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SANDWATCH

Adapting to climate change and educating for sustainable development

SANDWATCH

Revised and expanded edition

Adapting to climate change and educating for sustainable development

By Gillian Cambers and Paul Diamond

United Nations Educational, Scientific and Cultural Organization

Education Sector
Natural Sciences Sector

Ministry of Foreign Affairs of Denmark

Sandwatch Foundation

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Foreword

For small islands and coastal populations around the world, from the tropics to the Arctic, climate change is already being felt – whether in the form of increasingly frequent extreme weather events, acidification of the oceans, melting of Arctic ice, or the prospect of rising sea levels. The Secretary-General of the United Nations, Ban Ki-Moon, has stated that climate change is 'the defining issue of our era'. Nowhere is this more the case than in small islands and coastal areas, home to an ever-growing majority of the world's population.

There is no doubt that education plays a central role in the response at all levels to the projected changes in the world's climate. The key question is as far-reaching as it is urgent: how can we adjust and enhance the way we teach and learn so that we instil an understanding in children and young people of the nature and causes of climate change, while inspiring action to adapt and mitigate? This second, expanded edition of the Sandwatch manual makes particular reference to climate change adaptation within an approachable and interactive framework through which students, teachers and other practitioners can monitor their local environments, identify critical issues, and develop strategies for action.

Developed through UNESCO's Coasts and Small Islands Platform, Sandwatch began in 1998 as a regional activity involving the Caribbean UNESCO Associated Schools Project Network. It has since grown into a global programme, actively implemented in more than 50 countries worldwide with the support of UNESCO, the Sandwatch Foundation, and several other partners. This new, revised edition of the Sandwatch manual, made possible through the generous support of the Government of Denmark, builds upon more than a decade's experience of Sandwatch practitioners across the globe – teachers, students, universities, community groups, government agencies and individuals. It integrates the issue of climate change into all chapters and activities presented in the first edition, and adds a number of new activities, including a guide to documenting and sharing Sandwatch results through the use of social networking websites and other online resources.

Sandwatch links classroom activities to real-life issues relating to climate change, environment, sustainable development, cultural diversity, science and more. It links academic subjects across the curriculum from mathematics and natural science to social studies and the creative arts. Perhaps most important of all, Sandwatch stimulates and encourages practitioners, young and old, to take action by becoming involved in caring for their environment, and in understanding and influencing local government policy and action.

In this sense, Sandwatch embodies the principles of Education for Sustainable Development and serves as an excellent example of the new and innovative approaches to the kind of education essential for an effective global response to climate change.

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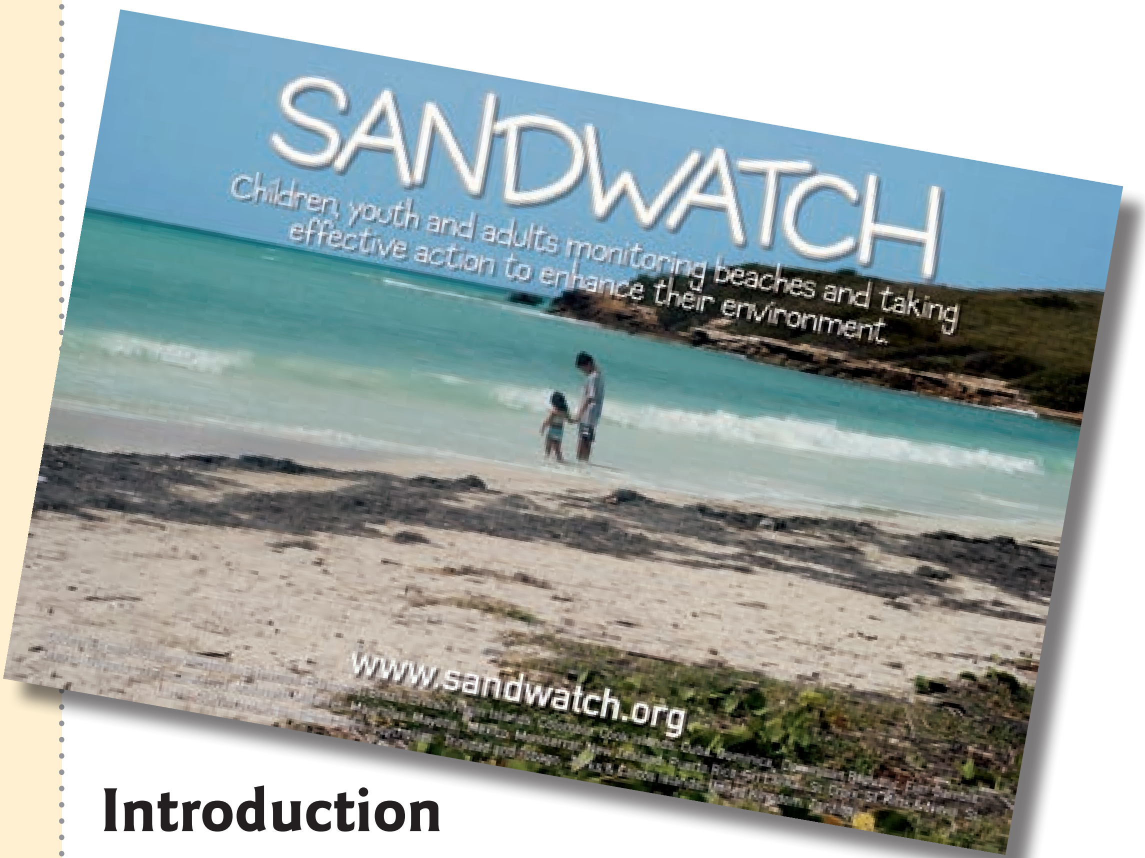


Sandwatch poster

1 Introduction

Summary

Sandwatch provides a 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. It also helps beaches become more resilient to climate change. The preliminary chapters of this publication focus on how to get started with Sandwatch activities and examine ways to address climate change impacts. The principle aim of this publication is to document the Sandwatch methodology: monitoring, analysing, sharing and taking action. 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 findings and create a Sandwatch network are detailed including methods such as the use of local media, websites, social networking and video production. Finally, ways are discussed to design, plan and implement a Sandwatch project to fulfill one or all of the following criteria: (a) addressing a particular beach-related issue, (b) enhancing the beach, and (c) promoting climate change adaptation.

Background

Sandwatch is a programme through which 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.

Initially a Caribbean regional initiative, Sandwatch today is 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.

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

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 more intense 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 has been supported since its conception by UNESCO, primarily through its education and science sectors and 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 standardized 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.

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

Above, other representatives from CORALINA talk with a beach user on how to best protect an eroding beach, 2003.

(CORALINA is the Corporation for the Sustainable Development of the Archipelago of San Andres, Old Providence and Santa Catalina.)

Following the training workshop, teachers worked with their students to monitor their beach environments and record the 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 beach monitoring methods that form an integral part of Sandwatch. The 30 entries, documented on the Sandwatch website (www.sandwatch.org), illustrate the effectiveness of the approach both from a learning perspective and a practical application. Entrants cooperated with different beach users, ranging from interested tourists to sceptical developers, working to preserve the beach environment, and displaying their knowledge as well as communication and media skills. Selected highlights are shown in Box 1.

Following the establishment of the Sandwatch website in 2006, the programme has expanded worldwide with networking becoming an increasingly important component. In 2006, Trinidad and Tobago organized 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 2010 work began on developing a web-based Sandwatch database.

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 awarding 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 incorporated building ecosystem resilience as an objective, 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, while a training workshop was conducted to provide Caribbean Sandwatch groups with communication skills to effectively convey information on climate change to a general audience, and a dedicated climate change section was established on the website.

Vision statement

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

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, in addition to new methods developed by Sandwatch groups. It therefore represents a useful tool for both new and established Sandwatch groups.

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 for the 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.

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:

- involve children, youth and adults in the scientific observation, measurement and analysis of changes in the beach environment using an inter-disciplinary approach;
- assist Sandwatch groups, with the help of local communities, to apply their information and knowledge to the wise management and enhancement of their beaches;
- integrate the Sandwatch approach into the formal and informal education system and contribute to Education for Sustainable Development;
- contribute to the understanding of how climate change affects beach systems; and
- build ecosystem resilience and contribute to climate change adaptation.

Sandwatch methodology

Taking action based on good scientific practice is the basis of the Sandwatch methodology. The Sandwatch methodology consists of the following four main steps – Monitoring, Analysing, Sharing, Taking Action (MAST):

Monitoring the beach

Selection of a specific beach for observation, preparation of a sketch map, and regular measurement of various parameters, including:

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

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).

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:

- 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.

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.

Credit: Candace Key

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, and 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 to 12 outline methods for measurement and analysis of specific components of the beach system, specifically:

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 information with other groups. Finally, Chapter 14 describes the fourth step of the Sandwatch methodology: taking action by planning, implementing and evaluating beach-related projects. A glossary at the end defines the terms used in this publication.

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

The 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.

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).

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 projections

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 good 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' that 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.unfcc.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°C
sea level rise*	increase of between 0.18 and 0.59m
ocean acidification	decrease in pH of 0.14–0.35pH units (resulting in increased acidity)
snow and ice extent	decrease in areal extent of ice and snow
extremes: heat wave and heavy precipitation	more extreme events
tropical cyclones	stronger tropical cyclones
precipitation	changes vary regionally, some areas getting dryer, some wetter

* Sea level rise projected change does not include the full effect of changes in ice sheet flow because a basis in published literature is lacking.

ACTIVITY 2.1 Conduct your own weather measurements

What to measure

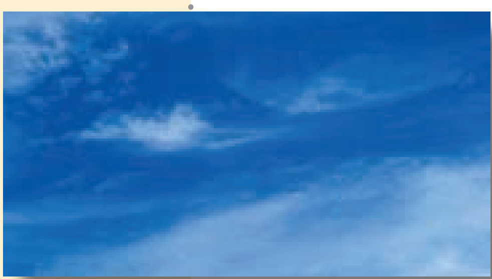
Depending on the age of the group, simple or more complex weather characteristics can be observed and/or measured on a daily basis to show how weather changes. Simple weather measurement kits are available. However, there are several weather measurements that require no special equipment and these are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

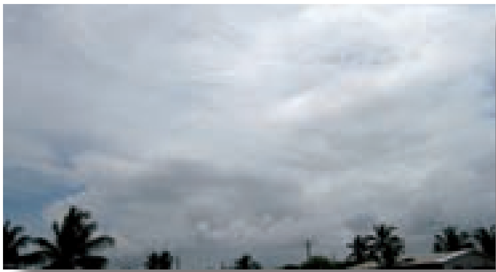
How to measure

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 including high and low clouds; cloud colour; cloud type e.g. cumulus, cirrus, stratus 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).

Simple cloud observations: Partly cloudy, high cirrus clouds (left); Completely cloudy, mid-level cumulus clouds (right).





When to measure

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

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. 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 show further differences.

Use the data to show how difficult it is to make any statement about climate based on the daily weather pattern. This emphasizes 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 to be 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 defences to protect valuable coastline infrastructure 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 to 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 represent 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.

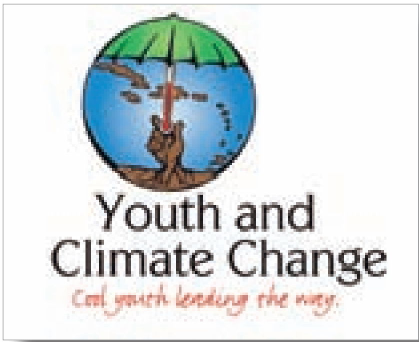
Sandwatch and climate change adaptation

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 over 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 have reached out to more than 30,000 people through news stories, videos, exhibitions and presentations.

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.

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).

Education for sustainable development

Education for Sustainable Development (ESD) is an approach to teaching and learning that seeks to empower and encourage 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 promotes 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.

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. ESD also means venturing into unknown areas and learning about new issues. 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 looking at 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 who have different levels of understanding and different priorities – 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, as well as how to critically select salient points and key issues. The process also encourages 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 within 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.

Education for sustainable development is education for life.

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

3 Getting started

Finding out more about Sandwatch

One of the best sources of information about Sandwatch is its 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, who 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. Moreover, 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 southern coast of the island. The programme is organized by a national committee comprising the Associated Schools Project Coordinator of the UNESCO National Commission, the Department of Environment and Natural Resources, the 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 that may be willing to help as part of its outreach activities. 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.

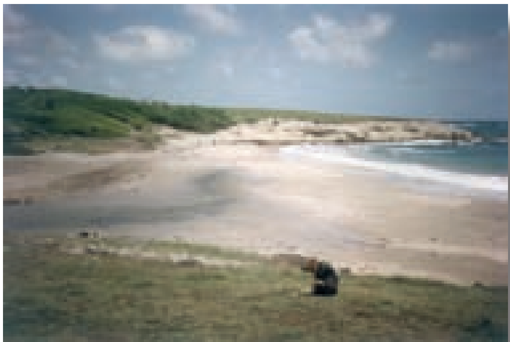
Select the beach to monitor

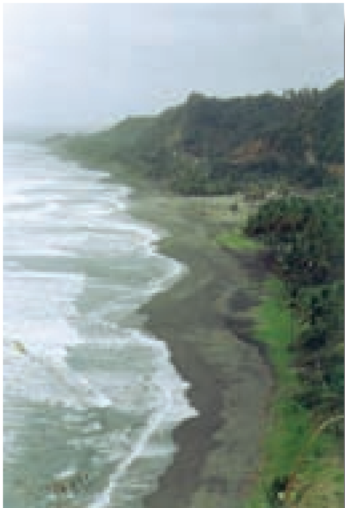
The key factors to consider here are:

Safety: the beach should provide a safe environment for the students. If there are very strong currents and/or very high waves, for example, 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.

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





Small beaches enclosed by headlands, also known as bayhead beaches, and seen here at Anse Ger in St Lucia (right), are ideal for Sandwatch monitoring.

Some beaches like those at Byera on the east coast of St Vincent and the Grenadines (far right) are very long, and in these cases a particular stretch should be selected for Sandwatch monitoring.

extend for several kilometres (or several miles). If one of these very long beaches has been selected for monitoring, it is recommended to focus on a particular section (about 1.6 km or 1 mile).

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 help ensure local interest in the monitoring activities and will also constitute an important factor during the design and implementation of beach enhancement projects.

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

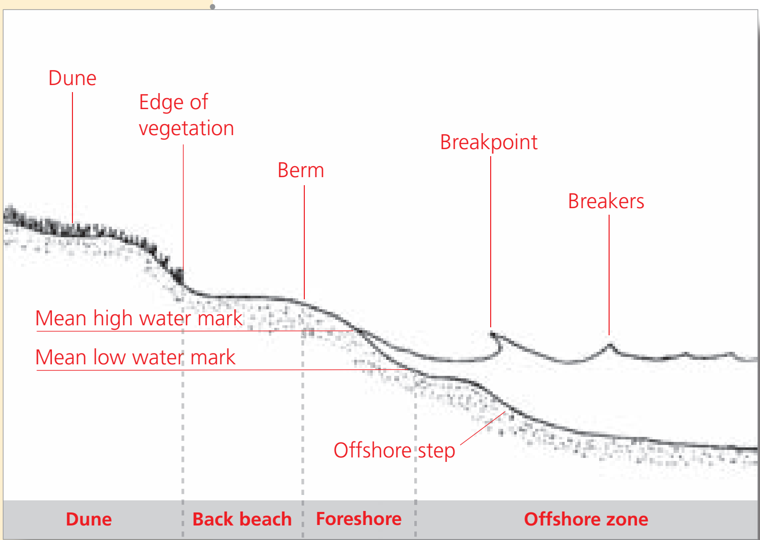
Define the boundaries of your beach

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 need to look at the 'beach system' from a broader perspective, taking into account the offshore zone out to a water depth of about 12 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.

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; then they can elect to perform all the measurements, or just one or two. However, there is one activity that is so important that it forms the starting point for every Sandwatch activity: 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, re-measuring afterwards could provide interesting results. 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 human actions, so it is always important to have a flexible approach when it comes to Sandwatch.

Entering your data in the Sandwatch 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 Database (being established at the time of publication) where these are stored permanently and made 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 activities cannot be performed in a classroom alone, it is essential that students go outside 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 school 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 school 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 scientific methods to explain changes in the natural environment (developing a hypothesis, making measurements, analysing 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 application 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 pervades all aspects of Sandwatch through creative writing, reports, storytelling, keeping journals, spelling and 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.

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

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.

