound map→Position students in different areas of the beach and ask the students to close their eyes for a period of two minutes while they listen, distinguish and record the different sounds they hear. For example:

- Sound of water moving, waves breaking, wind noise;
- Sound of children's shouts, music playing;
- Sound of cars and traffic;
- No sound at all.

This activity can be repeated at different times of the day. The results can be added to the sketch map of the beach.

Discuss the findings→Issues to discuss include:

- where are the quiet places and the noisy places on the beach;
- where can a visitor just hear natural sounds;
- is the beach a quiet and peaceful place, or is it a noisy, vibrant place; and
- should certain activities be restricted to specific places on the beach.

ACTIVITY 4.3→How the beach used to look

Having drawn your sketch map of how the beach looks now, it is often useful to research information on how the beach used to look in the past.

Examine the topographic map of your beach→Topographic maps may be available in your local library, or at a bookseller, or government department responsible for lands and surveys. Look at the key to the map to find out when it was made. Compare the map with your present day sketch map and note any changes (see Figure 4A).

Look at the aerial photographs of your beach→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 looking down at the beach from a height. 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 (see Figure 4B).

Figure 4 Different perspectives of Crane Beach, Barbados. (A – topographic map from 1970s, B – aerial photograph from 1970s, C – aerial photograph from Google Earth from 2006, and D – ordinary photograph from 1970s).

Look at aerial photographs of your beach with Internet sites→Sites such as 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 and these give you another perspective of the beach (see Figure 4C).

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Examine ordinary photographs of the beach and talk to local people who knew the beach from years back→Ordinary photographs also show how the beach used to be in the past. Sometimes postcards also show views of particular beaches (see Figure 4D). Another useful source of information is to talk to people who have lived by the particular beach for many years or have visited it regularly over a period of time.

Discuss how the beach used to be in the past and might be in the future→Items to discuss with the class might include:

- how has the beach changed?
- are the changes good or bad?
- do you prefer the beach as it was in the past or as it is now?
- how do you think the beach will look in ten years time?

ACTIVITY 4.4→How will the beach look as climate changes

Using the projected climate changes in Table 1, Chapter 2, discuss how climate change might impact your beach and how it will look in 10 and 20 years time. Items to consider are:

- size of the beach: will it be larger or smaller?
- trees and vegetation behind the beach: will they still exist?
- animals: will the crabs, birds, fish and coral reefs still be as plentiful and healthy as they are now?
- buildings behind the beach: will they be in the same condition and will there be more buildings?

Ask the students to draw the beach as it is now and as it might be in 20 years time, taking into account the possible impacts of climate change.

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.

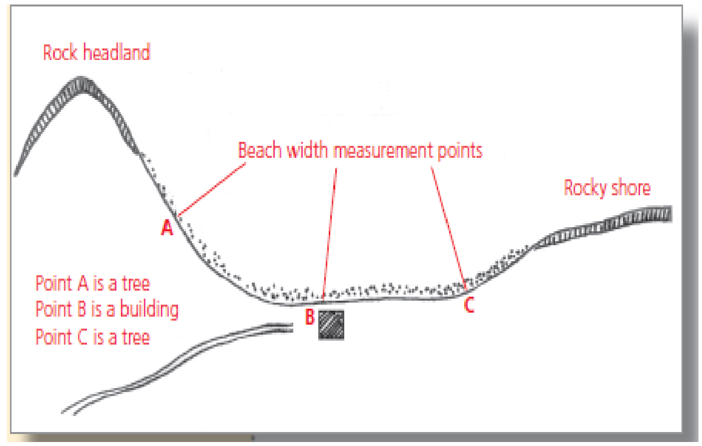


Figure 5 *(Left) Determining the high water mark, Savannah Bay, Anguilla. (The arrow shows the position of the high water mark on that date.)*
Figure 6 *(Right) Plan view of a sample beach showing suggested points for measuring beach width.*

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 end. 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).

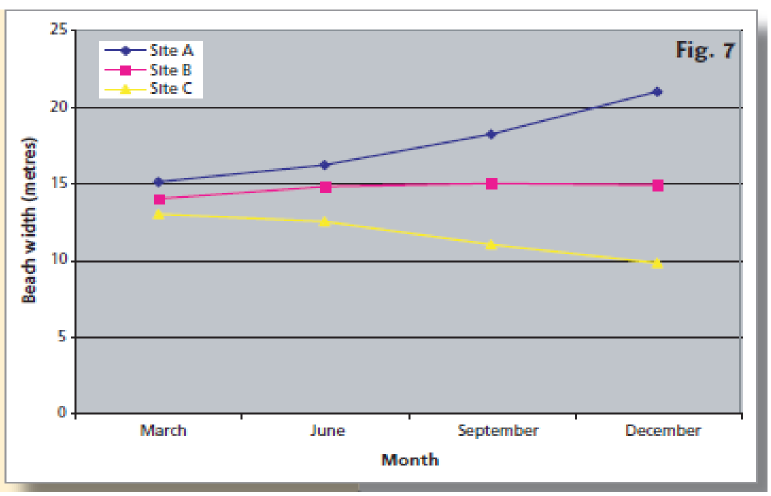


***Figure 7** Line graph showing erosion and accretion changes over time*

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.

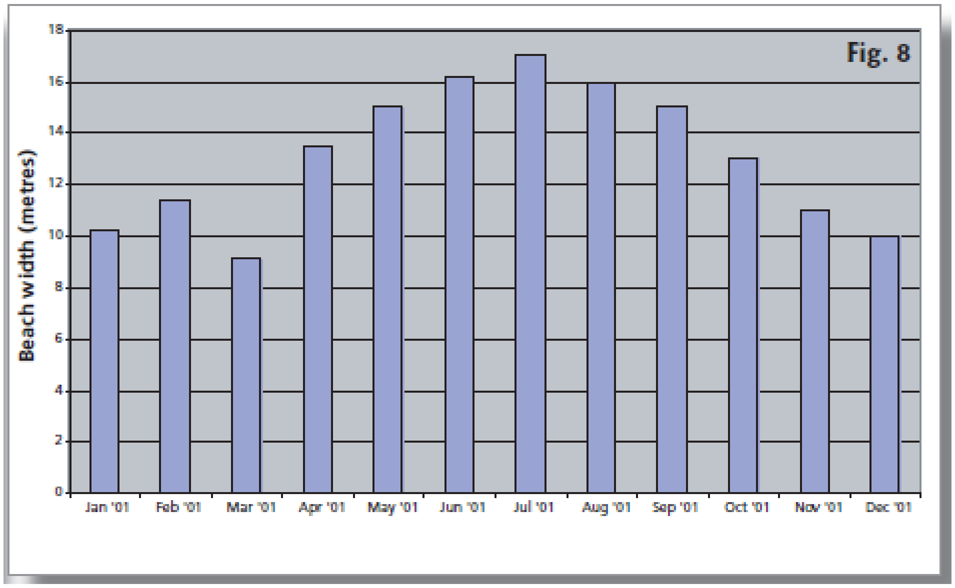


Figure 8 *Bar graph showing beach width changes over time*

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.

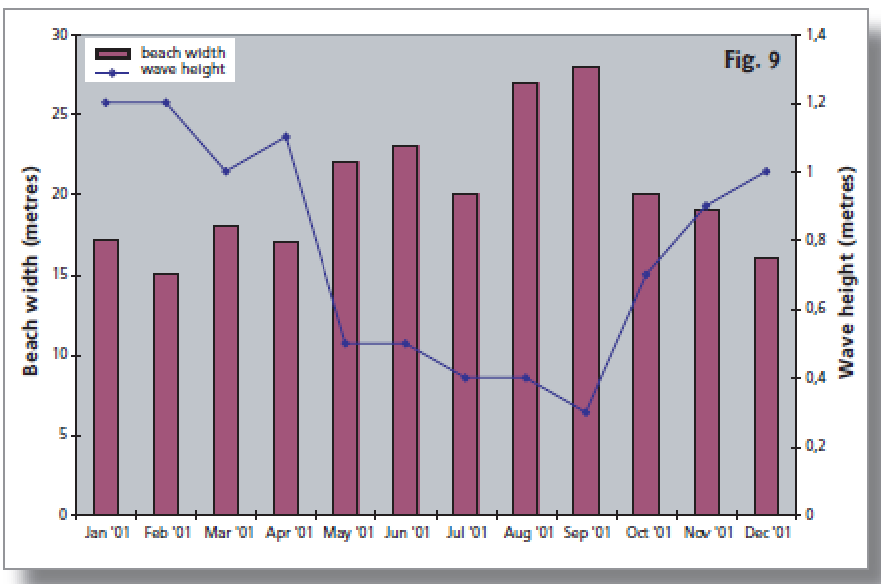


Figure 9 *Mixed graph showing changes in beach width and wave height*

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).

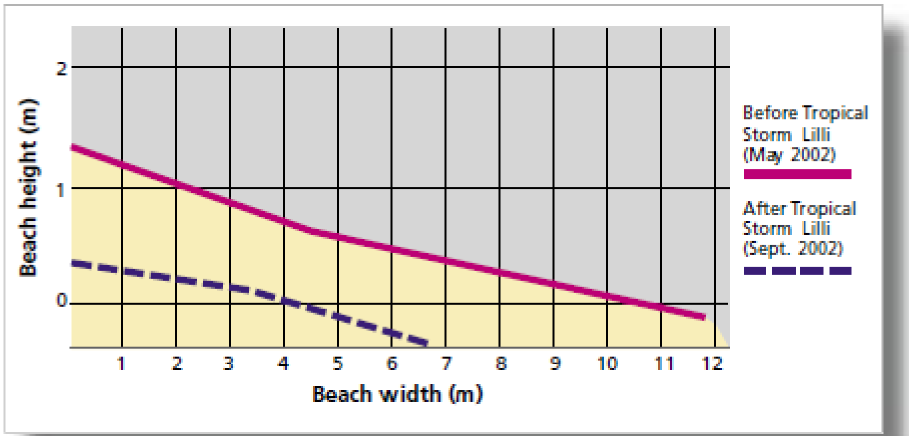


***Figure 10** Changes in a beach profile before and after Tropical Storm Lilli (2002), Port Elizabeth, Bequia, St Vincent and the Grenadines.*


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.

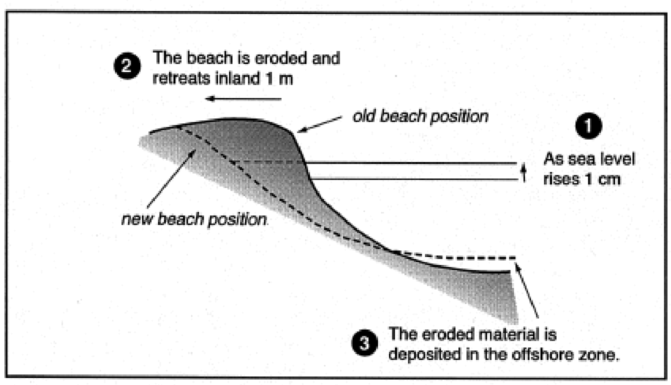
Beach erosion and sea level rise

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.

Bruun Rule



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 m/yr x 10 years x 100 = 5.9 m
- Repeat the calculation for the next 20 years and next 30 years:
  0.0059 m/yr x 20 years x 100 = 11.8 m
  0.0059 m/yr x 30 years x 100 = 17.7 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?

Powder white sand at Vlingilli, Maldives

Different sizes of material on a beach in Rarotonga, Cook Islands.

Chapter 6 Beach composition

Background

A beach consists of loose material of varying sizes. The actual material itself can tell a lot about the stability of the beach.

Ocean acidification

As the effects of climate change become apparent, one of the emerging concerns is the impact of ocean acidification. Atmospheric carbon dioxide dissolves naturally in the ocean forming carbonic acid, a weak acid. The pH of the oceans has decreased 0.1 unit compared to pre-industrial levels and the continued increases in atmospheric carbon dioxide are expected to significantly alter ocean pH levels, making them more acidic. The increased acidity will reduce carbonate, which is needed to build the calcareous shells and skeletons of many shellfish and coral reefs, and even some single celled plankton. Besides impacting marine ecosystems this will have significant impacts on beaches, since in many parts of the world beach sand consists of pieces of coral and shell fragments. In this way, coral reefs provide not only important protection for beaches and coasts but also serve as a source of sand.

ACTIVITY 6.1 Finding out where beach material comes from

Observe and record→Observe, describe and record the type of beach material. A beach may be composed of just one type of material, e.g. sand, or there may be a mixture of materials, e.g. sand, gravel and boulders. Beach material can be classified into different sizes (see the table below). Sand is just one size range.

Note and record the colour, size and texture of the material on the beach. A simple ruler or tape measure can be used to distinguish between the larger sizes, although obviously not for clay and silt. Use plastic bags to collect samples of material from different parts of the beach and label the location, e.g. near high water mark, beneath cliff face and so on.

SEDIMENT SIZES

Clay	Less than 0.004 mm	Less than 0.00015 inches
Silt	0.004–0.08 mm	0.00015–0.003 inches
Sand	0.08–4.6 mm	0.003–0.18 inches
Gravel	4.6–77 mm	0.18–3 inches
Cobbles	77–256 mm	3–10 inches
Boulders	Greater than 256 mm	Greater than 10 inches

WHAT IS SAND?

Sand consists of small pieces of stone or shell and can be classified into three main types:

• mineral sand, which is composed of mineral grains and/or rock fragments
• biogenic sand, which is composed of coral, red-algae, crustacean skeletons, shells
• mixtures of mineral and biogenic sands

Common components of mineral sand include the following:

• Quartz grains are clear, quartz is one of the most common minerals found in sand and is extremely weather resistant
• Feldspar grains are pink, light brown to yellow
• Magnetite grains are black and strongly magnetic
• Hornblende grains are black and prism-shaped

Common components of biogenic sand include the following:

• Coral may be identified by its many rounded holes
• Shell fragments may come from scallops, mussels, clams and be a variety of colours
• Sea urchin spines appear as small rods or tubes and may be a variety of colours

Sand samples may also include some organic material.

Discuss where the beach material originates→Back in the classroom, make a sketch map showing the different features (e.g. river mouth, rocky outcrop, cliff) on the beach and the different types of material. Discuss where the different types of material might originate.

Sand is composed of small pieces of stone or shell and its colour depends on its origin. Sand may come from inland rocks and be carried to the coast by rivers and streams. It may originate from nearby cliffs, or even far distant cliffs and be carried to a particular beach by longshore currents (see Chapter 11). Or the sand may have its source in the offshore coral reefs and seagrass beds.

Left: This yellow brown silica sand at Walkers Pond, Barbados, originates from the erosion of inland rocks; Right: This black sand at Londonderry, Dominica, is volcanic and is transported to the coast by the rivers.

The pure white sands of many tropical beaches are derived from coral reefs or coral reef limestone rocks. Yellow to brown silica sand found along some coasts comes from the erosion of inland rocks, while the black sand beaches of many volcanic islands consist of grains of olivine and magnetite, derived from the erosion of volcanic rocks.

Ask students to write a story about the life of a grain of sand, starting perhaps in an inland mountain and travelling to the beach by a stream, or originating on a coral reef and being moved by waves and currents to a beach. Ask them to imagine the sand grain's life on a beach and what happens when a storm strikes or a sand miner moves them. As climate change makes the oceans more acidic the biogenic sand grains may dissolve in seawater and disappear, leaving behind their mineral counterparts. A 'letter from a grain of sand' in the accompanying box provides some further ideas.

ACTIVITY 6.2 Exploring ocean acidification

Observe and record→Place some specimens of rock, sea shells, powdered chalk and beach sand in separate glass jars. Cover each specimen with vinegar and let the samples sit for an hour or so, or even overnight. Bubbles will form on the specimens containing calcium carbonate. The vinegar, which contains acetic acid, reacts with the calcium carbonate to produce calcium acetate and carbon dioxide (the bubbles).

Alternatively place an egg in a jar and cover the egg with vinegar. Wait a few minutes and look at the jar. You should see bubbles forming on the egg. Leave the egg in the vinegar for a full 24 hours in the refrigerator. After the 24 hours, carefully pour the old vinegar down the drain and cover the egg with fresh vinegar. Place the glass with the vinegar and egg back in the refrigerator for a full week. One week later pour off the vinegar and very carefully rinse the egg with water. The egg looks translucent because the outside shell is gone. The egg shell is made of calcium carbonate and is dissolved by the acetic acid in the vinegar.

