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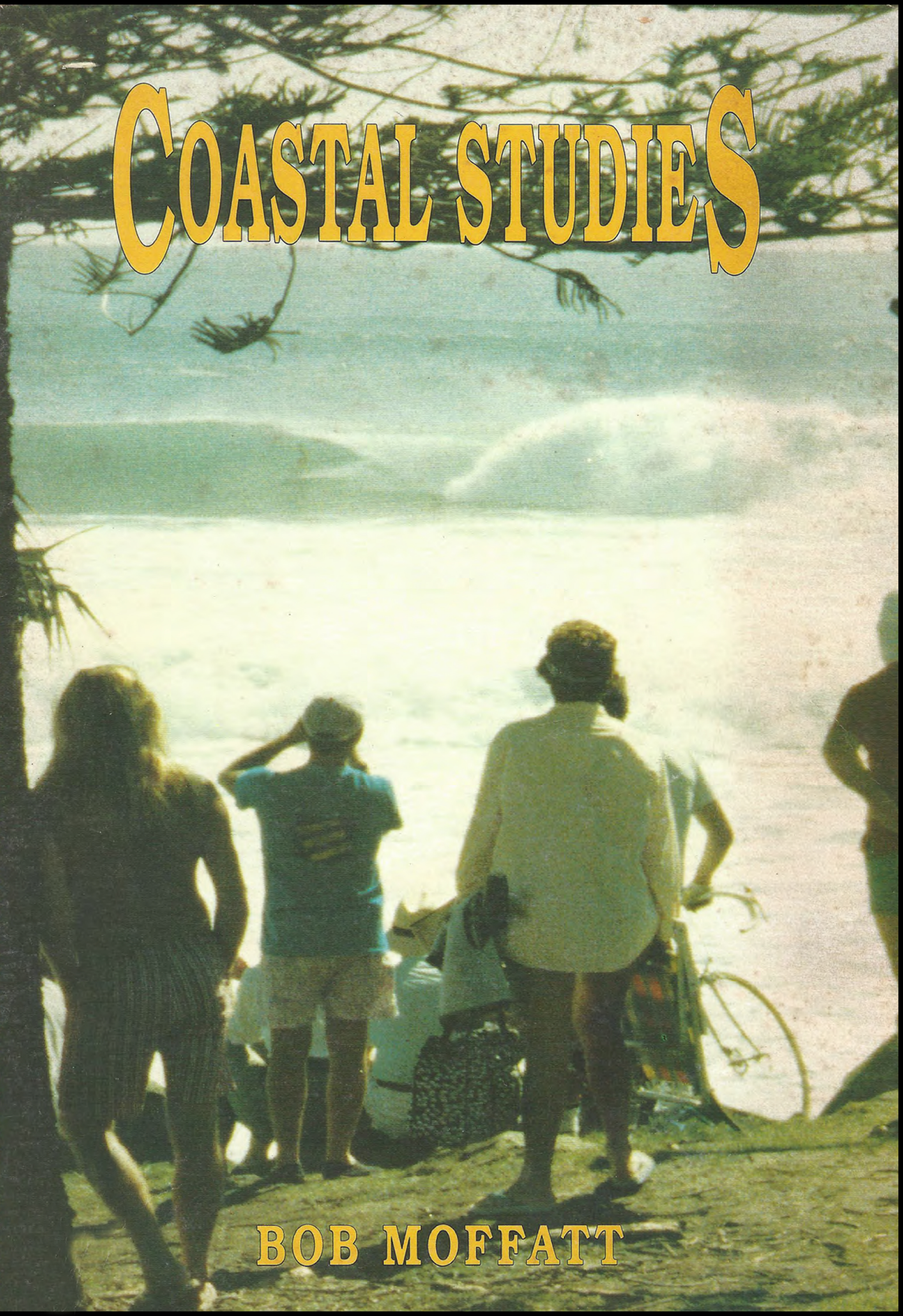
COASTAL STUDIES



BOB MOFFATT

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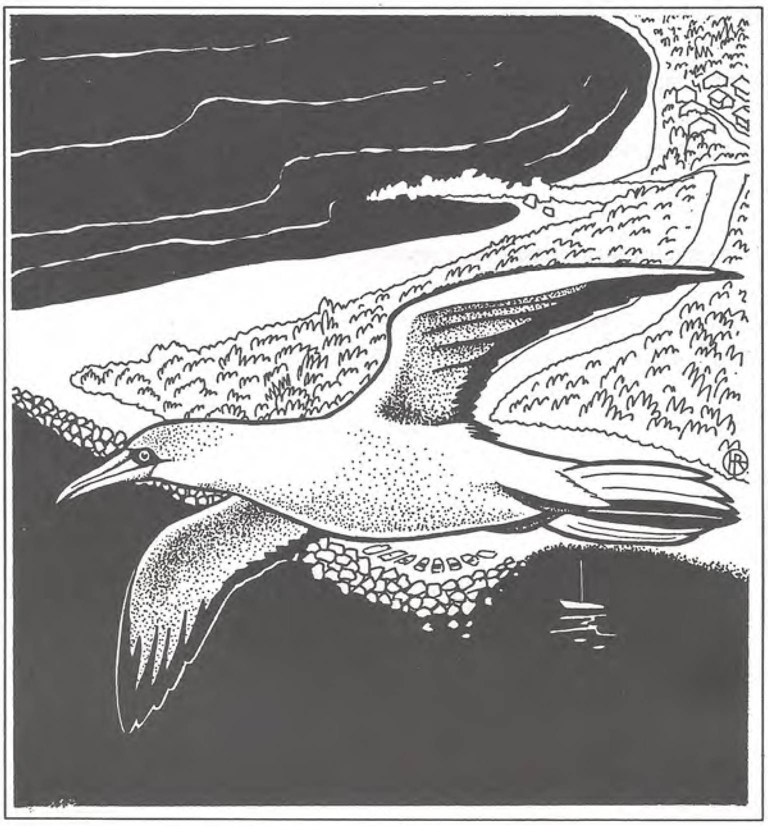
COASTAL STUDIES



By

BOB MOFFATT

B.Sc., Dip. Ed., M.A.C.E., Grad. Dip. Ed. Admin.