Sandwatch in the school curriculum

As of 2010, only the Cook Islands in the Pacific have 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*

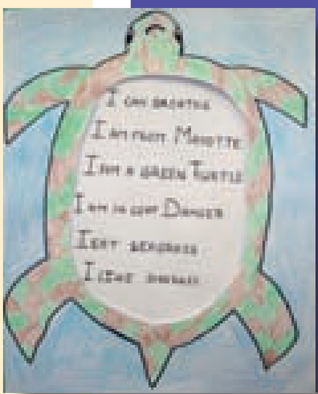
Before the first visit to the beach prepare a list of titles: date, time, weather, name of beach, shape and size, length and width, wave height, water and air temperature. Ask the students to prepare questions starting with the words: what, where and how, under each title, e.g. What is the date? What 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 as 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?

Students' work from Mayotte



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.

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

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.

Credit: Paul Diamond

Annex 1 lists the basic equipment required for each activity described in this manual, where the equipment can be obtained and its approximate cost. In some cases simple household materials can be substituted. The only activity for which specialized equipment is a necessity is water quality measurement, for which simple kits are available for purchase.

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

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

4

Observation and recording

Background

The first and most important 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 Observing the beach and making 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 access ways to the beach, litter bins, signs, lifeguard towers, jetties etc.;
- sea conditions, e.g. whether the sea is calm or rough;
- objects in the sea, e.g. mooring buoys, boats at anchor, buoyed swimming areas.

Encourage the students to make detailed observations, e.g. instead of recording three trees, encourage them to try and identify the trees, 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).

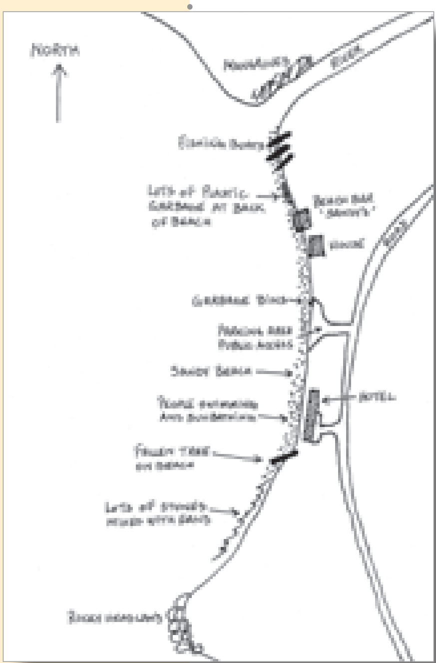


Figure 2
Sample sketch map (left)

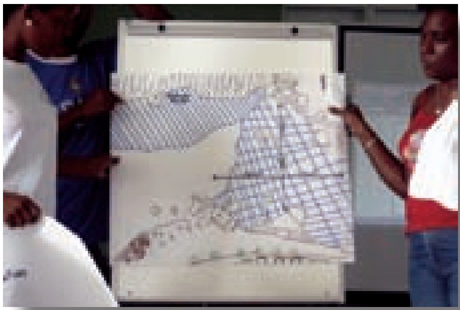
Figure 3
Sample topographic map (below).

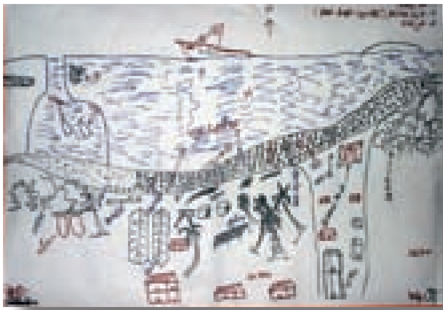
Source: Lands and Survey Department, Dominica

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) the problems facing the beach.

Examples of two sketch maps: a river section in Dominica (left) and a beach in the Maldives (right).
Source: from workshops sponsored by the Dominica UNESCO National Commission and the Sandwatch Foundation respectively





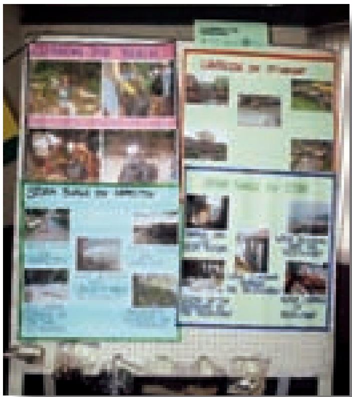
ACTIVITY 4.2 Looking and listening: creating a photo mural and sound map

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 of the beach can be enhanced and whether anything can be done about the bad aspects. This then 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 information 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 then be added to the sketch map of the beach.

Discuss the findings

Questions 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?
- 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 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 of the beach. You may be able to find aerial photographs of the beach taken in the 1960s or 1970s. Aerial photographs, like topographic maps, can be used quantitatively to determine the length, width and size of the beach. Compare the aerial photographs with your present-day sketch map and note any changes (see Figure 4B).

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. These can give you another perspective of the beach (see Figure 4C).

Examine ordinary photographs of the beach and talk to local people who knew the beach from years back

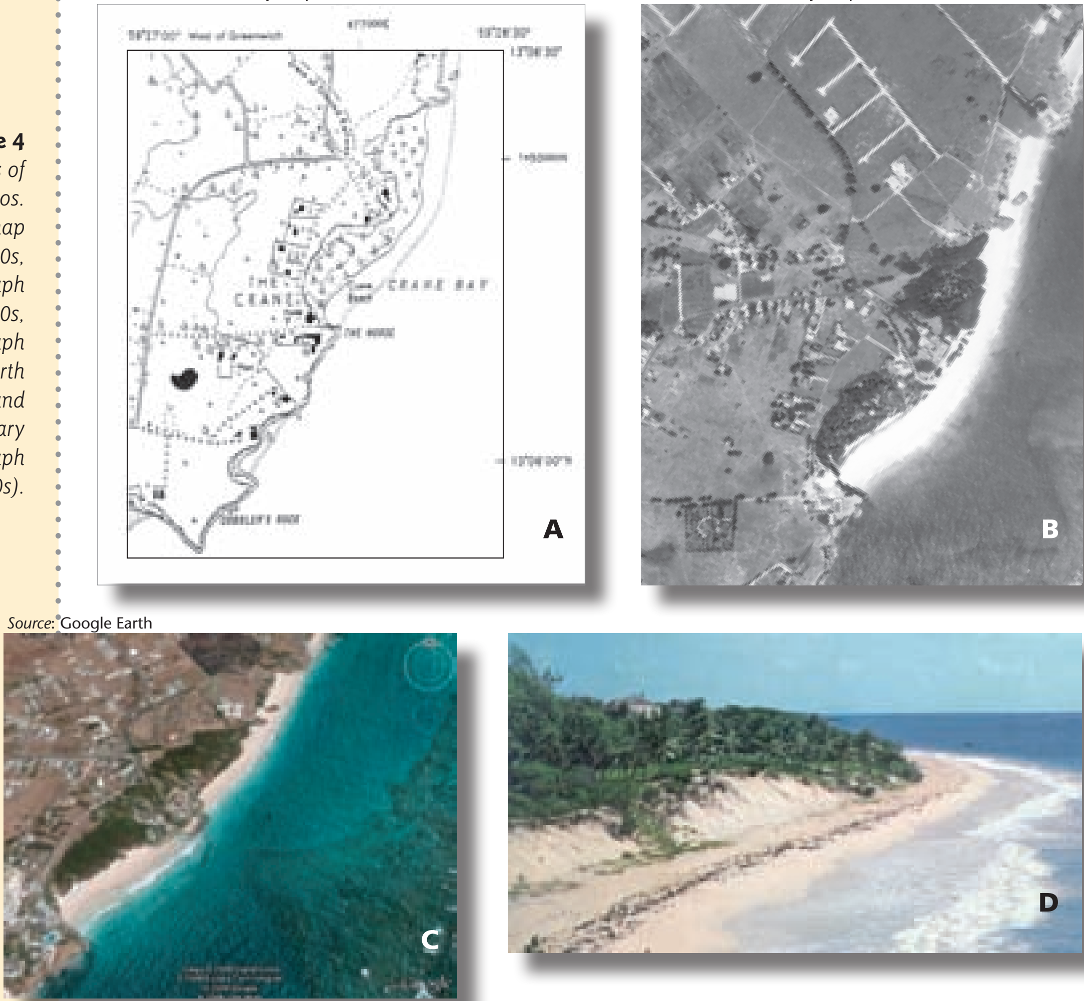
Ordinary photographs show how the beach used to look in the past. Sometimes postcards also show views of particular beaches (see Figure 4D). People who have lived by the beach for many years or have visited it regularly over a period of time are another source of useful information.

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).

Source: Lands and Surveys Department, Barbados

Source: Lands and Surveys Department, Barbados

Source: Google Earth



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 the beach will look as the climate changes

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

- the 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, 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.

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, for example, when sand is extracted from the beach for construction, or when jetties or other structures are built on the beach.

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 reached by waves on a 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 recently wetted by the water and the part that remains dry.

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

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

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

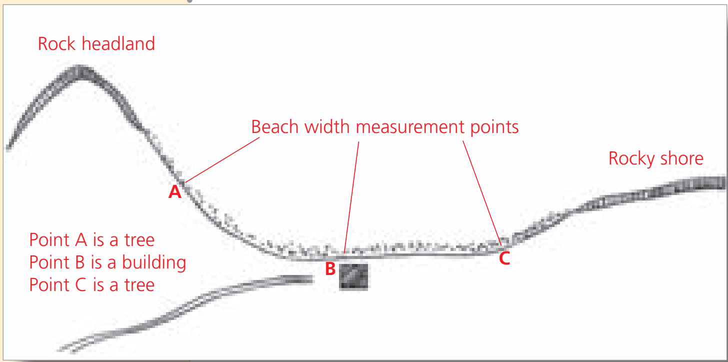


Figure 5 shows a photograph of a beach in Anguilla; the arrow shows the high water mark which, in this case, is the land-most edge of the band of seaweed.

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 taken at high tide, then subsequent measurements should also be made at high tide.

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

Most beaches show variation in erosion and accretion, for instance, sand may move from one end to the other. So when monitoring the physical changes on 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).

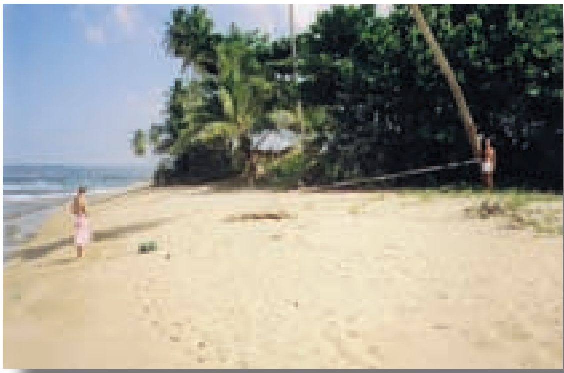
How to measure

At the first point, select the building or tree that you are going to use. Write down a description (and if possible photograph it). 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 tight. Note the distance either in feet and inches, or metres and centimetres, whichever system the students are familiar with, and record the measurement together with the date and 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).

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

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

Far right: Measuring the beach width, Sandy Beach, Puerto Rico.



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

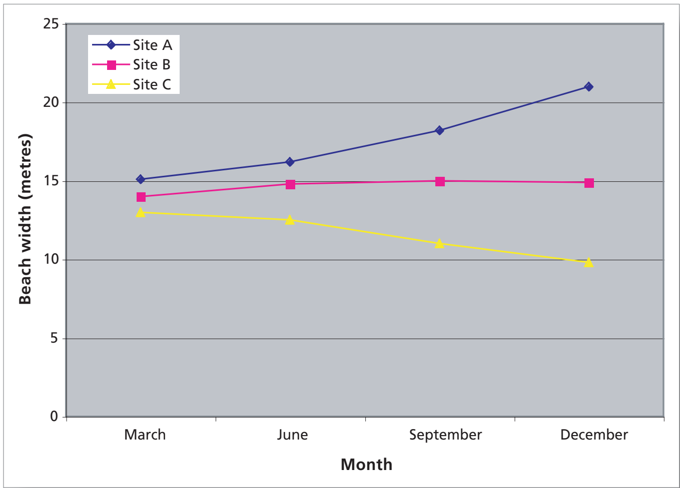
When to measure

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

What the measurements show

The data will show how the beach has changed over the monitoring period, and whether it has gained or lost sand – possibly one part of the beach will have 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.

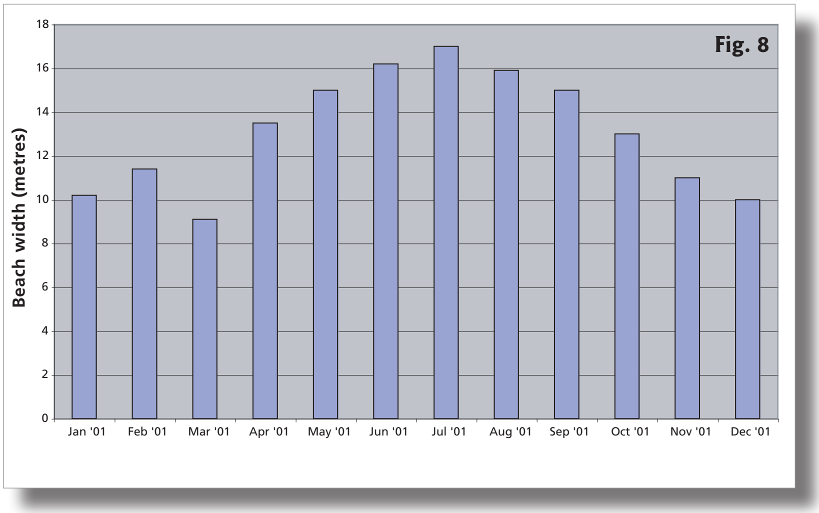
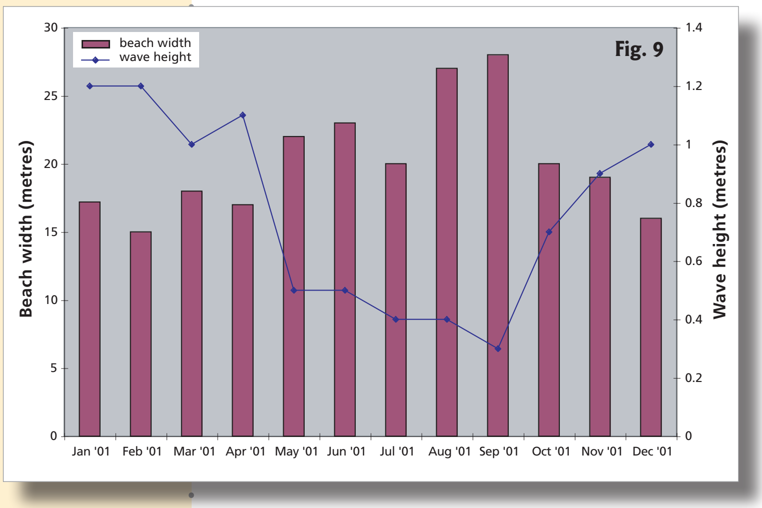


Figure 9
Mixed graph showing changes in beach width and wave height.



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.

ACTIVITY 5.2 Determining the effects of human structures on erosion and accretion

What to measure

Look for any human structures on or behind the beach (also called sea defences) such as jetties, groynes and seawalls. Note their numbers and where they are positioned.

How to measure

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).

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.

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.

Use the same techniques as described above in the activity dealing with erosion and accretion (Activity 5.1)

What the measurements 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 well 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 has 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 program 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).

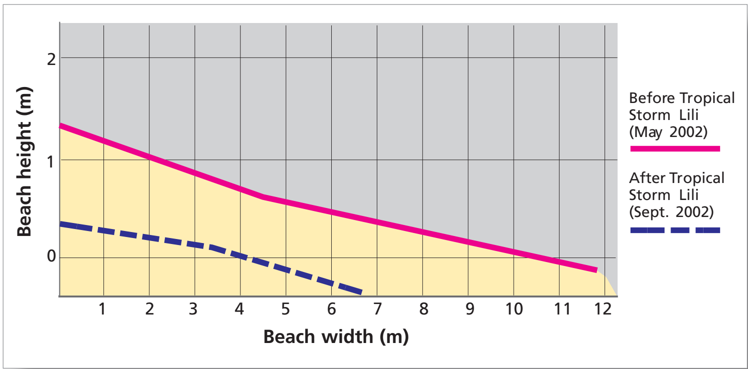


Figure 10
Changes in a beach profile before and after Tropical Storm Lili (2002), Port Elizabeth, Bequia, St Vincent and the Grenadines.

Credit: Herman Belmar

Upper: Group of students measuring a beach profile at Hamilton, Bequia, St Vincent and the Grenadines.

Lower: 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.

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 program allows successive profiles to be plotted on the same graph to see the changes.

