A SCHOOLTEACHER'S GUIDE TO MARINE ENVIRONMENTAL EDUCATION IN THE EASTERN AFRICAN REGION

Publication prepared for the EAF/5 Project on the Protection and Management of the Marine and Coastal Environment in the Eastern African Region, with support from Sida, FAO and UNEP.

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This publication was prepared by the Institute of Marine Sciences of the University of Dar es Salaam, as part of the ongoing broader concept within the framework of UNEP's Regional Seas Programme and the Eastern African Action Plan aimed at enhancing the quality of the marine and coastal environment in partnership with coastal communities and their governments in the eastern African region.

This publication has benefited from the input of a number of individuals. The initial draft was by Stephen Mwinuka and Julius Francis. Matthew Richmond provided additional input. Specially acknowledged is Mr Dixon Waruinge of FAO for his encouragement and strong support toward the successful completion of this publication. He reviewed several drafts of the textbook and made valuable suggestions. Dr S. Mohamed of IMS and many others also made useful contributions and helped in numerous ways during the preparation of this publication.

Special thanks go to Mr Mohammed Nur of IMS for drawing all the illustrations expertly and for his patience. Sincere thanks are also due to Ms Daisy Ouya for editorial and design support.

FOREWORD

The eastern African region, also referred to as the western Indian Ocean region, is comprised of the coastal states (Somalia, Kenya, Tanzania and Mozambique) and the island states (Reunion (France), Mauritius, Comoros, Seychelles and Madagascar) whose coasts are washed by the waters of the western part of the Indian Ocean. The coastal environment of this region is characterised by attractive beaches, high marine biodiversity and rich marine and coastal resources. However, widespread poverty, rapid population increase, destructive resource exploitation practices and inappropriate or poorly planned development, are among the major factors that have contributed to the growing environmental degradation observed in a number of places in the region.

To address environmental issues, a number of countries in the region have adopted and are implementing integrated coastal management (ICM) initiatives at different levels of governance. ICM provides the process and tools for addressing pertinent environmental issues. If implemented successfully, the resource base on which coastal communities depend for food and income can be maintained and improved, while new economic opportunities are developed.

One of the important components of ICM is environmental education. Environmental education empowers and provides people with the tools necessary to understand, solve and prevent environmental problems. When appropriately planned and delivered, environmental education can assist people acquire knowledge, skills, motivation, values and commitment to manage resources sustainably and take responsibility for maintaining environmental quality.

As part of their contribution to the promotion and development of environmental education in the region, the Food and Agriculture Organisation of the United Nations (FAO) and the United Nations Environment Programme (UNEP), have funded the Project for the Protection and Management of the Marine and Coastal Areas in the Eastern African Region (EAF/5). Within this project funding has been provided by the Swedish International Development Authority (Sida) for an activity entitled 'Development and Implementation of Public Awareness through Production of Educational Materials'. This activity falls within one of the main components of this project.

The EAF/5 project is part of the ongoing broader concept within the framework of the Eastern African Action Plan of UNEP's Regional Seas Programme, aimed at enhancing the quality of the marine and coastal environments in partnership with coastal communities and their governments in the eastern African region.

In addition to this guidebook for schoolteachers, a number of educational materials have been developed, including brochures and posters relevant to marine and coastal environmental issues. All these will contribute towards the introduction of environmental education in schools and ensure the participation of students in measures to protect, preserve and sustain the environment and its resources.

Dr Klaus Töpfer
Executive Director
United Nations Environment Programme

INTRODUCTION

The need to incorporate marine environmental issues into school curricula cannot be overstated. Several international and regional conventions and meetings have made specific reference to the need to introduce marine environmental education in schools. For example, Chapter 17 of the United Nations Conference on Environment and Development (Agenda 21) calls for coastal states to promote and facilitate the organisation of education and training in integrated coastal and marine environmental management and sustainable development. In 1993, the First Ministerial Conference (Arusha Workshop and Policy Conference on Integrated Coastal Zone Management) recommended amongst others, the promotion of environmental education in primary and secondary schools. The National Environment Policy for Zanzibar (1997) calls upon relevant government institutions to cooperate with educational institutions, the media and other organisations to devise and implement environmental education programmes. This is acknowledgement of the importance of raising environmental awareness among primary and secondary school students, so as to ensure their participation in measures to protect, preserve and sustain the environment and its resources.

The main objective of this book is to provide teachers of primary and secondary schools in the western Indian Ocean (WIO) region with a basic textbook that will allow them to introduce environmental components in the classroom as well as in outdoor activities. More specifically, it aims at supplying teachers, particularly those with a limited background in marine science, with an overview of the coastal and marine environment and its important ecosystems. Although some of the marine and coastal issues covered in this book already exist in the curricula of other subjects, such as science, geography and agriculture, their coverage in standard textbooks is either very limited or too detailed and specialised. Therefore, this book can be used individually or together with other available information on the topics concerned, to complement curriculum objectives of the different subjects.

The book comprises seven chapters, namely: Environment and Ecology; Oceans and Seas; The Seashore; Mangrove Forests; Coral Reefs; Coastal Pollution and Coastal Resource Management. In the introduction of each of these chapters a section on 'Specific Objectives' is included to act as a guide for teachers to help determine their success at conveying the 'Background Information' to their students.

To assist teachers measure changes in their students' attitudes towards the coastal environment in which they live, each chapter also includes a section on 'Skills and Behaviour to be Reinforced' which serves as a reminder of the overall goal of attitude change. Changing attitudes is the main aim

of this book, and to assist in this process teachers are encouraged to develop classroom and outdoor activities which include the participation of the students in order to help them acquire new skills. A section on 'teaching and learning strategies' is included at the end of each chapter, listing a few examples of such activities.

Teachers are free to decide how they wish to incorporate and disseminate the information provided. They are encouraged to develop their own individual presentation style and modify the teaching and learning strategies as they see fit to their situation and the experience of their students.

1 ENVIRONMENT AND ECOLOGY

INTRODUCTION

This section is aimed at assisting teachers understand what is meant by the terms environment, ecology and ecosystems.

Specific objectives

At the end of this Chapter, the student should be able to:

a) Define the environment,
b) List and describe the components of the environment,
c) Describe the importance of the environment to people and other creatures,
d) Explain the meaning of an ecosystem as one of the important areas of the environment,
e) Demonstrate that the coastal ecosystem is one of the important components of the environment,
f) Demonstrate that different ecosystems are linked and affect each other,
g) Emphasise that human beings are dependent on a healthy environment, and
h) Participate in practical activities related to the marine environment.

Student skills to be reinforced

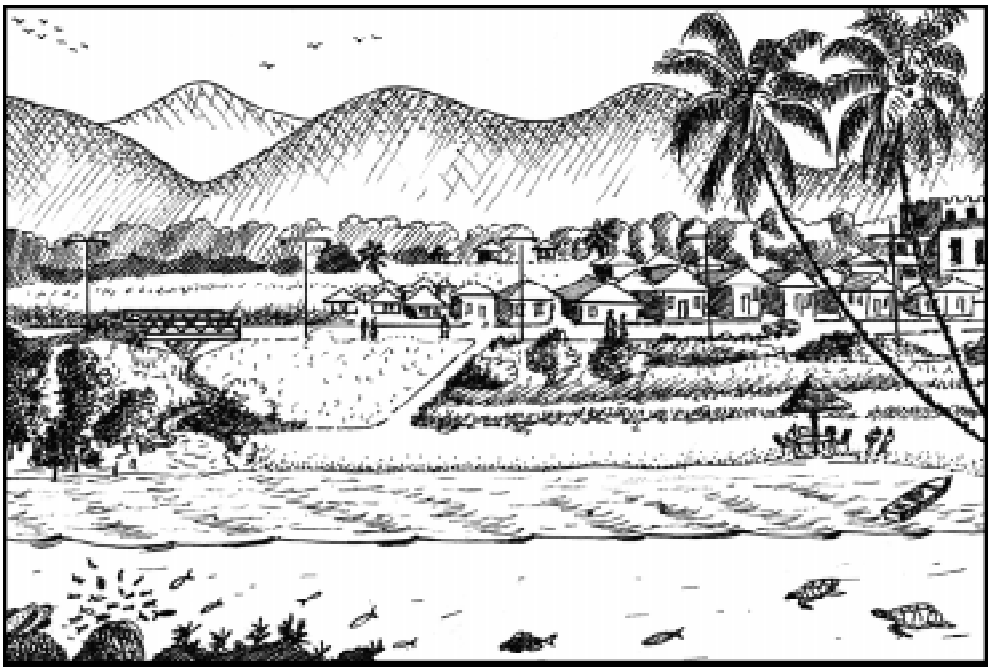
The ability to define and classify components of the environment as well as observe and distinguish different features of the environment.

Student behaviours to be reinforced

Students should develop a greater appreciation for nature, respect for other creatures in the environment and a sense of duty to care for the environment.

BACKGROUND INFORMATION

The word **environment** means our surroundings, which influence the growth, survival and continued existence of living things. When we see mountains, land, rivers, lakes and oceans; experience different climates and weather patterns; or interact with people in economic, political and social settings, we are experiencing the environment. In general, we call the place and conditions in which we live our environment.



The living and non-living environment around us

The environment is composed of living and non-living things. Living things include plants, animals and people, while non-living things include soil, rocks and water.

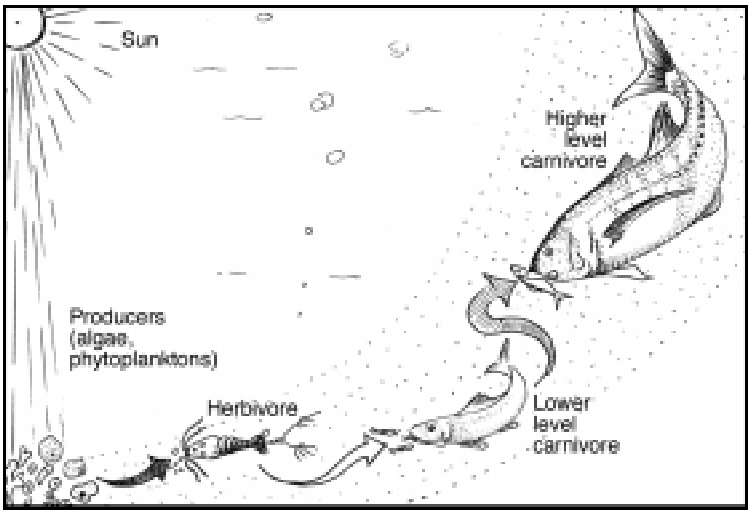
Ecology is the study of the relationship of living and non-living things in the environment. Ecosystems are the basic units of study in ecology. They can be big or small; they can have many living and non-living things in them or just a few. An **ecosystem** is the environment where a relationship exists between living and non-living things. An ecosystem may be a rainforest, a lake, a river or an ocean.