Goal

The development of our coastline is a reality.

In the past we have acted in ways which have caused many environmental and social problems.

Hopefully as future development occurs, we will apply the principles we have learnt in using our coastal zone wisely.

This book seeks to increase student awareness of

> some of the forces that shape our coastline,
>
> the natural behaviour of beaches, sediment flow, how man has interfered with this, and
>
> some management issues relevant to coastal land development

in the hope that future generations will know and understand more, so that they can adopt codes of behaviour consistent with effective management practices.

Contents

Preface

There is a **Teachers guide available** which is updated each year so that new ideas and issues can be discussed. It contains exam questions, suggested answers to most exercises and information on how to construct the equipment for the exercises. Page 102 details what resources are required for each of the units as well as the address for the videos. Concepts in many places are linked with activities. It is essential you see the videos as they tie in with the text.

The field work can be done as a single day excursion to the beach and should be carefully planned. All new words are in **bold** and are defined soon after.

List of activities and field exercises

Activity		Page	Classroom Exercise	Library Research	Video Activity	Field Exercise
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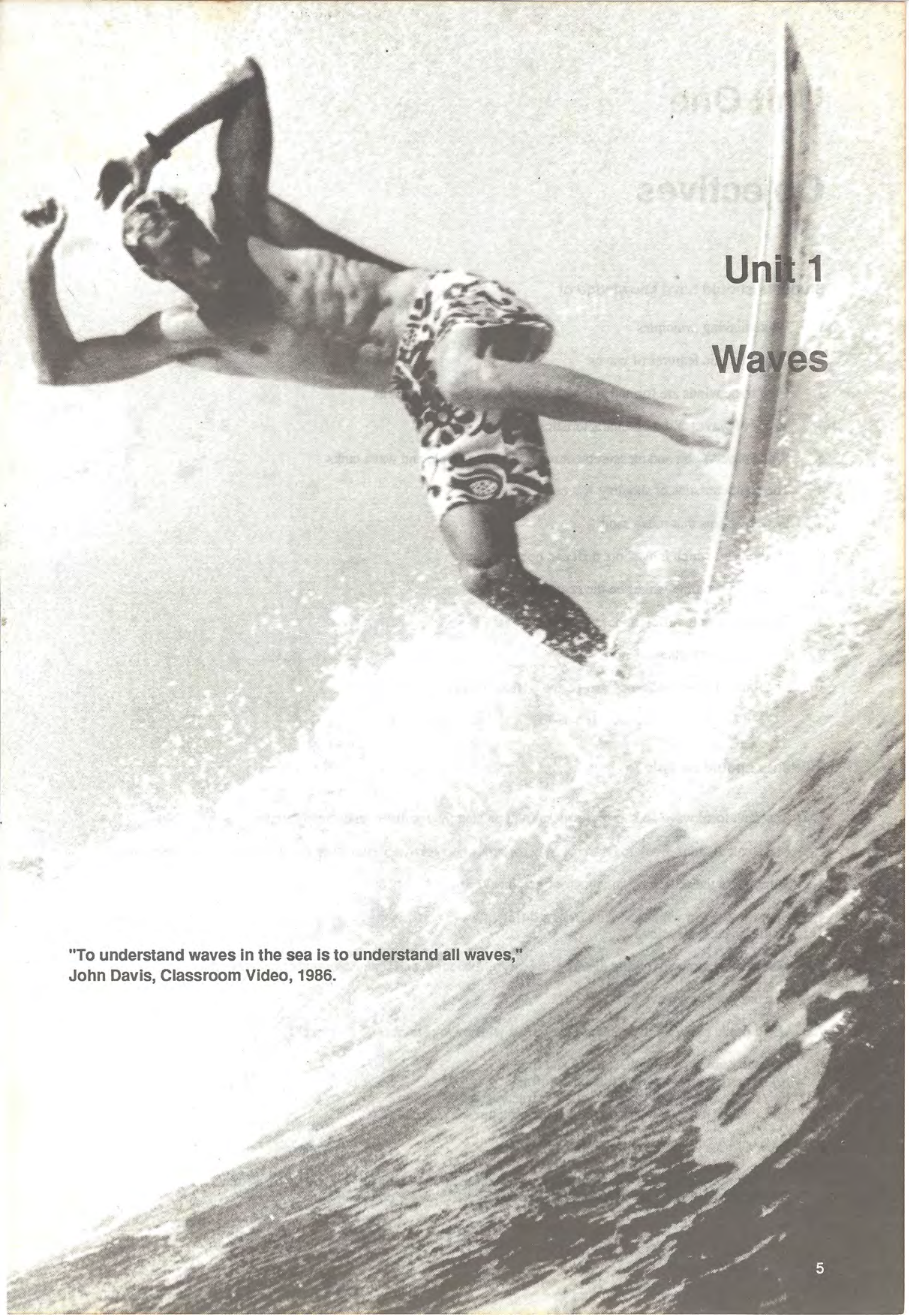
Unit 1

Waves



"To understand waves in the sea is to understand all waves,"
John Davis, Classroom Video, 1986.