LETTER FROM A GRAIN OF SAND

Hello friends!

Ernesto Ardisana Santa presenting "Letter from a Grain of Sand" at a workshop in Cuba

I am a tiny grain of sand, bathed by the sea spray, created by the waves of the Caribbean Sea. I live in a marvellous place where, every morning at sunrise, I listen to the tremulous murmur of flying fish shooting out of the transparent sea water. Many birds inhabit this place, particularly the small, delicate and dark sea swallows which fl y constantly in search of food.

The sea is sweet and beautiful, but it can also be cruel and can become angry all of a sudden. Perhaps you may be surprised at my referring to the sea in Spanish as if it were feminine. This is the way we, those that love her, refer to the sea. I consider her as belonging to the feminine gender and as someone who concedes or denies big favours, and if she does perverse deeds, it is because she cannot help it.

My Mom and Dad are also sand grains, already hundreds of thousands of years old, since in this beach toxic substances that could have degraded us have never been used. Those persons who visit us are sorry to tread on us, which explains their walking warily and their not leaving food leftovers behind. We are always tended by children and the young of the local beach community, who remove the plant litter that comes out of the sea.

Through this letter I wish to express my solidarity with all the suffering grains and tiny grains of sand in this world, and especially so those of the coasts of Galicia in Spain who are bearing the effects of an oil spill.

I wish to invite you all to my unpolluted world. You can fi nd me at the following e-mail address: letstakecare@everybody.world. I will receive you with pleasure. I now say goodbye with a great marine salutation, since it is the time to go to listen to the classes given by the snail on how to recycle the trash left daily on the coasts by humans, in order that this, my small paradise, may remain clean and pure and that I may be proud to live in my blue planet, helping to make it liveable for others too.

I am looking forward to your messages. I will give you my address later, because it is difficult, very difficult to understand, since unfortunately you must find your way through the paths of dreams.

With best wishes
The happy tiny grain of sand

Source: Instituto Pre Universitario Vocacional De Ciencias Exactas,
Comandante Ernesto Che Guevara, 2004

Discuss how ocean acidification works→Carbonic acid in the oceans works in the same way as the acetic acid in the vinegar, it dissolves the calcium carbonate. Ask the students to:

- list all the animals on the beach that have shells or skeletons made of calcium carbonate and ask them what will happen to those animals as the ocean acidifies;
- discuss how acidification affect the food chain and the world's fisheries;
- think about how will acidification affect the beach and coral reef.

Discuss what can be done:

- reducing carbon dioxide emissions;
- improving the health of coral reefs, e.g. by reducing pollution, preventing over-fishing, creating marine protected areas;
- making everyone, from fishermen to politicians more aware about ocean acidification.

ACTIVITY 6.3 Exploring what happens when sand and stones are removed for construction

Observe and record→Visit a beach that has been heavily mined for construction material as well as a beach that has not been mined. Observe and record the differences between the two beaches and relate them to the mining activity. Features to look for and discuss might include the following:

- how is the material being extracted – with heavy equipment or by people using spades;
- vehicle tracks all over the beach;
- deep holes where material has been extracted;
- whether the water reach further inland;
- trees that have been undermined or vegetation that has been trampled as a result of the mining activity;
- impact on turtle nesting and the ability of the hatchlings to reach the sea;
- the beauty and ambience of the beach;
- alternative sources of construction material besides the beach.

Mined beach at Brighton, St Vincent and the Grenadines.

Discuss how the beach material is used in construction→Ask the students to think about the construction materials used for houses and buildings in their country. Topics to discuss might include:

- materials and methods used to build houses in the past;
- advantages and disadvantages of concrete houses and wooden houses;
- materials needed to make concrete.

ACTIVITY 6.4→Measuring beach sand – size, shape and sorting

THREE 'S'S' OF SAND: SIZE, SHAPE AND SORTING

Sand size depends on the origin of the sand and the wave energy. Strong wave action, such as found on exposed coasts, washes out the finer sand particles leaving only coarse sand and a steep beach profile. Often stones and boulders may be present on such beaches. However, on more sheltered coasts, finer sand is deposited and a gently sloping beach results. Near mangroves and river mouths, silt and organic material also collects.

Sorting relates to the mixture of sizes, e.g. if all the sand grains are the same size, then the sample is well sorted. If there are a lot of different size grains in the sample, then it is poorly
sorted. As sand is moved about by the waves, it tends to get better sorted, in other words all the sand grains are about the same size.

The ***shape*** of the sand grains relates to whether the individual grains are angular and pointed or whether they are smooth and rounded. As the sand grains are moved about by the waves, they tend to become rounded with very few sharp points.

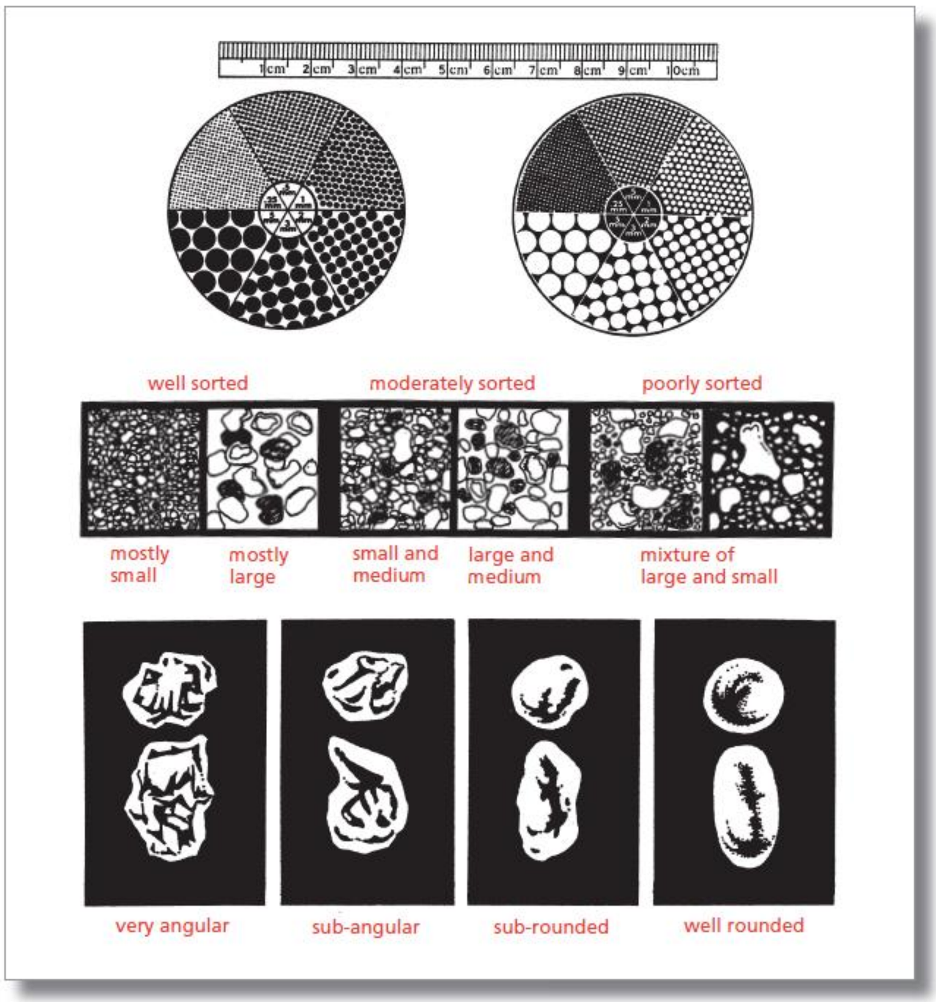
What to measure→Sand samples can be collected from different parts of the beach and the size, sorting and shape of the sand grains can be measured. These characteristics are likely to vary from one part of the beach to another.

How to measure→During a visit to the beach, sand samples can be collected from different areas, e.g. from a river mouth, from the inter-tidal zone where the sea is wetting the sand, from the dry sand at the back of the beach, from a dune behind the beach, or from beneath an eroding rock face or cliff.

Place the sand samples in clean plastic bags, label each bag and keep notes on exactly where the sample was collected.

On return to the classroom, the samples should be spread out on a flat surface to dry (if they are wet). Then sprinkle some dry grains on to a clear plastic sheet. Place the plastic sheet with the sand grains on top of the size charts in Figure 11. If the sand grains are light coloured use the left hand chart, while if the grains are dark coloured use the right hand chart. With a magnifying glass, determine the size category matching most of the grains and record the results. Then compare the sand grains on the plastic sheet with the sorting chart, and with the magnifying glass determine the best-fit sorting category. Finally, compare the sand grains in the sample with the angularity charts to determine the shape.

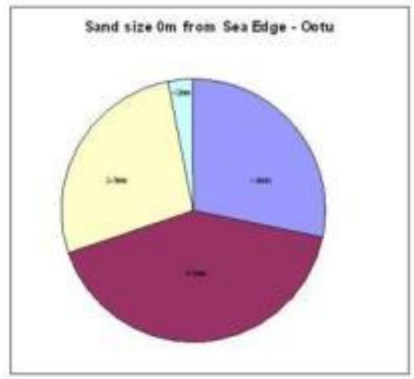
Figure 11
Sediment analysis charts for size, sorting and shape (adapted from Kandiko and Schwartz, 1987; and Powers, 1953).



Sieve the sand samples→ Alternatively sand size can be measured more accurately using a nest of sieves. These consist of trays with different size meshes. The mesh with the largest size holes in placed at the top of the sieve tower, and trays with smaller mesh sizes are placed below. The nest of sieves is shaken for a period of 20 minutes using a mechanical sieve shaker. However, this equipment is fairly expensive and often only available at specialised institutions and universities. Sandwatch teams in the Cook Islands have devised their own version of a nest of sieves:

Collect 4 clean plastic 500 gm ice-cream (or similar) containers:

- in the bottom of one container make a lot of 4 mm size holes;
- in the bottom of a second container make a series of 3 mm holes;
- in the bottom of a third container make a series of 2 mm holes;
- fill the fourth container with a sample of dry beach sand and weigh the container and sand;
- transfer the sand to the container with 4 mm holes;
- shake the container so that the smaller sand particles fall through the holes onto a sheet of paper;
- weigh the container with the sand that remains and record it as >4 mm size;
- transfer the sand on the paper to the container with 3 mm holes and repeat the previous 2 steps, recording the sand in the container as 3-4 mm size;
- transfer the remaining sand on the paper to the container with 2 mm holes and repeat the process;
- prepare a graph showing the results.



Method for sieving sand developed by Cook Islands Sandwatch teams

If the beach is made up of stones only, these can also be measured. Collect at least 20 stones, picking them randomly, measure the length along the longest axis and then calculate the average. The chart in Figure 11 can be used for determining the shape of the stones.

When to measure→You may wish to collect sand samples from different parts of the beach one time only, and compare the different samples.

Alternatively you may decide to collect and measure sand samples from the inter-tidal zone, at different times of the year and after different wave events, e.g. after the summer when often the waves are relatively calm and then again after a high wave event. Some beaches show marked differences in composition, having sand in the summer and stones in the winter. Size comparisons can be made and related to the wave energy (see Chapter 10).

What the measurements show→Variations in size, sorting and angularity will provide information about the different zones on the beach and the processes that shape these zones. For instance, dunes are formed by the wind lifting dry sand grains and carrying them to the back of the beach. So, dune sand might be expected to be smaller in size than sand in the inter-tidal zone. Similarly, sand near a river mouth might be expected to have more organic material in it than the sand in the inter-tidal zone. Some sandy beaches are completely replaced by stones at different times of the year.

In the summer months (April to October), Bunkum Bay in Montserrat is a sandy beach; while in the winter months (December to March) the sand is replaced by stones.

Comparisons of sand size over time might be shown in a bar graph, such as is shown in Figure 12, which displays the data for Bunkum Bay, Montserrat.

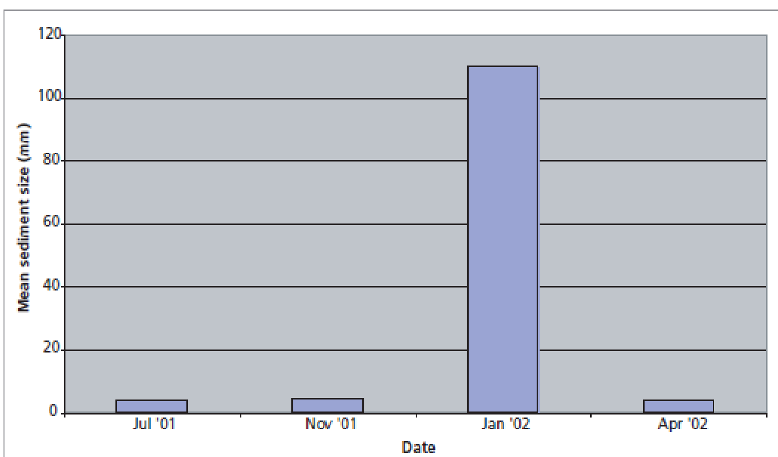


Figure 12 *Bar graph showing changes in sediment size*

Beaches are always popular places, especially at weekends and public holidays, Buje, Puerto Rico.

Chapter 7 Human activities on the beach

Background

Human activities include anything people do on the beach, from picnicking to swimming, and from mining sand to fishing. Any or all of these activities might impact the beach environment, e.g. picnickers may leave a lot of their garbage behind which might cause a bad smell and a lot of flies.

Fisherman's Day at Long Bay, Beef Island, British Virgin Islands, brings a large number of people to the beach.

Careful observation of the beach environment will likely yield a list of different activities taking place, often at different times of the day, e.g. fishers might take their boats out early in the morning, the sunbathers might not appear before noon, and the sand miners might only come at night when no one else is around.

Climate change will most likely impact many of these activities, e.g. if there is a coral reef that is popular with divers and snorkelers, then increased sea surface temperatures may impact the reef, bleaching it so that it is no longer an attractive place for them. Many people associate time on the beach as fun-time when they are outdoors and exposed to the sun, however, increased exposure to ultra violet radiation, linked to climate change impacts (although not directly caused by climate change), may cause more serious skin and eye conditions for human beings.

ACTIVITY 7.1 Observing different activities on the beach

What to measure→Observe and record the different activities taking place at the beach and the time of day, and draw up a time line of activities – a sample is shown below. The more detailed the observations, the better. Taking this activity a little further, list all the different activities and the number of people involved in those activities to try and build up a picture of the use pattern of the particular beach. The table below provides an example.

SAMPLE TIMELINE OF BEACH ACTIVITIES

6–7 am	Fishers take their boats out to sea. Early morning bathers visit the beach to bathe and swim.
7–10 am	Walkers, people with dogs.
10 am–3 pm	Sunbathers, picnickers use the beach, people bathing in the sea, children playing, people walking. Fishing boats return around 3 pm, catch is unloaded into pick-up trucks and taken into town. Fishing boats left on mooring buoys, one boat is pulled up on to the beach.
3–6 pm	Other groups of picnickers arrive, one group has a barbecue. Hotel guests playing volleyball on the beach.
6–7 pm	Few people walking the beach and watching the sun go down.

	6 am	8 am	10 am	12	2 pm	4 pm	6 pm
Number of sea bathers	2	0	4	22	19	14	4
Number of sunbathers	0	0	12	18	23	15	0
Number of walkers	5	8	10	11	13	4	9
Number of picnic groups	0	0	0	5	6	8	0
Number of fishers	7	0	0	1	2	5	1
Number of children/people playing	0	0	9	27	19	44	2
Number of windsurfers	0	0	0	0	0	2	0
Number of horse-riders	0	0	0	11	0	0	0

How to measure→This is simply a case of observing, counting and categorizing. It is best to prepare a data sheet first so that the numbers can be inserted in the appropriate column. While recording the different activities, further observations can be made such as how the different groups relate to each other, e.g. people having a party and playing loud music might disturb people trying to relax and sleep; horse and dog droppings left on the beach are not pleasant for other users; and overflowing garbage bins are unsightly and unhealthy.

Fishers may use the beach to launch and beach their boats early in the morning or late in the evening, Britannia Bay, Mustique, St Vincent and the Grenadines.