What the measurements show

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 affects 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

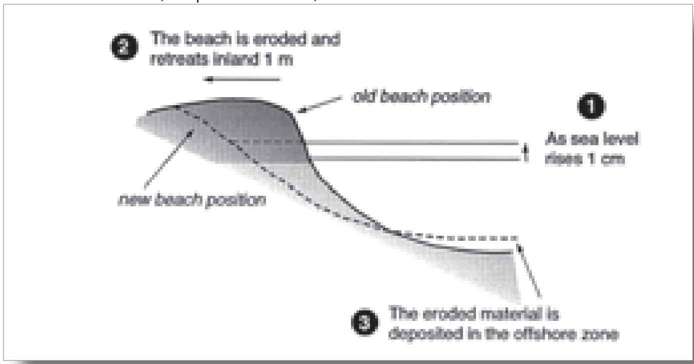
Chapter 2 discussed climate change and how it will affect beaches. As the temperature rises, the ocean water expands, and this change combined with the melting of the polar ice caps and glaciers, results in a rise in sea level. Rising sea levels increase beach erosion, reducing the area of beaches and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

Table 1 (Chapter 2) shows that global sea level is projected to rise between 0.18 and 0.59 m by 2099. (This projection does not fully reflect changes in the ice sheets). As new information is coming to light since the IPCC report was published in 2007, it appears that these sea level rise projections are on the low side so higher rates of sea level rise can be expected.

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

The **Bruun Rule**, as shown right, 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.

Source: UNESCO 1997; adapted from Brunn, P. 1962



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, it is always difficult to generalize about beaches because each one behaves differently; therefore, it is necessary to monitor how a particular beach changes over time. Indeed recent research is showing that some small low-lying sandy islets and atoll islands may respond to sea level rise by changing their shape as one side erodes and the other side accretes, with no net change in area.

Where the land behind the beach is developed with houses, hotels, roads and other infrastructure, the beach will not be able to retreat inland. 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.

Credit: Ruperto Chaparro

As sea level rises, 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 it.

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 are available.

Have the students do some simple research and calculations:

- Determine the annual rate of sea level rise in your country; if no data are 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

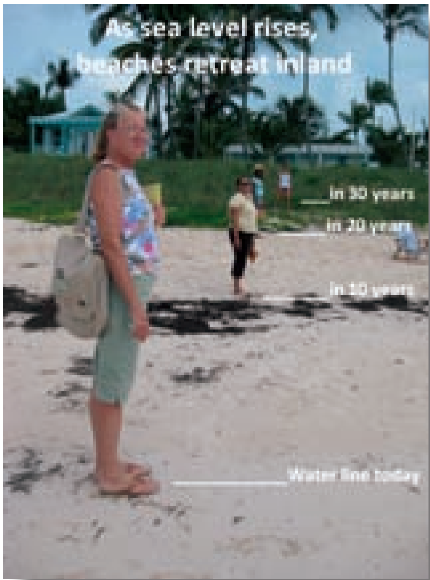
Using these figures, let the students determine where the high water mark is today, then using a tape measure, measure 5.9 m landward of that point and make a line in the sand; repeat the process for the 20 year and 30-year distances.

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 marks in 10/20/30 years time, and 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 that 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 a 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;
- the construction sector will benefit during the building phase;
- 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.

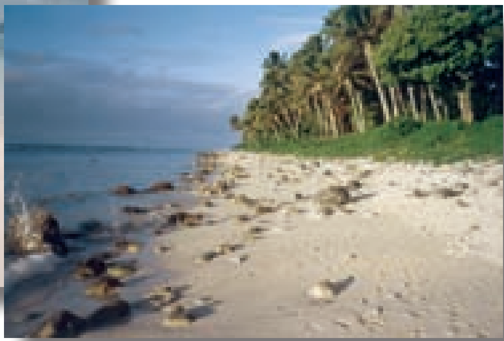
Points that might be raised by the government officers include:

- 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: how do the developers propose to cope with future erosion, including the impacts of climate change?
- beaches are public on 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 affected?
- 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 be able to use the beach at all times of day and night for fishing, picnicking and other activities?

Powder white sand at Villingili, Maldives.



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

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 growth of reef building corals and other key species that form strong reef ecosystems is expected to decline due to ocean acidification. 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, such as sand, gravel and boulders. Beach material can be classified into different sizes (see the table opposite). Sand is just one size range.

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

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.

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). Alternatively, the sand may have its source in the offshore coral reefs and seagrass beds.

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; and
- mixtures of mineral and biogenic sands.

Common components of mineral sand include the following:

- quartz grains, which are clear. Quartz is one of the most common minerals found in sand and is extremely weather resistant;
- feldspar grains, which are pink, light brown to yellow;
- magnetite grains, which are black and strongly magnetic; and
- hornblende grains, which are black and prism-shaped.

Common components of biogenic sand include the following:

- coral, which may be identified by its many rounded holes;
- shell fragments, which may come from scallops, mussels, clams and be a variety of colours; and
- sea urchin spines, which appear as small rods or tubes and may be a variety of colours.

Sand samples may also include some organic material.

Upper: This yellow brown silica sand at Walkers Pond, Barbados, originates from the erosion of inland rocks. Lower: 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.

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 will affect the food chain and the world's fisheries;
- think about how acidification will affect the beach and coral reef.

Discuss what can be done to:

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

Letter from a grain of sand

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

Hello friends!

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 fly 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 find 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 home 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

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 material is being extracted, e.g. heavy equipment or people using spades;
- vehicle tracks across the beach;
- deep holes where material has been extracted;
- whether the water reaches further inland;
- trees that have been undermined or vegetation that has been trampled as a result of the mining activity;
- the effect 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

What to measure

Sand samples can be collected from different parts of the beach and the size, shape and sorting 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

Three 'S's' of sand: size, shape and sorting

Measuring the shape of sand grains with a magnifying glass, St Lucia.

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.

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.

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 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.

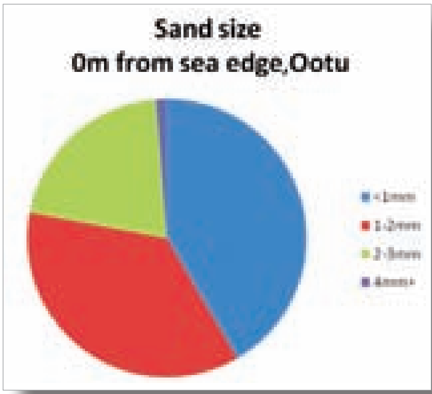
Sieve the sand samples

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 specialized 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 two 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.



Sand sizes at Ootu beach in Rarotonga, Cook Islands (right).

Source: Kandiko and Schwartz, 1987; and Powers, 1953

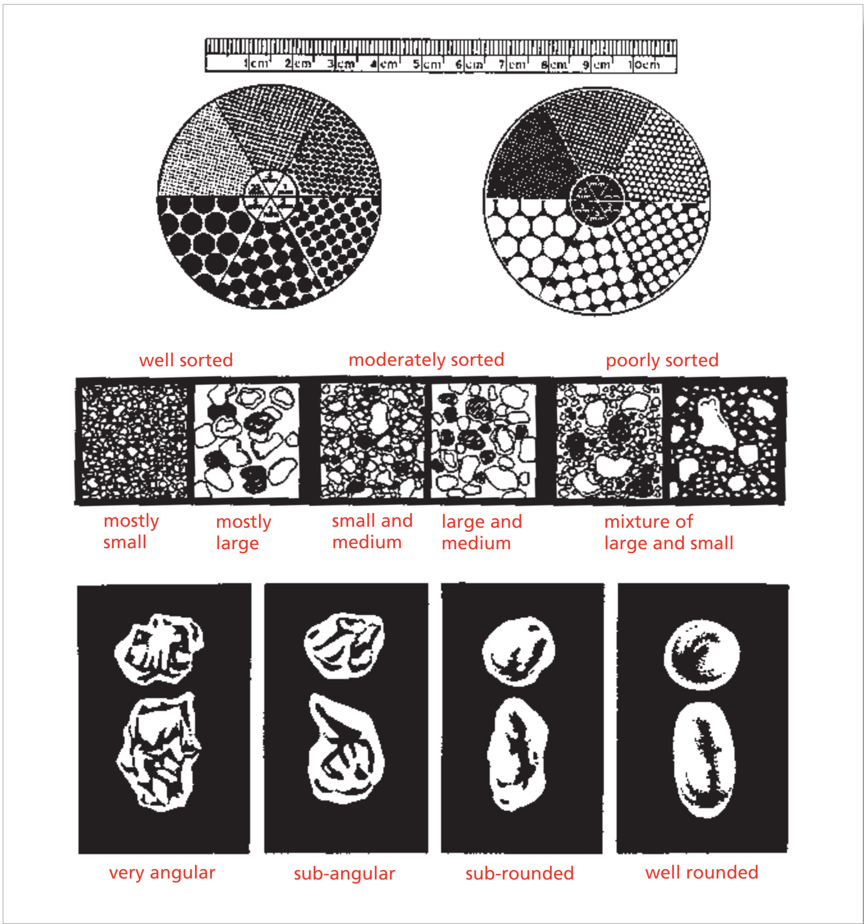


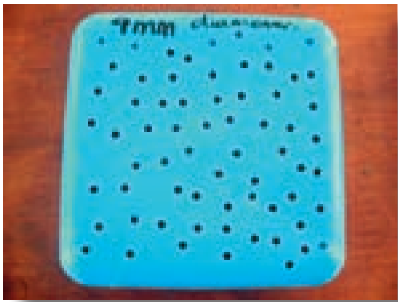
Figure 11
Sediment analysis charts for size, shape and sorting.

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.

Method for sieving sand developed by Cook Islands Sandwatch teams.

Credit: Araura College Cook islands

Credit: Araura College Cook islands



When to measure

You may wish to collect sand samples from different parts of the beach on a single occasion, and compare the different samples.

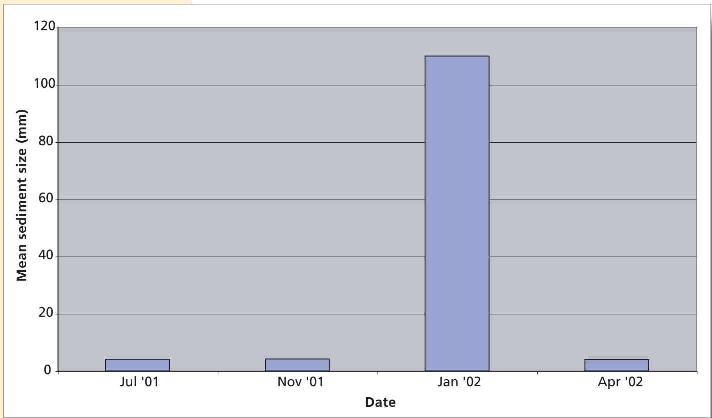
Alternatively, you may decide to collect and measure sand samples from the inter-tidal zone, at different times of the year and after different wave events, e.g. after the summer when often the waves are relatively calm and then again after a high wave event. Some beaches show marked differences in composition, 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.

Figure 12
Bar graph showing changes in sediment size.



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

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

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 attract flies.

Fisherman's Day at Long Bay, Tortola, 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, sunbathers might not appear before noon, and 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

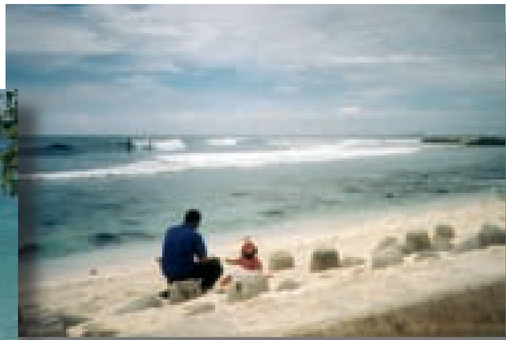
6–7 am	Fishers take their boats out to sea. Early morning bathers visit the beach to bathe and swim.
7–10 am	Walkers, people with dogs.
10 am–3 pm	Sunbathers, picnickers use the beach, people bathing in the sea, children playing, people walking. Fishing boats return around 3 pm, catch is unloaded into 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	A few people walk the beach and watch 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 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 any way; 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 related 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 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 trees for shade			

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 were 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.

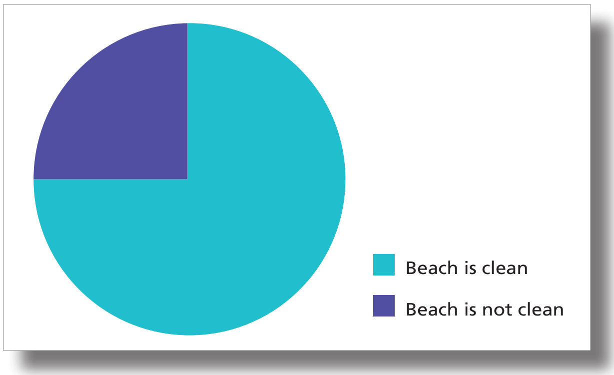


Figure 13
Pie chart showing users' views on beach cleanliness.

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

ACTIVITY 7.3 Finding out how climate change will affect beach users

What to measure

Brainstorm with the students on 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, which as a result 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.

Categorize 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?	Yes	No

What 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 sensitize 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. Shade trees may become more important as temperatures increase (Johnny Cay, San Andres, Colombia).

Credit: Ruperto Chaparro

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

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.

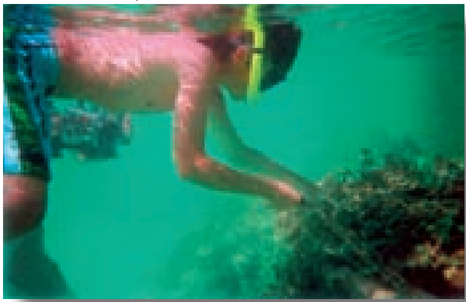
Bobbins of thread washed up from a container onto the beach of Anegada, British Virgin Islands. When unravelled the thread made thick underwater mats endangering marine life.

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 – remains healthy.

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.

Credit: Candace Key



Credit: Candace Key

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 measure 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. 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.

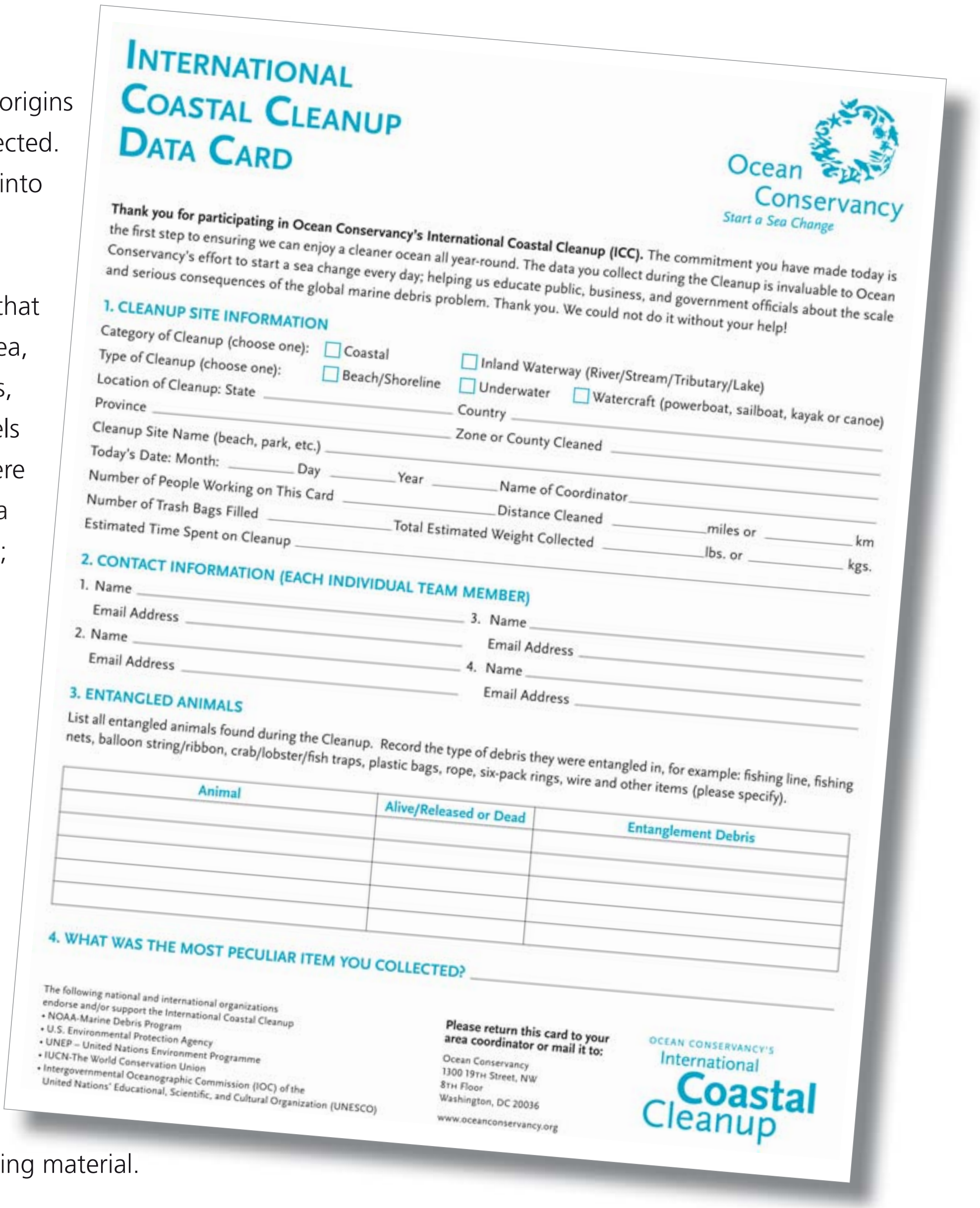
When to measure

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 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.