Unit One

Objectives

Students should have knowledge of

1. Wave making principles
2. Characteristic features of waves
3. How trade winds are formed and control our coastal wave patterns
4. Types of waves and their characteristics
5. Wave observation and measurement methods using ripple and wave tanks
4. The characteristics of shoaling waves
5. Wave patterns that move sand
6. Methods by which long shore drift can be measured
7. Effects of shoaling waves on the coastline
8. Wave refraction, diffraction, reflection and sets
9. Tides as a wave phenomenon
10. The units of time, frequency and period as they apply to waves

Students should be able to

1. Research local wave and current patterns and present the results in an excursion report
2. Make calculations involving the changing patterns of waves in a ripple or wave tank or from direct observation
3. Summarize these changes in tabular or graphical form
4. Suggest ways in which the data from a different wave patterns may change due to changing environmental conditions e.g. a cyclone
5. Make calculations involving distance, celerity, wavelength and time for hypothetical wave data
6. Discuss tides as a wave form
7. Use a ripple tank or wave tank to experiment with wave patterns and as a result:-

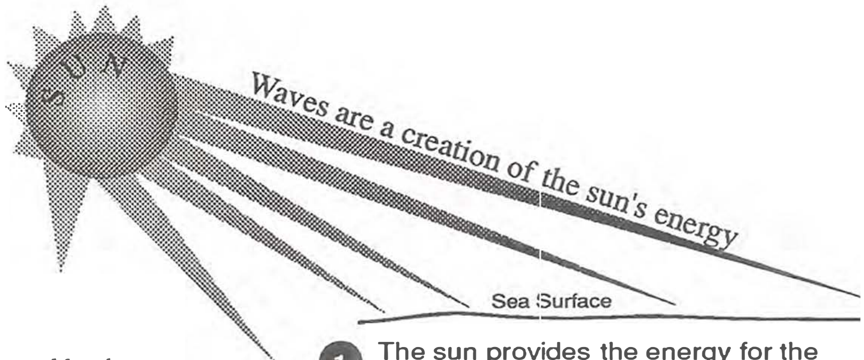
   (a) measure wave length, celerity and time
   (b) describe how waves refract and diffract
   (c) differentiate between diffraction, refraction and reflection
   (d) discuss different coastal engineering structures

8. View a series of videos and as a result:-

   (a) become more aware of wave shapes, characteristics and interactions with the coastline
   (b) become more aware of how weather patterns effect wave characteristics

Topic 1

Wave Formation



Waves are living energy created by the sun.

As the sun heats the oceans of the world, it causes parcels of air above the sea to rise. As a result, a partial vacuum above the ocean's surface is created and nearby, cooler air moves into this space.

This movement of air is called ***wind***. As the wind moves over the surface of the sea, it causes the surface to wrinkle and drags the water molecules into a **ripple**. The more the wind blows, the bigger the ripples until finally a wave is formed.

The distance over which the winds can actually manufacture waves is called **the fetch**.

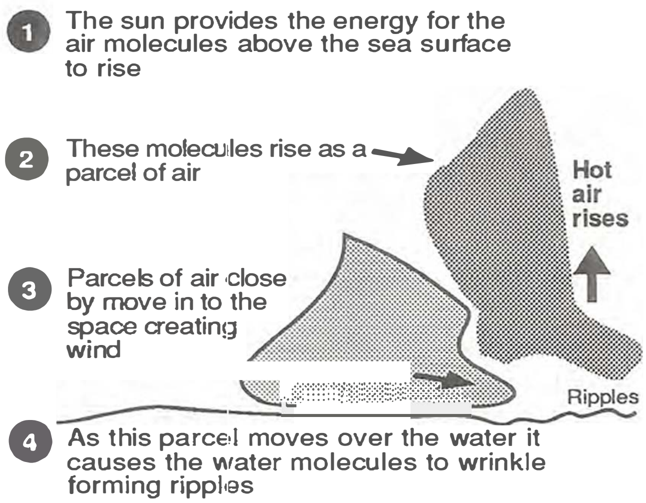


Fig 1.1: Principles of wave formation.

Fig 1.2: These waves have formed as a result of large amounts of wind. Photograph courtesy Australian Surfing Life

A study of waves is important because it helps engineers design ports, harbours, sea defence systems and lately, sandy beaches. We need to know how powerful waves are, when they will break, how they break and what their effects are on the sediments below. The design of boats, surfboards and ocean liners also depends on a knowledge of wave characterisitcs. Let us begin by looking at some general characteristics of waves. The significance of each will become apparent as we progress through the book.

* **A wave** is defined as a carrier of energy and is said to have the following general characteristics.

* **Energy.** This is transferred from the wind to the wave. When the wave breaks, the energy of the wave is transferred to the environment in which it breaks. (e.g: sand, rocks or even the wave breaking turbulence).

* **Celerity**: This is the speed of the wave in a certain direction and is expressed in metres per second and has the symbol C.

* **Wavelength**: The distance is metres between wave crests or troughs. The units are metres and the symbol is (L).
* **Frequency** is the number of wave crests that pass a fixed point in a certain time. Frequency has the symbol f. Frequency is expressed as waves per second.

* **Period:** This is the time between waves. The period has the symbol T and is expressed as seconds per wave. If you stood at the beach and counted the number of broken waves that touched your feet every minute, you would be measuring the period of the broken waves.

* **Crest.** The top of the wave is called the crest and the bottom of the wave is called the trough.

* **The orbit fields**. The wind causes the water to move in a series of circles called wave orbits. These circles or ***orbits*** move in a circular motion and decrease in diameter with depth. A series of wave orbits as shown in the figure below, is called an ***orbit field***.