Sharing family moments as seen here at Male, in the Maldives, is another way people use the beach

When to measure→This will depend on the depth of the investigation; however, it is always important to realize that user patterns vary according to the time of day, and whether it is a weekday, weekend or public holiday.

What will the measurements show→The measurements will show how many people use the beach on a particular day and the numbers involved in different activities.

Divide the activities into two lists:

- List A: activities that might harm the beach;
- List B: activities that do not harm the beach or may be good for the beach.

Have a classroom discussion about how some activities are good for the beach and do not harm it in anyway; and what can be done to stop or lessen the harmful activities.

You might also wish to compare use on a public holiday and use during a weekday, or alternatively do the same measurements on two different beaches and compare them.

ACTIVITY 7.2 Finding out the views of beach users

What to measure→ Finding out what people think about their beach or a particular beach-related problem can be done by a questionnaire survey. The first step is to define your objective – what do you want to know? Try to be as specific as possible, e.g. do beach users think the beach is too crowded, or do they think the beach is clean.

Tourists are another important group of beach users, as seen here at Pinney's Beach, Nevis.

How to measure→Design your questionnaire and decide how many people you plan to survey (sample size). When deciding on sample size, also consider:

- selection – there are two main choices here: (1) select people at random, e.g. every fourth person who arrives at the beach, or (2) select persons of a certain age or gender to survey, e.g. adults only or children/youth under 18-years only;
- Introductions – consider your approach and the way you introduce yourself to interviewees.

Putting students in pairs for this activity allows one student to speak and one to record the answers. In designing the questions, go back to your objective and prepare questions that will provide information relating to your objective. A sample is provided below.

SAMPLE QUESTIONNAIRE

Objective: To find out why people use a particular beach

1.	Is the bay safe for swimming?	Yes	No	Sometimes
2.	Is the water clean?	Yes	No	Sometimes
3.	Is the beach clean?	Yes	No	Sometimes
4.	Is there good access to the beach?	Yes	No	
5.	Are the parking facilities adequate?	Yes	No	Sometimes
6.	Are the bathroom facilities well maintained?	Yes	No	Sometimes
7.	Is the beach crowded?	Yes	No	Sometimes
8.	Is there sufficient shade on the beach?	Yes	No	Sometimes

9. How would you like to improve the beach?

Note that in this sample questionnaire, questions 1–8 are very simple and direct and can be answered with a 'yes,' 'no' or 'sometimes' response. Question 9 has been inserted as an 'open-ended' question and it is expected that respondents will provide various suggestions which can be written down.

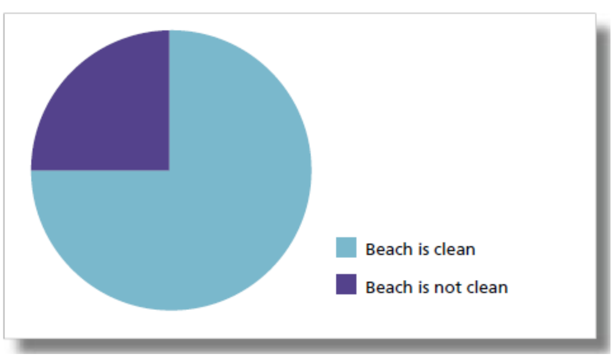
What will the measurements show→ After the results of the survey are tabulated, you should be able to answer the question underlying your objective.

For example, tabulating the results of the questionnaire above might show the following:

Number of people sampled = 20

Question	Yes	No	Sometimes
Bay is safe for swimming	19	0	1
Water is clean	18	1	1
Beach is clean	15	5	0
Good access	20	0	0
Adequate parking facilities	18	0	2
Bathroom facilities well maintained	9	7	4
Beach is crowded	13	3	4
There is adequate shade	10	7	3
Improvements required: More bathrooms Fewer people Less noise Plant more shade trees			

Thus, in this case the results showed quite clearly that people used this beach because they thought the water was safe and clean, that the beach itself was clean, and that there was good access and parking facilities. However, there was a need to keep the bathrooms cleaner and to provide more shade, and some people felt the beach was too crowded. Finally there were requests for improvements to the beach.



Graphs can be prepared to illustrate the answers to the different questions (see example in Figure 13 left).

Figure 13 Pie graph showing users' views on beach cleanliness.

Activity 7.3 Finding out how climate change will affect beach users

What to measure→Brainstorm with the students how they think climate change will affect their beach. Some suggestions include:

- beach will erode and get smaller as a result of rising sea levels;
- rising temperatures will cause coral bleaching and the corals may die;
- high waves from increased storms and cyclones will undermine the trees and as a result they will fall down and die providing less shade for the beach;
- a more acidic ocean will result in fewer shells and marine animals;
- there will be no space or vegetation for the sea turtles to nest;
- rising air temperatures will make the beach too hot to visit.

This list contains mainly negative changes likely to affect tropical beaches, but in some parts of the world there may be positive changes, e.g. in temperate climates, the warmer temperatures may make the beach a more attractive environment for visitors and residents.

Categorise the users of the beach:

- are users residents or tourists or both?
- what type of groups use the beach: families, couples, party-goers, fishermen?
- are the beach users ecologically conscious or not?

How to measure→Design a questionnaire to find out how the beach users at your beach will respond to one or two of the most relevant climate change impacts. An example is given below. Your questions will depend on the particular climate change impacts that are most important at your beach and the type of beach users.

Sample Questionnaire

The most significant climate change impact at the sample beach is beach erosion.

1. Are you a resident or a tourist?

2. (If you are a tourist) is this your first time to this island (country)? Yes No

3. Climate change is going to erode this beach and it will get smaller:

- would you still come to this beach if it were 50% smaller?	Yes	No
- would you look for a different beach?	Yes	No
- would you select a different holiday destination?	Yes	No
- would you stop going to the beach altogether?	Yes	No

4. If there were no trees at this beach:

- would you still come to this beach?	Yes	No
- would you look for a different beach with shade?	Yes	No

5. When you visit this beach do you go:

swimming	Yes	No
snorkelling	Yes	No
diving	Yes	No

walking Yes No
other (please specify)

6. Where do you live?

7. Is climate change a big issue in your country?

What will the measurements show→Tabulate the results of your survey using a similar method as for Activity 7.2. Discuss the responses with the students and ask them whether they expected these results. You might like to share the results of your survey with a government environmental department or a tourism agency since this might sensitise officials as to how beach users value the beach resources under threat from climate change.

Many beach users like to shelter from the hot sun under the shade of a tree, climate change may result in fewer trees (Johhny Cay, San Andres, Colombia).

Garbage dumped near a beach in Puerto Rico
looks unsightly and is eventually washed into the sea where it impacts marine life.

Chapter 8 Beach debris

Background

Beach debris includes garbage left behind by beach users, as well as materials – both natural and man-made – washed onto the beach by the waves or transported by rivers. Such materials may include tree trunks or branches; seaweed and seagrass; tarballs, which are large or small pieces of tar (solidified oil) and are usually soft to touch; pieces of boats; plastic oil containers etc. The presence of litter such as plastic bottles, snack wrappers and sewage-related debris on beaches and in the water is unattractive, has health and economic impacts on beach users and local communities, and is potentially harmful to marine wildlife through entanglement and ingestion.

Bobbins of thread washed up from a container onto the beach of Anegada, British Virgin Islands. When unravelled the thread made thick underwater mats endangering marine life.

A Sandwatch group in Hope Town, Bahamas, found a large fishing net smothering a nearshore patch reef. With the help of some volunteers they swam out to the reef, carefully cut it away from the reef and swam back to the beach with the net.

Beach debris and climate change

One of the best ways to help beaches cope with the adverse impacts of climate change, such as sea level rise, ocean acidification and an increase in storms and cyclones, is to maintain beaches, and associated systems (rivers, dunes, wetlands, coral reefs, seagrass beds), in a clean state so that the entire ecosystem – the plants, animals and their habitat – remain healthy. This is sometimes referred to as building resilience. So activities such as keeping the beach, and dunes and nearshore waters clean, and making everybody aware of the need for a clean environment are especially important.

Activity 8.1 Measuring beach debris

What and how to measure→Select a point behind the beach and mark off a straight line across the beach towards the sea; this is called a transect line. Collect all the debris found 2 m (2 yds) on each side of this line. Sort the debris into different groups using the categories listed in Figure 14. This figure shows the Beach cleanup data card used by the Ocean Conservancy in their International Beach Clean-ups. Record, count and weigh all the debris found within 2 m (2 yds) either side of the transect line. If you do not have a set of weighing scales available, then count the number of items.

You may also wish to add tarballs to the list of items since these are often numerous on exposed ocean beaches. Tarballs can be recorded in the same way as other debris items, and if these are of particular interest, or they represent a special problem at the beach, they can be counted and the diameter along the longest axis measured.

Record the location of the transect so as to be able to return to the same point at a future date and repeat the measurement. Several transects may be set up on one beach.

It is important to take adequate safety precautions when conducting marine debris surveys. Gloves should be used, and students should be cautioned not to touch anything they may be suspicious about, e.g. any container marked with poison, or syringes.

Once the debris has been recorded, be sure to dispose of it in a proper garbage receptacle.

INTERNATIONAL COASTAL CLEANUP DATA CARD

Ocean Conservancy
Start a Sea Change

Thank you for participating in Ocean Conservancy's International Coastal Cleanup (ICC). The commitment you have made today is the first step to ensuring we can enjoy a cleaner ocean all year-round. The data you collect during the Cleanup is invaluable to Ocean Conservancy's effort to start a sea change every day; helping us educate public, business, and government officials about the scale and serious consequences of the global marine debris problem. Thank you. We could not do it without your help!

1. CLEANUP SITE INFORMATION

Category of Cleanup (choose one): ☐ Coastal ☐ Inland Waterway (River/Stream/Tributary/Lake)
Type of Cleanup (choose one): ☐ Beach/Shoreline ☐ Underwater ☐ Watercraft (powerboat, sailboat, kayak or canoe)
Location of Cleanup: State ____________ Country ____________
Province ____________ Zone or County Cleaned ____________
Cleanup Site Name (beach, park, etc.) ____________
Today's Date: Month ______ Day ______ Year ______ Name of Coordinator ____________
Number of People Working on This Card ______ Distance Cleaned ______ miles or ______ km
Number of Trash Bags Filled ______ Total Estimated Weight Collected ______ lbs. or ______ kgs.
Estimated Time Spent on Cleanup ____________

2. CONTACT INFORMATION (EACH INDIVIDUAL TEAM MEMBER)

1. Name ____________ 3. Name ____________
Email Address ____________ Email Address ____________
2. Name ____________ 4. Name ____________
Email Address ____________ Email Address ____________

3. ENTANGLED ANIMALS

List all entangled animals found during the Cleanup. Record the type of debris they were entangled in, for example: fishing line, fishing nets, balloon string/ribbon, crab/lobster/fish traps, plastic bags, rope, six-pack rings, wire and other items (please specify).

Animal	Alive/Released or Dead	Entanglement Debris

4. WHAT WAS THE MOST PECULIAR ITEM YOU COLLECTED? ____________

The following national and international organizations endorse and/or support the International Coastal Cleanup
- NOAA-Marine Debris Program
- U.S. Environmental Protection Agency
- UNEP – United Nations Environment Programme
- IUCN-The World Conservation Union
- Intergovernmental Oceanographic Commission (IOC) of the United Nations' Educational, Scientific, and Cultural Organization (UNESCO)

Please return this card to your area coordinator or mail it to:
Ocean Conservancy
1300 19th Street, NW
8th Floor
Washington, DC 20036
www.oceanconservancy.org

Ocean Conservancy's International Coastal Cleanup

***Figure** 14 Beach Clean-up Data Card (See Annex 3 to reproduce for classroom purposes)*

When to measure→The surveys can be done just once, or they can be repeated and done at different beaches to provide comparative data. They can also be combined with beach cleanups – see the next activity (8.2).

What will the measurements show→The measurements will show first of all the total amounts and different types of debris at a particular beach, and if repeated at different times of the year, they will show variations over time.

Discuss the possible origins of the materials collected. Divide the materials into three groups:

- group 1: debris that came from the sea, e.g. fishing floats, plastics with labels showing they were used in a different country ;
- group 2: debris that came from careless beach users or nearby communities, e.g. cigarette filters, styrofoam containers;

- group 3: debris that might have come from either group 1 or 2, e.g. pieces of rope and timber, packing material.

Discuss which group is largest and why.

Patches of oil on the beach at Long Bay, Beef Island, British Virgin Islands.

If you measure debris at different times of the year you might be able to relate the amounts of various categories of debris to weather events and to wave and weather conditions (see Chapter 10). For instance, tarballs might only appear at certain times of the year. Figure 15 shows a sample graph of some debris surveys conducted at different times of the year and the graph shows large increases in the volume of debris after a hurricane passed over the island in September.

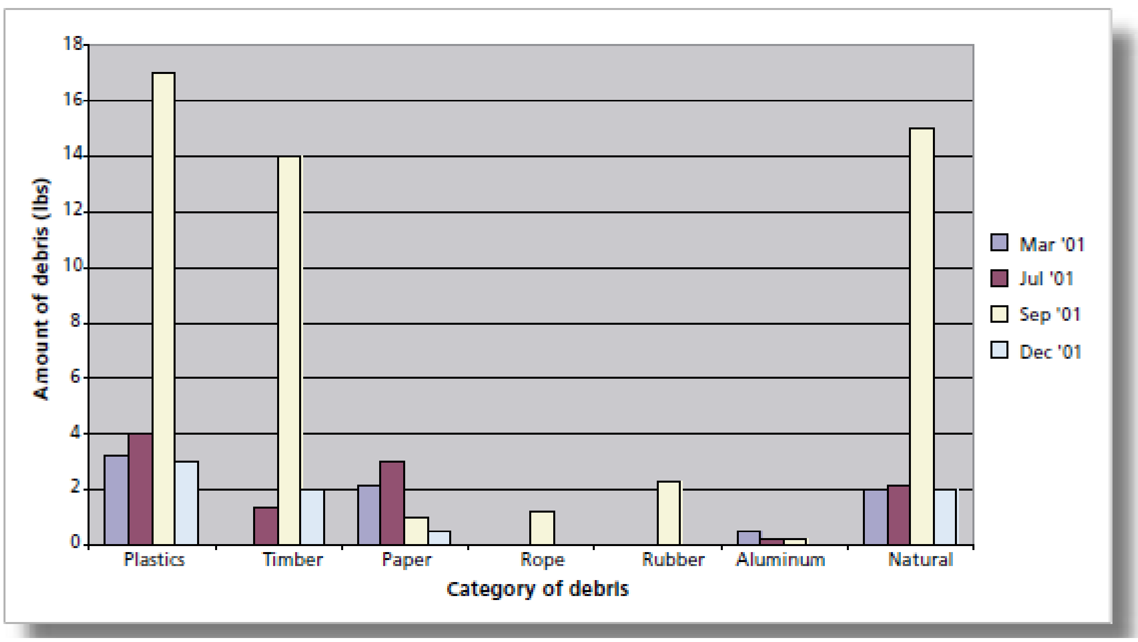


Figure 15 *Bar graph showing beach debris changes.*

You can also discuss how to inform beach users and the rest of the community about the negative impacts of littering and to encourage them to keep the beaches clean.

Large volumes of seaweed (natural debris) accumulate and cover the sand at this beach in Barbados at certain times of the year.

ACTIVITY 8.2 Conducting a beach cleanup Beach cleanups can be done at any time of the year. You might also want to consider taking part in the International Beach Cleanup organized by the Ocean Conservancy. They organize an international beach cleanups in September each year. The activity focuses on educating and empowering people to become a part of the marine debris solution and consists of data collection (see the data cards referred to in Figure 14) as well as cleaning the beach.

Debris piled up at the back of the beach at Morne Rouge, Grenada

Some points you might want to keep in mind when doing a clean-up activity are the following:

- take photos of the beach before and after the cleanup;
- combine data collection with the cleanup – see activity 8.1;
- see if the students can make something creative from the safe debris items – see photo of the 'Canny boy' prepared by the Mayotte Sandwatch group;
- try and involve students, their parents and nearby communities in the cleanup;
- encourage everyone to wear gloves and not to touch any potentially dangerous items
- provide food and drink;
- take into account the temperature at the beach; it may be best to conduct a cleanup early in the day when it is cooler;
- ensure there are sufficient garbage bags;
- make arrangements in advance for the garbage and debris to be removed to a proper waste disposal site;
- inform the press to get maximum publicity;
- make the activity fun.