Ecosystems are governed by **laws of nature**. These are:

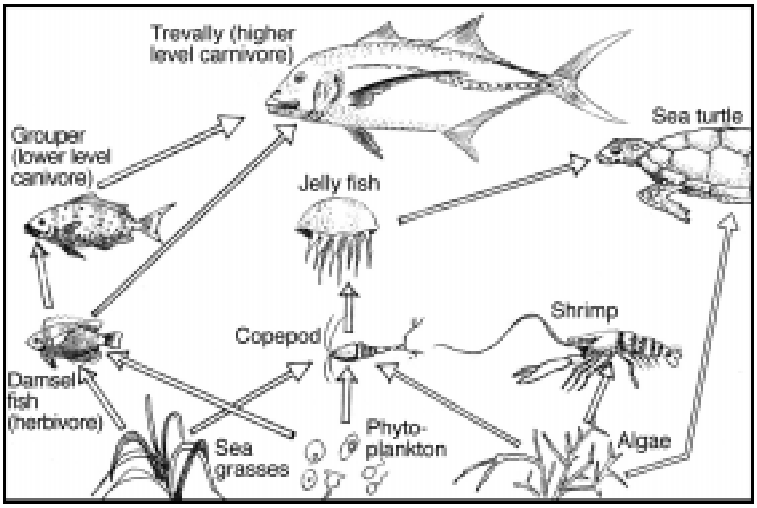
a) Every living organism is part of a continuing transfer of food energy along what is called a **food chain**. This means that all plants produce and provide food while animals get food, a process of eating and being eaten. For example, a man eats a big fish that eats a little fish that eats small ocean animals that eat small ocean plants that grow using dissolved gases, water and sunlight.

b) All living things in a food chain are either producers or consumers. Plants are producers and exist at the bottom of the food chain, while animals are consumers and usually occupy the middle or top parts of the food chain.

c) All consumers in a food chain are either predators, prey or both. This means that all animals are either eating (as predators) or being eaten (as prey).
d) The producers and consumers, i.e. the prey and predators, which make up the food chain, are interdependent, and their relationships form an interconnecting pattern known as a **food web**.
e) All natural ecosystems on earth are in ecological balance with food webs and environmental conditions. This balance allows the ecosystem to support plants, animals and humans. Changes in the food web or in environmental conditions can disturb the **ecological balance.**



A simple marine food chain

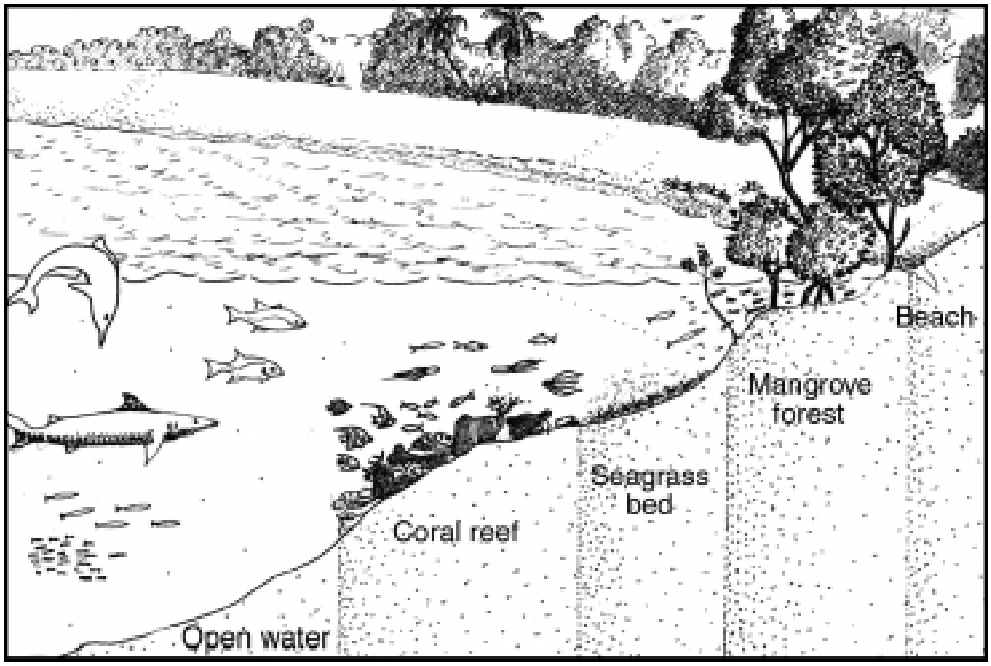


A marine food web

Coastal ecosystems are part of our environment. In the same way that different plants and animals form a complex food web, coastal ecosystems are also connected with each other. The connections, or links, may be for example, through some fish feeding in one ecosystem (e.g. a coral reef) but breeding in another (e.g. a mangrove forest). More direct links would also include rivers bringing freshwater, dissolved nutrients and sediments from inland to the coastal seas and the evaporation of the sea providing moisture in the atmosphere which eventually falls as rain inland.

Coastal ecosystems are rich in marine plants and animals and provide some important resources including fish, minerals and oil. Coastal ecosystems also offer opportunity for recreation to both local people and tourists. Coastal tourism is an important commercial activity for countries in the western Indian Ocean.

Many different types of ecosystems are associated with coastal regions. These include beaches, coral reefs, lagoons, mangroves and seagrass beds. These ecosystems are interlinked and interrelated, and things that affect one ecosystem may affect other ecosystems, even some distance away. Some of these ecosystems may be distributed sequentially from the shore to deep water, as shown below.



Distribution of coastal ecosystems

TEACHING AND LEARNING STRATEGIES

Combine the use of at least two strategies to teach the concept of interlinkages in the environment. Suggestions include an excursion and two question and answer sessions leading to class discussions. The importance of all the links in the food web should be emphasised, resulting in the recognition of the importance of respecting all parts of nature.

Excursion

Lead the students outside the class. Divide the class into groups of about seven students. Let them walk around the school grounds and ask them to observe what they see. For each group, prepare a task. For example, ask them to list the following:

Group A: At least 10 living things;
Group B: At least 10 non-living things;
Group C: 10 man-made features;
Group D: 10 natural features;
Group E: Types of ecosystems around the school.

Once this has been done, and you are back in the classroom, let each group prepare a brief report on what was observed during the excursion. Then, organise a short discussion on what the class agrees constitutes the environment, its components and ecosystems.

Question and answer session

Based on the findings of Group A above, lead a question and answer session to find out who lives on who or who eats who. Then ask each group to draw at least two food chains/webs from the information obtained around their school. One such food web should involve humans.

Teachers should ask each student in turn for an example of the importance of an item in their surroundings (e.g. a desk, chalk, pen, tree, grass, chicken, bird, rock, etc.) with an explanation of how the item fits in the environment. Some items will be related to humans, to nature, or to non-living parts of the environment.

2 OCEANS AND SEAS

INTRODUCTION

This section introduces the students to simple concepts about the oceans and seas and their associated processes.

Specific objectives

The students should be able to:
a) Understand what oceans and ocean currents are,
b) Know the importance and role of oceans in the hydrologic (water) cycle,
c) Understand how the oceans influence weather and climate, and
d) Appreciate the importance of the ocean.

Student skills to be reinforced

After completing this Chapter students should have the ability to:
a) Identify the various parts of the hydrologic cycle,
b) Measure the local tidal range,
c) Estimate the range in relation to the lunar phase, and
d) Identify the various resources derived from the oceans.

Student behaviours to be reinforced

a) Awareness, understanding, knowledge and appreciation of the ocean and associated processes.
b) Care for the oceans, and willingness to take actions that will contribute to the maintenance of healthy seas.

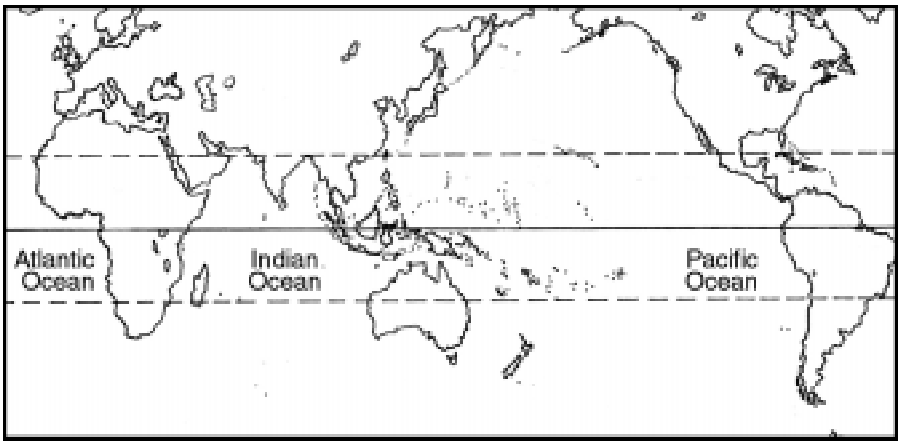
BACKGROUND INFORMATION

Oceans and seas

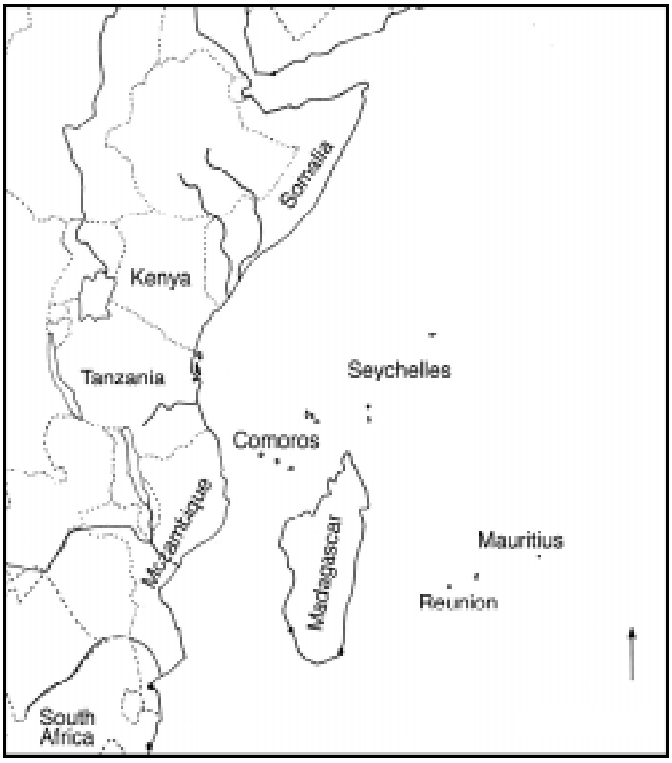
The ocean is a continuous body of salt water that covers two-thirds of the earth's surface. Bays, gulfs, seas, and oceans together constitute one vast expanse of water from which the continents emerge like big islands. About 70% of the earth is covered with water, most of which is seawater. The three major oceans are the Pacific, Atlantic and Indian Oceans. Others are the Arctic and Southern Oceans.