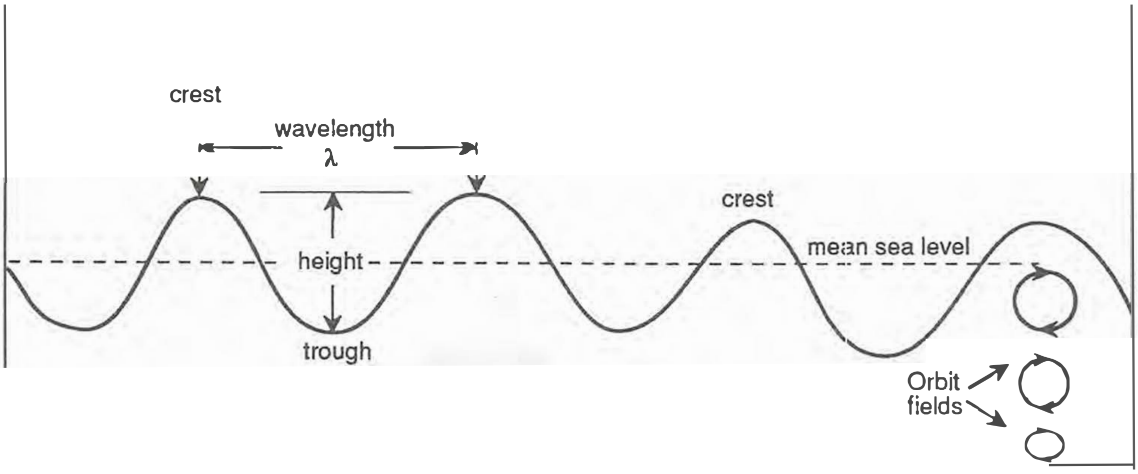


Fig 1.3: Some general characteristics of waves.

Now waves in the sea develop to a plan. Look at Figures 1.4 and 1.5, and assume that no waves have entered the system.

When there is no wind there are no waves. The first wind blows causing an initial disturbance and **ripples** form. The ripples are very irregular and uneven and the direction in which they travel varies. The crests are barely perceptible.

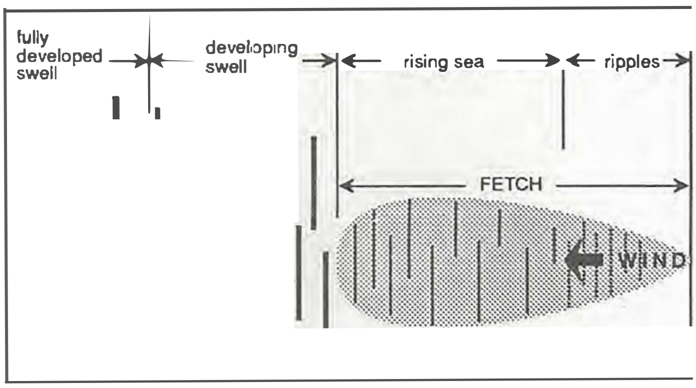


Fig 1.4: Plan view of how waves develop.

The wind now starts to blow over a much greater distance called a **rising sea**. The waves are still in a confused state. The distance between waves is small; however the ripples have captured themselves to become a **developing wave**.

The wind continues to blow and the sea adjusts to become a **swell** with the ripples dying out. The trough lowers and elongates to become parallel with other troughs. The crest length increases and as the waves get larger they become part of an **escaping sea** and are called **adjusting waves.**

As the waves gather more speed they become part of a **mature swell** or **fully developed sea.** The crest and trough are symmetrical, the energy is fully balanced, they have a long crest length and are in an optimum cruising state. They are now called **airy waves.**

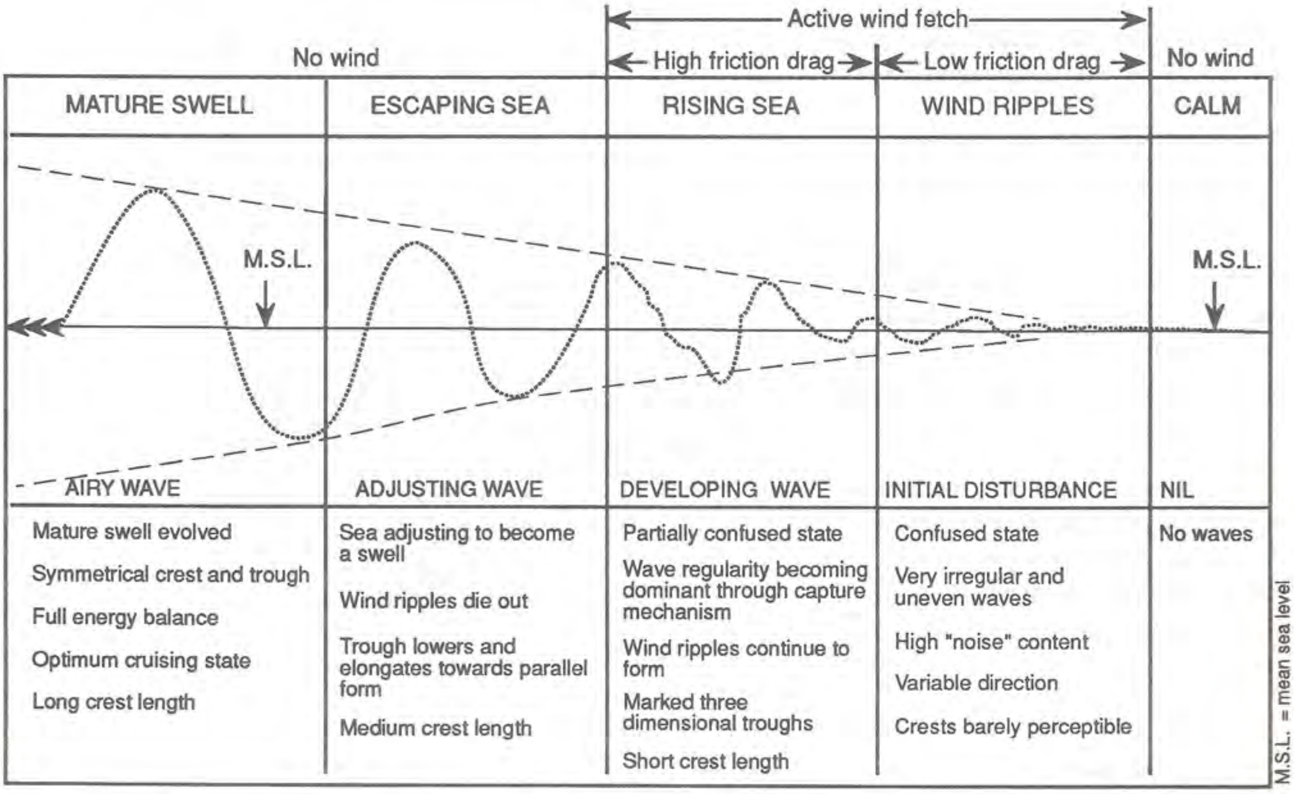
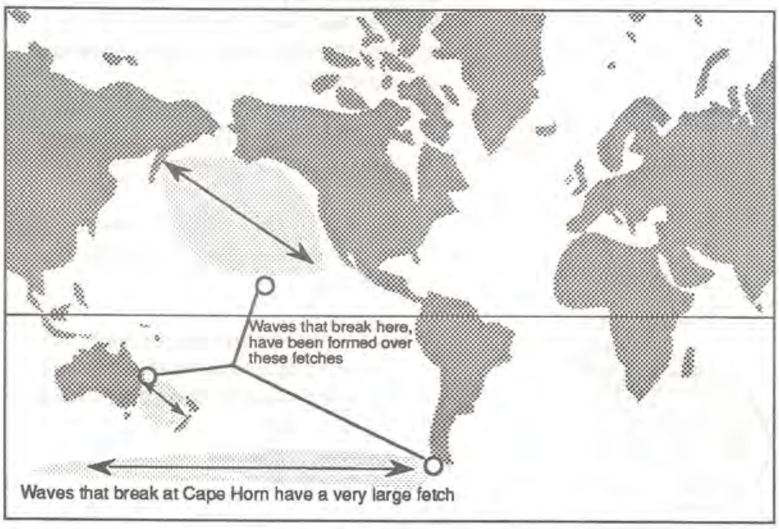