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



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 ______
Email Address ______
2. Name ______
Email Address ______
3. Name ______
Email Address ______
4. Name ______
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

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

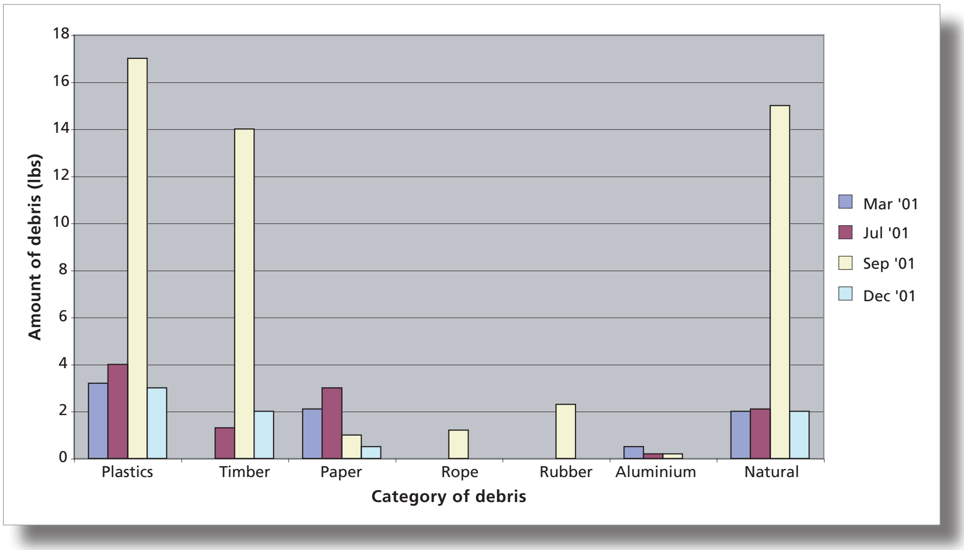
- Group 1: debris that came from the sea, e.g. fishing floats, plastics with labels showing they were made for use in a different country;
- Group 2: debris that came from careless beach users or nearby communities, e.g. cigarette filters, styrofoam containers;
- Group 3: debris that might have come from either group 1 or 2, e.g. pieces of rope and timber, packing material.

Discuss which group is largest and why.

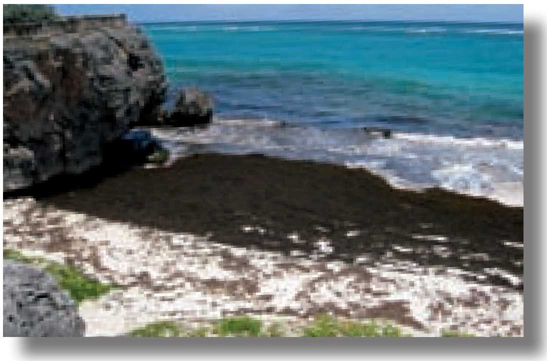
If you measure debris at different times of the year you might be able to relate the amounts of various categories of debris to weather events and to wave and weather conditions (see Chapter 10). For instance, tarballs might only appear at certain times of the year. Figure 15 shows a sample graph of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

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

Figure 15
Bar graph showing beach debris changes.



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



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.

ACTIVITY 8.2 Conducting a beach clean-up

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

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 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.

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

- 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 that 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.

Credit: Pascale Gabriel

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

Credit: Ruperto Chaparro

Runoff from coastal development pollutes coastal waters.

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 affected. 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 affects beaches as reefs provide protection and act as a source of sand for many coralline beaches in tropical regions.

Credit: NOAA

Credit: CORALINA

Left: Coral bleaching.

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

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:

- 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 measure quantitatively 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 water 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 before collecting your sample 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 away from you;
- allow the water to flow into the container for 30 seconds;
- cap the full container while it is still submerged and 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.

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

What 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.

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, 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.

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

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.

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 1 July – 30 September for the last three years. Plot the daily temperatures on a graph for each of the three years and determine whether the temperatures were higher during the year of the bleaching, and/or whether there was a prolonged period of high temperatures.

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.

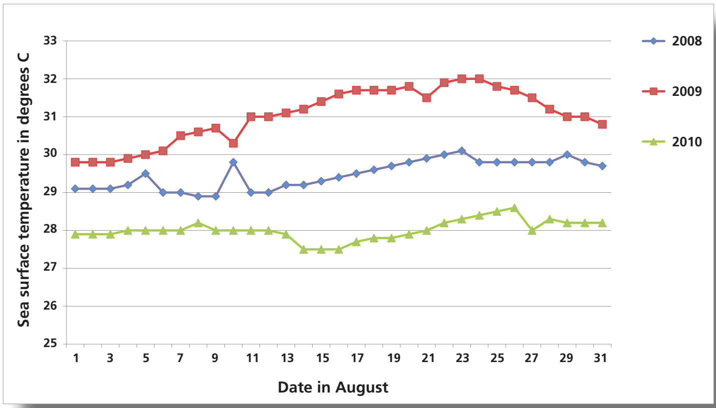


Figure 17
Line graph showing sea surface temperature variation over time; the high temperatures in excess of 31 °C between 14–27 August 2009 coincided with a period of coral bleaching at the sample beach.

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 show

The measurements will show that bleaching occurs during periods of very high and prolonged sea surface temperatures, probably over 30°C, 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 effects this might have on the beach.

Credit: Ruperto Chaparro

High waves at Rincón, Puerto Rico.

10 Wave characteristics

Background

Waves are the main source of energy that cause 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.

Source: adapted from US Army Corps of Engineers, 1981a

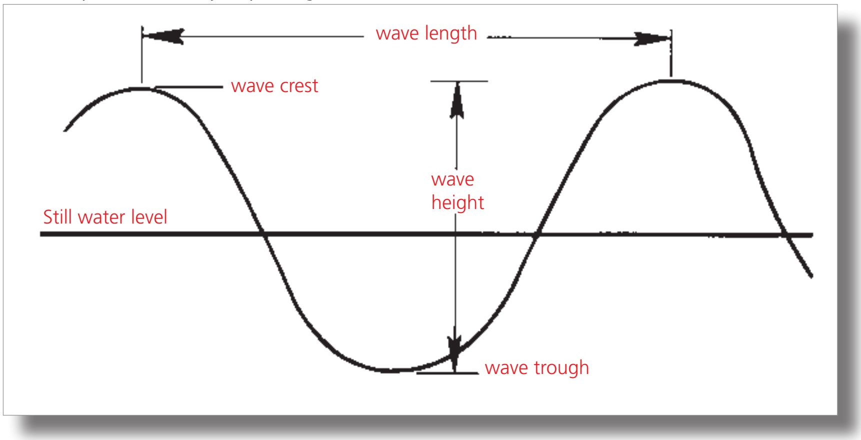


Figure 18 *Characteristics of a wave.*

How to measure

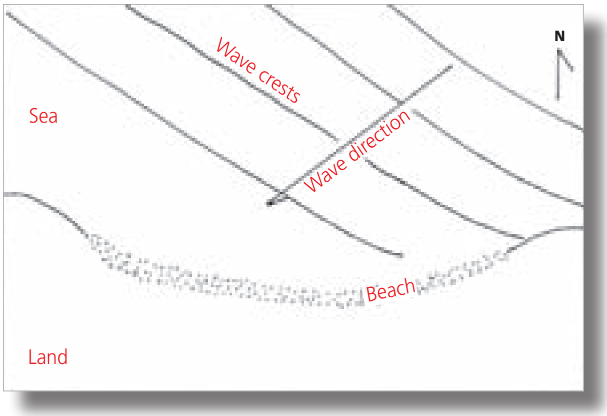
Wave height is measured by having an observer with a graduated staff or a ranging pole (pole with measured sections in red and white) walk out into the sea to just seaward of where the waves are breaking, and then to have the observer record where the wave crest and the following wave trough cut the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

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

Right: Measuring wave height with a wave pole in Fiji.

Wave period is the time in seconds between two successive wave crests. Measure the time for eleven wave crests to pass a fixed object, or if no such object exists, measure the time for eleven waves to break on the beach. Use a stopwatch if available, or a wristwatch with a seconds hand. 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.

Figure 19
Wave direction



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).

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 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).

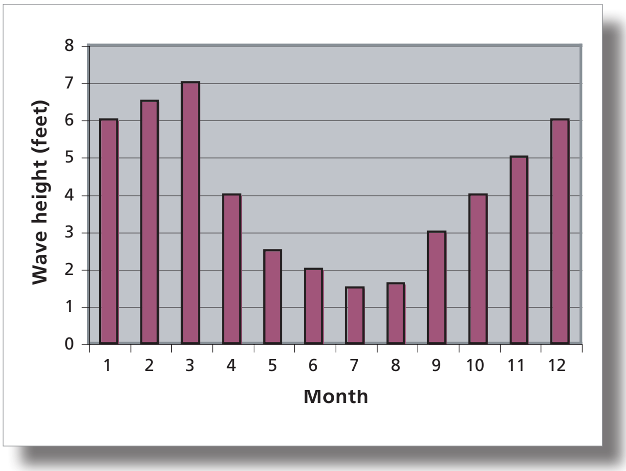
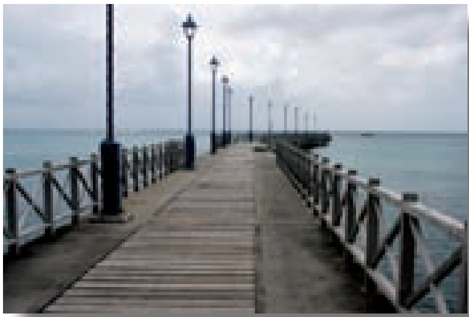


Figure 20
Bar graph showing wave height variations over time.

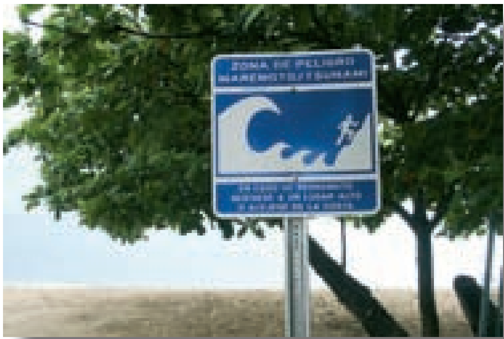
Waves vary according to the time of year. The photo on the left shows calm conditions at Speightstown Jetty in Barbados in July, while the photo on the right shows the same site in high swell conditions in March.



ACTIVITY 10.2 Watching out for a tsunami

Learning about tsunamis

Following the Indian Ocean tsunami that occurred on 26 December 2004, most people are now aware of these phenomena. Tsunamis are extremely high waves caused by earthquakes or huge undersea landslides. They are rare events and 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.



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.)

Recognizing the warning signs

During tsunamis, low-lying coastal areas, those below 6 m (20 ft) in height, may be flooded. Tsunami waves travel very fast (800 km/hr or 500 mph), so 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 (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 your 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 view an aerial photograph of your beach; 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.
- 14 January 2010, large sea swells more than 3 m high affected the beach for two days. No beach users or tourists could go swimming. A lot of sand disappeared and tree roots were exposed, one tree fell down.
- 4 June 2010, a tropical depression affected the island for two 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 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 Database (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 this 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. The information also contributes to the growing inventory about climate change and how it impacts ecosystems locally and globally.

Measuring longshore currents with fluorescent dye.

11 Currents

Background

While waves are the most important process for transporting 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 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

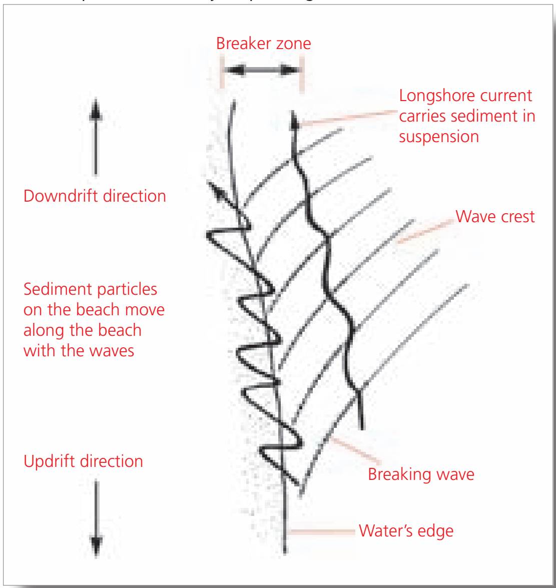
What to measure

When the waves approach a 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).

Figure 21
Longshore currents.

Source: adapted from US Army Corps of Engineers, 1981b



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 9). Together, these provide a picture of the processes that move sand around on the beach.

The longshore current flows in a direction roughly parallel to the beach, near where the waves break. Current speed and direction can be measured: current speed is recorded in feet per second or cm per second and current direction is recorded in degrees.

Figure 22
Effect of a groyne on longshore transport.

Source: adapted from Bush et al, 1995

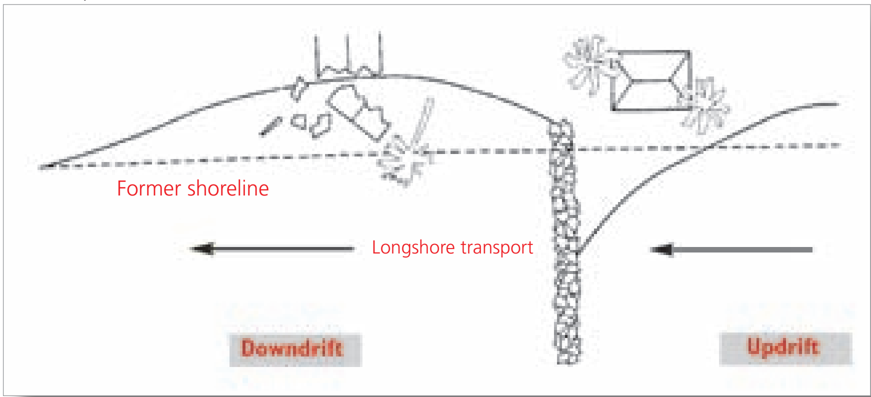


Photo: Groyne at Nisbett Plantation, Nevis. The sand has built up on the updrift side of the groyne in the foreground, while the waves reach further inland on the downdrift side as a result of erosion.

Current direction is the direction towards which the current is moving. So if a current is moving from north to south, the current direction is recorded as south or south-going; similarly, a current moving 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 from the stick into the water 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 after five minutes 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 there is unlikely to be enough time to take daily measurements, weekly or twice monthly measurements will yield some interesting information.

What 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 also be possible 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
Mixed graph showing current speed and direction.

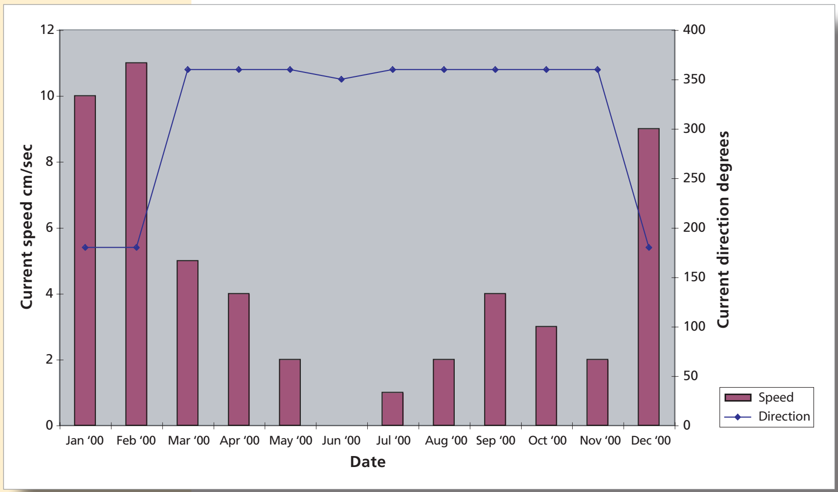


Figure 23 shows current speed and direction based on once/month measurements over a one-year period. The speed was highest in the winter months when the current direction was south-going. While in the middle months of the year, the current speed was lower and the direction of current movement was north-going.