Sandwatch students from Mayotte in the Indian Ocean created this life-size "Canny Boy" from debris found on the beach and won a prize in an environmental competition.

A clear, blue sea does not necessarily indicate clean water, South Friar's Bay, St Kitts.

Runoff from coastal development pollutes coastal waters

Chapter 9 Water quality

Background

The condition or quality of coastal waters is very important for health and safety reasons and also for visual impact. Disease-carrying bacteria and viruses (or pathogens) associated with human and animal wastes pose threats to humans by contaminating seafood, drinking water and swimming areas. Eating seafood and even swimming can result in hepatitis, gastrointestinal disorders, and infections. There are several sources of bacterial contamination in coastal waters, e.g. leaking septic tanks, poorly maintained sewage treatment plants, discharges from boats, and runoff from the land during heavy rains and storms.

Water quality also depends on the level of nutrients. These are dissolved organic and inorganic substances that organisms need to live. The most important nutrients of concern in coastal waters are nitrates and phosphates. In excessive quantities these can cause the rapid growth of marine plants, and result in algal blooms. Sewage discharges, and household and commercial waste that is carried to the sea by storm runoff, add excess nutrients to coastal waters. Detergents and fertilizers supply high quantities of nutrients to streams and rivers and ultimately the marine environment.

The visual quality of the water is also important; a beach environment is much more attractive when the water is clear and one can see the sea bottom. However, even clear water may sometimes be polluted. Rivers and streams often carry a heavy load of sediment (soil particles) to the sea, and in many countries, the nearshore waters may turn a brown colour after heavy rainfall.

Water quality and climate change

As climate changes water quality is also impacted. As sea surface temperatures rise, coral reefs are damaged. This phenomenon, known as coral bleaching, has been widely reported in tropical waters since the early 1980s. The high sea surface temperatures cause corals to expel their microscopic symbiotic algal cells and as a result coral colonies turn brilliant white. Corals may recover when more normal conditions return, but they may be permanently weakened with lower growth rates and reduced reproductive ability. If bleaching is prolonged, or if sea surface temperature exceeds 2°C above average seasonal maxima, many corals die. This then impacts beaches as reefs provide protection and act as a source of sand for many coralline beaches in tropical regions.

Measuring water quality at Old Point Regional Mangrove Park in San Andres, Colombia.

Coral bleaching in Tobago (photo credits www.buccooreef.org)

Higher water temperatures also reduce dissolved oxygen levels which can then affect marine life. Higher carbon dioxide concentrations in sea water result in oceans becoming more acidic, see discussion in Chapter 6.

ACTIVITY 9.1 Measuring water quality

What to measure→There are a number of simple indicators which can be used to measure water quality. These are:

- faecal coliform bacteria: naturally present in the human digestive tract, but rare or absent in unpolluted water;
- dissolved oxygen: needed by all aquatic organisms for respiration and their survival;
- biochemical oxygen demand: a measure of the quantity of dissolved oxygen used by bacteria as they break down organic wastes in the water;
- nitrate: a nutrient needed by all aquatic plants and animals to build protein;
- phosphate: also a nutrient, and needed for plant and animal growth;
- pH: a measure of the acidic or alkaline properties of the water (pH is measured on a scale of 0-14, with 0 being very acidic, 7 being neutral and 14 being very alkaline);
- temperature;
- turbidity: a measure of the amount of suspended matter and plankton in the water.

How to measure→ There are many sophisticated field and laboratory methods to measure water quality, and there are also simple kits that can be purchased which quantitatively measure the various indicators described above. One such kit referred to in Annex 1 is designed for testing salt and brackish waters for coliform bacteria, salinity, dissolved oxygen, biochemical oxygen demand, nitrate, phosphate, pH and turbidity. The kit comes with all reagents and components to test 10 water samples together with complete instructions, colour charts and safety information. Similar kits are also available for freshwater. Since the kits vary with different manufacturers, no attempt is made here to describe the step by step instructions – rather the reader is referred to the detailed instructions that come with the kit. These kits are designed for schools and citizen monitoring groups and are very easy to use.

Collecting the water sample properly is very important to ensure that correct results are obtained. Collect the sample in a sterile, wide mouthed jar or container (approximately 1 litre) that has a cap. If possible, boil the sample container and cap for several minutes to sterilize it and avoid touching the inside of the container or the cap with your hands. The container should be filled completely with your water sample and capped to prevent the loss of dissolved gases. Test each sample as soon as possible within one hour of collection. When possible, perform the dissolved oxygen and biochemical oxygen demand procedures at the monitoring site immediately after collecting the water sample.

The collection procedure is as follows:

- remove the cap of the sampling container;
- wear protective gloves and rinse the bottle 2–3 times with the seawater;
- hold the container near the bottom and plunge it (opening downward) below the water surface;
- turn the submerged container into the current or waves and away from you;
- allow the water to flow into the container for 30 seconds;
- cap the full container while it is still submerged; remove it from the sea immediately.

When to measure→The kits only have a limited supply of tests; however, there are some indicators such as temperature and turbidity which do not require specific reagents or chemicals and can be measured as many times as desired. It is important to design the monitoring programme based on the number of tests/kits available, e.g. if one kit only has enough materials for 10 phosphate tests, and two samples are measured each time, then this will allow five tests over the monitoring period. When measuring water samples, it is advisable to collect two sets of water samples and duplicate each test. This way more students can be involved and sample duplication also provides for added reliability of the results.

What will the measurements show→The measurements will show variation in the water quality indicators over a period of time. The accompanying box gives some ideas on interpreting what the indicators signify. It is not necessary to measure all the indicators described; a school group may wish to select just two or three.

Using a kit to measure the level of phosphate, Fiji.

Understanding water quality indicators

Faecal coliform bacteria themselves are not harmful; however, they occur with intestinal pathogens (bacteria or viruses) that are dangerous to human health. Hence, their presence in water serves as a reliable indicator of sewage or faecal contamination. These organisms may enter waters through a number of routes, including inadequately treated sewage, stormwater drains, septic tanks, runoff from animal grazing land, animal processing plants and from wildlife living in and around water bodies.

Dissolved oxygen is an important indicator of water quality and is measured as percentage saturation. Much of the dissolved oxygen in water comes from the atmosphere. After dissolving at the surface, oxygen is distributed throughout the water column by currents and mixing. Algae and rooted aquatic plants also deliver oxygen to water through photosynthesis. Natural and human-induced changes to the aquatic environment can affect the availability of dissolved oxygen. For instance, cold water can hold more oxygen than warm water, and high levels of bacteria from sewage pollution can cause the percentage saturation to decrease. As the climate changes and water temperatures rise, the amount of dissolved oxygen in the seawater will decrease.

Biochemical oxygen demand is an indicator of the amount of organic matter in the water. In general, the higher the biochemical oxygen demand, the worse the quality of the water. Natural sources of organic matter include dead and decaying organisms. However, human activities can greatly increase the available organic matter through pollution from sewage, fertilizers or other types of organic wastes. The decomposition of organic wastes consumes the oxygen dissolved in the water – the same oxygen that is needed by fish and shellfish.

Nitrate – excess nitrate will cause increased plant growth and algal blooms, which may then compete with the native submerged aquatic vegetation. The excess algae and plants may smother the habitat used by the aquatic fauna, and their decomposition can lead to oxygen depletion. Sources of nitrate in coastal waters include runoff containing animal wastes and fertilizers from agriculture, and the discharge of sewage or waste effluents.

Phosphate is a fundamental element in metabolic reactions. Sources and effects of excess phosphates are similar to those of nitrates. High levels may cause overgrowth of plants and increased bacterial activity and decreased dissolved oxygen levels.

pH – the pH scale ranges from 0–14, 0 is very acidic and 14 is very alkaline; freshwater usually has pH values between 6.5 and 8.2. Most organisms have adapted to life in water of a specific pH and may die if it changes even slightly. The pH level can be affected by industrial waste, agricultural runoff or drainage from unmanaged mining operations. As the climate changes, the oceans are becoming more acidic. This means the pH will decrease. The oceans are naturally alkaline with an average pH of 8.2 ±0.3, although this may vary in waters close to the beach where pH is directly impacted by freshwater from rivers flowing into the sea.

Temperature affects many physical, biological and chemical processes, e.g. the amount of oxygen that can be dissolved in water, the rate of photosynthesis of plants, metabolic rates of animals, and the sensitivity of organisms to toxic wastes, parasites and diseases. It is most often measured in degrees Celsius. Many factors affect water temperature. These include changes in air temperature, cloudiness and currents, and of course – in the longer term - climate change. Wastes discharged into water can also affect temperature if the effluent processing or treatment temperature is substantially different to the background water temperature. For example, discharges of water used for cooling in industrial processes can be considerably warmer than the water into which they are discharged.

Turbidity is often measured in arbitrary units called Jackson Turbidity Units (JTU). Suspended matter usually consists of organic debris, plankton and inorganic matter, e.g. clay, soil and rock particles. Turbidity is a measure of water clarity and should not be confused with colour, since darkly coloured water can still be clear, not turbid. High turbidity affects the aesthetic appeal of waters, and in the case of recreational areas may obscure hazards for swimmers and boaters. Its environmental effects include a reduction in light penetration which reduces plant growth, and in turn reduces the food source for invertebrates and fish. If turbidity is largely caused by organic particles, their microbial breakdown can lead to oxygen depletion.

One example might be to see how turbidity conditions vary between the rainy season and the dry season, e.g. the turbidity may be higher during the rainy season when storm runoff is high and excess organic and inorganic materials are carried into the sea. Such a case is shown in Figure 16. Rainfall records can be obtained from the local/national meteorological office.

It is important to realize that water quality measurements often show considerable variation, and tests need to be repeated to verify the results. Furthermore, if water quality problems such as high coliform bacteria readings are found at a local beach, the first step should be to contact the local environmental and health authorities.

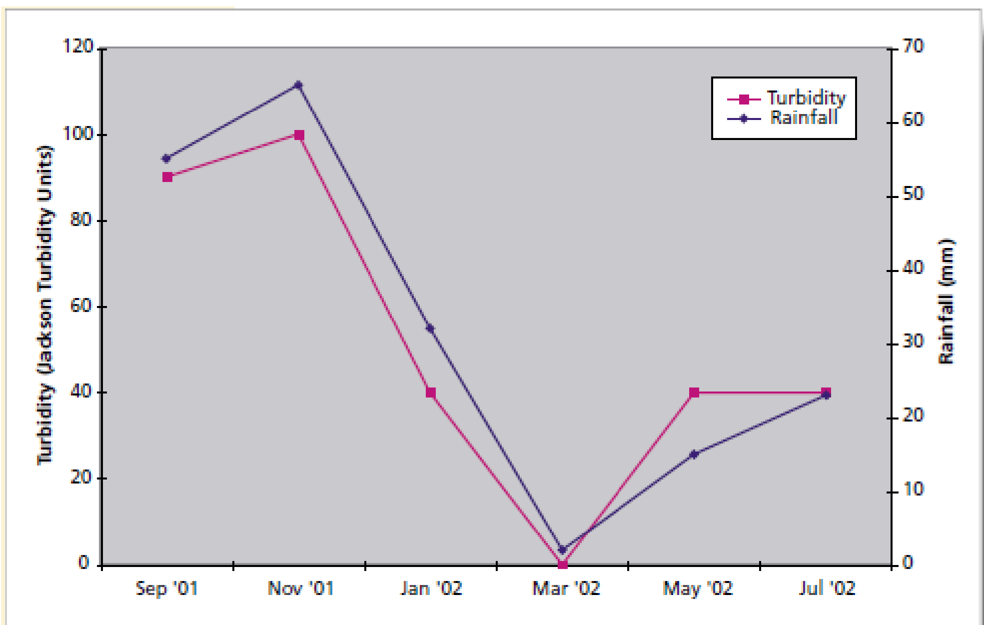


Figure 16 *Line graph showing turbidity and rainfall changes over time.*

Activity 9.2 Climate change and coral bleaching

What to measure→ If your school and beach is in the Tropics, find out if there is a coral reef at or near the beach. Your measurements will include sea surface temperature and the occurrence of coral bleaching.

How to measure→ Carry out 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 July 1 – September 30 for the last 3 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.

Carry out some present day monitoring. 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. (Seawater 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. Compare the occurrences of bleaching with the measured sea surface temperatures. Figure 17 shows some sample results. For those schools not in the Tropics there are similar exercises relating to sea surface temperature available on the web.

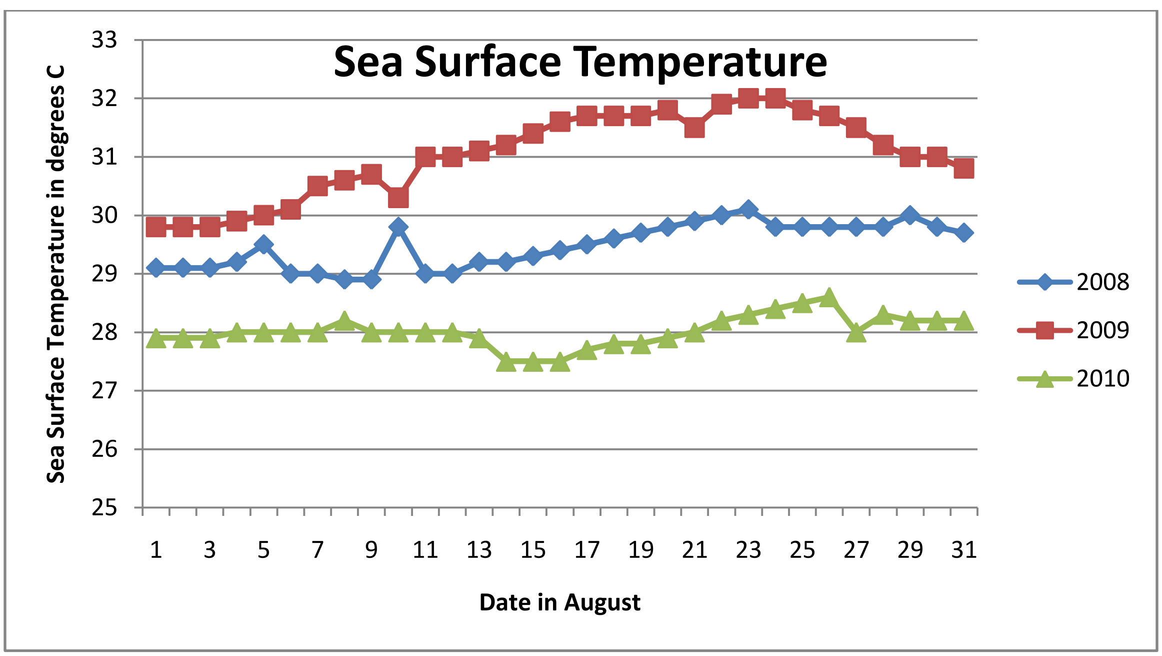


__Figure 17__ Line graph showing sea temperature variation over time; the high temperatures in excess of 31ºC between August 14-27, 2009 coincided with a period of coral bleaching at the sample beach.

When to measure→The research activity can be carried out at any time. The present day monitoring of temperature and bleaching incidents will have to be done during the three hottest months of the year.

What the measurements will show→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 coral bleaches, whether there is any recovery after the bleaching event and what impacts this might have on the beach.

High waves at Rincón, Puerto Rico,

Chapter 10 Wave characteristics

Background

Waves are the main source of energy that causes beaches to change in size, shape and sediment type. They also move marine debris between the beach and offshore zone. Waves are generated by the wind blowing over water. Waves formed where the wind is blowing are often irregular and are called wind waves. As these waves move away from the area where the wind is blowing, they sort themselves out into groups with similar speeds and form a regular pattern known as swell.

Waves and climate change

Changing wind systems projected to occur with climate change will have the effect of altering the wave energy felt on coasts around the world. These changes have not yet been fully quantified. However, it is already known that there will likely be more extreme events resulting in coastal flooding as a result of sea level rise, storm surge, and ocean waves.   In tropical areas affected by hurricanes/typhoons/cyclones, these are projected to become stronger and more intense.   It is during such storms and extreme events that serious damage to the coast and beach occurs.