The eastern part of Africa (Somalia, Kenya, Tanzania, Mozambique and South Africa) and the western Indian Ocean islands (Comoros, Mayotte,

Reunion, Mauritius, Madagascar and Seychelles) are washed by the waters of the Indian Ocean. These countries comprise the western Indian Ocean region.



Major oceans of the world



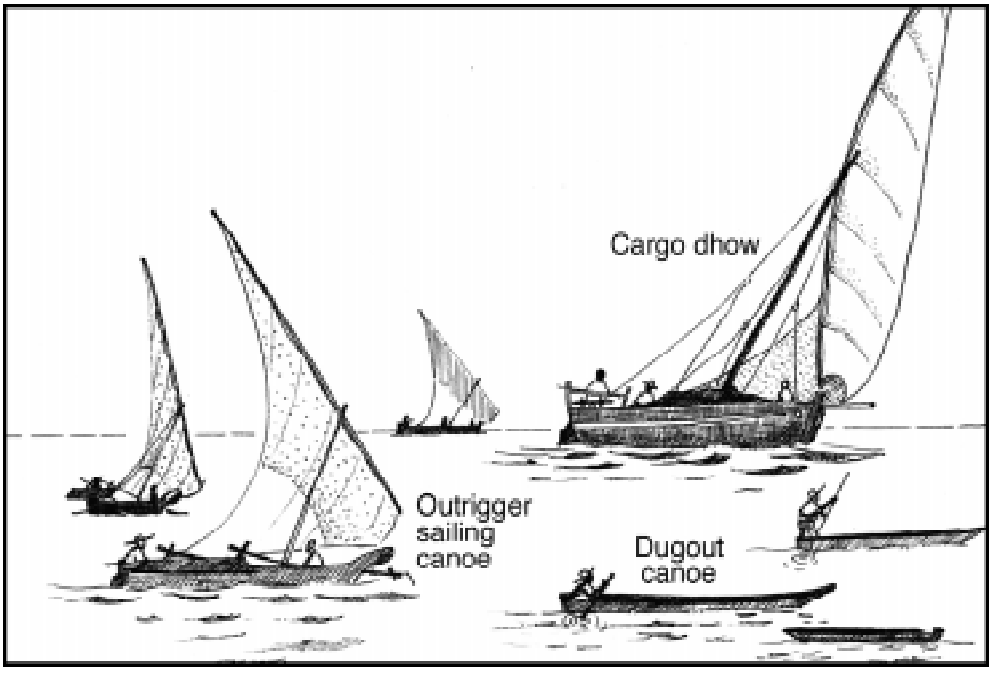
Countries of the western Indian Ocean region

The early uses of the ocean

The sea played an important role in human life long before human history was recorded. Transportation by sea must also have been very important in early human history and in the distribution of humans.

In the early days, sailors used their knowledge of the sky and the sea, reading the moon and stars, sea currents and waves, birds, fishes, and floating materials, to navigate the sea.

For example, for over 1000 years, passengers and cargo were shipped by dhows between the coast of eastern Africa and the Middle East, Oman in particular. These dhows made use of the monsoon winds, sailing south to the eastern African coast during the northeast monsoon and back to the Middle East during the southeast monsoon. Various designs of local boats exist in the region, some used for fishing and others for the transportation of people and cargo.



Traditional boats

Ocean topography

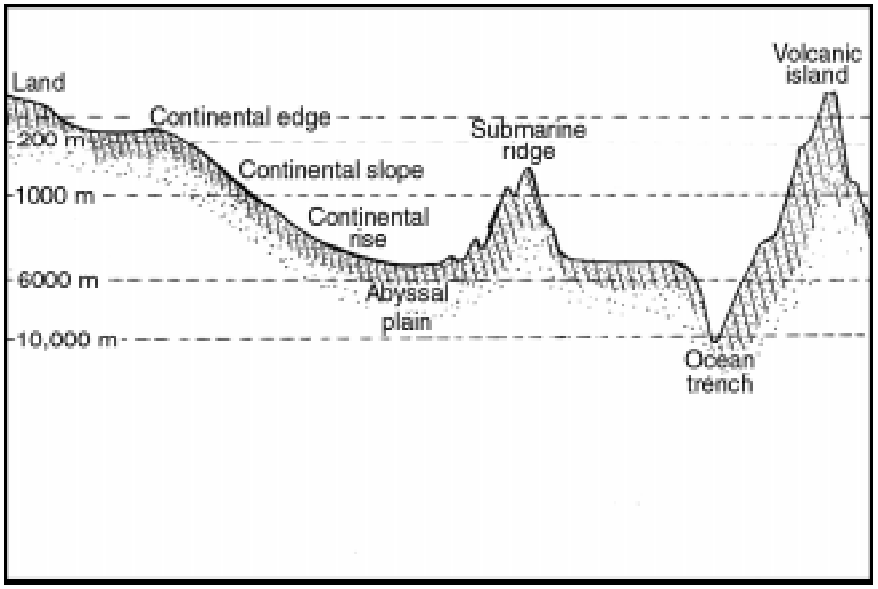
The ocean bottom is not a smooth, plane surface. It is irregular, consisting of shelves, slopes, mountains, ridges, plains, and deep trenches (see below). Some of these features are quite spectacular. For example, the deepest trench, the Mariana Trench, found in the Pacific Ocean, is 10,850 metres deep, almost twice as deep as the height of Mount Kilimanjaro (5895 metres).

Ocean processes

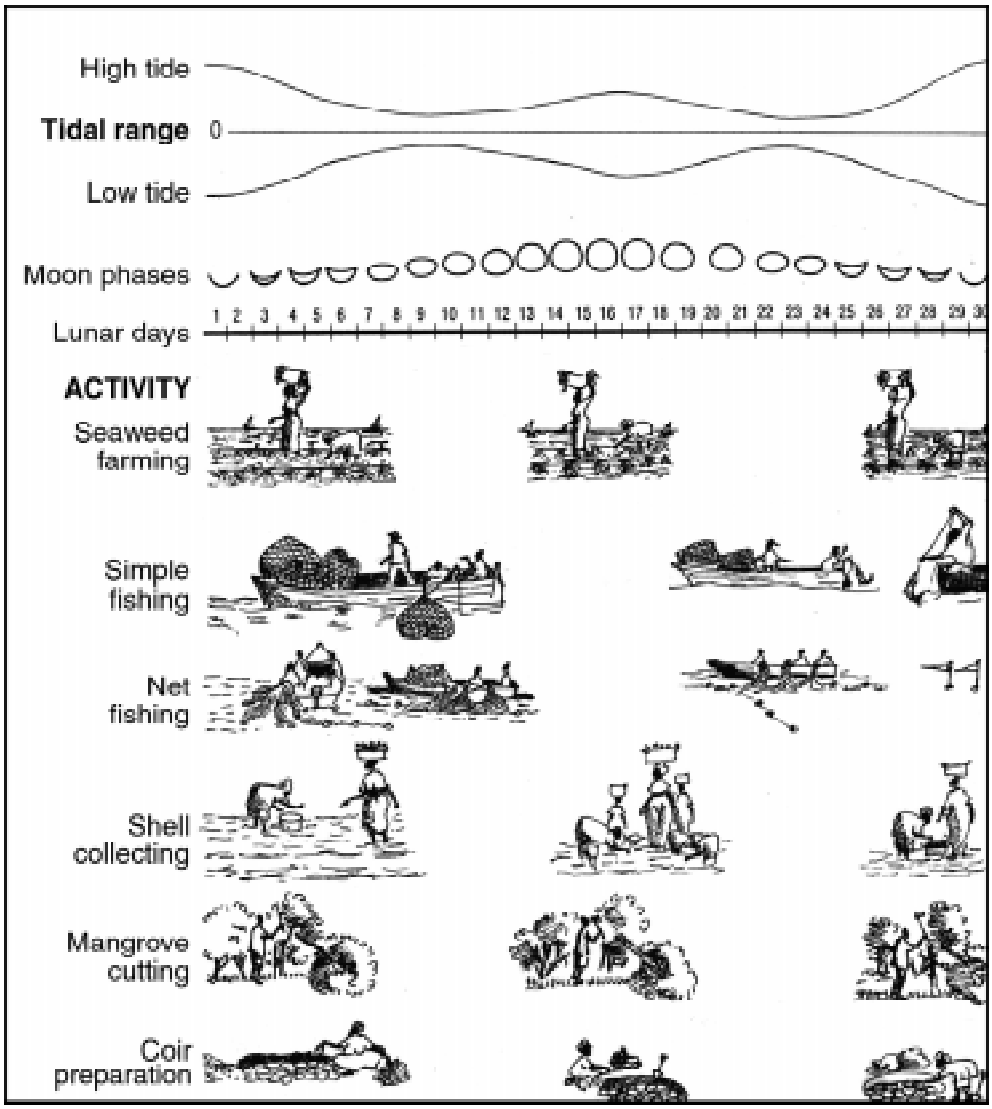
The ocean is always in motion, mainly through three different mechanisms:

Tides

Tides are the regularly changing sea levels at the coast. This changing also occurs offshore and in the deep ocean. Tides produce tidal currents which are necessary in order to move water from one place to another, and influence sea level. Tides are caused by the gravitational attraction of the moon and the sun to the earth, resulting in pulling on large areas of water, setting them swinging in a regular motion, twice in every 24-hour spin of the earth.



Profile of the ocean floor



Human activities and the lunar cycle

Spring tides (largest tidal range) occur when the earth, moon and sun are all in line, during the full and new moon. Neap tides (smallest tidal range) occur when the earth-moon line is perpendicular to the earth-sun line, during half moon. The spring tidal range along the coasts of eastern Africa, Comoros, Mayotte and west Madagascar is about 3.5 metres while the neap tidal range is about 1.5 metres. The smaller remaining islands of the western Indian Ocean (Seychelles, Mauritius and Reunion), by contrast, have spring tidal ranges of only about 1.5 metres.

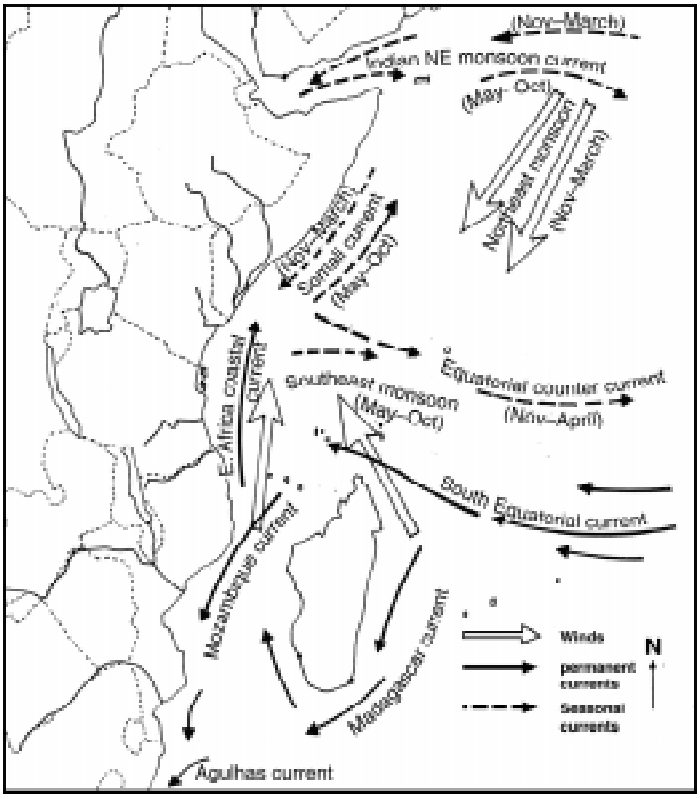
Currents

These are the circular flows of water in the oceans. Currents are caused by two principal factors: changes in water density (caused by climate changes) and wind stress.