Further activities

Relate the direction of the longshore current to the source of beach material (see also Chapter 6). Some of the material at the monitored beach may have originated from an adjacent beach or coral reef and been 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 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 that students 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 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.*

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 and 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 to adapt and would thus become locally extinct. Survival would depend on migration to cooler areas although such migration may be more difficult for intertidal species than for oceanic species.

Source: Illustration compiled by Aurèle Clemencin

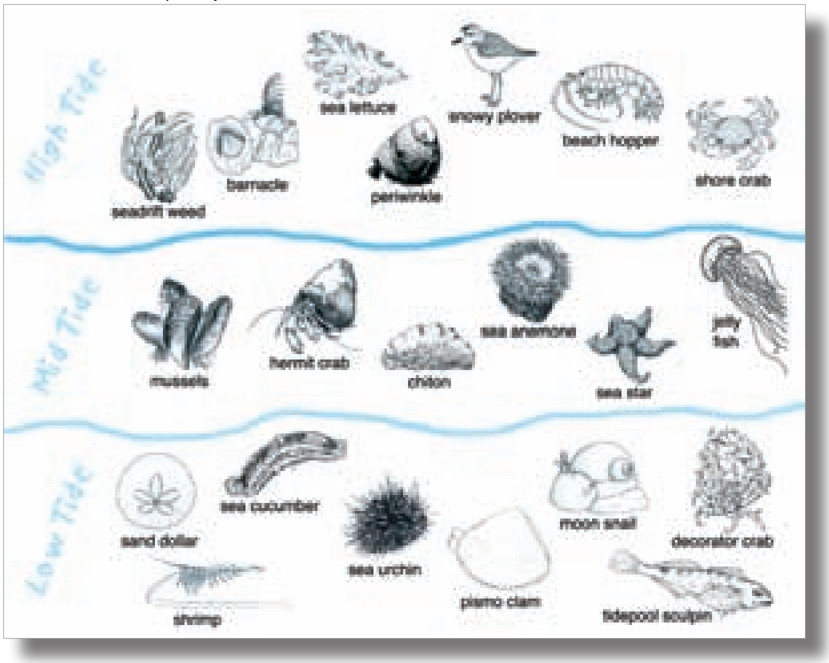


Figure 24 *Common plants and animals found between the high and low water mark.*

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 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.

Figure 25
Simple food chain.

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

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 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.

Source: adapted from Craig, 1984

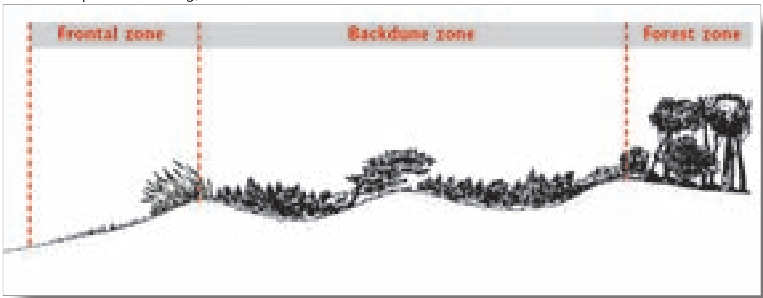


Figure 26
Vegetation succession: the frontal zone is covered with grasses and vines, which gives way to shrubs and herbaceous plants and eventually the coastal woodland.

Left: Coastal forest in Puerto Rico – palm trees and almond trees.

Right: Sea purslane, a low succulent vine colonizing 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 other measures to increase resilience may be more appropriate, e.g. the planting of 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, 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 organizations;
- 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 publicize the activity;
- monitor carefully how many of the seedlings survive over the first six months, and care for the trees, in particular, 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*)

How to measure

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 for natural resource managers.

Right: Turtle tracks at Long Beach, Ascension Island.

Far right: Safeguarding a turtle nest on a busy tourist beach, Bayibe, Dominican Republic.

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:

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

1 *Varela-Acevedo, E., Eckert, K.L, Cambers, G. and Horrocks, J.A. 2009. Sea Turtle Nesting Beach Characterization Manual. 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, US, p.46–97.*

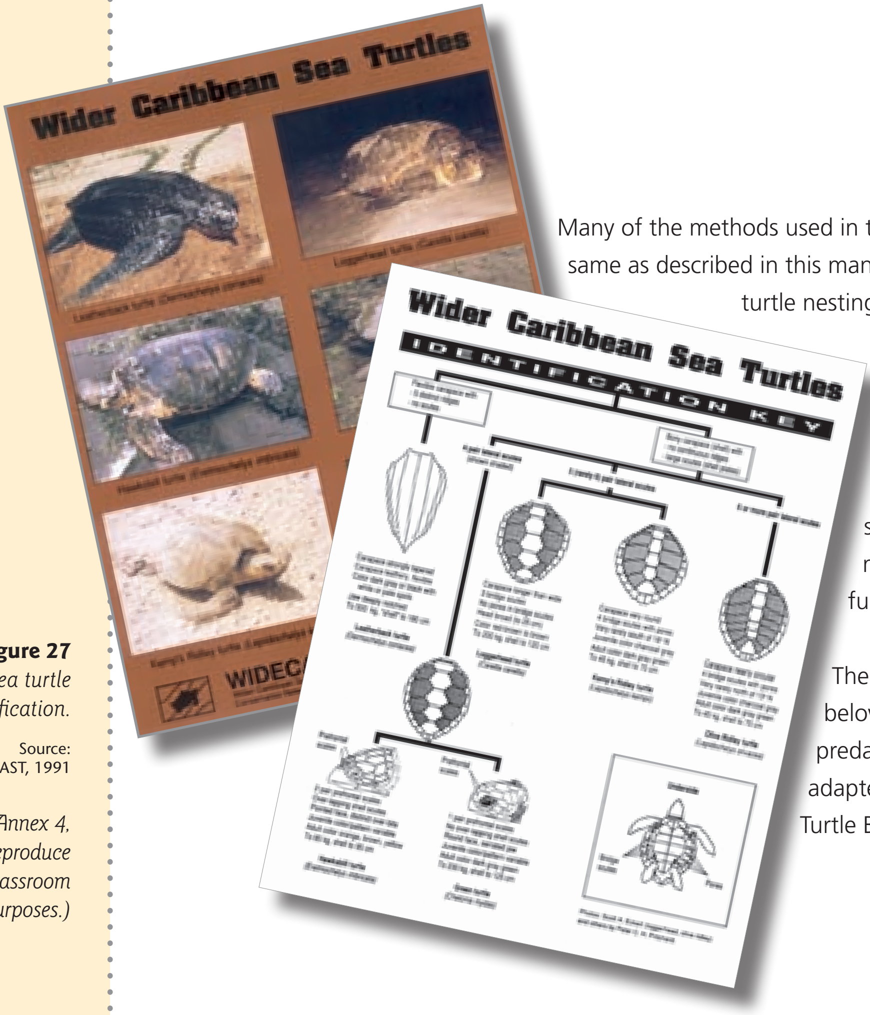


Figure 27
Sea turtle identification.

Source: WIDECAST, 1991

(See also Annex 4, to reproduce for classroom purposes.)

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 garbage.

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.

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 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.

Credit: Paul Diamond

Beach sign demonstrating Hope Town Sandwatch students' project, Bahamas.

13

Creating your Sandwatch network

Background

Sandwatch's greatest strength and asset is that it is an international community of active participants. Each team conducts its monitoring and enters its results in the Sandwatch Database (under preparation), and shares news and photos about Sandwatch activities with the international Sandwatch community and others via the website (www.sandwatch.org) and 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.

Involving 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.

Reaching out to the wider community

Once you have your project established, organize meetings with other schools, faith-based 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 and protecting turtle nesting sites.

Preparing a PowerPoint presentation

This is an excellent tool to use at community meetings to demonstrate 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 is 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 form part of a local or regional science fair or a community event such as an agricultural fair, 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 may be several 'Special Events' where you can display your Sandwatch Team efforts, such as International Coastal Cleanup Day (www.oceanconservancy.org), held every third Saturday in September, International Earth Day – 22 April or World Environment Day – 5 June (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.

Making use of the 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 the media 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. Involving students in writing and producing a short play that can be performed at school and community functions 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 the project 'on the road' to other schools and community events. In addition, if you digitally record the performance you can post it online on your website, YouTube, Facebook or similar forums.

Establishing a project website

The success of Sandwatch and its website is largely due to the responsiveness of its 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 group 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, e.g. 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 of hours of practice. There are a wide variety of easy-to-build website software programs available on the internet, many of which are free. An excellent, easy to use starter program is Microsoft's FrontPage, though there are many other similar, free programs available.

Regardless of which program 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 Sandwatch newsletter, 'The Sandwatcher', has proven to be a highly useful tool for building a global sense of community, sharing information worldwide and generating local and international publicity.

'The Sandwatcher' newsletter is produced regularly in different languages.

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

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. 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.

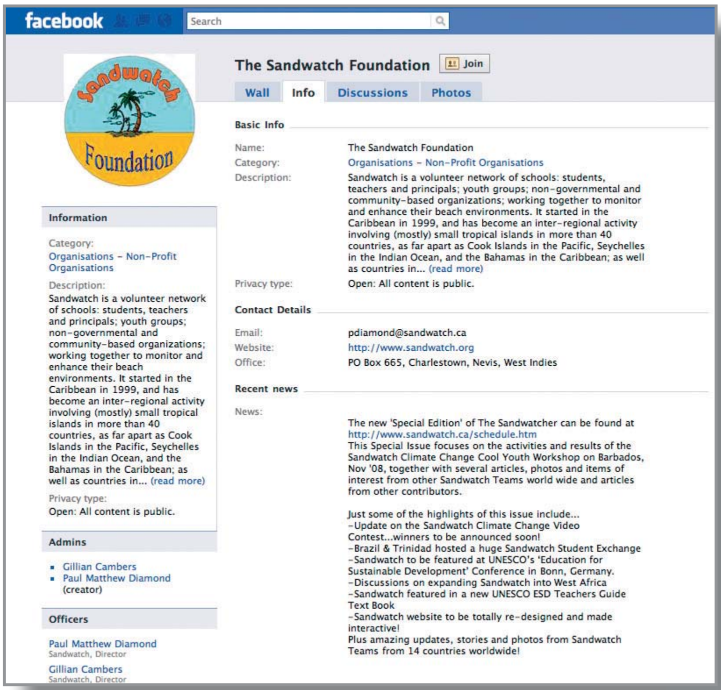
Social networking websites

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

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

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

If you are a member of Facebook, or are considering joining, then simply do a Facebook search using the phrase 'The Sandwatch Foundation', and the forum will appear on your screen. Then simply click on the dialogue box that asks you if you would like to join this group.



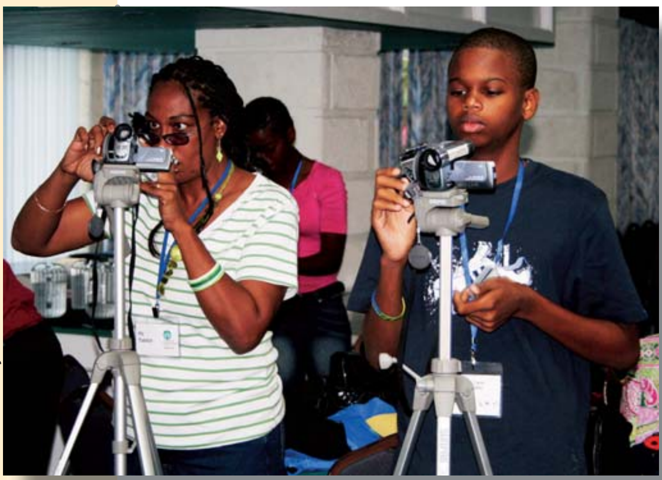
Once a member of the Sandwatch forum you can post photos and web links, ask questions, communicate with other members globally, and receive regular updates on Sandwatch events and activities. You can even post short videos.

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.

Learning to use a video camera at a workshop in Barbados.



Credit: Cha Boyce

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.

'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 with Windows Me, XP and Vista.

If for some reason your Windows computer doesn't have this program pre-installed, you can download it 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, in Movie Maker you add together video clips and audio to make a short movie in almost exactly the same way.

Getting started with Windows 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.

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 program in about 20–30 minutes. It then took about another hour and a 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 program, you may be surprised to learn that you have become inspired to be very creative with your own movies, using them far beyond the goals of Sandwatch.

If you have one or two computer-savvy students, it is recommended that you encourage them to learn how to use Movie Maker 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, Macs come pre-installed with a similar program to Movie Maker, called i-Movie, which is as simple to use as 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. 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-effective alternative available to most Sandwatch participants: video conferencing.

An excellent and free utility for use with Sandwatch and other projects is the free Voice-Over-Internet Protocol (VOIP) application 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 are located in different parts of the world.

As long as your internet connection is reasonably fast (faster than dial-up), for example, using a DSL or Cable modem, and both you and your partner classrooms have web-cams, then setting up a free video conferencing 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 simply click on the persons name to start a free long-distance call. 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.

Demonstrating Windows Movie Maker in Barbados.

Credit: Cha Boyce

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.

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: enabling groups to recruit participants, find sponsors, update the website, create newsletters, organize and coordinate regional workshops and conferences and so much more.

Email can be used to keep in touch with one another, locate new partners and sponsors, and 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 great 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 you to view your country, island and even school yard from satellite images. This can be 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 illustrate some of the different ways that you can use 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 recognition as valued members of a larger community.

Credit: Herman Belmar

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.

14 Taking action

The fourth step of the Sandwatch methodology (Monitoring, Analysing, Sharing, Taking Action) consists of designing, implementing and evaluating a beach-related project to fulfil one or all of the following criteria:

- addressing a particular beach-related issue;
- enhancing the beach; and
- promoting 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 the 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 started 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.

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 the time frame, participants and resources required for each activity.

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 information 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 on 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.

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.

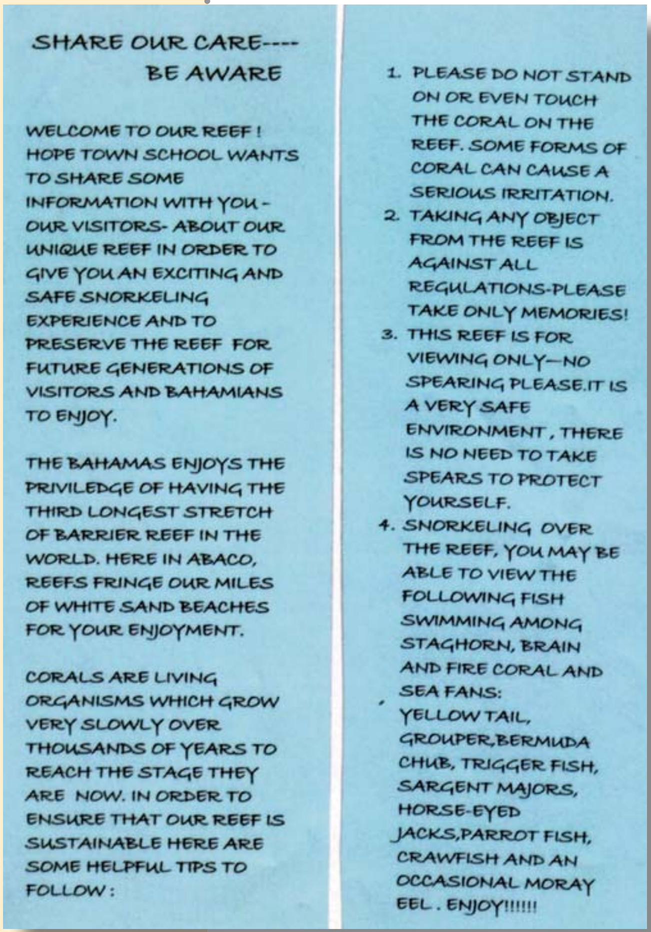
Examples of Sandwatch projects from the Bahamas

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 measuring various beach characteristics and noting 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 different types of beach debris they used their art classes to make decorative items with the discarded material.

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

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.

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



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!!!!!!

Credit: Candace Key

Tourist brochure produced by students at Hope Town Primary School (above left).

Planting the restored sand dunes with sea oats (above right).

Their ***first project*** addressed the particular issue 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 to 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.

There followed several severe hurricanes that eroded the beach and dunes. The government scraped sand from the sea bottom to restore the sand dunes. Their ***second project*** 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.

Four years later the restored sand dune stabilized 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. 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.**

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Glossary

Accretion: accumulation of sand or other beach material due to the natural action of waves, currents and wind; a build-up of sand.