ACTIVITY 10.1 Measuring waves

What to measure→ The three main characteristics of waves are the height, the wavelength and the direction from which they approach. Figure 18 shows a diagram of a simple wave. Wave height is the vertical distance from the crest of the wave to the trough. Wave period is the time measured in seconds between two successive wave crests. Wave direction is the direction from which the waves approach.

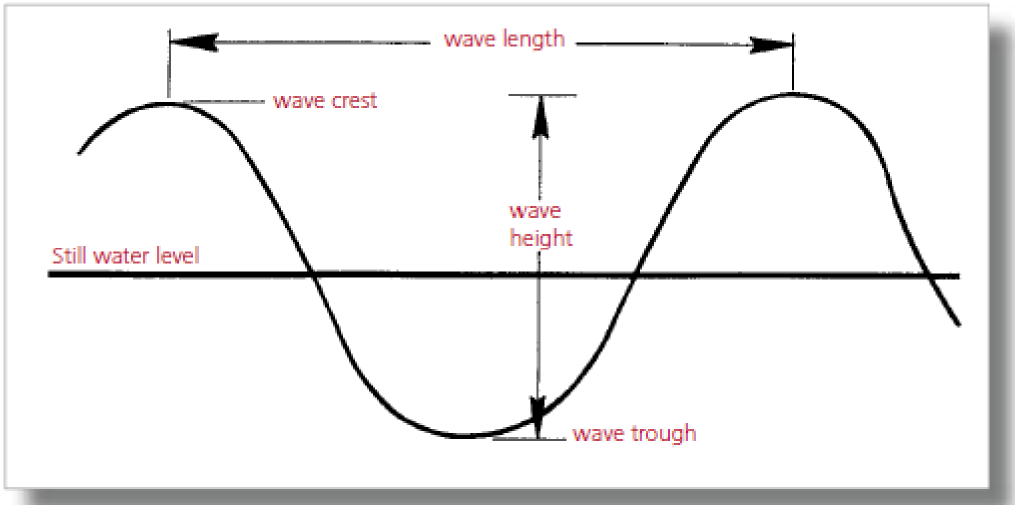


Figure 18 *Characteristics of a wave (adapted from US Army Corps of Engineers, 1981a).*

How to measure→ Wave height is measured by having an observer with a graduated staff or a ranging pole (pole with measured sections in red and white) walk out into the sea to just seaward of where the waves are breaking, and then to have the observer record where the wave crest and the following wave trough cut the staff; the difference between the two is the wave height. If no graduated staff or pole is available an improvised wave staff can be made with any long piece of wood or bamboo that may be lying on the beach. Alternatively, an estimate may be made of the wave height in whichever units the observer feels most comfortable with. Often it is best to have two observers independently estimate wave height and then to compare their results. The height of at least five separate waves should be estimated and the average taken.

Making a wave pole from a piece of bamboo found on the beach, Jamaica

Measuring wave height with a wave pole in Fiji

Wave period is the time in seconds for eleven wave crests to pass a fixed object, or if no such object exists, the time for eleven waves to break on the beach. Use a stopwatch if available or a wristwatch with a hand for measuring seconds. Start the timing when the first wave passes the object or breaks on the beach, and stop it on the eleventh. Divide the total number of seconds by ten to get the wave period.

Wave direction is the direction from which the waves approach and is measured in degrees. This can be measured with a compass, standing high up on the beach and sighting the compass along the direction from which the waves are coming, which will be at right angles to the wave crests (see Figure 19).

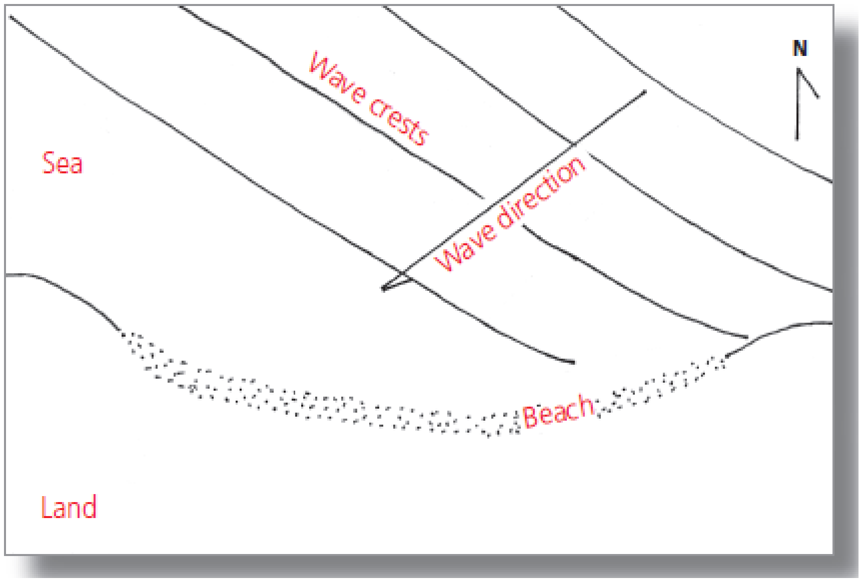


Figure 19 *Wave direction.*

When to measure→ This will depend on the time available and the nature of the monitoring activity. Waves change from day to day, so daily measurements are the most useful. However, if time is not available for daily measurements, weekly measurements or even twice-monthly measurements can still provide useful data.

What will the measurements show→ The measurements will show how the wave characteristics change over time. Depending on how often the data are collected, the measurements can be averaged over weeks or months and plotted on graphs. If beach width or marine debris is also being measured, it may be possible to correlate changes in the width of the beach or the amount of debris with the wave height. It may also be possible to pick out seasonal changes from the data such as the time of year when the waves are highest (see Figure 20).

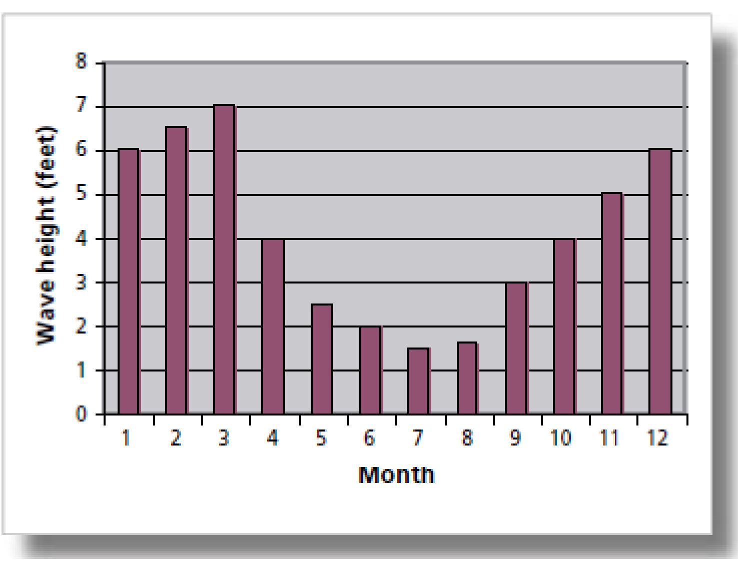


Figure 20 *Bar graph showing wave height variations over time*

Waves vary according to the time of year. The photo on the left shows calm conditions at Speightstown Jetty in Barbados in July, while the photo on the right shows the same site in high swell conditions in March.

ACTIVITY 10.2 Watching out for a tsunami

Tsunami warning sign, Rincón, Puerto Rico. (Translation: Danger zone, earthquake/tsunami. In case of an earthquake, move to a high place or move away from the coast.)

Learning about tsunamis→In the aftermath of the Indian Ocean tsunami that occurred on 26 December 2004, most people are now aware of these phenomena. Tsunamis are extremely high waves that are caused by earthquakes or huge undersea landslides. They are rare events. They occur most frequently in the Pacific Ocean where a tsunami warning system has been established. However, they have also been recorded in historic times in the Atlantic and Indian Oceans and in the Caribbean Sea where tsunami warning systems are being installed.

Recognising the warning signs→ During tsunamis, low-lying coastal areas, those below 6 m (20 ft) in height, may be flooded. However, because of the speed at which tsunami waves travel (800 km/hr or 500 mph) an earthquake off the Venezuelan coast might result in a tsunami reaching some Caribbean islands within minutes. However, in the Pacific Ocean, where distances are larger, an earthquake in Alaska might result in a tsunami reaching Hawaii and Japan several hours later. Knowing the warning signs could result in saving lives. One of the best warning signs is the earthquake itself, though it should be noted that not every earthquake generates a tsunami. A second warning sign is when the sea recedes – before the arrival of the tsunami wave(s), the sea recedes a considerable distance leaving a significant portion of the seabed (which is usually covered by water) dry. If you are at the beach or near the shore, and you see either or both of these warning signs, run inland for higher ground and alert as many people as possible to do the same.

Discussion topics and beach activities

- Research the tsunamis that have affected their country within historic times (if any);
- Determine whether previous tsunamis caused damage or loss of life;
- discuss whether there has been a lot of coastal development in your country since the last tsunami;
- ask the students if they know the tsunami warning signs and ask them to find out if their parents are aware of these signs;
- use Google Earth (or a similar programme, see Chapter 4, Activity 4.3) to see an aerial photograph of your beach, and if the land behind the beach is low-lying, calculate how many houses and people might be in danger if the water extended 1 km inland.

Activity 10.3 Keeping a beach journal

What to measure→ Keeping an accurate and permanent record of major wave events, storms and other activities that affect your beach can provide useful information for beach managers and others wanting to help the beach become more resilient to climate change.

How to measure→ Visit the beach and take photos after a major weather event and keep a record of significant storms and major beach changes over a period of months or a year. Encourage the students to make the journal entries as detailed and accurate as possible. Drawings and photographs are useful additions to the journal. Sample entries are as follows:

- 24 October, 2009 heavy rains cut a deep channel 10 m wide at the southern end of the beach; by 15 November, 2009 the channel had filled up with sand.
- January 14, 2010, large sea swells more than 3 m high affected the beach for 2 days. No beach users or tourists could go swimming. A lot of sand disappeared and tree roots were exposed, one tree fell down.
- June 4, 2010, a tropical depression affected the island and for 2 days there were high winds, high waves and a lot of rain. Again a lot of sand disappeared and the lifeguard station had to be moved further inland.

When to measure→Observations and entries should be made after a major weather event such as a storm, a period of very high winds or heavy rainfall.

What the measurements will show→The observations and records can provide a permanent record of major weather events and how they affect the beach. This information can be entered in the Sandwatch Climate Change inventory (under preparation) and if your Sandwatch group has set up its own website (see Chapter 13) the journal entries can also be stored there.

You will be surprised how useful such information can be – for beach managers, for coastal engineers and even for persons wishing to develop coastal property. Such information is rarely recorded, so your group may be the first to do so at your beach. Such information also contributes to the growing inventory about climate change and how its impacts ecosystems locally and globally.

Measuring longshore currents with fluorescent dye.

Chapter 11 Currents

Background

While waves are the most important process moving sediment particles on a beach, longshore currents also have a role to play. These currents move parallel to the beach near where the waves break. Their existence is dependent on wave action. As was seen in Chapter 10, climate change will likely impact wave regimes and therefore too longshore current regimes. Monitoring longshore currents will help to contribute to knowledge of a specific beach and to the body of knowledge relating to climate change.

Activity 11.1→ Measuring longshore currents

What to measure →When the waves approach the beach at an angle, they generate a longshore current which moves parallel to the beach (see Figure 21). While this current is not in itself strong enough to pick up sediment particles from the sea bottom, it can move material that has already been stirred up by the waves.

The longshore current is responsible for moving material from one part of the beach to another. When a structure such as a jetty or groyne is built out into the sea, this longshore current results in sand building up on one side of the structure (see Figure 22).

Measurements of longshore currents are best combined with wave measurements. So if longshore currents are being monitored, then waves should also be measured (see Chapter 10). Together, these provide a picture of the processes moving sand around on the beach.

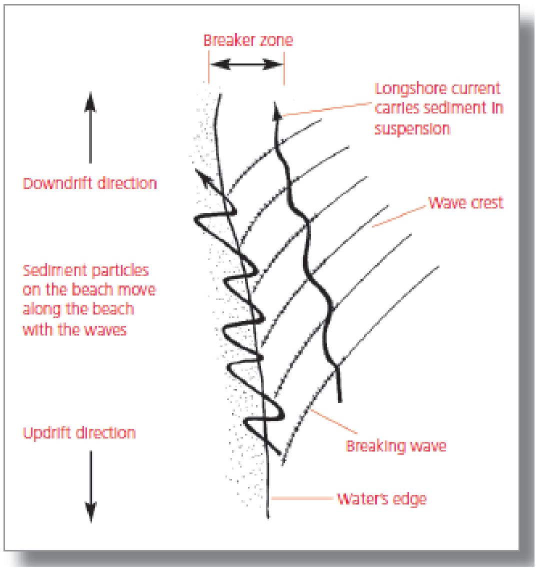


Figure 21 Longshore currents (adapted from US Army Corps of Engineers, 1981b).

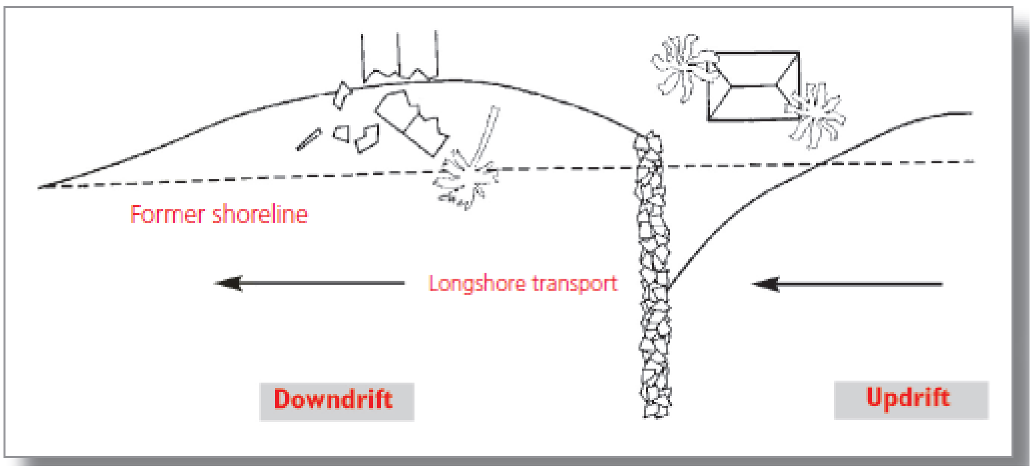


Figure 22 Effect of a groyne on longshore transport (adapted from Bush et al., 1995).

Groyne at Nisbett Plantation, Nevis. The sand has built up on the updrift side of the groyne in the foreground, while the waves reach further inland on the downdrift side as a result of erosion.

The longshore current flows in a

direction roughly parallel to the beach, near where the waves break. The current speed and direction can be measured. Current speeds are recorded in feet per second or cm per second. Current direction is recorded in degrees and is the direction towards which the current is going. So if a current is going from north to south, the current direction is recorded as south or south-going; similarly, a current going from east to west is recorded as west or west-going. (This is opposite to wind and wave direction, which are recorded as the direction from which the wind is blowing or the waves are coming.)

How to measure→ Place a stick in the sand near the water's edge. One observer walks into the water from the stick and crumbles a dye tablet into the water, as near as possible to where the waves are breaking. (Dye tablets can be replaced by food colouring – available in the baking sections of most grocery stores).The observers on the beach stand by the stick, watch the coloured water and observe the direction in which it moves. After one minute, the maximum distance the coloured water has moved is measured along the beach starting from the stick. This is recorded. The measurement is made again after 2 minutes.

The distance moved per minute is used to determine the current speed in ft/second or cm/second. The direction in which the dye moved must also be recorded.

These measurements can be repeated at several different places along the beach to see if the current speed and direction is the same or whether it varies.

If the dye does not move much, but just remains in a pool near the stick, then this means there is no longshore current on that day.

When to measure → As with the wave measurements, this will depend on the nature of the monitoring and the time available. While the time is not likely to be available for daily measurements, weekly or twice monthly measurements will yield some interesting information.