Fig 1.5: Side on view of wave formation, after Smith S., 1990.



Large waves form as a result of wind blowing over great distances. The waves that break in Hawaii or Cape Horn, developed this way..

In Australia waves that break on the shore rarely exceed 6 metres in height. On the east coast they develop in the Tasman Sea and on the west coast in the Atlantic and Indian Oceans. These waves are driven by the high and low pressure systems that move across Australia.

Fig 1.6: The size of the fetch will determine the size of the waves that break on distant shores.

Trade winds and surf

The sun's rays heat the earth unequally. More earth is heated at the equator than at the poles. On a large scale, air heated at the equator rises faster and creates an area of low pressure below it.

Because of this rising air, cells of low pressure form around the equator. The places where air sinks form areas of high pressure.

The spinning earth moves these pressure cells in patterns called **trade winds.**

As the high pressure moves from left to right the direction in which the wind blows will vary.

During January and March high pressure systems tend to move at lower latitudes over Australia creating different wind patterns and sea conditions compared to September to December.

For those who surf, this makes a big difference to the type of surf experienced. From Bells Beach in Victoria, Margaret River in Western Australia or to Noosa Heads in Queensland, the surf can vary on the coast.

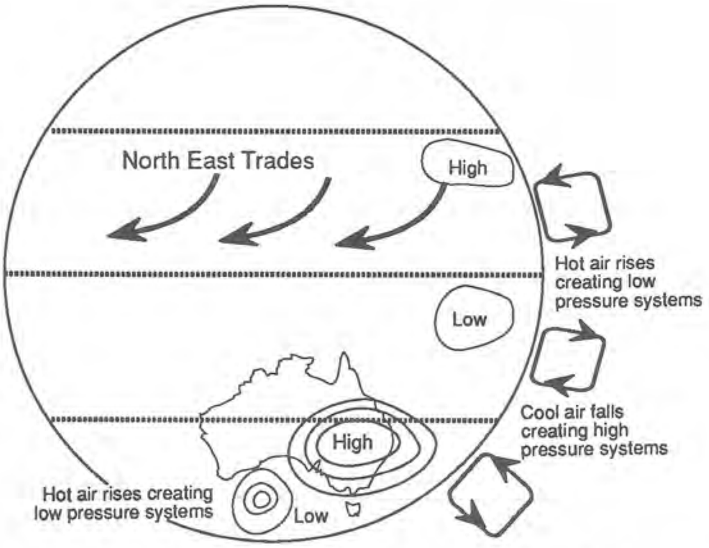


Fig 1.7: Trade wind principle showing how high and low pressure systems form.