Adaptation (to climate change): refers to adjustment in natural or human systems in response to actual or expected climatic stimuli or their effects, which moderates harm or exploits beneficial opportunities (Intergovernmental Panel on Climate Change).

Algae: class of almost exclusively aquatic plants including seaweeds and their fresh-water allies. They range in size from single cell forms to giant seaweeds several metres long.

Algal bloom: an over-growth of algae in water that shade out other aquatic plants and use up the water's oxygen supply; blooms are often caused by pollution from excessive nutrient input.

Bacteria: mostly microscopic and unicellular organisms with a relatively simple cell structure and lacking a nucleus.

Beach: zone of loose material extending from the low water mark or a point landward where either the topography abruptly changes or permanent vegetation first appears.

Biogenic: originating from living forms.

Breaker: a wave as it collapses on a shore.

Breaker zone: area in the sea where the waves break.

Coliform bacteria: widely distributed micro-organisms found in the intestinal tract of humans and other animals, and in soils.

Coral reef: complex tropical marine ecosystem dominated by soft and stony (hard) corals, anemones and sea fans. Stony corals are microscopic animals with an outer skeleton of calcium carbonate that form colonies and are responsible for reef building.

Cliff: high steep bank at the water's edge, often used to refer to a bank composed primarily of rock.

Climate change: refers to a change in climate attributed directly or indirectly to human activity which alters the composition of the global atmosphere and which is additional to natural climate variability observed over comparable time periods (United Nations Framework Convention on Climate Change).

Climate variability: refers to variations in the mean state and other statistics (such as standard deviations, the occurrence of extremes, etc.) of the climate on all temporal and spatial scales beyond that of individual weather events (United Nations Framework Convention on Climate Change).

Crustacean: animal, usually aquatic, with two pairs of antennae on the head, jointed legs and a hard shell.

Current: flow of air or water in a given direction.

Dune: accumulation of wind-blown sand in ridges or mounds that lie landward of the beach and usually parallel to the shoreline.

Ecology: study of the relationships between organisms and their environments.
Ecosystem: represents a community of plants, animals and micro-organisms that are linked by energy and nutrient flows and that interact with each other and with the physical environment.
Erosion: wearing away of the land, usually by the action of natural forces.

Feldspar: mineral, mixture of calcium, potassium, alumino-silicates.
Fertilizer: substance added to the soil to increase its productivity.
Food chain: shows how each living thing gets its food and how energy is transferred from one organism to another.

Geology: scientific study of the composition, history and structure of the Earth's crust.
Global warming: refers to an average increase in the Earth's temperature, which in turn causes changes in climate.
Greenhouse gases: Any gas that absorbs infra-red radiation in the atmosphere. Greenhouse gases include water vapour, carbon dioxide, methane, nitrous oxide, halogenated fluorocarbons, ozone, perfluorinated carbons and hydrofluorocarbons.
Groyne: shore protection structure built perpendicular to the shore, designed to trap sediment.

Headland: cliff or rock promontory jutting out into the sea.
Hepatitis: disease of the liver.
High water mark: the highest reach of the water at high tide. It is sometimes marked by a line of debris, e.g. seagrass, pieces of wood, line of shells.
Human ecology: an academic discipline that deals with the interrelationship between humans and the entire environment; it is an interdisciplinary applied field that uses a holistic approach to address human-environment-development issues.
Hurricane: intense low-pressure weather system with maximum surface wind speeds that exceed 118 km/hr (74 mph); also referred to as a tropical cyclone or typhoon, depending on the region.

Inorganic: not organic; composed of lifeless matter.

Jetty: structure projecting into the sea for the purpose of mooring boats; also solid structure projecting into the sea for the purpose of protecting a navigational channel.

Limestone: sedimentary rock consisting essentially of calcium carbonate.
Longshore current: a movement of water parallel to the shore, caused by waves.
Low water mark: the highest reach of the water at low tide.

Magnetite: black mineral composed of iron oxide.
Mineral: natural inorganic substance of specific composition found in the earth.
Monitoring: systematic recording over time.

Nitrate: a salt of nitric acid.

Nutrient: any substance assimilated by living things for bodily maintenance or to promote growth; the term is often applied to nitrogen and phosphorus, but may also be applied to other essential and trace elements such as carbon and silica.

Offshore zone: extends from the low water mark to a water depth of about 15 m (49 ft) and is permanently covered with water.

Olivine: green, yellow or brown mineral composed of iron and magnesium.

Pathogen: organism causing disease.

Phosphate: a salt of phosphoric acid.

Pollution: the action of contaminating (an environment) especially with man-made waste.

Quartz: a mineral, oxide of silica, often white.

Sand: rock particles, 0.08–4.6 mm (0.003–0.18 inches) in diameter.

Sand mining: removal of large or small quantities of sand from the beach, by machine or by hand, usually for building purposes.

Saturation: state of containing as much solute as can be dissolved.

Sediment: particles of rock covering a size range from clay to boulders.

Seagrass bed: area of the offshore sea-bottom colonized by seagrasses.

Septic tank: outdoor tank in which sewage is broken down by bacteria.

Shore: narrow strip of land in immediate contact with the sea.

Shrub: plant with woody stems branching from the root.

Silica: hard white or colourless mineral with a high melting point.

Silt: fine rock particles, 0.004–0.08 mm (0.00015–0.003 inches) in diameter.

Surf zone: area between the water's edge and the wave breakpoint.

Suspended matter: particles moving in suspension in the water.

Swell: waves that have travelled out of the area in which they were generated.

Tar: thick, black sticky material obtained from the destructive distillation of coal.

Tar balls: small pieces of tar, often shaped like balls.

Tide: periodic rising and falling of large bodies of water resulting from the gravitational attraction of the moon and sun acting on the rotating Earth.

Topography: configuration of a surface including its relief and the position of its natural and man-made features.

Transect: a line cut across (a beach).

Translucent: permitting partial passage of light; not completely transparent.

Tropical storm: low-pressure weather system with maximum surface wind speeds between 61 km/hr and 118 km/hr (38 mph and 73 mph).

Tsunami: a series of giant waves generated by submarine volcanic eruptions, earthquakes and landslides that can rise to great heights and catastrophically inundate low-lying coastal areas.

Turbidity: reduced water clarity resulting from the presence of suspended matter.

Vegetation edge: place where the vegetation (e.g. grasses, vines) meets the bare sand area of the back beach.

Vine: slender stemmed plant that climbs or trails.

Virus: organism smaller than bacteria, causing infectious diseases in plants and animals.

Watershed: geographically defined region within which all water drains through a particular system of rivers, streams or other water bodies.

Wave breakpoint: the point where waves break.

Wave direction: direction from which waves approach the shore.

Wave height: the vertical distance between the wave crest and the following wave trough.

Wave period: time period of the passage of two successive crests (or troughs) of a wave past a specific point.

Wind waves: waves formed in the area in which the wind is blowing.

Annex 1

Sandwatch equipment

Most of the Sandwatch measurements described in Chapters 3–12 can be undertaken with easily available equipment:

- pen and paper for recording;
- tape measure;
- magnifying glass;
- plastic bags;
- disposable gloves.

Other useful equipment includes a digital camera, or a cellular phone with an inbuilt camera.

If funds are available the following specific materials can be purchased (these items are available from large international environmental equipment suppliers, such as those that exist in the USA and other large countries. Prices are approximate, in US$ and relate to 2009 costs):

1. Water quality kits suitable for use by students and community groups to measure temperature, salinity, dissolved oxygen, biochemical oxygen demand, pH, nitrates, phosphates, coliform bacteria in brackish and salt water. For example, a GREEN Program Estuary Monitoring kit is offered by Forestry Suppliers (www.forestry-suppliers.com), with enough chemicals and reagents for 10 samples. Cost US$45

2. Dye tablets to measure currents. Cost for 200 tablets US$40

3. Folding pocket magnifying glass. Cost US$3

4. Tape measure, 30 m, fibreglass. Cost US$30

5. Hand-held compass, Cost US$25.

6. Digital stop-watch. Cost US$25.

7. Hardboard clipboard. Cost US$2.

8. Hand-held wind meter. Cost US$ 20.

However, Sandwatch groups around the world have found innovative ways of improvising and making their own equipment. Some examples are given in the table overleaf.

Substitutes for Sandwatch equipment

Sandwatch activity	Equipment required as listed in the Sandwatch manual	Substitute equipment
Chapter 2 Weather and climate	Graduated cylinder or measuring cup; thermometer; wind meter; compass	
Chapter 4 Observing and recording	No special equipment; digital or disposable camera useful but not essential.	
Chapter 5 Erosion and accretion	30 m tape measure; abney level/ clinometer and 2 ranging poles for Activity 5.3	Any tape measure can be used here; Discarded wood on the beach, e.g. lengths of bamboo can be substituted for ranging poles, or lengths of PVC pipe.
Chapter 6 Beach composition	Hand-held lens; plastic bags to collect the sediment; clear plastic sheet on which to spread the sand; tape measure; egg; vinegar.	Any magnifying glass can be used here. Plastic containers can be modified for sieving sand (see Activity 6.4).
Chapter 7 Human activities on the beach	No special equipment	
Chapter 8 Beach debris	Tape measure; disposable gloves; garbage bags.	
Chapter 9 Water quality	Simple kit to measure temperature, salinity, dissolved oxygen, biochemical oxygen demand, phosphates, nitrates, coliform bacteria, turbidity; thermometer.	A Secchi disk can be made from a piece of wood or metal and used to measure water clarity, which also indicates turbidity (see www.mlswa.org/secchi.htm).
Chapter 10 Wave characteristics	Wave pole; stopwatch; compass.	A wave pole can be made using a piece of wood or bamboo and marking 10 cm intervals; a watch with a seconds hand can be substituted for a stopwatch.
Chapter 11 Currents	Dye tablets; tape measure; stopwatch.	Food colouring can be substituted for dye tablets; a watch with a seconds-hand can be substituted for a stopwatch
Chapter 12 Plants and animals	Plastic bags; magnifying glass; tape measure; metre square quadrat.	A metre square quadrat can be made with PVC pipe

Annex 2

Method for measuring and analysing beach profiles

Measuring beach profiles is an ideal activity for science-based assessments and science fair projects. Beach size often changes so quickly – in a matter of days – that interesting results can be guaranteed in a short time period. Furthermore, the information gathered may also be useful for environmental management and planning authorities who need such information when planning new developments, but rarely have the resources themselves to collect the data.

Field methods

The monitoring consists of surveying the beach profile from a fixed point set up behind the beach. The fixed point is called the reference mark and is the starting point for the measurement. The reference mark is usually a painted square on a wall or tree. (Ultimately, permanent surveying monuments may be constructed which should withstand hurricanes better than the trees or buildings.) It is essential to always start the beach profile measurement at the reference mark. The profiles run at right angles across the beach and in most cases specific orientations for the beach profiles are determined. Photographs should be taken of the reference marks.

When to measure

The beach profile at each location should be measured every three months. This will give four data sets a year and will adequately cover seasonal changes. However, this is only a guide, and depending on the time available, the frequency of monitoring can be increased or decreased. If the profiles are set up in May 2010, subsequent measurements are due in August, November 2010, February and May 2011, and so on. In addition, the beach profiles should be re-measured as soon as possible after a major event such as a tropical storm or hurricane.

Preparations for going in the field

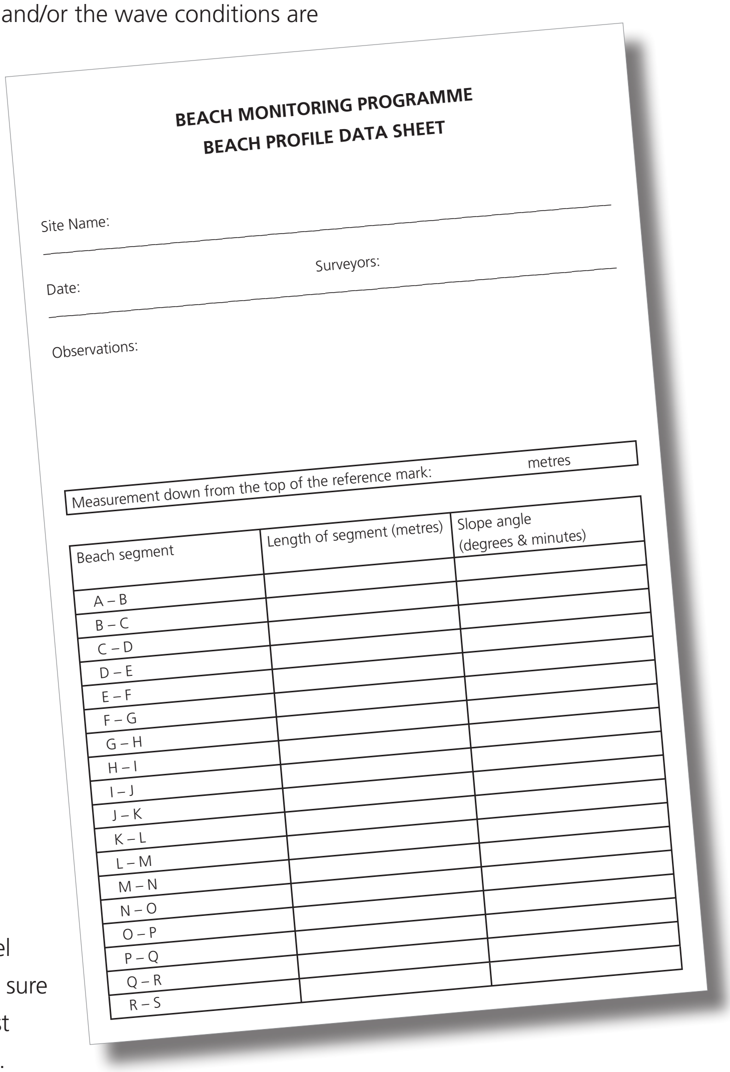
- Prepare data sheets; a standard data form is shown in Figure A.
- Gather together the equipment: data sheets, clipboard, pencils, Abney level, tape measure, ranging poles, masking tape, camera loaded with film, spray paint.
- Prepare a plan for which beaches are to be measured on that day and in which order.
- Arrange transport for the field work.

Field measurements

a) On arrival at the beach site, locate the reference mark.

b) Lay out the profile in segments, place a ranging pole at each break of slope, ensuring the line of the profile follows the fixed orientation. The end point of the profile is the offshore step. This is near where the waves break and there is usually a marked downward step. If no offshore step exists at that location or time, and/or the wave conditions are too rough, just continue the profile as far into the sea ***as safety permits***.

Figure A *Beach monitoring data form.*



BEACH MONITORING PROGRAMME
BEACH PROFILE DATA SHEET

Site Name:

Date: Surveyors:

Observations:

Measurement down from the top of the reference mark: metres

Beach segment	Length of segment (metres)	Slope angle (degrees & minutes)
A – B		
B – C		
C – D		
D – E		
E – F		
F – G		
G – H		
H – I		
I – J		
J – K		
K – L		
L – M		
M – N		
N – O		
O – P		
P – Q		
Q – R		
R – S		

c) Write the beach name and date on the data form, as well as the names of the field personnel. (If using a number system for the sites, it helps to add a location, e.g. 'Grand Bay #1, southern site'.) This reduces the possibility of error when the data are entered in the computer.

d) Measure the vertical distance from the ***top*** of the reference mark to the ground level with the tape measure. Measure to the nearest cm. Record all measurements in metric units. Write the measurement down on the form.