What will the measurements show→The measurements will show how the longshore current varies over time, and how it changes with the wave height and direction. For instance, if the waves usually approach a beach from the south, and it is only during winter storms that the waves come from the north, then monitoring currents and waves during the normal southerly wave regime and the less frequent northerly storm wave regime, will yield some interesting results. It may be possible also to relate these variations to visual changes in the sand build-up on the beach or measurements of beach width (see Chapter 5).

Figure 23 shows current speed and direction based on once/month measurements over a one-year period. The speed was highest in the winter months when the current direction was south-going. While in the middle months of the year, the current speed was lower and the direction of current movement was north-going.

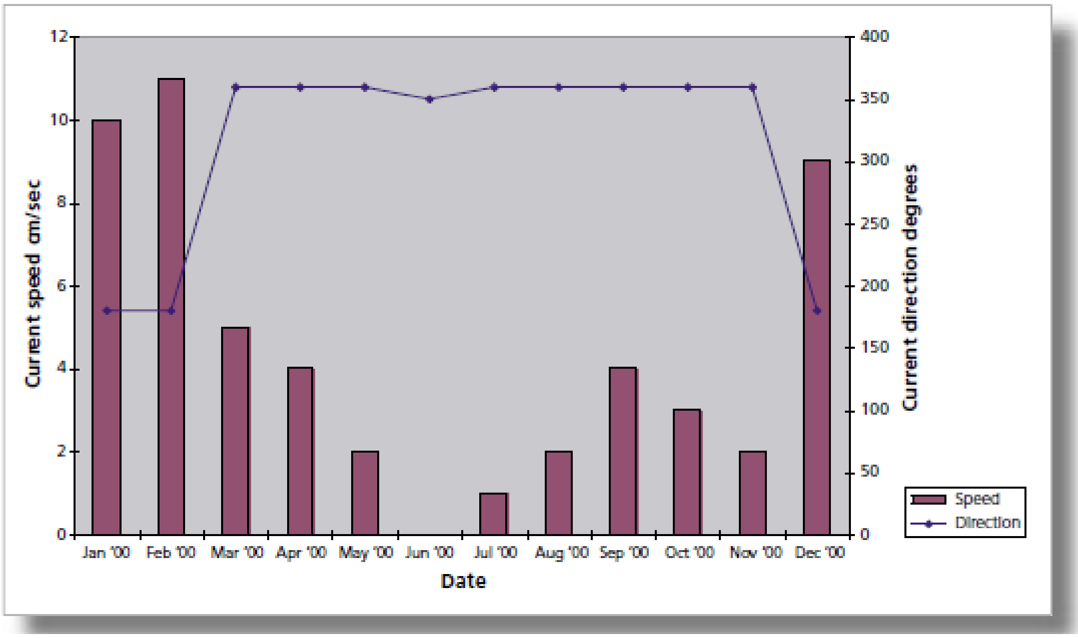


Figure 23 Mixed graph showing current speed and direction

Further activities→Relate the direction of the longshore current to the source of beach material (see also Chapter 6); possibly some of the material at the monitored beach originates from an adjacent beach or coral reef and is moved to the sample beach by waves and longshore currents.

Discuss the impact of groynes and jetties in your area and the role of longshore currents. Often beachfront home owners build such structures to try and protect their homes, but sometimes homeowners on the other side of the groyne or jetty may experience erosion as a result of the structure. Discuss such measures in the context of the entire beach, not just the affected homeowners.

Suggest the students to carry out research into who owns the beach in your country. What does the law say? Are there any particular building restrictions near beaches so as to protect the public's right to use the beach?

Watch out for rip currents→Rip currents are narrow localized currents that that flow away from the shore towards the ocean at right angles to the shoreline. They form near breaks in offshore sand bars, near groynes and jetties, and at places where the longshore current is very strong. At beaches with very high waves, rip currents can be very dangerous, and it is safest not to bathe at such beaches unless lifeguards are present. Swimmers caught in a rip current sometimes panic as they are carried offshore. Trying desperately to swim back to shallower water, they can tire and drown. The safest action is to swim parallel to the beach until out of the rip, then swim in.

Green turtle (Chelonian mydas) returning to the sea after nesting, English Bay, Ascension Island.

Chapter 12 Plants and animals

Background

While at a glance beaches may appear as barren stretches of sand, in reality they are diverse and productive transitional ecosystems – sometimes 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 or to prevent drying out during low tide. Others are just visitors, such as birds and fishes. While different animals are found in different zones, they often move up and down the beach with tides. Hence, zonation patterns along sandy shores are not as clearly defined as on rocky shores.

Beach ecosystems and climate change

Many of the projected impacts of climate change will adversely affect beach ecosystems, in particular sea level rise, ocean acidification and temperature increases (see Chapters 5, 6, and 8 respectively for more information). Resident and visiting species, e.g. sea turtles, migrating birds, will be affected. Rising sea levels and increased frequency of extreme events with higher waves will increase beach erosion and 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. Within decades, acidification of the oceans will negatively affect marine organisms that need calcium carbonate to form skeletons and shells, such as coral reefs, sea urchins and snails. Temperature increases will probably change the geographical distributions of some species and the assemblage composition on any shore. Species now living close to their upper thermal limit may be unable adapt and would thus become locally extinct. Survival would depend on migration to cooler areas although such migration for intertidal species may be more difficult than for oceanic species.

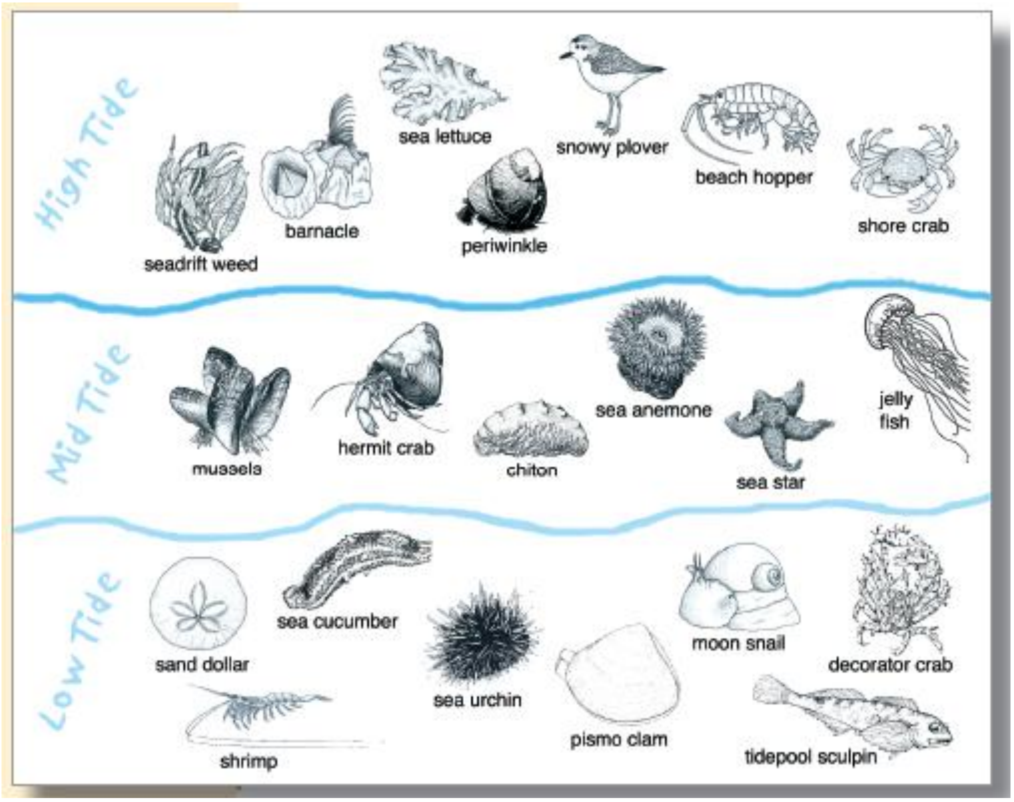


Figure 24 *Common plants and animals found between the high and low water mark.*
(Illustration compiled by Aurèle Clemencin)

Activity 12.1 Observing and recording plants and animals on the beach

Collect, observe and record→ For this activity, give the students plastic bags and ask each of them to collect ten different objects from the beach and to record where on the beach each object was found. Remind them not to collect live animals, and if they select a live plant, then to just take a small piece or leaf from the plant. The idea is to observe and conserve the flora and fauna. If the class is large, you might wish to ask some of the students to record five different plants they see and five different animals; if they cannot identify a particular plant or animal, suggest they make a sketch.

Identify the collected items→ Back in the classroom, get the students to separate biological from non-biological items, and plants from animals. Then ask them to identify the items in their collections. Once this has been completed and discussed, ask each student to select one of the plants or animals they collected and to describe it – shape, colour, size – and draw a picture of it. As a further activity, ask the students to research its habits – diet, movement, reproduction, protection – and note any unusual or interesting features. Include ways in which it might be affected by humans and climate change and how it might be protected.

Understand the beach ecosystem→ The beach ecosystem represents the interaction between the biological organisms and the physical environment in the beach area. Thus the birds and the crabs are as much a part of the ecosystem as the sand and the waves. Learning how the different components interact and depend on each other is the study of ecology.

Use the organisms collected on the beach to build a food chain to show how the various plants and animals interact within the ecosystem and how energy passes from one organism to another. Figure 25 shows a simple food chain.

Sun	Sun
↓	↓
Plants (producers)	Algae in coral and seagrass
↓	↓
Plant eaters (herbivores)	Parrot fish, Green turtle
↓	↓
Meat eaters (carnivores)	Sharks, Barracuda

Figure 25 *Simple food chain*.

Activity 12.2 Understanding the role of coastal vegetation

What to measure→ Vegetation on the beach and behind the beach plays an important role in helping to 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 colonizing 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.

How to measure → Identify the vegetation succession at the beach. Lay out the tape measure starting at the seaward edge of the vegetation and, at 2 m (2 yd) intervals, note down the number of plant species present and identify them, or describe them if names are not known. Note particularly if any plants appear to be stressed, e.g. roots exposed or brown leaves.

When to measure→This activity may be carried out once only, or perhaps repeated after a severe storm.

What the measurements will show→Use the data collected to describe the vegetation succession. A typical coastal succession is shown in Figure 26. Discuss the environmental conditions in the different zones, e.g. the frontal zone may be subject to wave action during storms and will receive the full force of the salt spray (or sea blast), while the forest zone may be more protected from the salt spray and the wind, and the soil and nutrient conditions may be better. Ask the students to:

- forecast what will happen to the vegetation succession as sea level rises and the beach retreats inland;
- forecast what would happen to the beach environment if all the vegetation was removed for a new development project such as a 100+ room hotel complex.

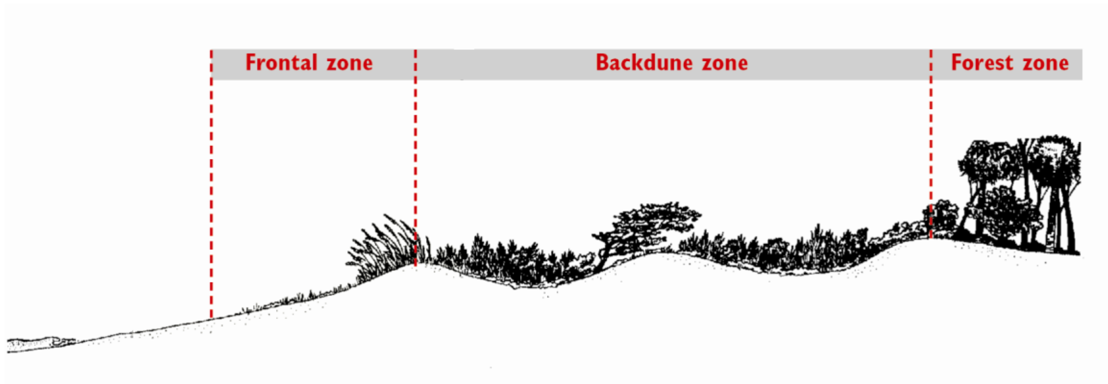


Figure 26 Vegetation succession*: The frontal zone is covered with grasses and vines, which gives way to shrubs and herbaceous plants and eventually the coastal woodland (adapted from Craig, 1984).*

Coastal forest in Puerto Rico – palm trees and almond trees

Sea purslane, a low succulent vine colonising the sand surface

Activity 12.3 Increasing beach resilience to climate change

While coastal forests help increase the resilience of most beaches, they do not work in every location – generally they will only work in sandy areas that are not inundated by the sea. Very strong predominant winds will also limit the existence of a coastal forest. On coastlines where there are wetlands it may be more appropriate to investigate other measures e.g. planting mangroves.

What to measure→Record the type of vegetation behind your beach and investigate the potential to strengthen or create a coastal forest. A coastal forest may be a single line of trees, one tree deep, or it may be an extensive forest several trees deep, or it may be part of a coastal wetland. Well established, mature coastal trees will help make the beach more resilient, since the roots naturally trap sand and slow down erosion (although tree roots do **not** stop erosion). The trees enhance the biodiversity by providing additional habitat for animals and birds. They also provide shade for beach users and generally improve the aesthetics of the beach.

- record the type of vegetation behind the beach;

- investigate who owns the land immediately behind the beach.

Determine if a coastal forest is feasible →Consult with the owners or managers of the land as to whether they agree to the idea of planting more trees on the land. You will have to explain how trees will help the beach cope with climate change. Be aware that in some places people may not be in favour of planting more trees since they wish to have an uninterrupted view of the sea. Also be sure to plant native species since these will be more resilient to climate change than species imported from other regions.

Design, implement and monitor your tree planting project →

- look for partners to help with your project, e.g. Agriculture Department, community group, environmental non-governmental organisation;
- design your planting plan (native tree species, numbers of seedlings, space between seedlings, fertilizer needs), this must include a follow-up plan to care for the plants while they are small;
- plant the trees and publicise the activity;
- monitor carefully how many of the seedlings survive over the first 6 months, and care for the trees, particularly providing them with water since the beach is a very harsh environment for new plants.

Activity 12.4 Monitoring beaches for nesting turtles

What to measure→Many tropical sandy beaches are used for nesting by sea turtles. There are seven species of marine turtles:

Leatherback turtle (*Dermochelys coriacea*)
Hawksbill turtle (*Eretmochelys imbricata*)
Green turtle (*Chelonia mydas*)
Loggerhead turtle (*Caretta caretta*)
Kemp's Ridley turtle (Lepidochelys kempii)
Olive Ridley turtle (Lepidochelys olivacea)
Flatback turtle (*Natator depressus*)

At night-time, female turtles crawl up onto the beach, dig their nests at the back of the beach or in the vegetation behind the beach and lay their eggs in the sand. The period for nesting differs according to the species and the geographical area of the world, e.g. in the Caribbean, most nesting takes place between April and September. After the eggs have been laid, the female covers the nest with sand and returns to the sea. Between 55 and 72 days later the hatchlings emerge and make their perilous journey down the beach to the sea.

Sea turtles are classified as endangered because of over-harvesting in the past; today, many countries have programmes to conserve and protect them.

Monitoring may consist of night-time watches at key nesting beaches, checking beaches early in the morning for evidence of turtle tracks, and watching nest sites for emerging hatchlings. Some turtle conservation programmes, with appropriate training and permission, tag the flippers of sea turtles during nesting. When the turtle is seen again later, her new location, growth rate, etc. provide valuable information to natural resource managers.

Left: Turtle tracks at Long Beach, Ascension Island; right: Safeguarding a turtle nest on a busy tourist beach, Bayibe, Dominican Republic.