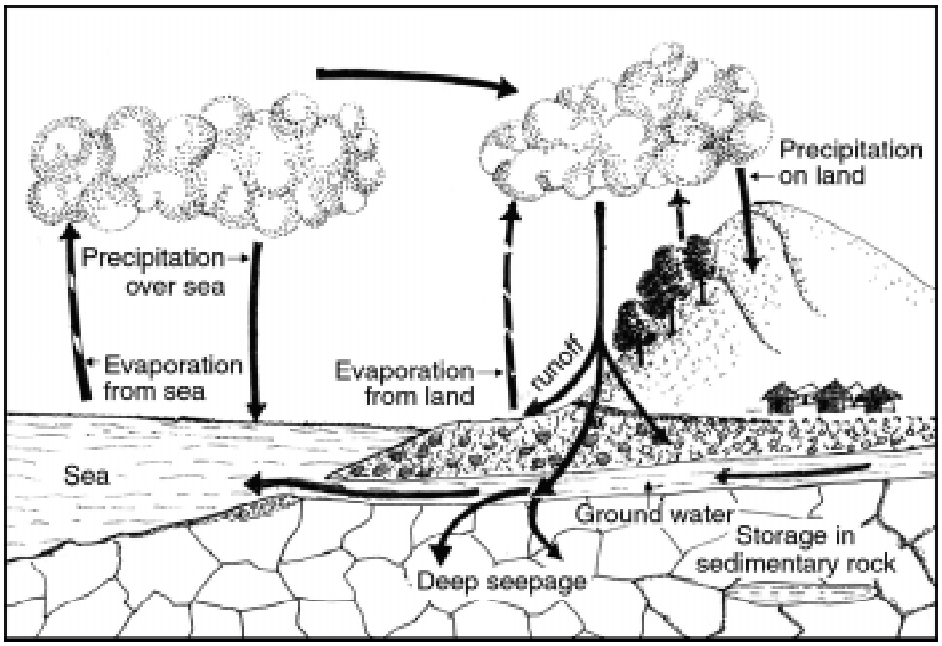
Due to the rotation of the earth, the currents move both from and towards the equator. Those currents from the equator are warm while those from the North and South Poles are cold. The major currents in the western Indian Ocean (WIO) region are the East African Coastal Current, Mozambique Current, Agulhas Current, Madagascar Current, Somali Current, South Equatorial Current and Equatorial Counter Current.

Waves

Waves are the most obvious processes on the ocean surface. Waves are the movement of energy through the top layer of water, caused by winds. Currents and turbulence generated by waves stir up sediments, which can be transported by long-shore currents. Beach waves change seasonally in response to changes in overall wind direction.



Major currents of the western Indian Ocean region



The hydrologic cycle

How the sea affects the weather and climate

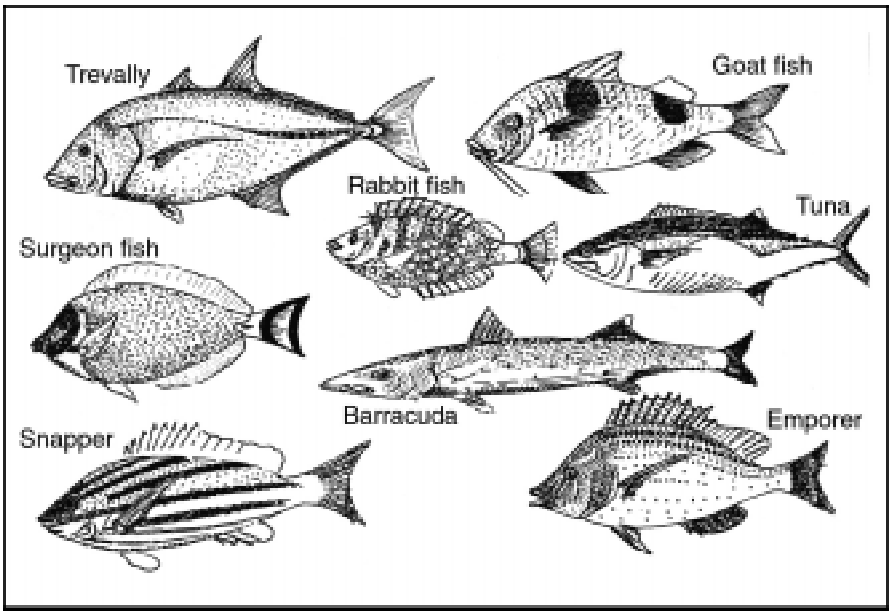
The atmosphere and the ocean are always moving and constantly affecting each other. The interaction between the atmosphere and the oceans is complex. This interaction is shown more clearly through a water (hydrologic) cycle, which shows how water is continuously carried from the ocean to land and back to the ocean.

Important marine resources

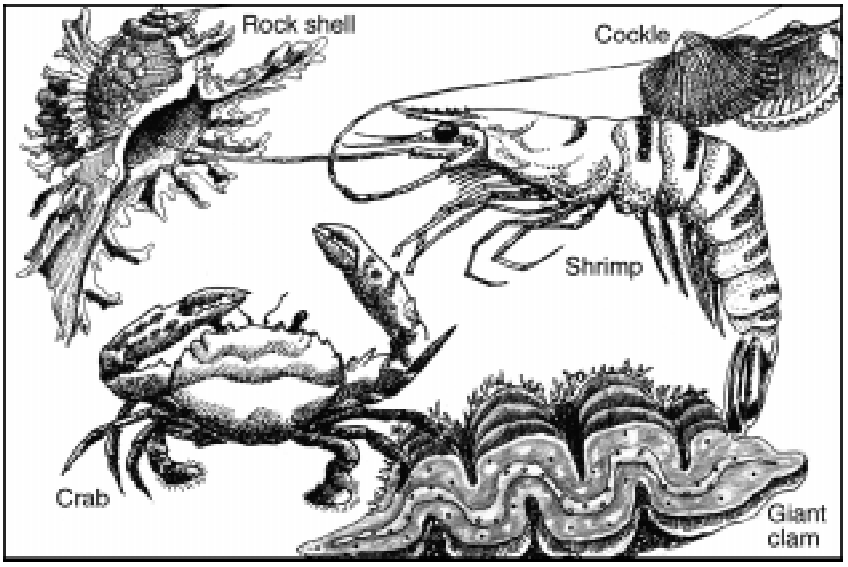
The oceans are full of different types of resources which are useful to humans. These include:

Fisheries

Many different types of fishes are found in the western Indian Ocean. These include tuna, mullet, rabbit fish, surgeon fish, goat fish, sardine, shark, emperor, trevally, snapper and barracuda. Crustaceans such as crabs and shrimp, molluscs such as oysters, cockles, trochus and giant clams, and echinoderms such as sea cucumbers are also common. All of these are caught or harvested for local consumption, or for export to feed people living outside the region.



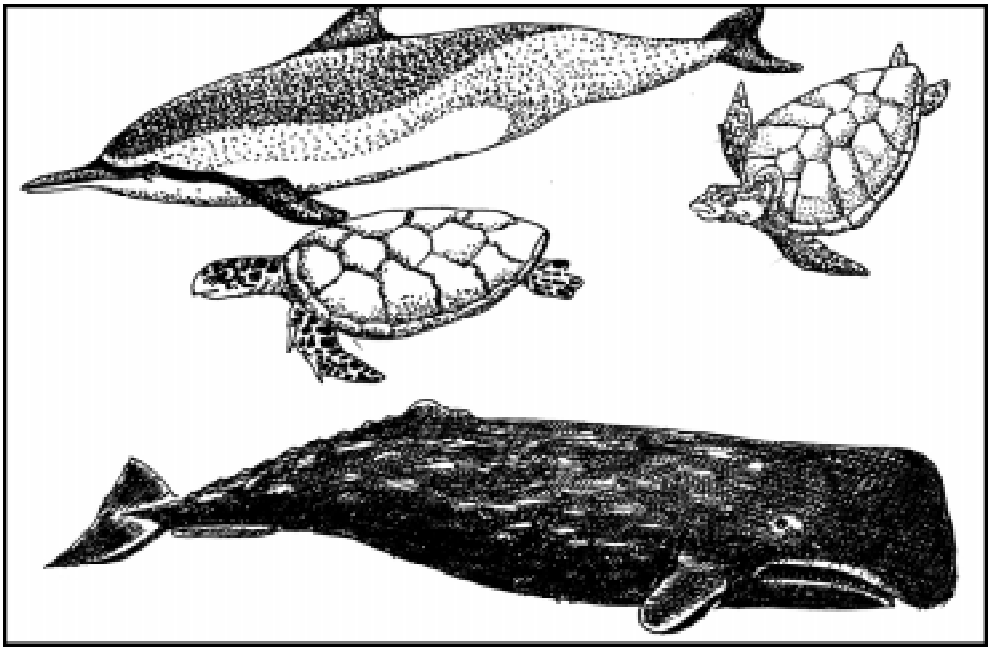
Some common fishes of the Indian Ocean



Common crustaceans of the Indian Ocean

The marine creatures in the pictures on p.15 feed on a variety of food items. The rabbit fish eats seaweed and seagrasses; the trevally catches smaller fish around coral reefs; the goat fish eats small shrimps and crabs which live in the sand; bivalve molluscs (e.g. cockles and giant clams) filter seawater through their gills, to trap tiny pieces of food and plankton; the crab feeds on dead worms and other small creatures; the rock shell feeds off other smaller shells; and the shrimp eats tiny pieces of algae and detritus from the sand.

Other marine animals like turtles, whales and dolphins are not as common as fishes and invertebrates. Whales were in the past hunted for food and oil (for lamps) but their populations became so low that they are now protected by law. Oil lamps have largely been replaced by electric lights. Turtles are also protected by law because they too have become endangered due to being caught for food, and their eggs being taken from their nests before hatching. Dolphins are not usually eaten. They are very popular with tourists.