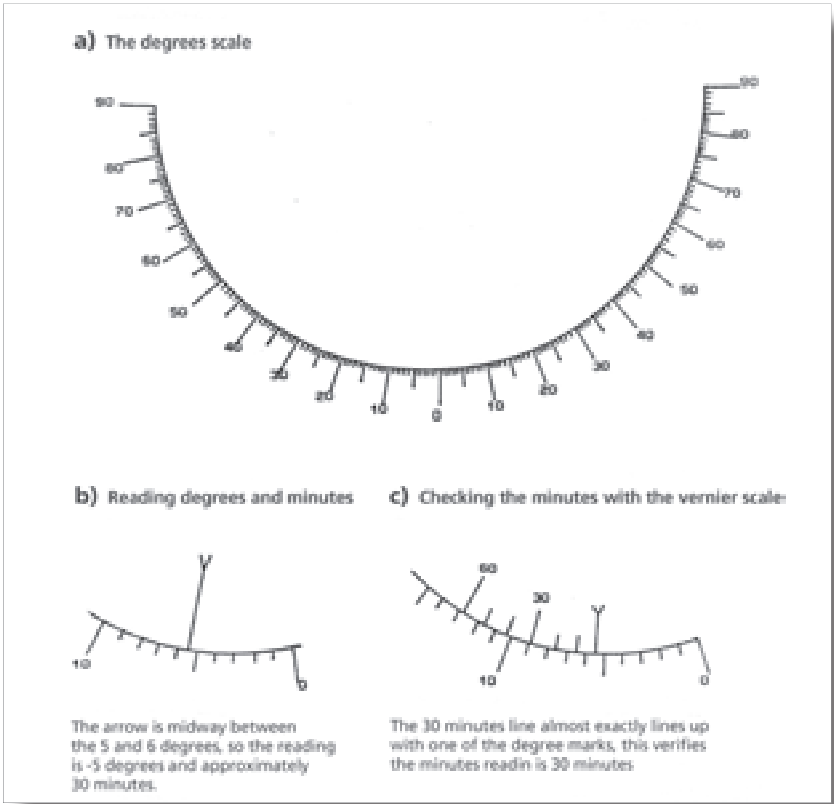
e) Measure the observer's eye level on both ranging poles, making sure that the surface of the sand just covers the black tip of the pole.

f) Place the ranging pole at the first break of slope always ensuring that the surface of the sand just covers the black metal tip of the pole. Check the profile alignment and re-position the pole if necessary. Always ensure the pole is vertical.

g) The observer stands by the reference mark and uses the Abney level to sight onto his/her eye level on the ranging pole.

h) To read the Abney level refer to Figure B. As can be seen from the first drawing, the Abney level is divided into degrees; every 10 degrees is numbered. Readings to the left of the zero are negative or downhill; readings to the right of the zero are positive or uphill. To read the angle, determine where the arrow intersects the degrees scale. In the example, drawing b), the arrow falls midway between -5 and -6 degrees. So the degrees would be recorded as -5 degrees. Since the arrow falls approximately midway between -5 and -6 degrees, it is likely that the minutes reading is about 30 minutes. To check the minutes, use the vernier scale. For a downhill slope use the vernier lines to the left of the arrow. These are at 10 minute intervals and the 30 and 60 minute lines are numbered. Determine which of the vernier lines most closely intersects one of the degree lines below. In this case the 30 minute vernier line almost exactly lines up with the degree line below, so the vernier reading will be 30 minutes. So this reading will be recorded as -5 degrees 30 minutes.

Figure B
Reading the Abney level.



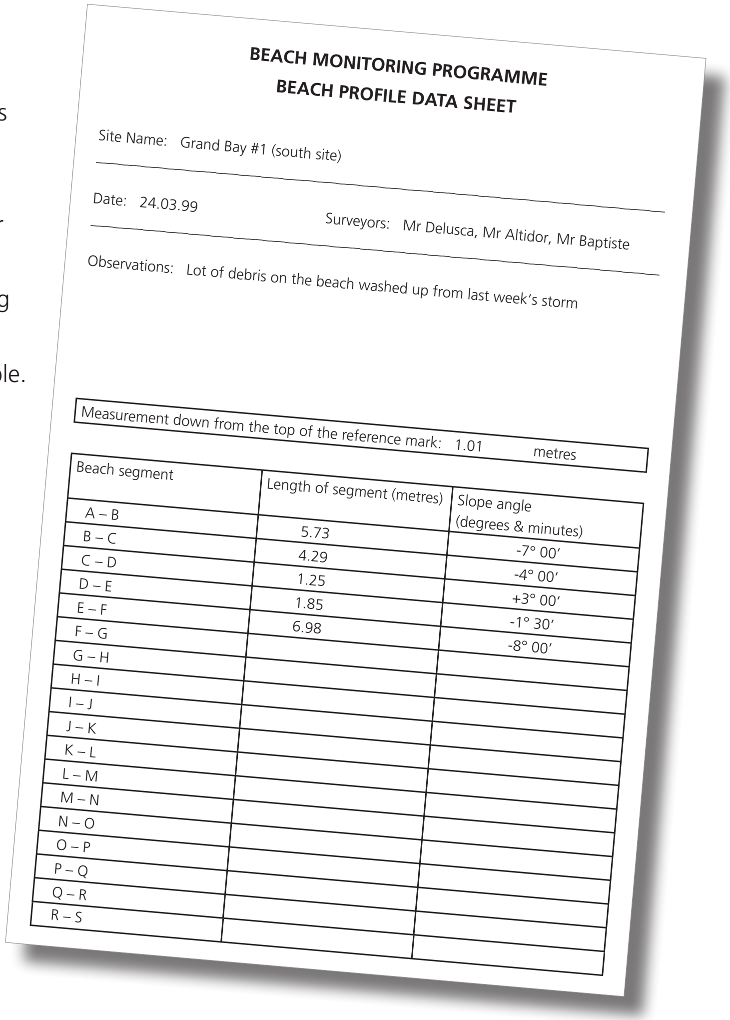
i) Record the segment slope in degrees and minutes, to the nearest ten minutes on the data sheet. Always remember to record whether it is a plus or a minus slope (plus is an uphill slope, minus is a downhill slope).

j) Measure the ground distance from the base of the reference point to the first ranging pole with the tape measure, to the nearest cm; record this measurement on the data form. Measure along the slope, not the horizontal distance.

k) The observer then proceeds to the ranging pole at the first break of slope and sights onto the ranging pole which has been placed at the second break of slope – remember to check for profile alignment – and repeats steps g) through j). This is continued until the endpoint of the profile, see step b).

l) Ensure all measurements are recorded clearly. Figure C shows a completed data form.

Figure C
Completed data form.



BEACH MONITORING PROGRAMME
BEACH PROFILE DATA SHEET

Site Name: Grand Bay #1 (south site)

Date: 24.03.99 Surveyors: Mr Delusca, Mr Altidor, Mr Baptiste

Observations: Lot of debris on the beach washed up from last week's storm

Measurement down from the top of the reference mark: 1.01 metres

Beach segment	Length of segment (metres)	Slope angle (degrees & minutes)
A – B	5.73	-7° 00′
B – C	4.29	-4° 00′
C – D	1.25	+3° 00′
D – E	1.85	-1° 30′
E – F	6.98	-8° 00′
F – G		
G – H		
H – I		
I – J		
J – K		
K – L		
L – M		
M – N		
N – O		
O – P		
P – Q		
Q – R		
R – S		

m) Record on the data sheet under 'Observations' anything else of interest, e.g. recent sand mining pits, evidence of recent storms etc.; take photographs if possible.

n) As the paint squares (reference marks) begin to fade, touch them up with spray paint.

o) Collect all equipment and return to vehicle and proceed onto the next site.

p) Should a reference mark be lost due to a particularly severe storm or due to human action in cutting down a tree etc., establish a new reference mark as near as possible to the old one.

q) If there have been very significant changes at a beach, perhaps due to heavy seas or human activity, then take photographs of the beach.

On return from the field

- Check each data sheet, make sure it is complete, and place it in a binder or folder. It is advisable to set up a binder/folder for each site. Keep the binders/folders safely.
- Wash sand out of the tape measure in fresh water, leave to dry and rewind.
- Check the Abney level; if it has any sand on it, wipe it carefully with a soft cloth.
- Store equipment carefully for future use.

Data analysis

This methodology and computer program was prepared by Gillian Cambers and David F. Gray, with the support of the University of Puerto Rico Sea Grant College Program (MRPD-11-75-1-98), November 1999, and is available free on request from the Sandwatch Foundation (www.sandwatch.org).

This section describes the main routines of the computer program, Beach Profile Analysis (***Profile***). It draws the beach profile to scale and then determines the cross-sectional area and beach width. The program can display and print graphs of the profiles and superimpose up to eight profiles on top of each other. Tables showing changes in beach size over time can also be prepared and graphs plotted showing the resulting trends.

The computer program has been written for the Windows operating system and works on Windows 95 and newer versions. It contains fully compiled 'Help' files. This manual refers to Version 3.2, January 2000, and outlines the main routines.

Getting started

Enter the data promptly: It is always recommended that field data be entered on computer as soon as possible after the field measurements. This avoids the possibility of losing data sheets and personal memory of the beach conditions is clearer. In addition, the team can see the results and perhaps make changes to the monitoring programme in a timely manner, e.g. if a particular beach is showing very significant changes it may be advisable to add another site where profiles are to be measured, or to increase the frequency of measurement.

Each site should have its own data file: Each beach site has its data entered in a separate file. So the site at Grand Bay North will have its own data file and the site at Grand Bay Central will have a separate data file.

Furthermore, if the reference point is lost at Grand Bay North (file name Grand Bay North 1), possibly as the result of a hurricane, and a new reference point is selected, then a new file will have to be established; this will then have the file name Grand Bay North 2.

The main parameters – profile area and profile width: First of all, a note about what the parameters really measure. The program draws the beach profile to scale and then determines the area under the profile mathematically in square metres (m^2). The program also determines the profile width in metres (m).

Starting the program: Go to '*My Computer*' and select the drive where the program (*Profile*) has been installed. Select *Profile* and you will see an opening screen and at the top left hand corner, a ***main menu*** with four selections as follows:

Site File	Profile	Selection	Help
New	New	By year	Contents
Open	Delete		Index
Save	Uncheck all profiles		About
Save As	Fix all drops		
Close			
Options			
Print			
Printer Set-up			
Exit			

The sub-menu: As you work through the routines in the main menu, you will see a sub-menu appear about a third of the way down the screen on the left-hand side. (To see this sub-menu, select '*Site file*' from the main menu, select '*New*', then select '*Profile*' from the main menu, and select '*New*'.) This sub-menu has four options:

- Profile sub-menu: this is where the data is entered and quality control functions are performed.
- Profile graphs sub-menu: this is where the graphs for each profile are displayed and can be printed or transferred to other programs.
- Table sub-menu: this is where the values for profile area and profile width are listed in a table and annual mean values calculated.
- Table graphs sub-menu: this is where the values for profile area and width are shown graphically over time, either as actual values (in line graphs) or mean values (in bar graphs).

Profile sub-menu – entering data and quality control

Establishing a new site: At the opening screen, select '*Site File*' from the main menu and then select '*New*'. In the box by '*Description*', type the name of the beach site, e.g. Grand Bay South 1. Then select '*Profile*' from the main menu, and select '*New*'. The screen will show a blank spreadsheet where the data for the first profile for a new site, e.g. Grand Bay South 1, can be entered.

Entering the data for the first profile: Start by entering the date when the first profile at the site was measured. The box by '*Profile date*' shows today's date. To enter the date the profile was measured, click on the figures in the box by '*Profile date*' and enter the appropriate date (month/day/year). Alternatively, select the arrow by the side of the '*Profile date*' box, and a calendar will be displayed. The month and year can be changed by selecting the arrows at the top left or right on the calendar; the day can be selected by just clicking on the correct day.

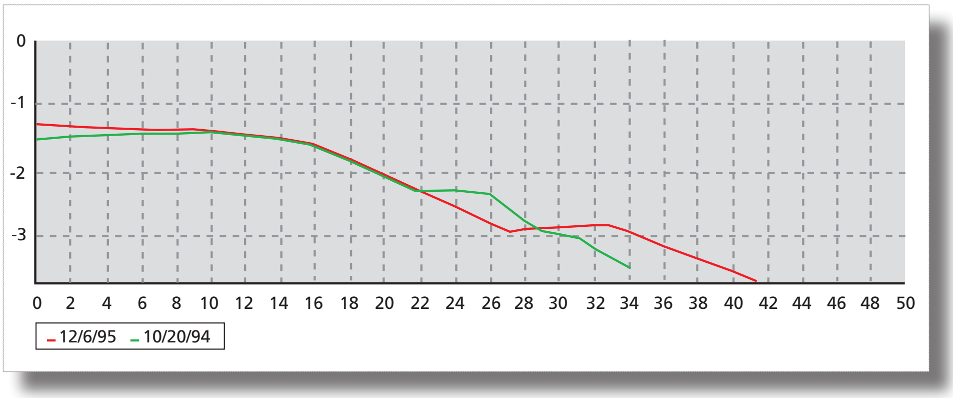
Enter the distance down from the top of the reference point to the ground surface: Next, go the box below '*Profile date*' labelled '*Distance – reference point to surface*.' Enter the distance down from the top of the reference point to the surface that was recorded on the field sheet.

Enter the distance and slope measurements: Now, enter the profile data – the distance and slope measurements for each segment. To move around the spreadsheet use the arrow or Tab keys. For the first segment, a–b, enter the distance measurement in the column with the heading '*Distance metres*', enter the degrees in the column with the heading '*Angle degrees*' and enter the minutes in the column with the heading '*Angle minutes*'. The program assumes the numbers are positive, so if a negative slope was recorded, e.g. -7° 30′, enter -7 in the '*degrees*' column and 30 in the '*minutes*' column. If the slope measurement is -0° 30′, mathematically minus zero does not exist, so enter 0 in the degrees column and -30 in the minutes column. Enter all the data for that profile.

Computation of the area and width values: As you enter the data, the program will calculate the cumulative horizontal and vertical values, so you will notice the figures in the columns labelled '*Cumulative Horizontal*' and '*Cumulative Drop*' change. You do not have to enter any values in these columns. The spreadsheet shows the profile area and profile width in two boxes at the bottom left of the screen labelled '*Area*' and '*Width*'.

Fixing the standard total vertical drop: The 'standard total vertical drop' finalizes the end point of the profile. A particular profile always has the same starting point – the reference point or paint square. However, profiles end in the sea by the 'offshore step'; this is a variable point which changes with the wave conditions. Reference to Figure D shows a hypothetical first profile measurement (green line) with a total vertical drop of 3.5 m. However, during the second measurement of the profile (red line) three months later, the offshore step had moved and the total vertical drop was 3.7 m. To compare the two profiles mathematically, the starting point and the end point of the profile have to be the same. In order to do this, the total vertical drop of the first profile at a site becomes the standard and the program will adjust all subsequent measurements at the site to the standard either by adding or deleting a section to the final slope segment. The first profile (green line) had a total drop of 3.5 m. This value of 3.5 m becomes the standard total vertical drop for this site. The second profile at this site (red line) had a total drop of 3.7 m. So when 'Fix Drop' is selected, the program will cut off a small portion of the bottom of the second graph (red line), so that the total drop remains 3.5 m.

Figure D
Finalizing the profile end point.



Setting the standard vertical drop: Once the data for the first profile at a site have been entered, it is necessary to set the standard total vertical drop. If the final segment of the first profile is f–g, ***move the cursor down to the next line***, g–h, and note the value in the column with the heading '*Cumulative Drop*'. Enter this value in the box labelled '*Standard total vertical drop*'. (This box is located near the top of the screen below the box labelled '*Description*'.)

Adjusting the drop for subsequent profile measurements: For subsequent profile measurements at this site, the program will standardize the total vertical drop (profile end point) when the '*Fix Drop*' box is selected. For example, when entering the data for the second profile measurement at a site, after the data are all entered, click on the '*Fix Drop*' box (located below the '*Distance – reference point to surface*' box). The program will adjust the distance measurement of the final segment accordingly, and also make the necessary adjustments to the profile area and profile width values.

Saving the file for the first time: From the main menu, select '*Site File*', then '*Save As*'. In the box by '*File Name*', type the name of the file (e.g. Grand Bay South 1 in our example) and select '*Save*'. Before doing this, you may wish to set up a separate folder to store all your beach data files.

Closing the site file: From the main menu, select '*Site File*', then '*Close File*', the program returns to the opening screen. If you have not saved your data or changes, the program will ask you whether you want to save them, select '*Yes*' or '*No*' accordingly.

Exit the program: From the main menu, select '*Site File*', then '*Exit*'. If you select '*Exit*' without saving your changes, the program will ask you if you want to change your changes, select '*Yes*' or '*No*' accordingly.

Entering the data for the second profile: From the main menu '*Site File*', select '*Open*'. Select the folder where the beach data is stored. The program will list the files; select the appropriate file then select '*Open*'. The screen will show the spreadsheet for the most recent measurement at this site. From the main menu, select '*Profile*', then '*New*'. The screen will show a blank spreadsheet. Enter the data for the second profile as described earlier. Once all the data have been entered, select '*Fix Drop*', this will standardize the profile endpoint.

Select '*Site File*' from the main menu and '*Save*' to save the second set of measurements. However, if you try to close the file or exit the program without saving the data, a check box will automatically appear asking if you want to save the changes.

When you have finished entering the data for second profile measurements, a box may appear on screen telling you to check the data.

Displaying spreadsheet data for different dates: From the main menu '*Site File*', select '*Open*'. Select the folder where the beach data is stored. The program will list the files; select the appropriate file and select '*Open*'. Go to the box at the top right-hand side of the screen showing the dates of the profile measurements. Click on the date you wish to view (use the up/down arrows to see further dates) and the screen will display the spreadsheet for that date.

Deleting a profile spreadsheet: To delete a profile spreadsheet, first of all display the spreadsheet you wish to delete on the screen. Once it is displayed, select '*Profile*' from the main menu, then select '*Delete*'.