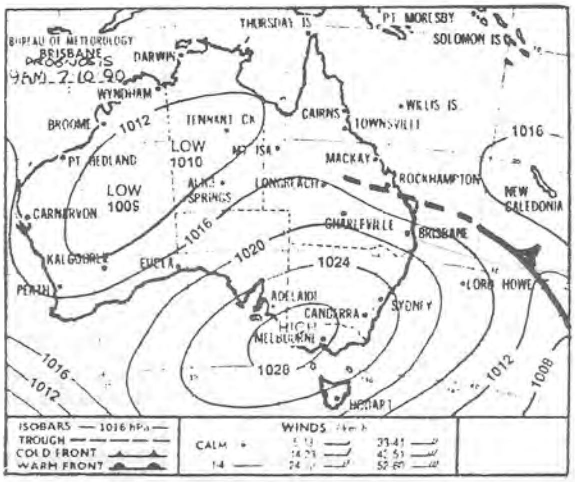


Fig 1.8: High pressure system

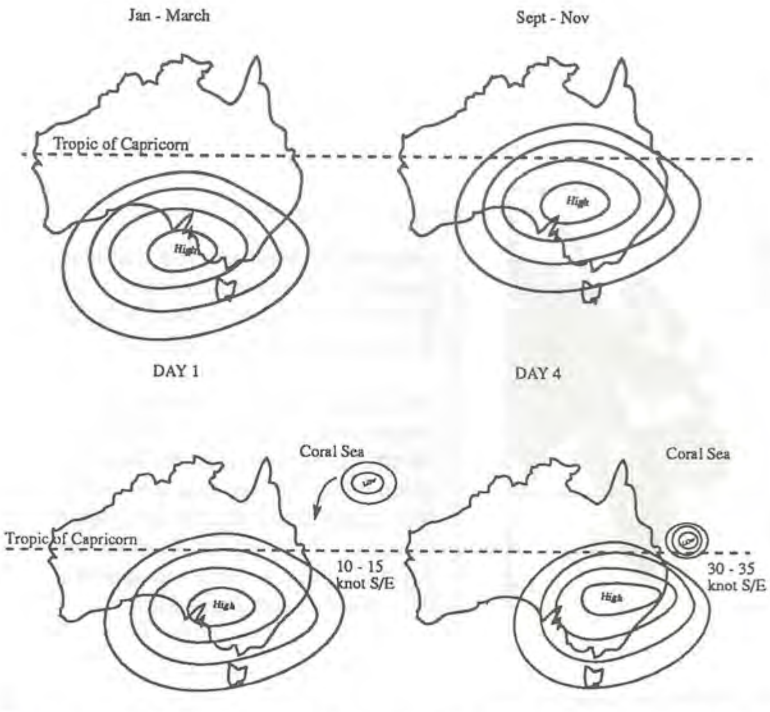


Fig 1.9: Wind patterns can be affected by the latitudes over which high and low pressure systems move

Pressure systems

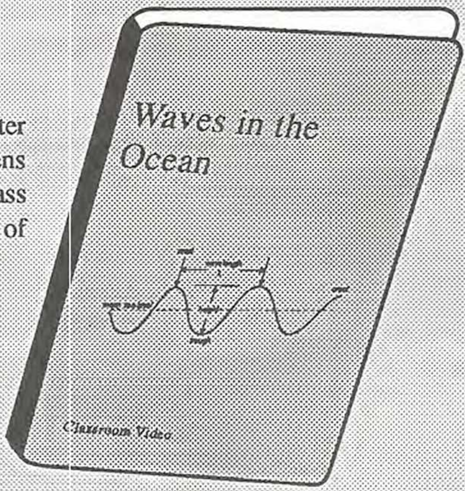
Low pressure systems can also increase wind speed and direction as they squeeze high pressure systems **isobars** close together.

Winds increase as the isobars squeeze together as shown by Figure 1.9.

Wind speeds of 35 - 45 knots over a day can increase the wave height from 1 to 3 - 5 metres.

However once the low moves out to sea and the wind decreases back to 5 - 10 knots, the wave height soon drops back to a metre of swell.

Activity 1.1 Waves in the Ocean Video



Aim

As a result of watching this video you should have gained a better understanding of how waves move in the ocean, described what happens when waves approach a shore, recalled the effects of waves as they pass around headlands and breakwaters and appreciated the movements of sediment flow in these regions

You will need

* Video player
* Video on *Waves in the Ocean**

What to do

View the video and write a paragraph on each of the following.

1. How w[illegible]rm
2. The waters path in a wave
3. Wave sets or beats
4. Diffraction
5. Reflection of waves
6. Refraction of waves
7. Translatory waves
8. Why waves break

These videos are available from:-

Classroom Video
81 Frenchs Forest Rd
Frenchs Forest 2089

Activity 1.2 Weath[illegible]s

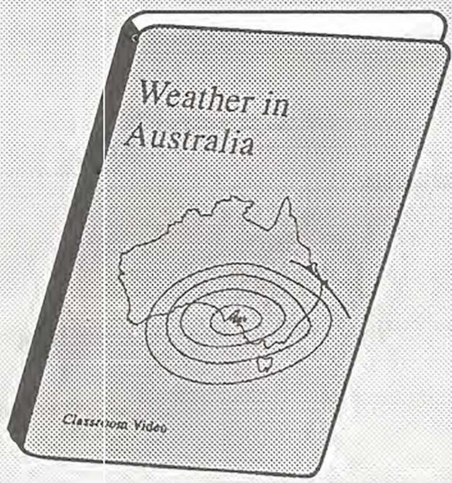
You will nee[illegible]

* Video player
* Video on *Weather in Australia*

What to do

View the video and write a paragraph on each of the following.

1. How hot air rises
2. Water Vapour
3. Meteorology
4. Barometric pressure
5. Wind
6. Cyclones
7. Cold and Warm fronts
8. Rainfall
9 Weather maps



Measuring wave characteristics

(Waves in the ocean travel with different characteristics than shallow water waves. The difference is not discussed here.)

In general we can relate wave speed (celerity), frequency and wavelength as follows:

Wave Celerity (speed) = frequency x wavelength

Sample problem: A wave has a length of 15 metres and you count 5 seconds between each wave (i.e. a period of 5 seconds per wave). What is its celerity?