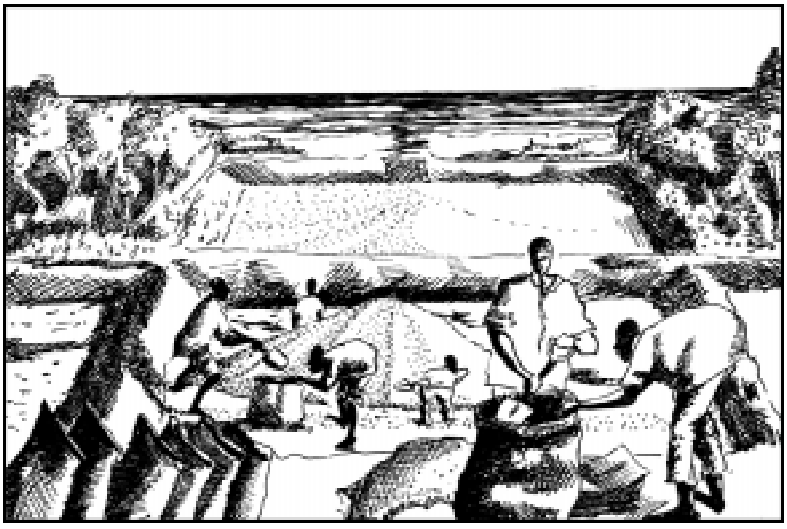
Dolphin, turtles and whale

Minerals

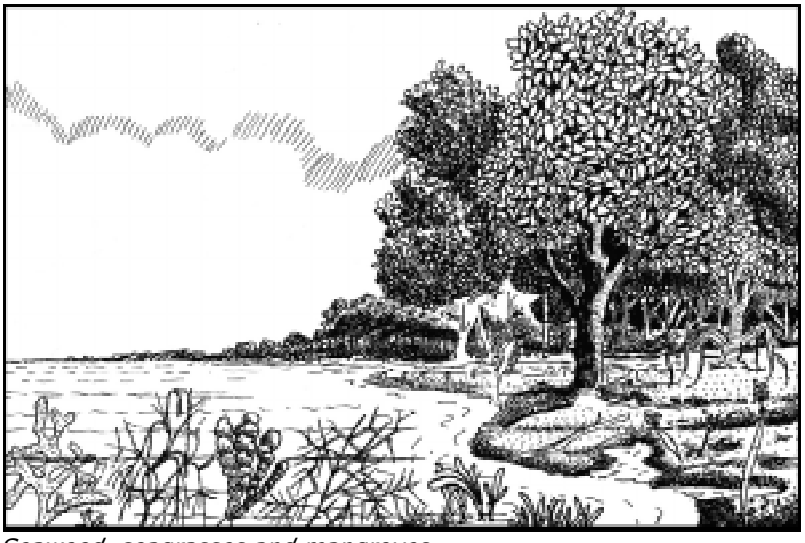
Salt is one of the common resources from the sea, and is commonly produced by evaporation from salt pans. Oil, gas and other minerals are also important non-living resources from the sea.

Plants

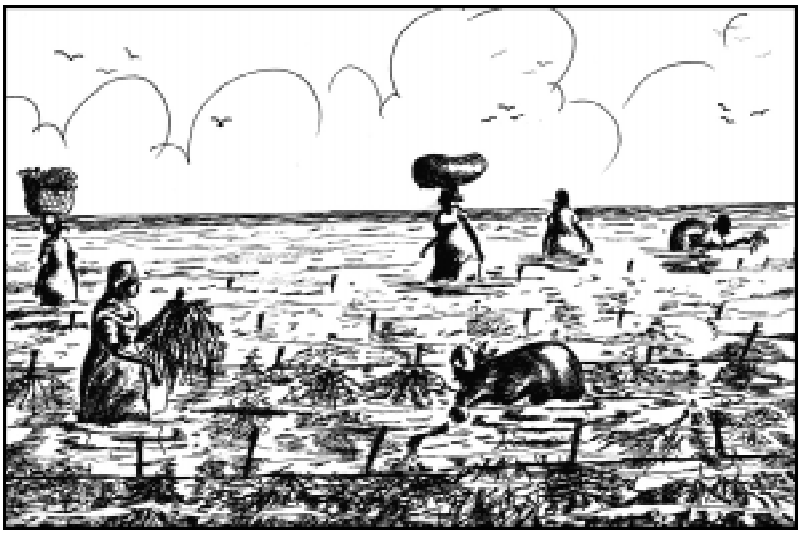
The sea is rich in different types of vegetation. Seaweed, seagrasses and mangroves are some of its important plant resources.



Salt production through evaporation



Seaweed, seagrasses and mangroves



Seaweed farming

TEACHING AND LEARNING STRATEGIES

Following the lesson, students should be asked to do the following:

Essay writing

Students may prepare a brief 2-3 page essay on 'Why the ocean is important to all of us'.

Field trip

Teachers should take small groups of students (5-7) on trips to the beach during low tide to mark the level of the tide (on a pole, harbour wall or on the beach). As the tide comes in, over the following six hours, the level of the sea should be monitored until high tide, thus obtaining the tidal range for that day. Different student groups should be involved during spring tides (full moon and new moon) and neap tides (half moon). The difference between low tide and high tide can be measured with a ruler or tape measure. All students should be told to watch the changes of the moon and the tides, especially the level of high tide on the beach.

Field observations

After the last of the above field trips students should answer these questions:

a) Are the highest tides with the new, full or half moon?
b) Do they come exactly with the moon extremes (full and new moon), or a day or two before or after?

3 THE SEASHORE

INTRODUCTION

This section introduces the students to the seashore and its processes.

Specific objectives

The student should be able to:
a) Define the seashore,
b) State the importance of the seashore, and
c) Describe the natural processes taking place there.

Student skills to be reinforced

Ability to describe and identify the main features and processes taking place on the seashore.

Student behaviours to be reinforced

Responsibility, care, appreciation and willingness to conserve the seashore.

BACKGROUND INFORMATION

Seashores

Seashores, also known as shorelines or coasts, are where the land meets the sea. There are different types of shores: sandy shores, rocky shores and muddy shores (see overleaf). They are dynamic features and often change with the changing seasons. Shores are often under the combined influence of many changing factors. These include geological, climatic and oceanographic processes. Consequently, no two stretches of shores are exactly alike.

Beaches are formed by particles of material washed ashore by waves and currents, or, in some cases, particles carried from inland by rivers. Eastern Africa mainland beaches mainly get their sand from rivers. The beaches of the smaller western Indian Ocean islands (Seychelles, Mauritius, Reunion and Comoros) derive their sand from erosion of the surrounding rock (granitic, basaltic or limestone).

Seashores are rich in flora and fauna. Most of the organisms that live on the seashore are specially adapted to survive well in this unstable environment.

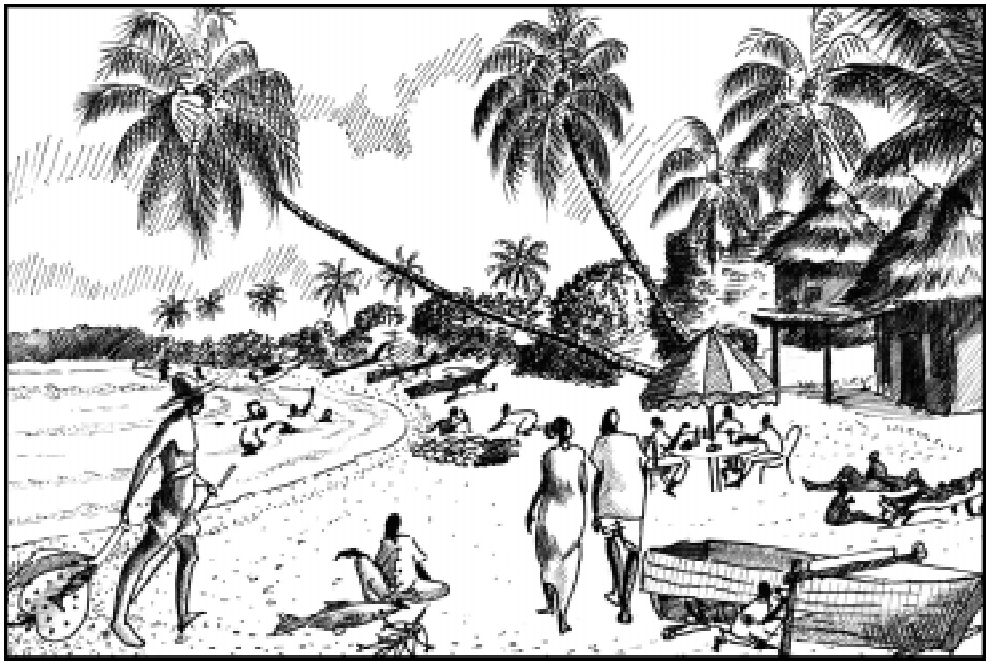
Sandy shore

Rocky shore

Muddy shore

Shorelines are both ecologically and economically important. For example, sandy beaches are important as nesting habitats for marine turtles. They also offer recreational areas for tourists and local people alike. Muddy beaches support a variety of animals which live on or in the mud. These are preyed upon by assorted bird species, some of which visit the region every year, or are permanent residents. Moreover, seashores offer a range of things to humans, such as: relaxing and attractive environments, a source of income through tourism, and employment for coastal communities. Unfortunately, in many countries, especially of mainland Africa and Madagascar where coastal communities do not have adequate waste disposal systems, the shore is often used for sanitary cleansing. This practice often leads to contamination of the shore and seawater which can lead to health problems for the local people.

Within a single seashore, there exists a series of different zones starting from the edge of the land to the sea (see figure on page 6). Each of these zones accommodates a variety of animals and plants that have adapted themselves to live in that particular zone. Plants found on the seashore from the land towards the sea include coconut palms, mangroves, seagrasses and seaweeds (see page 17). Characteristic animals of the upper shore include barnacles, limpets, chitons and winkles on rocks, and ghost crabs and sand-hoppers on the sand. Lower down the shore, shy



Human activities on the seashore

crabs, seacucumbers and brittlestars are common, while corals, sponges and giant clams occur at the lower edges of the sea.

Seagrasses are important for three main reasons: they provide food for fish, nursery grounds for fish and shrimps and they stabilise and reduce coastal erosion. Coastal vegetation high on the beach also helps reduce the effects of wave action during high tide, thus assisting in reducing beach erosion.

TEACHING AND LEARNING STRATEGIES

The strategies proposed here include:

Field trip

Organise a visit to a nearby seashore with students to observe the different aspects of the shore, such as: shore type, quality, etc. Include a walk along the seashore with the students. Give them a guide on what to do. The guide could include observing the following:

a) Type of shoreline,
b) Shape of the shoreline,
c) Types of animals observed (alive or dead). Establish why?
d) Types of plants observed (alive or destroyed). Why?
e) List of observable human activities, including any harmful activities.

Class discussion

After the field trip, arrange a class discussion of all that has been recorded during the trip.

Essay

Ask the students to select any organism they identified and write a two-page essay describing the following: its form (e.g. shape, colour, size); its habits (e.g. its diet, protection, reproduction, movement, etc,); any interesting or unusual features; and ways in which it might be affected by human activities and how it might be protected.

4 MANGROVE FORESTS

INTRODUCTION

In this chapter the mangrove forest ecosystem and mangrove trees are discussed.