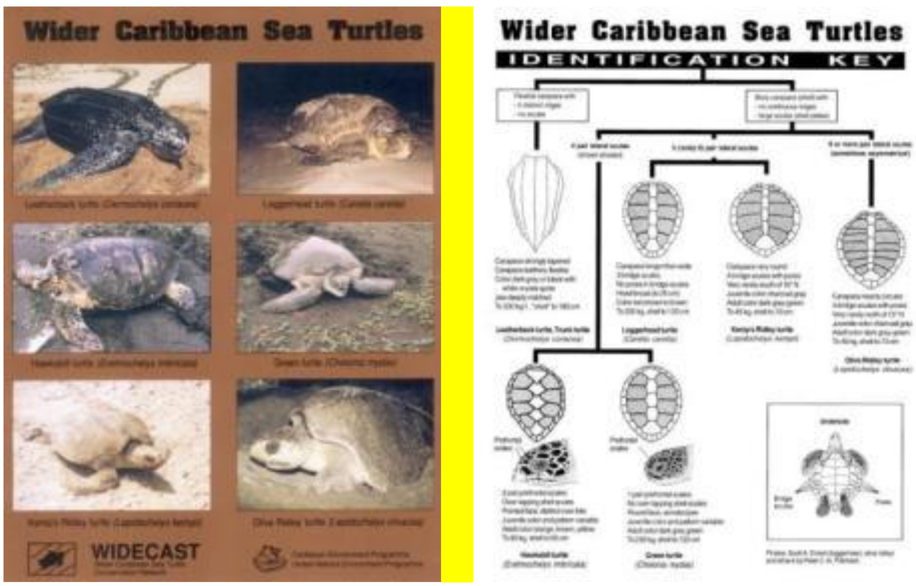


Figure 27 *Sea turtle identification (Source: WIDECAST, 1991) (See also Annex 4, to reproduce for classroom purposes.)*

A Sea Turtle Beach Toolkit has been designed to inform and educate coastal communities about how beach dynamics and climate change affect beaches and biodiversity, with a focus on endangered Hawksbill sea turtles[1]. This well-designed and well-illustrated toolkit, available on the Sandwatch (www.sandwatch.org) and WIDECAST (www.widecast.org) websites, is particularly useful for groups who are primarily interested in sea turtles and who wish to understand the characteristics of their nesting habitat. The toolkit describes easy-to-use methods to measure beach characterization parameters:

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[1] Varela-Acevedo, Elda, Karen L. Eckert, Scott A. Eckert, Gillian Cambers and Julia A. Horrocks. 2009. **Sea Turtle Nesting Beach Characterization Manual**, p.46-97. In: Examining the Effects of Changing Coastline Processes on Hawksbill Sea Turtle (*Eretmochelys imbricata*) Nesting Habitat, Master's Project, Nicholas School of the Environment and Earth Sciences, Duke University. Beaufort, N. Carolina USA. 97 pp.

- beach profile;
- beach elevation;
- beach width;
- boundary parameter;
- sand softness;
- sand composition;
- sea defences;
- vegetation;
- predation risk;
- beachfront lighting;
- general observations.

Many of the methods used in the Toolkit are the same as described in this manual. The study of sea turtle nesting habitats is a complex undertaking, so care must be taken to ensure that nests are not damaged or disturbed. Contact local sea turtle experts and/or marine biologists for further information.

The two activities described below: sand softness and predation risk have been adapted directly from the Sea Turtle Beach Toolkit.

Measuring sand softness →This can be measured on the flat/gently sloping section of the beach above the high water mark, and again at the vegetation line. Sand softness has been observed to be an important variable in that it may facilitate (or hinder) the digging of a nest chamber. Beaches characterized by very wet or very dry sand can create difficult digging conditions for a female sea turtle, and successful hatchling emergence has been correlated with nest depth and sand compaction. Sometimes what appears to be a wide, vegetated and attractive nesting beach may be nothing more than a veneer of sand overlaying rubble or cement.

Digging a hole 50 cm deep at the back of the beach to see if the sand is soft enough for sea turtle nesting

Dig a hole 50 cm deep and with a 10 cm diameter. Note whether it is easy or difficult to dig the hole using the following scale of difficulty:

- high difficulty: cannot dig a 50 cm depth hole due to the tough nature of the substrate or obstacles such as gravel, cement or rock;
- medium difficulty: can dig to 50 cm, but struggle to do so;
- low difficulty: can dig to 50 cm with relative ease.

Note any obstacles found while digging, e.g. tree roots, rocks or buried trash.

Measuring predation risk (crab holes per square metre) →Beach crabs (e.g. *Ocypode quadratus*) prey on sea turtle hatchlings and can be a hindrance as the hatchlings journey from the nest to the sea. Other predators could include feral dogs and mongoose. Counting the number of crabs per m^2, and using that number to estimate crab density, can provide an indicator for the number of predators a hatchling might face. Other species may be used in areas where crabs are not a major predator.

How to measure→Make a PVC metre square quadrant by cutting a 5 m length of PVC pipe into four 1 m length pieces. In a well-ventilated area, use PVC glue to attach the PVC elbows to make a square. Randomly toss the quadrant close to a sea turtle nest on the beach. As crabs tend to hide in holes when there is human activity on the beach, proceed to count the number of crab holes within the quadrant in order to estimate crab density in the area. Repeat up to three times and average the number of holes counted. Monitor crab density early and late in the sea turtle hatching season, determine whether it changes and discuss how any changes might affect hatchling survival.

A PVC metre square quadrant

Crab holes on a beach in Barbados

How to get involved in monitoring sea turtles →If sea turtle nesting occurs in your area, contact your environmental agency or local conservation organization and ask whether there are programmes that monitor and conserve turtles.

Observing turtle nesting at night, from a safe distance so as not to disturb the female turtle, can be a very interesting and exciting experience. The same is true for monitoring the nest to see the hatchlings emerge and make their journey to the sea.

In some areas, key turtle nesting beaches are monitored during the turtle nesting season to observe and record turtle tracks and evidence of successful nesting. Often these programmes need volunteers, and your family, school, Sandwatch group or organization could play a role in ensuring the survival of these gentle marine animals.

Follow-up activities→ If students take part in any aspect of turtle monitoring, there are many areas where they can conduct further work and research; here are just a few ideas:

- conduct research to find out which turtle species nest in your country and how many successful nests are laid. Compare these figures with historical information;

- create a map of sea turtle nesting beaches in your country;
- investigate why sea turtles are endangered and what threats they face;
- discuss within your class or school why sea turtle populations have declined (or increased) in your area. Have threats to their survival increased or decreased?
- interview a Fisheries or Wildlife Officer to find out more about what is being done to protect sea turtles in your country;
- determine what you, your family and your Sandwatch group can do to help conserve sea turtles.

Sea turtles and climate change→ Because sea turtles use both marine and terrestrial habitats during their life cycles, the effects of climate change are likely to have a serious impact on these endangered species. Sea turtles return to the beach where they hatched, and as beaches get smaller or even disappear with rising sea levels and increased storms, turtle reproduction will come under threat. Another impact is an increase in the temperature of beach sand. The gender of sea turtles is determined by the temperature at which the eggs incubate. With increasing nest temperatures, scientists predict that there will be more female than male hatchlings, creating a potential threat to both reproductive success and genetic diversity. Finally, warmer sea surface temperatures and changing current patterns may change the distribution and abundance of important food sources and this, in turn, may confuse and confound sea turtles as they migrate to feeding grounds that can no longer support them.

Sandwatch students on Tekaaroa in the Cook Islands show one of their beach signs

Chapter 13 Creating your Sandwatch network

Background

Sandwatch's greatest strength and asset is that it is an international community of active participants with each team conducting their monitoring and entering their results in the Sandwatch Climate Change Database (under preparation), and sharing their news and photos about Sandwatch activities with the international Sandwatch community and others via the website (www.sandwatch.org) and the newsletter 'The Sandwatcher'.

It is this sense of being a part of a *real community* that has allowed Sandwatch to expand in just a few years from a regional Caribbean project, to a global environmental programme with active teams in more than 40 countries worldwide and still growing.

Of course this new found popularity did not happen by accident or overnight, it took a great deal of planning, hard work and more than a little bit of luck, as various ways of networking, adapting and expanding the approach were tested and implemented.

With the widespread availability of high-speed internet services, inexpensive digital cameras, easy to use video editing software, and popular social networking websites such as Facebook and Youtube, it has literally never been easier for anyone, anywhere to reach a wide audience and involve more school, youth and community groups in Sandwatch.

This chapter sets out to explain how you can share your findings with others, both locally and worldwide, and thereby create your own Sandwatch network.

Establishing a local network→Once you have decided to participate in Sandwatch, there are a few easy steps you can take to build up support for your students' efforts within your school and the wider community.

Involve the school community→Getting school principals and other teachers involved is always a good first step. Demonstrate to other teachers and school principals that:

- Sandwatch is a global project;
- students will "learn by doing" about environmental and climate change issues, and will be able to give something back to the community;
- your school will have a free web presence on the project website;
- articles featuring your group's activities can be regularly published in The Sandwatcher, which is translated into several languages and distributed globally;
- Sandwatch is perfect for science fair projects, regional environmental contests and school-based assessments;
- opportunities exist for your group to participate in regional and international Sandwatch events, e.g. workshops, seminars and conferences.

By pointing out that participation in the project can bring advantages and recognition to the school, it will be that much easier for you to recruit your colleagues and supervisors and enlist their aid in accomplishing the Sandwatch goals.

Reach out to the wider community→Once you have your project established, organize meetings with other schools, church groups, youth groups, NGOs and community groups. Tell them what you are doing and encourage them to get involved. This will also help with sponsorship and with Sandwatch projects e.g. beach cleanups, signage, protecting turtle nesting sites.

Prepare a PowerPoint presentation→This is an excellent tool to use at a community meeting to show what the project is all about and how it can benefit the local community.

PowerPoint is part of the Microsoft Office Suite that comes preinstalled on most computers. It is basically a computerized slide show and it's as simple to use as collecting and organizing photos and typing captions for them.

They say a photograph is worth a thousand words, and this is especially so for slideshow presentations. Keep text to a minimum and try to limit the number of photos/slides in your presentation to a maximum of 20.

Making a display→Another common strategy Sandwatch Teams use is presenting the project using cardboard display stands as part of an exhibition. This could be for a local or regional science fair or a community event such as an agricultural fair or similar, but the main thing is to make your presence and contributions known to your community.

The Sandwatch Team from Saint Lucia created this display for a regional Sandwatch workshop

Throughout the year there are several ‘Special Events’ where you can display your Sandwatch Team efforts, such as, International Coastal Cleanup Day (www.oceanconservancy.org) which is held every third Saturday in September, International Earth Day - April 22nd or World Environment Day - June 5th (http://www.unep.org/wed/2008/english)

By participating in these events and more importantly letting your community know that your team is taking part in them, your efforts can really start to make a difference in changing people’s perceptions and behaviours concerning their local environment.

Make use of local media

An extremely efficient and cost-effective way to publicize your project locally and even regionally is to actively involve your local media, newspapers, magazines, TV and radio stations to cover your events such as a presentation from a guest speaker or a successful field trip.

Even if they are unable to assign a reporter to attend your project’s latest activity, if you send them press releases or pre-written articles with photos, they are often printed verbatim in local newspapers as a ‘free community service’. Getting students to write these articles and press releases themselves is also an excellent way to build their self confidence and writing skills.

Many local newspapers will even grant your project a free page once a month, to showcase your programme’s ongoing efforts on behalf of the community, especially if you can guarantee them a regular supply of articles, photos and project updates.

To cut down on the amount of photography and writing all these activities entail, don’t be afraid to recycle your work. For example, if you draft a press release with photos for the local media describing your team’s efforts at protecting turtle nesting sites, the same text and pictures can be adapted for the website, and for an article in The Sandwatcher.

Another strategy several Sandwatch teams have used effectively is drama. By involving students in writing and producing a short play that can be performed at school and community functions; it can really raise the community’s awareness of your activities. Creating a small, dramatic presentation also encourages creativity and participation by students who might otherwise not be active in environmental issues.

Short student performed plays are also perfect for ‘taking on the road’ to other schools and community events. In addition, if you digitally record the performance you can easily post it online on your web pages, YouTube, Facebook or similar forums.

Establishing a project website

The success of Sandwatch and its website is largely due to its responsiveness to participants.

When information, data or photographs are emailed to the site’s webmaster, it is usually posted online within 24 hours, and often less if requested. This allows educators to have a web presence for their students and communities on the internet without necessarily having to set up their own website

Each new group that joins Sandwatch is automatically given their own personal ‘homepage’ on the Sandwatch website, where they can display photographs, data, greetings, community news, press releases or anything else that relates to their Sandwatch and general environmental efforts.

This has proven especially helpful to schools who are engaged in special events, such as science fair projects, or trying to draw local media attention to their specific environmental efforts, such as a beach clean-up campaign, replanting mangroves or a dune stabilization project.

Building a website is a relatively complex task but it is well within the skill sets of most educators and especially senior students with just a couple hours of practice. There is a wide variety of easy-to-build website software programmes available on the internet, many of which are free. An excellent, easy to use starter programme is Microsoft's FrontPage, though there are many other similar, free programmes available on the internet.

Regardless of which programme you use, the ultimate goal is to establish a presence for your project on the internet. In this way you can easily communicate and make contact with other like-minded people and organizations around the world.

Fortunately, many internet service providers such as telephone or cable TV companies offer the establishment of a *free website* to their subscribers, particularly for schools and related community organizations. Their staff can also be an invaluable source of free expert advice in building your website. It is just a matter of seeking them out and asking for their assistance.

Of course publically mentioning their support for the project on your website and newsletter also serves to let their contributions to your project be widely known, and is thus an excellent way of enlisting their continued support, assistance and even sponsorship. Consider recruiting a budding computer scientist from your local high school, college or community. You will often find that they are very eager to help you build a project website as a personal or even school project.

By using Microsoft's FrontPage or a similar website construction programme, it is then only a matter of registering your websites domain name (e.g., www.ourproject.org) with a suitable hosting company, such as your local internet service provider, or other hosting companies.

Creating a newsletter


The Sandwatcher – Special Issue

The Sandwatch & Cool Youth Climate Change Workshop

The Sandwatch newsletter, The Sandwatcher, has proven to be an extremely useful tool for strengthening a global sense of community, sharing information worldwide and generating local and international publicity.

Newsletters can be a great way to publicize your Sandwatch and other environmental activities. This can be easily accomplished by using Microsoft's MS-Publisher programme that comes as part of Microsoft's Office Suite. (It may be necessary to manually install MS-Publisher from the CD).

The Sandwatcher newsletter is produced several times in several languages.

By using MS-Publisher's pre-installed 'newsletter templates' all you have to do is cut and paste your students' own stories and photographs into the pre-made newsletter document formats, and within minutes you can create a very professional-looking publication.

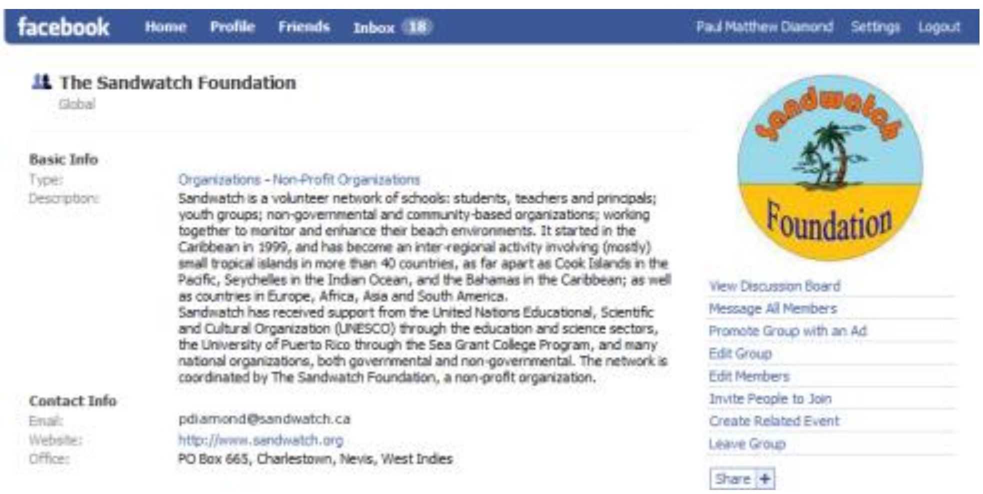
Teachers have found that by encouraging their students to write and edit the stories themselves, the students markedly improved their reading, writing, spelling and comprehension skills as a result. Students are also often excited and inspired by viewing the finished newsletter and seeing their words in print. If a student is not a gifted writer, making him/her a 'staff photographer' can have the same inspirational effect.