Ans: Celerity = frequency x wavelength
Frequency = 1/period

Celerity $= \frac{\text{wavelength}}{\text{period}}$

$= \frac{\text{15 metres}}{\text{5 seconds per wave}}$

= 3 metres per second

Relationship between celerity, frequency and wavelength.

$$\text{Speed} = \frac{\text{Distance}}{\text{Time}}$$

$$\therefore \text{Celerity} = \frac{\text{Wavelength L}}{\text{Time}}$$

$$\text{or } C = \frac{L}{\text{Time}}$$

$$\text{but } f = \frac{1}{T}$$

$$\text{so } C = f \times L$$

Revision problems

Q1. A wave has a length of 15 metres and period of 3 seconds per wave. What is its celerity?
Q2. A wave has a L of 25 metres and a T of 6 seconds per wave. How fast is it travelling?
Q3. A wave having a frequency of 5 seconds per wave is found to be travelling at 25 metres per second. What is its wavelength?

Wave buoys

Waves at sea can be measured by using a wave rider buoy like the one shown in the Figures 1.10 and 1.11.

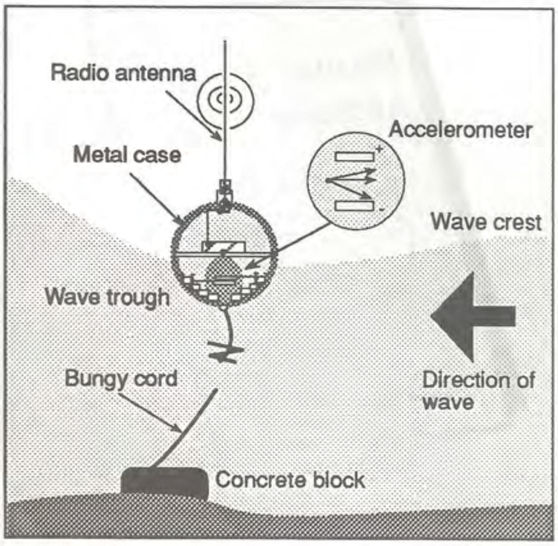


Fig:1.10: Generalised wave buoy construction and positioning. Page 14 discusses its operation and use.

FIG 1.11: A wave buoy ready for shipping. Photo courtesy Qld Beach Protection Authority

Activity 1.3 A long wave tank

Aim:

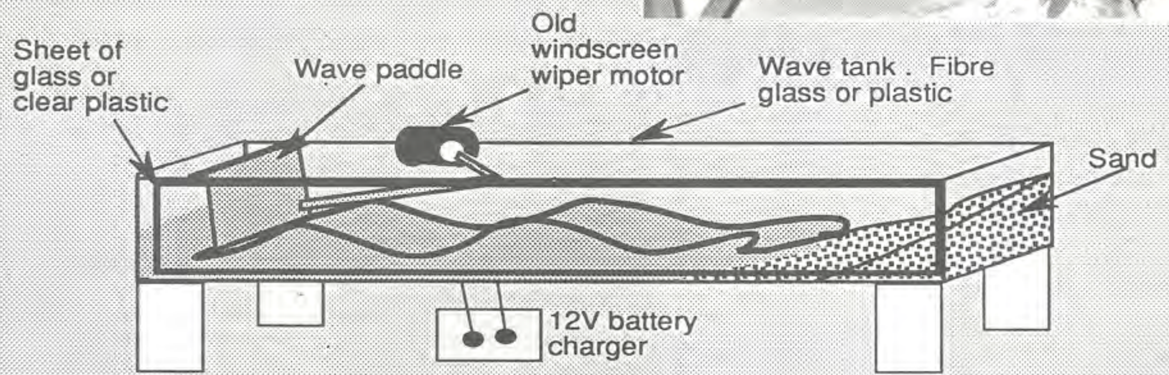
* To measure some wave characteristics in the classroom

You will need

* wave tank
* 12V battery charger
* old windscreen wiper motor
* friendly Manual Arts Teacher

What to do

(1) Use your friendly Manual Arts Teacher to help you build your wave tank out of scrap wood, fibre glass and plastic as shown. The windscreen wiper motor gives a good constant period to create the waves necessary for the experiments. Once the motor is screwed in place and working at about 6 volts, add sand and water.



(2) You could build one using plastic, timber and have a manual paddle or you could even use a stream tray supplied to schools to show how streams flow, however these have limited use as you need a **side on view**.

(3) Set the wave tank in operation to give slow small waves.

(4) With a ruler measure the wave length by working with a partner and using a marking pen to accurately mark off two crests on the front of the tank.

(5) Count the number of crests that pass a fixed point in 10 or 20 seconds and calculate the frequency in waves per second as per the formula on page 12.

(6) Now calculate the wave celerity. Complete a data table like the one below and then use other wave patterns to record different results.

Questions

1. Are the wavelengths different for the different paddle speeds?
2. Does the frequency increase or decrease with wave-length?
3. How does celerity compare with wavelength? Is there any relationship?
4. If the wave tank is run for any length of time, does the sand at the bottom of the tank move? If so in which direction and under what wave conditions?
5. Can you derive a formula for the conditions under which waves break. See fig 1.20 Page 19.
6. Can you suggest who might use such calculations and for what purpose?

Data table

Trial (metres)	Wavelength (waves/sec)	Frequency (m/sec)	Celerity
1			
2			
3			

The Teachers Guide details how to build this tank. You could also use an aquarium and a hand paddle.

The buoy consists of a metal sphere, radio antenna and bungy cable attached to a concrete block on the sea floor. Inside the metal case is an **accelerometer**, which measures how far the buoy accelerates above and below mean sea level. This measurement is in the form of an electrical impulse which is equivalent to the wave height.

The electrical impulse from the buoy is converted into a radio signal which is then beamed back to a receiver on shore. A computer logs the raw frequency data and counts the signals. This counting is important in determining the frequency of the signal.