Specific objectives

Students should be able to:

a) Understand what mangroves are,
b) Be able to distinguish the different types of mangrove trees,
c) Understand the importance of mangroves and the role they play in marine ecosystems,
d) Recognise harmful human practices in mangrove forests, and
e) Propose ways to conserve mangrove forests.

Student skills to be reinforced

Observation, identification and description of issues related to mangrove forests.

Student behaviours to be reinforced

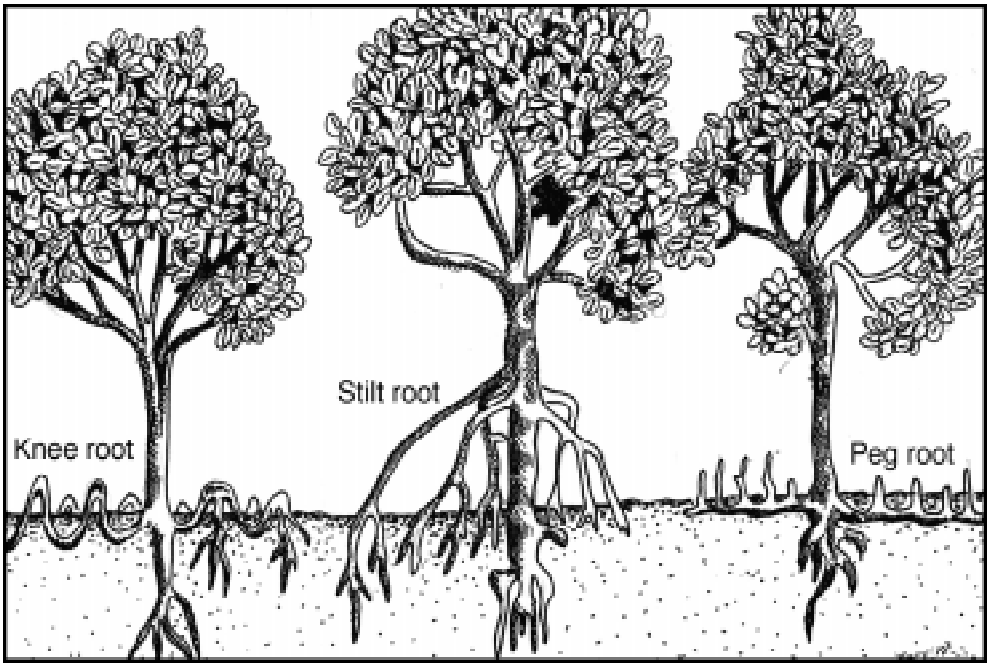
a) Increased understanding of the mangrove ecosystem, and
b) A sense of responsibility to take action and conserve the mangrove ecosystems.

BACKGROUND INFORMATION

Mangroves are **salt-tolerant** trees that grow well in salty, acidic soils with little air (**anaerobic**). Mangroves grow in muddy estuaries, lagoons, bays, tidal creeks and inlets. In these areas freshwater mixes with seawater, halfway between the land and the sea. Thus mangroves grow in an alternating environment of seawater and freshwater runoff from the land.

Different species of mangroves have developed different adaptations to grow at different zonal gradients from land to sea. Consequently, if one moves from the land to the sea one can often see distinct zones of different mangrove species or a combination of species.

To grow in an environment where few other plants can survive, mangroves have special adaptive features. For example, they have specialised roots (e.g. knee, stilt and peg roots) and buttressed trunks that provide support



Different types of mangrove roots

in an unstable, soft mud environment. To cope with high salinity, mangroves have specialised root cell membranes that prevent or greatly reduce, the entry of excess salt. They also remove excess salt when they shed their leaves, or secrete salt through their leaf pores. To cope with the waterlogged environment in which they grow, mangroves have developed spreading, breathing roots (called **pneumatophores**) which increase breathing capabilities of the plants in such environments.

Importance of mangroves

Mangrove ecosystems are rich in biodiversity and play a key ecological role in the coastal environment, by providing:

a) Feeding areas for larger fish, such as snappers, which visit mangroves to feed on smaller fish and other organisms,
b) Shelter for coastal and marine creatures such as fishes, oysters, crabs, prawns, hippos, crocodiles and monkeys,
c) Safe sites for the young of some species, e.g. shrimps, to grow before moving into deeper waters, and
d) Good roosting sites for migratory and resident birds.

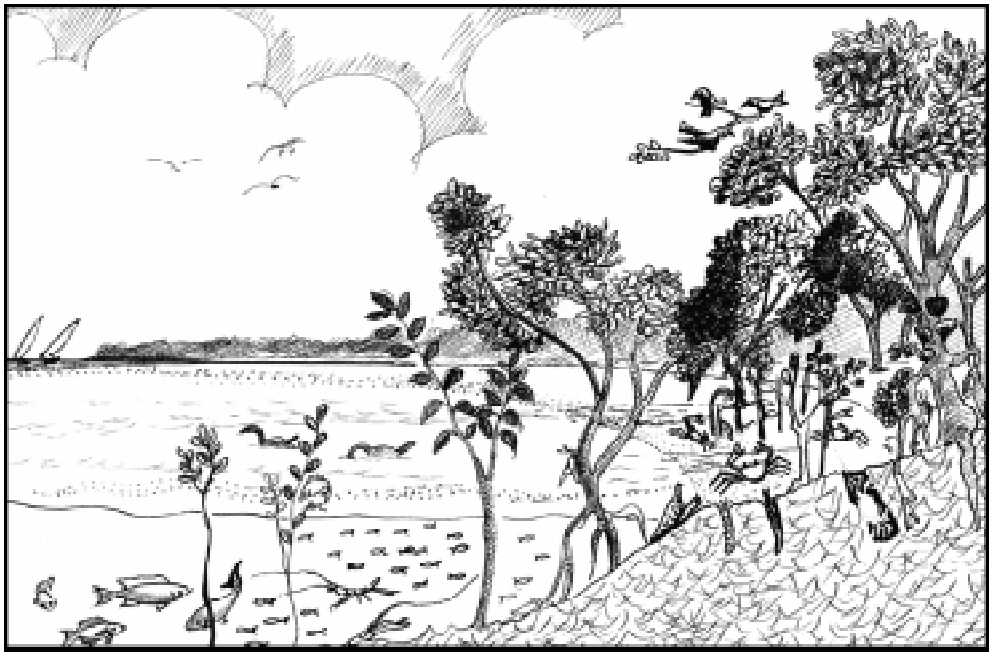
Mangrove forests also act as wave breaks, protecting shorelines from erosion by the action of currents and torrential storms. They stabilise shorelines and promote **coastal accretion**. Scientific studies have also confirmed that mangroves contribute towards improving the quality of water by filtration, as their roots are capable of trapping sediments, debris, and toxins found in water.

If the mangrove ecosystem were destroyed all these functions would vanish, thus affecting the life cycle of some important species, including humans.

Importance of mangroves to people

Mangroves have served human beings for millennia, and continue to be an important natural resource. For example:

a) Mangroves support rich fisheries which provide a valuable protein source and/or generate income for coastal communities;
b) They are used to make construction poles, dyes, tannin and medicine and also provide timber for boat construction and fuelwood;
c) Mangrove forests and the varied wildlife that inhabits them offer a high potential for eco-tourism.



The mangrove ecosystem

Impacts of humans on mangroves

Some of the activities that people carry out in mangroves threaten this important ecosystem. The over-exploitation of mangroves for housing, fuelwood, export for the construction industry, etc., has in many areas adversely affected this resource. Mangrove forests are lost when large tracts are cut down to make room for industrial sites, residential houses, hotels, aquaculture, salt production and agriculture. Pollution from industries, agriculture, oil and sewage also has a negative impact on mangroves.

Mangroves are likewise under threat from activities that affect the environment in which they grow, for instance changes in the tidal flow and the salt and sediment levels of their surrounding water.

TEACHING AND LEARNING STRATEGIES

Group excursion

Organise for an excursion to study mangroves and their associated components. At the site:

a) Identify the existence of different mangrove species at different zones;
b) Observe the variety of creatures you can see—birds, crabs, fishes and others left behind after the tide has ebbed, and where they are found;
c) Make a checklist of human uses of mangroves and the various activities that destroy mangroves;
d) Look for signs of mangroves that have been destroyed; and
e) Look for signs of conservation efforts in the area.

Group discussions

Let students work in groups and discuss their views about what we would lose if mangroves disappeared. Also discuss how this would affect local coastal communities who depend on mangroves for their livelihood.

5 CORAL REEFS

INTRODUCTION

This chapter introduces students to coral and coral reefs and their importance. It also describes the impact of human activities on coral reefs. Finally, it offers guidance on how we can protect the coral reef ecosystem.

Specific objectives

The student should be able to:
a) Understand what coral and coral reefs are,
b) Understand their importance, and
c) Discuss the ways in which corals and coral reefs are being degraded.

Student skills to be reinforced

Recognition of the different types of coral reefs and the understanding of their importance to humans and the coastal ecosystem.

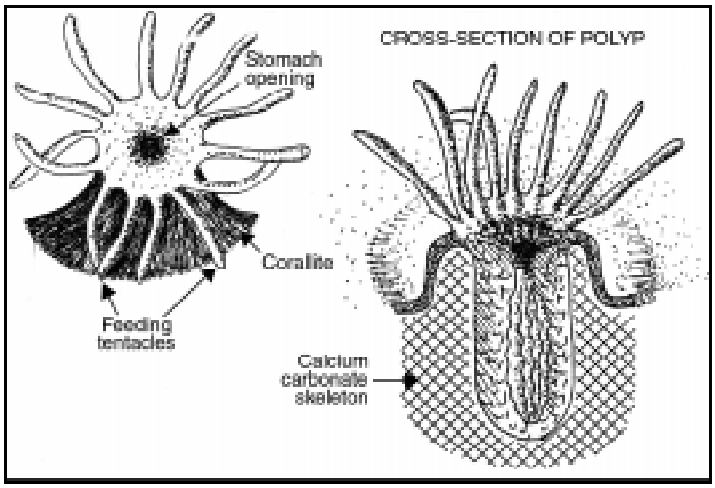
Student behaviours to be reinforced

Care and willingness to conserve and preserve coral reefs.