Social networking websites

As an alternative to actually creating your own dedicated website, you may consider utilizing one (or more) of the so-called social networking websites, such as Facebook, and MySpace that have become extremely popular worldwide, especially with students, as they are both easy to use and totally free.

Given the popularity and ease of use of these websites, Sandwatch is committed to finding ways to utilise this new communications medium.

A Sandwatch Foundation Forum has been established on Facebook and this is proving very popular particularly with the young Sandwatchers.



If you are a member of Facebook, or are considering joining the website (and membership is free) then simply do a Facebook search using the phrase 'The Sandwatch Foundation', and the forum will pop up on your screen. Then you click on the dialog box that asks you if you would like to join this group.

Once a member of the Sandwatch forum you can post photos, web links, ask questions, communicate with other members globally, and be regularly updated on Sandwatch events and activities. You can even post short videos.

Making and posting videos online

A similar application to Facebook or MySpace is YouTube, and though this is more of a video sharing website than a social networking site, there is a lot of overlap. For example, Youtube videos and links are routinely added to member's personal Facebook and MySpace pages.

The great thing about Youtube is that it allows anyone to easily post their home made videos online, advertise them, tell their friends about them, and get feedback.

The Sandwatch Foundation successfully used Youtube to host and promote the 2008 'Coping with Climate Change: Sandwatch Leading the Way Video Competition'. The video competition was open to Sandwatch Teams worldwide, with the conditions that the submitted videos be a maximum of 3 minutes long, and that they be amateur productions. Of the more than a dozen primary and secondary schools worldwide that entered the contest, none had previously made or edited a video.

Learning to use a video camera at a workshop in Barbados

"Fourth Grade Sandwatchers" Winning Video from Good Hope School, St. Croix, US Virgin Islands

Fortunately, creating and editing a video is fairly easy using the free 'Windows Movie Maker' software that comes pre-installed on all Windows XP and Windows Vista computers.

If for some reason your Windows computer doesn't have this program pre-installed, you can download from the Microsoft website at:
www.microsoft.com/windowsxp/downloads/updates/moviemaker2.mspx

If you can make a PowerPoint Presentation then you can use Movie Maker, as they are almost identical in format and structure. In PowerPoint you add a series of photos and text to make a presentation, and in Movie Maker you add together video clips and audio to make a short movie…in almost exactly the same way!

Getting started with Window's Movie Maker

To help you get started and learn the basics, there are a series of excellent step-by-step instructions on the Microsoft Movie Maker website. Many of the instructions are accompanied by short video clips, showing you exactly what they are demonstrating.

By following these easy steps and watching the short videos, you can learn how to create and edit a pretty good video within about half an hour. Then it's just a matter of experimenting with your own video clips to make your first simple video, suitable for posting on the Sandwatch website, Youtube or your own school website.

Sandwatch teachers reported that by using this online tutorial method they were able to learn the basics of the programme in about 20-30 minutes, and then it took about another hour and half to experiment with editing together some video clips into a rough movie. So in about two hours, they had made their very first movie ready for posting online. It really is that simple!

Once you have taken the time to learn the basics of the programme, you may be surprised to learn that you are inspired to become very creative with your own movies and use them far beyond the goals of Sandwatch.

It is recommended that if you have one or two computer-savvy students, that you encourage them learn how to use the Movie Maker programme and experiment with taking and editing short video clips, as students seem to grasp the concepts of video editing even faster than their teachers.

For Mac Users: We have been told that Macs come pre-installed with a similar programme to Movie Maker, called "I-Movie", which we have been reliably informed is even easier to use that Movie Maker.

Video conferencing

One of the best ways to build a community like Sandwatch is to hold meetings, conferences, fairs and student exchanges. In this way teachers and students from different countries meet, exchange ideas and projects, and often make lasting friendships. For example, a student exchange programme between Trinidad and Tobago and Brazil in 2008 was extremely productive.

Unfortunately, the high cost of travelling (and especially air travel's large carbon footprint) makes such events very expensive. However there is a simple and cost effect alternative available to most Sandwatch participants; that of video conferencing.

An excellent and free utility to use for Sandwatch and other projects is the free Voice-Over-Internet Programme (VOIP), called Skype (www.skype.com). Using simple web-cameras that come preinstalled on most new computers, it is fast and simple to hold real time video conferences between schools, even if they in different parts of the world.

As long as your internet connection is reasonably fast (faster than dial-up) such DSL or Cable modem, and both you and your partner classrooms have web-cams, then setting up a free video conference between your students is as simple as sending an email.

Both parties simply register their user names with Skype, exchange these names via email, then conduct a search on Skype for the name. When your partner's name is found, you add it to your Skype contact list.

Now that you are both listed as contacts, you just click on the persons name to start a free long distance call. Then once a successful voice connection has been established, Skype will automatically detect if a web-cam is installed on your computer, and will ask you if you wish to start a video call. It's that simple and costs absolutely nothing.

If your school is fortunate enough to own a digital projector that can be plugged into your computer and projected on to a wall or screen, then you and your students can really have fun, asking each other questions and showing each other what their classrooms look like. The only problem Sandwatchers have reported with using Skype is co-ordinating the different time zones between countries.

Video conferencing in St. Croix

Other free web-based resources

It is doubtful whether Sandwatch would have been so successful without the use of email. It has been the backbone of the entire project: allowing for recruiting participants, finding sponsors, updating the website, creating the newsletters, organizing and coordinating regional workshops and conferences and so much more.

Email can be used to keep in touch with each other, locate new partners and sponsors, pass along information and ideas. As simple as this concept may be for many people, some still do not appreciate the power of email, literally at your fingertips.

Do not be hesitant to email a person, a website or even a large organization and ask for advice or assistance on a specific issue. Even if they cannot help you they may well surprise you by suggesting something or someone who can.

Networking and making contacts has been of significant importance to the overall success of Sandwatch, so you can make it work for you.

Google Earth (http://earth.google.com) is another useful, free programme that allows teachers to view their country, island and even school yard from satellite images. This can be an extremely useful if you are studying local or regional geography or even the effects of deforestation on hill sides or the destruction of local wetlands. You can also view the beach you have adopted for Sandwatch (see also Chapter 4, where Google Earth is used in Activity 4.3 on how the beach used to look), and compare the satellite image(s) before and after a major storm or hurricane for example.

This chapter has attempted to show you some different ways to share your Sandwatch activities both locally and worldwide. The wide availability of inexpensive computers, peripheral devices, software and free ‘online services’, can all be significant assets to your Sandwatch activities and the creation of your own Sandwatch network. Providing students and youth with the opportunity to acquire and expand their skills also gives them a sense of self confidence and recognitions as a valued member of a larger community.

Students in Bequia, St. Vincent and the Grenadines, undertaking a Sandwatch project to clear a coastal drain and reduce pollution at the beach and in marine waters

Chapter 14 Taking action

The fourth step of the Sandwatch methodology (**M**onitoring, **A**nalysing, **S**haring, **T**aking action) consists of designing, implementing and evaluating a beach-related project to fulfil one or all of the following criteria:

- addresses a particular beach-related issue;
- enhances the beach; and
- promotes climate change adaptation.

This fourth step is what distinguishes Sandwatch from other environmental monitoring activities, and makes it an example of education for sustainable development (see also discussion in Chapter 2). The Sandwatch “Taking action” component is based on science and consultation with others.

Designing a Sandwatch project→ Based on the results and analysis of the monitoring activities and the feedback received when sharing you findings with other persons and groups, brainstorm ideas for beach related projects. This might be a good time to return to the sketch map of the beach that you prepared when you were starting Sandwatch.

- List the ideas received, and try and keep each suggestion simple so that it focuses on just one activity;
- discuss each idea with the group and identify how the suggestions fulfil one or all of the three criteria listed above;
- prepare a shortlist with just two or three suggestions that can be implemented by your group;
- make a selection.

Examples of Sandwatch projects

- Tree planting behind the beach.
- Planting and conserving sand dunes.
- Beach beautification activities.
- Beach and underwater clean-ups.
- Promoting recycling at the beach.
- Placing informational signs at the beach
- Preparation and distribution of educational brochures and videos to specific target groups.
- Murals, dramatic presentations and exhibitions to create awareness among the general public.
- Influencing tourism developers about the fragility of the beach.
- Relocating endangered species, e.g. iguanas threatened by development.
- Conserving sea turtles, e.g. monitoring nesting activity and protecting nests.

Planning a Sandwatch project→

- Define the project's objective(s): be specific and identify what you hope to achieve at the end of the project;
- list the project's activities and place them in a consecutive and logical order;
- estimate the time frame for project implementation;
- determine if the project requires support or funding from outside the group; if so, identify the nature of the support required and likely sources to approach;
- prepare a simple table (see Figure 28) showing for each activity the time frame, participants and resources required.

Evaluating a Sandwatch project→ Evaluation is a very important step that will help the group determine the effectiveness of the activity.

- Review the project objectives and determine whether they were fulfilled;
- identify the activities that went well;
- identify the activities where improvement is needed;
- write up the results of your project for the Sandwatch website, and your own web page.

Examples of Sandwatch projects from The Bahamas

Over a four-year period, students aged 10-11 years from Hope Town Primary School in Abaco, Bahamas, have implemented a series of Sandwatch projects that have fulfilled the three criteria. First of all they spent several months in measuring various beach characteristics and how they changed over time. They interviewed beach users and recorded their activities: walking, swimming, sunbathing and snorkelling. They observed the different types of boats and found that sport fishing and tourist rental boats were the most common. They measured the width of the beach and observed how it was eroded and virtually disappeared during the 2004 hurricanes. They used a simple kit to measure water quality. After recording and counting the

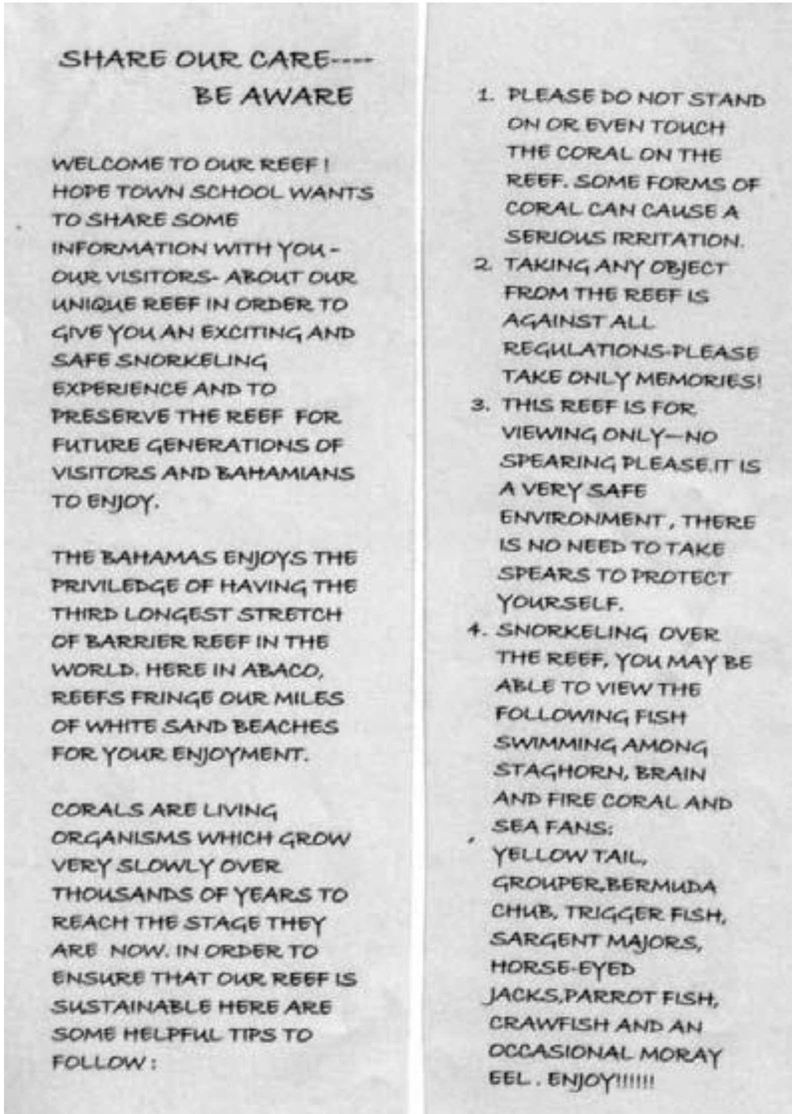
Action	Time Schedule	Persons Involved	Activities and Resources Needed	Expected Outcome
1. Plan and design the content of the mural	January - February	Class 4 students and teachers for science, art, language, woodwork	a. Visit to beach to assess potential sites	a. Storyboard showing what the mural will 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 - 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. 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.

Figure 28*: Sample Project Action Plan*
Project to create awareness about beach health and climate change resilience with a beach mural

different types of beach debris they used their art classes to make decorative items with the discarded material.

After graphing and analysing their data 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.

Their first project addressed this particular issue that of unwise user practices destroying a reef. They designed a questionnaire to find out how visitors viewed the reef. After discussing the results of their questionnaire survey with the rest of the school, their parents and a local environment group, they decided to try and educate the tourists by designing a brochure on proper reef etiquette. Copies of the brochure were placed in hotels and nearby rental properties and were very well received by visitors.



SHARE OUR CARE----
BE AWARE

WELCOME TO OUR REEF! HOPE TOWN SCHOOL WANTS TO SHARE SOME INFORMATION WITH YOU - OUR VISITORS- ABOUT OUR UNIQUE REEF IN ORDER TO GIVE YOU AN EXCITING AND SAFE SNORKELING EXPERIENCE AND TO PRESERVE THE REEF FOR FUTURE GENERATIONS OF VISITORS AND BAHAMIANS TO ENJOY.

THE BAHAMAS ENJOYS THE PRIVILEDGE OF HAVING THE THIRD LONGEST STRETCH OF BARRIER REEF IN THE WORLD. HERE IN ABACO, REEFS FRINGE OUR MILES OF WHITE SAND BEACHES FOR YOUR ENJOYMENT.

CORALS ARE LIVING ORGANISMS WHICH GROW VERY SLOWLY OVER THOUSANDS OF YEARS TO REACH THE STAGE THEY ARE NOW. IN ORDER TO ENSURE THAT OUR REEF IS SUSTAINABLE HERE ARE SOME HELPFUL TIPS TO FOLLOW:

1. PLEASE DO NOT STAND ON OR EVEN TOUCH THE CORAL ON THE REEF. SOME FORMS OF CORAL CAN CAUSE A SERIOUS IRRITATION.
2. TAKING ANY OBJECT FROM THE REEF IS AGAINST ALL REGULATIONS-PLEASE TAKE ONLY MEMORIES!
3. THIS REEF IS FOR VIEWING ONLY—NO SPEARING PLEASE.IT IS A VERY SAFE ENVIRONMENT, THERE IS NO NEED TO TAKE SPEARS TO PROTECT YOURSELF.
4. SNORKELING OVER THE REEF, YOU MAY BE ABLE TO VIEW THE FOLLOWING FISH SWIMMING AMONG STAGHORN, BRAIN AND FIRE CORAL AND SEA FANS: YELLOW TAIL, GROUPER,BERMUDA CHUB, TRIGGER FISH, SARGENT MAJORS, HORSE-EYED JACKS,PARROT FISH, CRAWFISH AND AN OCCASIONAL MORAY EEL. ENJOY!!!!!!

Tourist brochure produced by students at Hope Town Primary School

There following several severe hurricanes that eroded the beach and dunes. The government scraped sand from the sea bottom to restore the sand dunes. Their <u>second project</u> focused on enhancing the beach and making the dunes more resilient to future storms and hurricanes as they worked with other groups to replant the damaged dunes with sea oats.

Planting the restored sand dunes with sea oats.

Four years later the restored sand dune stabilised with sea oats

As their third project they prepared a short video showing viewers how their activities to protect their beach and nearshore reefs were keeping their beach healthy and thereby more resilient to climate change (visit the Sandwatch youtube channel to view the video, see also Chapter 13).

Final comments

This example from the Bahamas provides a glimpse of Sandwatch in practice, and there are many other examples from countries around the world documented on the Sandwatch website. Sandwatch has the potential to become a worldwide movement for change – taking effective action to care for the beach environment and thereby building its resilience to climate change.

Visit www.sandwatch.org and become a part of the change.