Printing the spreadsheet: To print a spreadsheet, select '*Site File*' from the main menu, then select '*Print*'. Click on the box by '*Include profiles*' and a tick mark will appear, then select '*All*' (to print all the profile spreadsheets in the file), and '*Current*' (to print the profile spreadsheet displayed) or '*Selected*' (to print the profile spreadsheets you have selected by ticking the boxes to the left of the dates – displayed at the top right of the screen). Click on '*OK*' and the spreadsheet(s) will be printed.

Data quality control: After the data for a new profile at a particular site have been entered, then as you select '*Fix Drop*', a box may appear on the screen warning you that the new data set is significantly different to the average for the previous twelve months. Select '*OK*' and *then check your data entries* making sure the data are entered accurately, and correct any mistakes. In particular, check whether you have entered negative slopes correctly.

The quality control has been set at 20%, i.e. if the profile measurement varies by more than 20% from the average of the measurements for the previous twelve months, the quality control check box will appear. At most sites there are only small changes from profile to profile, so 20% is reasonable. However, at some high energy beaches, changes may be of considerable magnitude from one measurement date to the next, so it may be advisable to change the quality control percentage setting for the data files for these sites.

To change the quality control percentage setting, select '*Site File*' from the main menu, then '*Options*' and change the percentage value accordingly in the box by '*Check percent for area and width*'.

Establishing an actual datum height for the reference point: If an absolute height is established for the reference point (using surveying techniques to tie in the reference point to a known datum), this can be displayed on the profile graph. Select '*Site File*', '*Options*', '*Have datum height for reference point*' and '*OK*'. A box will appear under '*Standard total vertical drop*' named '*Datum height for reference point*'. Enter the actual height in this box. The spreadsheet will then show another column under '*Cumulative*' named '*Height*'. When the '*Profile Graphs*' sub-menu is selected, the profile will be displayed with the absolute height of the reference point.

Profile graphs sub-menu – display and print the graphs

After opening a data file, from the program sub-menu select '*Profile graphs*'. The screen will show the graph for the current spreadsheet. The following section describes how to display, alter, save and print the graphs.

'Max. horizontal for the graph': This box is located in the top mid-section of the screen below and to the right of the box for '*Standard total vertical drop*'. This sets the maximum distance for the 'X' axis on the graph. To change the setting, delete the figures displayed in the box and substitute a new value.

'Current': This is the box at the bottom left of the screen and allows you to display the graph for the current spreadsheet.

'Selected': This box is to the right of '*Current*' and allows you to select up to a maximum of eight profiles to show on one graph. To select the profiles you want, go to the box at the top right-hand corner of the screen where the dates of the profile measurements are listed. Check the profile dates you wish to display on the screen by clicking on the box next to the desired date; a tick mark will appear in the box. (To uncheck a date, click on the tick mark. To uncheck all the profiles, select '*Profile*' from the main menu and select '*Uncheck all profiles*'.)

'Top': This box is to the right of '*Selected*', next to a box with a number and an up/down arrow. This allows you to select the top (up to a maximum of eight) profiles to show on the graph. By changing the number in the box you can select the top 2, 3, 4, etc. profiles to display on the graph.

'Print': The program will print the graph displayed on the screen.

'Copy': This copies the displayed graph to the clipboard; you can then paste it into a word processing program such as Microsoft Word.

'Save': This saves the graph as a BITMAP (BMP) file. A box appears on the screen asking you to confirm the file name. This file can then be inserted as a picture in a word processing program, e.g. Microsoft Word.

'Markers': This box to the right of '*Save*' inserts markers onto the displayed profiles.

'B & W': This box, below '*Markers*' allows you to display the graph in colour or in black and white.

'Adjust scale': This box to the right of '*B & W*' has two boxes to the right, '*Vert*' and '*Hor*'. These allow you to adjust the vertical exaggeration of the graph and the size of the graph.

Table sub-menu – list values and annual means for profile area and width

For each profile, the profile area and width are displayed on the spreadsheet screen. It is also possible to display a table showing the profile area and profile width for each measurement date. To do this, select '***Table***' from the sub-menu. This table shows the profile area and width value for each date as well as the mean value for each year. This enables determination of long-term trends where seasonal changes are averaged out.

To print the table, select '***Site File***' from the main menu, then '***Print***'. Click on the box by 'Include table', a tick mark will appear, then click on '***OK***' and the table will be printed. (Make sure to uncheck the '***Include profiles***' box.)

Table graphs sub-menu – graphs showing changes over time

This function graphs the values of profile area and/or width over time.

'Profiles': This shows a line graph of the values for profile area and/or width over time. To select profile area only, place a tick in the '***Areas***' box; to select profile width only, remove the tick marks in the '***Areas***' box and tick the '***Widths***' box. To display both profile area and profile width values on the same graph, place a tick in both the '***Areas***' box and the '***Widths***' box.

'Means': This displays a bar graph of the mean annual values for profile area and/or profile width over time. To display profile area or profile width mean values separately, tick the '***Areas***' or '***Widths***' box accordingly.

'Show only selected years': This allows you to show a line graph or a bar graph for selected years only. Go to '***Selection***' on the main menu, select '***By year***', enter the first and last years of your selection in the boxes by '***Show***', click on '***Select profiles***' and '***OK***', then click on the box below the graph by '***Show only selected years***'. The graph will then display the values for the time period you have selected.

'Print': The program will print the graph displayed on the screen.

'Copy': This copies the displayed graph to the clipboard; you can then paste it into a word processing program.

'Save': This saves the graph as a BITMAP (BMP) file. A box appears on the screen asking you to confirm the file name. This file can then be inserted as a picture in a word processing program, e.g. Microsoft Word.

'Markers': This box to the right of '***Save***' inserts markers onto the displayed profiles.

'B & W': This box, below '***Markers***', allows you to display the graph in colour or in black and white.

ANNEX 3

BEACH CLEANUP DATA CARD

Thank you for completing this data card. Answer the questions and return to your area coordinator or to the address at the bottom of this card. This information will be used in the Center for Marine Conservation's National Marine Debris Data Base and Report to help develop solutions to stopping marine debris.

Name ______________________ Affiliation ______________________

Address ______________ Occupation ______________ Phone (______) ______________

City ______________________ State ______ Zip __________ M____ F____ Age: ______

Today's Date: Month: ______ Day ______ Year ______ Name of Coordinator ______________

Location of beach cleaned ______________________ Nearest city ______________________

How did you hear about the cleanup? ______________________________________

SAFETY TIPS

1. **Do not go near any large drums.**
2. **Be careful with sharp objects.**
3. **Wear gloves.**
4. **Stay out of the dune areas.**
5. **Watch out for snakes.**
6. **Don't lift anything too heavy.**

WE WANT YOU TO BE SAFE

Number of people working together on this data card ______ Estimated distance of beach cleaned ______ Number of bags filled ______

SOURCES OF DEBRIS: Please list all items with foreign labels (such as plastic bleach bottles from Mexico) or other markings that indicate the item's origin (such as cruise line names, military identification or debris with names and/or address of shipping/freighting or fishing companies, or oil/gas exploration activities).

SOURCE	ITEM FOUND
Example: ABC Shipping Company	plastic strapping band

STRANDED AND/OR ENTANGLED ANIMALS (Please describe type of animal and type of entangling debris. Be as specific as you can.)

____

____

____

What was the most peculiar item you collected? ______________________________________

Comments ______________________________________

____

Thank you!

PLEASE RETURN THIS CARD TO YOUR AREA COORDINATOR OR MAIL IT TO:

Center for Marine Conservation
1725 DeSales Street, NW
Washington, DC 20036

A Membership Organization

Center for Marine Conservation

Formerly Center for Environmental Education, Est. 1972

Printed on recycled paper.

ITEMS COLLECTED

You may find it helpful to work with a buddy as you clean the beach, one of you picking up trash and the other taking notes. An easy way to keep track of the items you find is by making tick marks. The box is for total items, see sample below

Example:
egg cartons ~~||||~~ ~~||||~~ ~~||||~~ | TOTAL 16 cups ~~||||~~ ~~||||~~ ~~||||~~ ~~||||~~ || TOTAL 22

PLASTIC

Total number of items

- bags:
  - food bags/wrappers
  - trash
  - salt
  - other bags
- bottles:
  - beverage, soda
  - bleach, cleaner
  - milk/water gal. jugs
  - oil, lube
  - other bottles
- buckets
- caps, lids
- cigarette filters
- cigarette lighters
- cups, utensils
- diapers
- fishing line
- fishing lures, floats
- fishing nets
- hard hats
- light sticks
- pieces
- pipe thread protector
- rope
- sheeting:
  - longer than 2 feet
  - 2 feet or shorter
- 6-pack holders
- strapping bands
- straws
- syringes
- tampon applicators
- toys
- vegetable sacks
- "write protection" rings
- other plastic (specify)

STYROFOAM®
(or other plastic foam)

- buoys
- cups
- egg cartons
- fast food containers
- meat trays
- packaging material
- pieces
- plates
- other Styrofoam® (specify)

FOLD ALONG THIS LINE

GLASS

- bottles/jars:
  - beverage bottles
  - food jars
  - other bottles/jars
- fluorescent light tubes
- light bulbs
- pieces
- other glass (specify)

RUBBER

- balloons
- condoms
- gloves
- tires
- other rubber (specify)

METAL

- bottle caps
- cans:
  - aerosol
  - beverage
  - food
  - other
- crab/fish traps
- 55 gallon drums:
  - rusty
  - new
- pieces
- pull tabs
- wire
- other metal (specify)

PAPER

- bags
- cardboard
- cartons
- cups
- newspapers/magazines
- pieces
- plates
- other paper (specify)

WOOD
(leave driftwood on the beach)

- crab/lobster traps
- crates
- lumber pieces
- pallets
- other wood (specify)

CLOTH

- clothing/pieces

Remember to turn the card over and fill out your name and address and to record sources and entangled wildlife!

Annex 4

Wider Caribbean Sea Turtles

Leatherback turtle *(Dermochelys coriacea)*

Loggerhead turtle *(Caretta caretta)*

Hawksbill turtle *(Eretmochelys imbricata)*

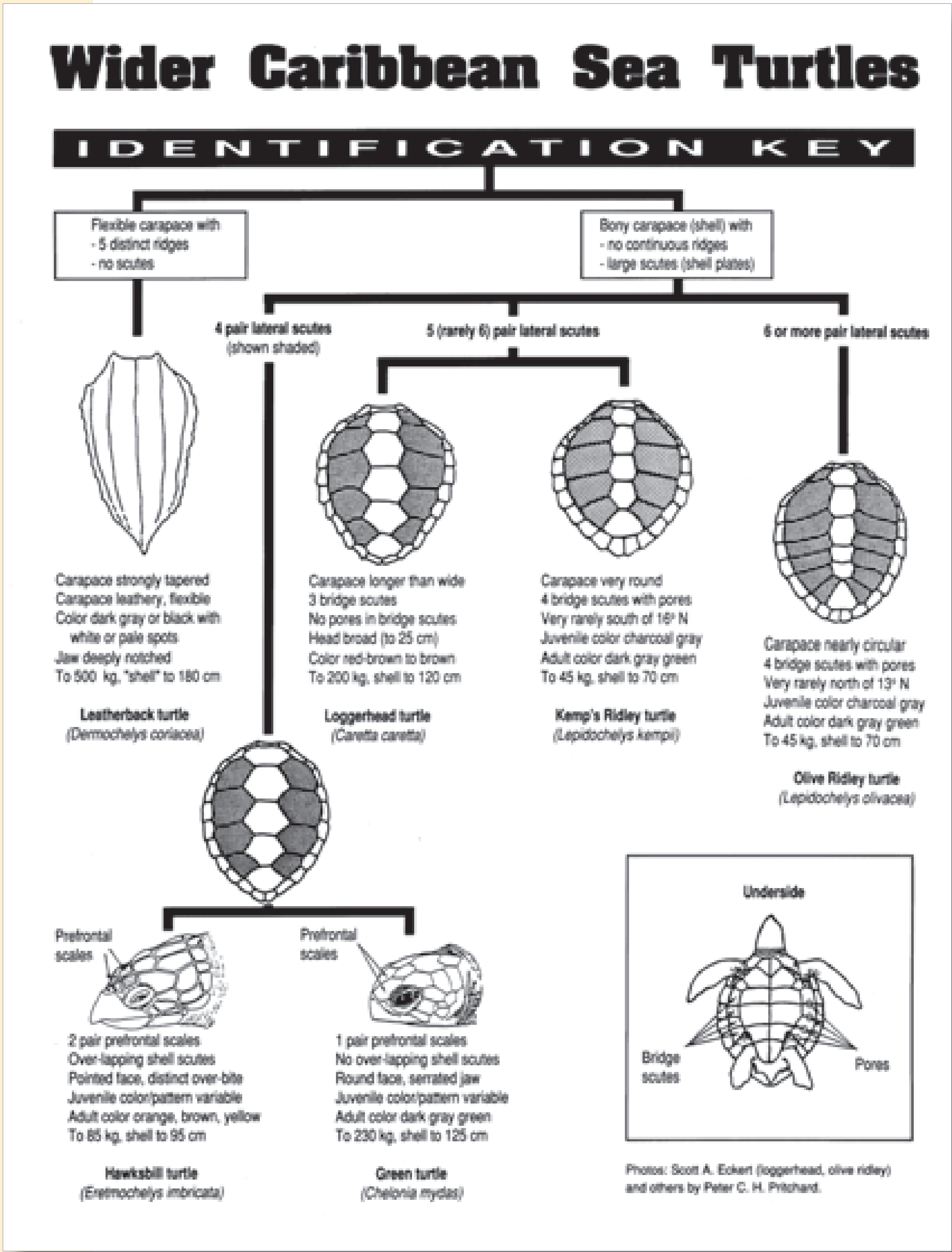
Green turtle *(Chelonia mydas)*

Kemp's Ridley turtle *(Lepidochelys kempii)*

Olive Ridley turtle *(Lepidochelys olivacea)*

WIDECAST
Wider Caribbean Sea Turtle
Conservation Network

Caribbean Environment Programme
United Nations Environment Programme


Wider Caribbean Sea Turtles
IDENTIFICATION KEY
Flexible carapace with
- 5 distinct ridges
- no scutes
Bony carapace (shell) with
- no continuous ridges
- large scutes (shell plates)
4 pair lateral scutes
(shown shaded)
5 (rarely 6) pair lateral scutes
6 or more pair lateral scutes
Carapace strongly tapered
Carapace leathery, flexible
Color dark gray or black with
white or pale spots
Jaw deeply notched
To 500 kg, "shell" to 180 cm
Leatherback turtle
(Dermochelys coriacea)
Carapace longer than wide
3 bridge scutes
No pores in bridge scutes
Head broad (to 25 cm)
Color red-brown to brown
To 200 kg, shell to 120 cm
Loggerhead turtle
(Caretta caretta)
Carapace very round
4 bridge scutes with pores
Very rarely south of 16° N
Juvenile color charcoal gray
Adult color dark gray green
To 45 kg, shell to 70 cm
Kemp's Ridley turtle
(Lepidochelys kempii)
Carapace nearly circular
4 bridge scutes with pores
Very rarely north of 13° N
Juvenile color charcoal gray
Adult color dark gray green
To 45 kg, shell to 70 cm
Olive Ridley turtle
(Lepidochelys olivacea)
Prefrontal scales
2 pair prefrontal scales
Over-lapping shell scutes
Pointed face, distinct over-bite
Juvenile color/pattern variable
Adult color orange, brown, yellow
To 85 kg, shell to 95 cm
Hawksbill turtle
(Eretmochelys imbricata)
Prefrontal scales
1 pair prefrontal scales
No over-lapping shell scutes
Round face, serrated jaw
Juvenile color/pattern variable
Adult color dark gray green
To 230 kg, shell to 125 cm
Green turtle
(Chelonia mydas)
Underside
Bridge scutes
Pores
Photos: Scott A. Eckert (loggerhead, olive ridley) and others by Peter C. H. Pritchard.

Subject index

Location index

Sandwatch is a global programme, actively implemented in more than 50 countries worldwide. It provides a framework for children, youth and adults – along with 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.

Sandwatch links classroom activities to real-life issues related to climate change, environment, sustainable development, cultural diversity, science and more. It stimulates and encourages people of all ages to take action by becoming involved in caring for their environment.

This new revised and expanded edition of the Sandwatch manual integrates climate change into all chapters and activities presented in the first edition, and adds a number of new activities, including a guide to documenting and sharing Sandwatch results through the use of social networking websites and other online resources.

UNESCO
United Nations
Educational, Scientific and
Cultural Organization

Natural Sciences Sector
Education Sector

Ministry of Foreign Affairs of Denmark

Sandwatch Foundation

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