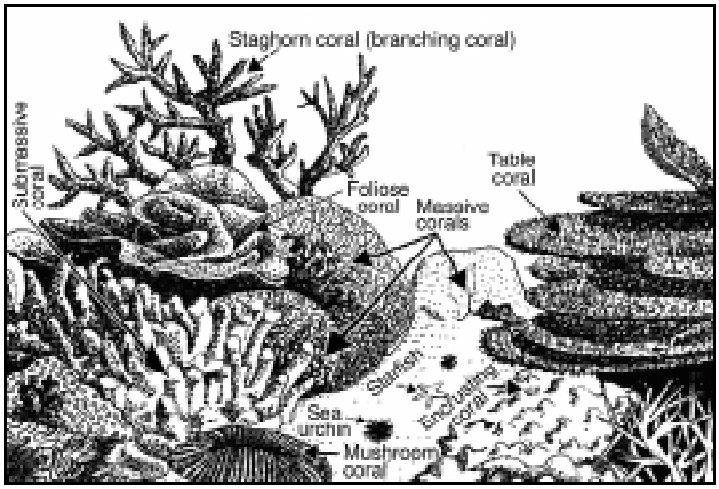
BACKGROUND INFORMATION

Corals are made up of small animals called **polyps** (see overleaf). Polyps are simple marine animals related to jellyfish and sea anemones. They obtain food by capturing tiny particles or plankton drifting in the water currents as well as from small plant cells (called **zooxanthellae**) which live inside their tissues. The zooxanthellae use sunlight and nutrients in the seawater to produce food which is shared with the coral, while the coral provides them shelter and protection. This is an example of a **symbiotic relationship**—two different organisms living together for the benefit of both organisms. Coral reefs encourage many symbiotic/ commensalism relationships that may be of interest to students, e.g. cleaner fish which eat parasites off the skin of larger fish such as groupers.

A coral reef is made up of the skeleton of coral polyps. As polyps die, new ones grow on top of the old empty skeletons. Over time, the collection of shells left behind by dead coral polyps and dead coral colonies build large groups of rock-like structure called **coral reefs**. Coral reefs are made from individual coral colonies of various sizes, shapes and ages. In other words coral reefs are massive deposits of calcium carbonate, which were built over centuries by living polyps, coralline algae and other marine organisms such as sponges and molluscs. Only a thin top layer of the coral reefs is alive.



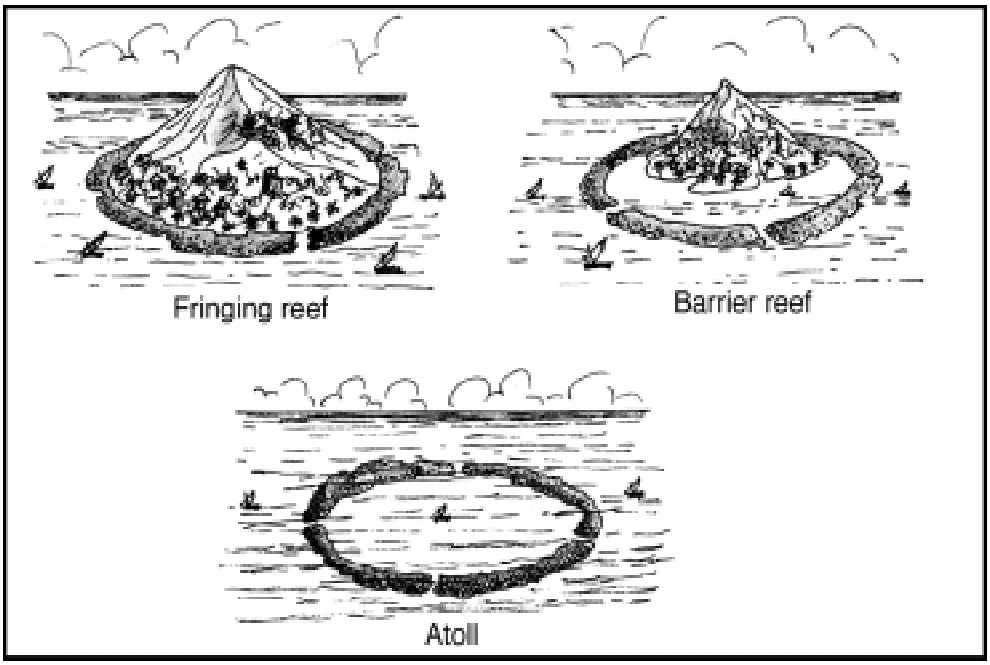
A coral polyp



Different types of corals

Types of coral reefs

There are three main types of coral reefs formations. These are the **fringing** reefs, **barrier** reefs and **atolls**. Fringing reefs grow at the edges of continents and islands, with the reef front containing actively growing corals. Often a shallow lagoon separates the fringing reef from land. Barrier reefs are offshore structures separated from the shoreline by a deep channel. Atolls are coral reefs growing in the shape of a circle, often with small islets on it, surrounding a central lagoon. Most of the coral reefs of the western Indian Ocean are fringing reefs, as seen in the map on page 30.

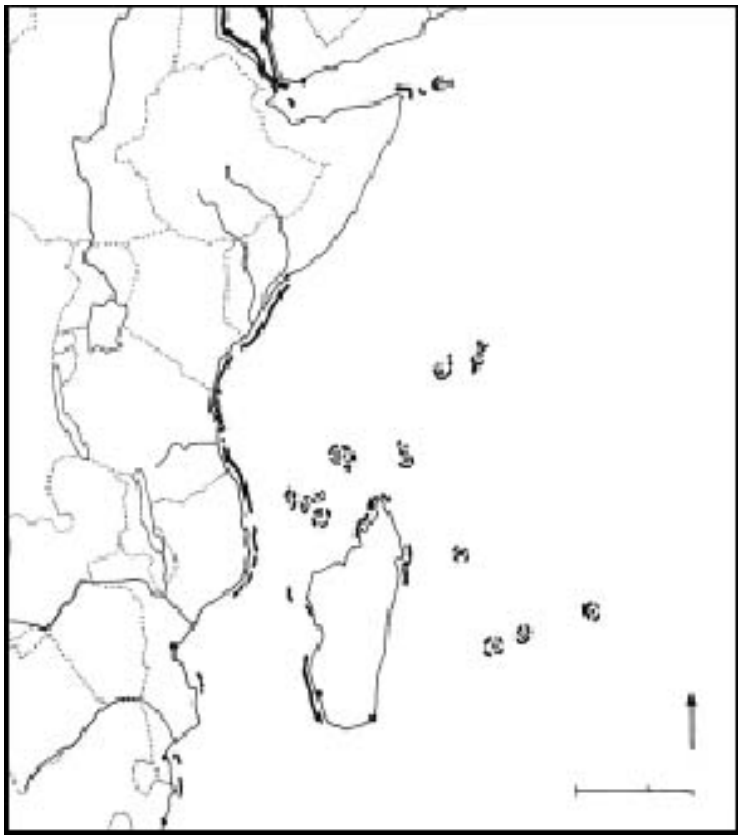


Aerial view of the main types of coral reefs

Importance of coral reefs

Coral reefs are among nature's most spectacular creations. They are endowed with a multitude of colourful creatures and are among the most biologically diverse and productive ecosystems known to man. Coral reefs have many ecological functions:

a) As part of the coastal ecosystem, coral reefs provide food and shelter to animals such as fishes, crabs, lobsters and clams, and hence support many important fisheries.
b) Coral reefs protect the seashores from erosion as they act as natural barriers against wave action and storms.
c) They provide scenic and spectacular sites for tourism, especially for divers and snorkellers.
d) When coral reefs break down, the products form sand which contributes to the building up of beaches and shorelines.
e) Some coral reef animals have medicinal value.

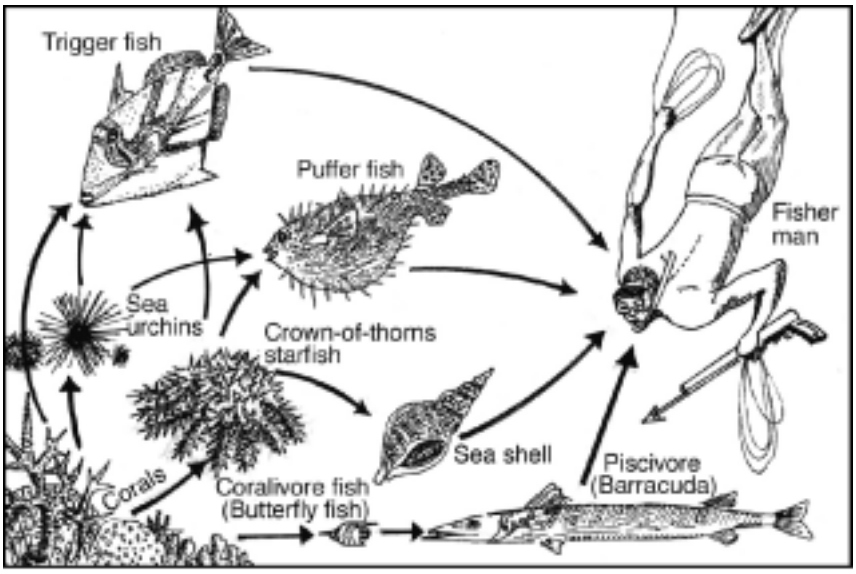


Distribution of coral reefs in the western Indian Ocean (dark areas)

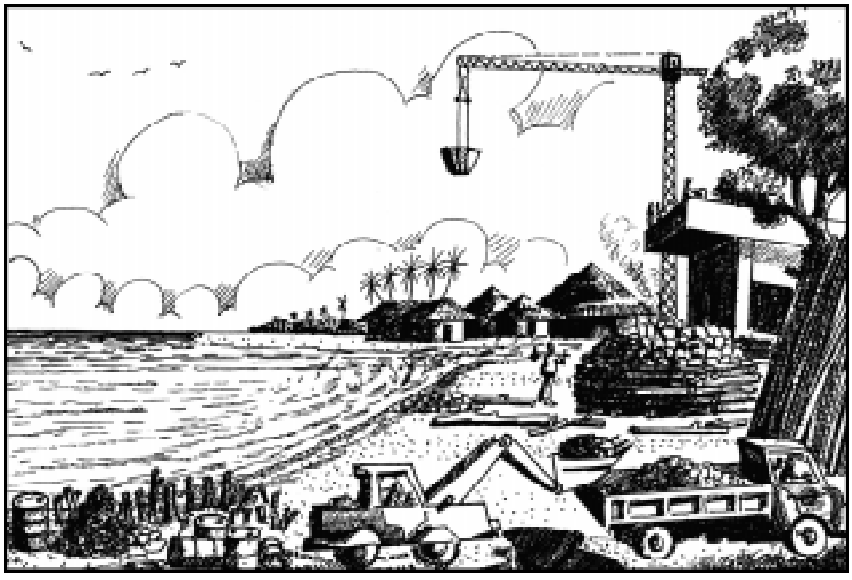
Destruction of coral reefs

Coral reefs face a number of threats from human activities. These include:

a) Sediments from land-based activities such as agriculture and mining;
b) Pollution from sewage and industrial wastes;
c) The use of destructive fishing methods such as dynamite fishing and poison fishing;
d) Collection of coral for lime making or as souvenirs for sale to tourists;
e) Damage of live coral by anchoring boats on the reefs or trampling during snorkelling or diving;
f) Activities that affect the ecological balance between living things on the reefs, for instance, overfishing;
g) Natural events such as damage from storms and hurricanes, river flooding carrying sediments onto reefs close to the shore, coral bleaching and outbreak of diseases and predators, especially the crown-of-thorns starfish.



A coral reef food web



Examples of human activities destructive to coral reefs

When coral reefs are destroyed the balance of life and overall productivity of the reef ecosystem is affected. Fish which feed off living coral, for example, have to change their diet or move away.

Management of coral reefs

People can stop the destruction of coral reefs through:

a) Restricting, or preventing altogether, activities that damage the corals, and
b) Raising awareness of the importance of corals and the need to conserve them.

TEACHING AND LEARNING STRATEGIES

The strategies proposed here include:

Excursion

Go out in groups of 4 to 6 onto the reef at low tide (being especially careful not to step on any living animals). Let each group choose a small area and explore the animals that live down among the dead coral and sand, making notes of all that they see. On returning to the classroom allow each group to give a five-minutes presentation about their observations.

Note to teachers: *Students should wear adequate footware to prevent injury, and be aware of the tide.*

Essay writing

Have students write a short essay explaining 'Why coral reefs are important to us'.

Question and answer session

Imagine the coral reefs ecosystem as a factory or industry. Who works there and what do they produce?

6 COASTAL POLLUTION

INTRODUCTION

This section discusses other sources of pollution, with particular emphasis on waste and litter.

Specific objectives

The students should be able to:
a) Understand what pollution means,
b) List sources of waste and litter, and
c) Propose ways of controlling and reducing wastes and litter.

Student skills to be reinforced

Ability to observe and identify various pollutants and litter, and to dispose of waste properly.

Student behaviours to be reinforced

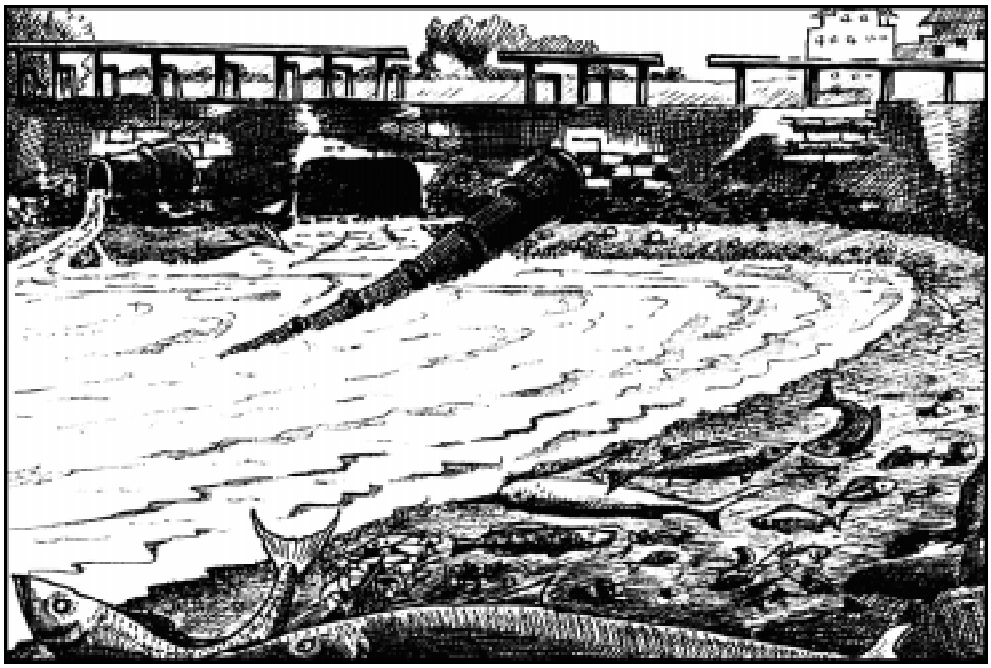
Recognition of the importance of keeping our surroundings clean, and the effects of pollution on the environment.

BACKGROUND INFORMATION

Wastes are discarded domestic or industrial products. They may be solid (litter), gaseous or liquid. When these get into the environment, pollution takes place.

Pollution affects the impression people have of an area's quality. Litter carried by wind, runoff and streams is present on almost all beaches in the WIO region. Most coastal pollutants originate from activities on land. Wastes thrown onto streets is washed into storm water drains, rivers and eventually into the sea.

The impacts of litter on the marine environment can be broadly classified into biological and economic impacts. Biologically, litter can be harmful to marine organisms. In economic terms, it has a negative impact on coastal communities whose livelihood (from fishing, coastal tourism, etc.) and recreational activities depend on clean waters and beaches.



Example of coastal pollution and fish kills

Facts about litter

a) Litter is waste in the wrong place and is always caused by people,
b) The beauty of an area is reduced by litter, and
c) Litter is a health hazard and may attract pests (e.g. rats), birds (e.g. Indian crows) and insects (e.g. flies, mosquitoes) which can spread disease.

Possible ways of controlling waste

There are many ways through which people can control coastal littering and pollution:

a) Make sure that all litter goes into bins for appropriate disposal. Don't let it get washed down the drain as it eventually ends up in the sea.
b) Use better methods to dispose of domestic waste (e.g. by **recycling** it or taking it to special dumping sites and landfills).
c) Organise frequent clean-up of beaches.

TEACHING AND LEARNING STRATEGIES

The strategies proposed here include:

Excursion/litter survey

In the school grounds, take a collecting bag and a notebook with you. Each time you find a piece of litter:

a) Identify and categorise it into broad categories such as 'paper', 'metal' and 'plastic',
b) Put it in your collecting bag,
c) Keep a tally of each piece of rubbish and the collection time,
d) Weigh the bag of rubbish,
e) Burn or bury the material collected. Beware of dangerous items like glass or syringes!

Group discussion

Having returned from the excursion around the school grounds:

a) Suggest possible origins of the materials collected, and
b) Plot a graph showing the number of items in each category. Provide an explanation for the trend observed.

Newspaper article

The students should prepare a half-page article entitled 'City Council plans to develop a rubbish dump in a mangrove area'.

7 COASTAL RESOURCE MANAGEMENT

INTRODUCTION

This last chapter discusses the need to manage the resources of the coastal zone to maximise their long-term sustainability. The concept of **marine tenure** is introduced. Conflict resolution, education and the roles of the individual and the government are discussed.

Specific objectives

The students should be able to:
a) Explain sustainability,
b) Explain who owns the seas around them,
c) List examples of conflicts within the coastal zone,
d) Suggest ways to resolve conflicts, and
e) Appreciate the need to manage resources and protect the environment.

Student skills to be reinforced

Recognition of the various types of coastal resource use discussed in earlier chapters and the problems these can cause.

Student behaviours to be reinforced

Awareness of the limited nature of the sea and its resources, the need to manage them for the future, and the difficulties associated with trying to satisfy everyone.

BACKGROUND INFORMATION

In Chapters 4 and 5 some of the destructive activities that damage the coastal ecosystem were discussed. For example, excessive cutting of mangrove forests and coral reef degradation through physical damage caused by anchors are clear and obvious effects. There are also less obvious effects, such as overfishing or the alteration of food chains, which upset the balance of life in the sea. Pollution can also have a significant effect on the marine environment, as discussed in Chapter 6.

The need for management

Traditionally, the main objective of resource management, particularly fisheries management, has been the conservation of economically important fish stocks. In recent times, the broad objectives of fisheries management

may include not only the conservation of fisheries stocks, but also their marine environment. Resource management also seeks to maximise the economic benefits from exploitation of the resource, and the sharing of the benefits with local communities.

Irresponsible and thoughtless use of the seas' resources may result in the long-term decline of those resources. As a result, future generations may no longer be able to benefit from the resources which have been destroyed. The use of a resource in a way which results in a decline of the resource for the future is called **unsustainable** use. For the benefit of future users resources should be used in a **sustainable** way.

The diversity of the seas' resources is matched by the diversity of users. Fishermen, mangrove cutters, shell collectors, seaweed farmers, fish farmers, hotel developers, municipal authorities, harbours and shipping are a few examples. Each one of these has their own specific use of the sea. Often, different uses develop into conflicts because the resources needed are either in the same area of coast or one activity prevents other activities from taking place. In an attempt to resolve these issues of conflict and unsustainability, some form of management is necessary.

Possible ways of managing coastal resources

One of the most important first steps is that the users recognise who owns the resource. Boundaries in the sea are not visible like on land, and in many countries conflicts exist because ownership of areas of sea is not clear. In some places traditional ownership or **marine tenure** is recognised where specific villages own clearly defined areas of sea or shore. On the larger scale, governments have a 200-mile economic exclusion zone (EEZ) along their shores. This area is internationally recognised as being part of that country. The Seychelles, for example, has a very large EEZ because that country is composed of many islands scattered throughout the Indian Ocean, each with its 200-mile boundary. Many tuna fishing boats operate in the EEZ of the Seychelles only with the permission of the Seychelles government. Kenya, by comparison, has only a small EEZ due to its relatively short coastline. Marine resources in the International waters outside of the EEZ are available to any nation.

At the local level it is very important that resource users be aware of the effects of their activity on neighbouring ecosystems and on the activities of other coastal resource users. Education, both formal and environmental, is an important tool in the process of developing a good management programme or plan for use at local and national levels.

The renewability of coastal resources depends on the enforcement of regulations for management of the coastal environment and its resources. These regulations are either developed by the communities themselves and/or by the government. They aim at either reducing the amount of resources utilised, protecting the environment, or both. Examples of such regulations applied to fisheries resources might include:

a) Limited entry of fishermen to the area,
b) Controls on fishing gear and methods, and
c) Closed seasons or areas.

The methods used to manage coastal resources can be implemented at various levels of society. Some of these include:

Village level management, where the community agrees to use their resources in a sustainable way. This may be done by limiting certain activities to specific areas or seasons, compensating some users for their loss, or developing alternative resources;
District level management, where the various activities in a district are discussed by representatives and agreements are reached on the best ways to satisfy everybody's interests;
National level management through licensing of fishing vessels in the EEZ; and
Regional level management, where national governments within a region agree to cooperate on controlling certain activities.

TEACHING AND LEARNING STRATEGIES

The strategies proposed here include:

Field trip

Within the school grounds and beyond, the students should identify and categorise at least 10 different human activities, describing the activity, its location and the resource used.

Group discussion

Having returned from an excursion around the school grounds the students should:

a) Suggest possible conflicts among the different activities identified, and
b) Suggest possible ways of resolving these conflicts so that all groups are satisfied.

Role simulation

Divide the class into groups of five students. Each student should then select a role as a coastal zone user. Examples of some of the roles that groups might consider include:

a) Fisherman, hotel developer, rubbish dump developer, mangrove cutter and school nature club representative.
b) Shell collector, boat builder, harbour developer, local resident and Department of Environment representative.
c) Bait digger, housing developer, school teacher, religious leader and seaweed farmer.
d) Dynamite fisherman, tourism guide, school nature club representative, businessman and policeman.

Each group should imagine that a stretch of coastline in their vicinity is being sold and each user has an opportunity to explain why their activity should be allowed. For 5—10 minutes each group should act out their roles. The rest of the class acts as judges, finally agreeing on a management plan for the coast.

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