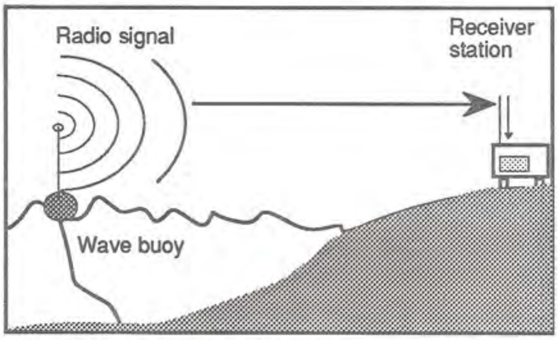


Fig: 1.12 Information from the wave rider buoy is transmitted back to a shore recording computer

Computer program software is then used to make calculations based on the frequencies of the radio signal and the number of times the signal is received. The types of calculations done give the coastal engineer an idea of the types of waves that approach a shoreline and the power they exert on a headland, breakwater or beach over time.

Wave sets

In the sea, swell waves capture ripples and developing waves to form adjusting and airey waves. When two or more of these captured waves travel together, they form a beat or **wave set**. The photograph below shows wave sets approaching a headland. Wave sets can also approach a beach, however the effect is not as regular.

Fig: 1.13 A wave rider receiver, computer and modem

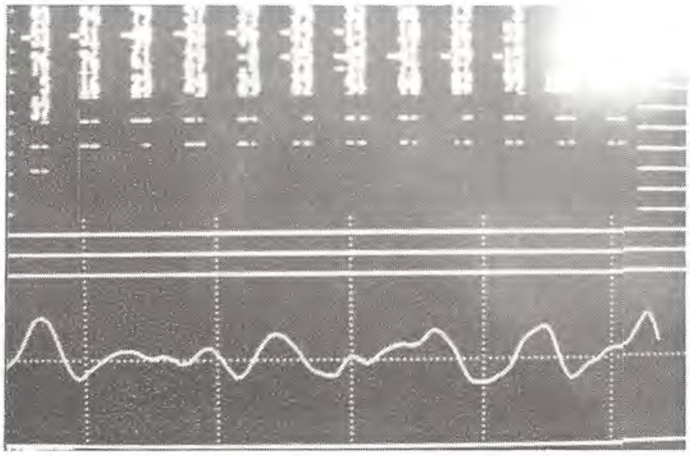


Fig: 1.14 Patterns seen on a video monitor from a computer program which plots real time wave data.

Fig 1.15 Wave sets approaching a headland. Photograph courtesy of Gold Coast City Council.

Wave sets are the result of what has happened many hours and many kilometres earlier. Their size depends on the fetch.

Sometimes one wave in the set is bigger than others. It catches surfers inside the break and is called a cleanup wave. Surfing in big seas requires great skills and knowledge and should only be attempted by experienced surfers.

Field Study

Activity 1.4 Wave Watching

Introduction

To gain a real appreciation of how waves break and observe some of their characteristics, an excursion to a beach or headland is essential.

It may be possible to study a series of videos on waves however there is nothing like actual observation to understand all the features. The best place to watch waves is from a headland looking down on a beach system. Patterns can be seen and an overall picture of waves can be observed. It is most likely that this activity will be part of many that your group will do as part of a day's excursion.

You will need

* pencil and worksheet
* compass or local knowledge of wind directions
* a partner
* camera (optional)

Time required

30 minutes + whatever time it takes you to get to the beach.

What to do

(1) Read the wave watchers observation guide over and make notes and sketches as required on the worksheet

(2) Take photos of the wave patterns to illustrate the answers to the questions.

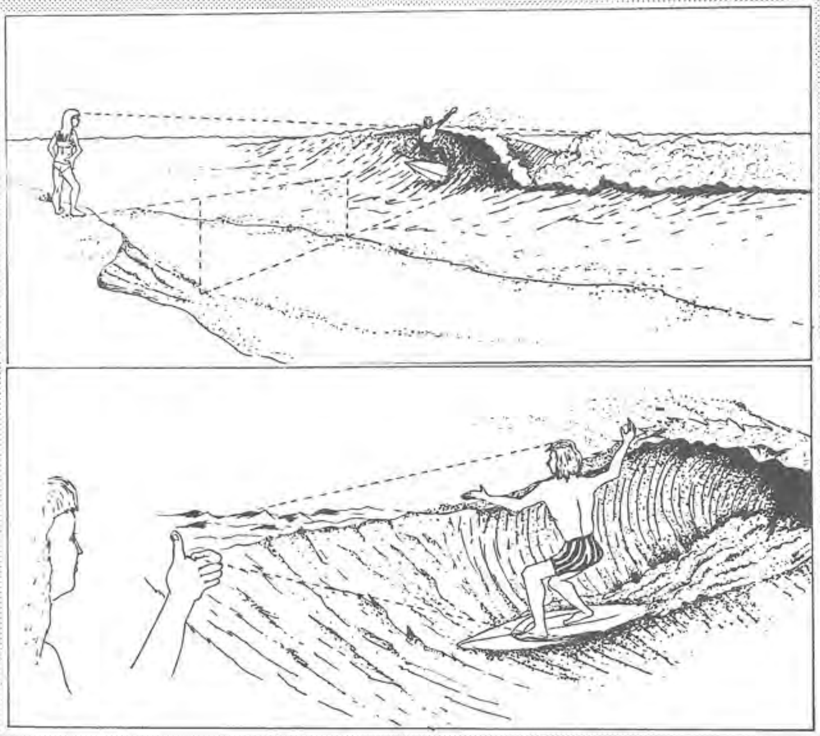


Fig 1.16 Two methods for estimating wave height

Questions

1. Make a sketch of the headland system as if you were looking down from an aeroplane. Now draw in the direction the waves are travelling. Mark in where the rocks are and where the sand begins. Note also the areas where waves break and where sand accumulates. Complete the date, time, wave height, wind direction and tide information in the spaces provided.
2. Can you tell where the water is flowing the fastest? Mark this on your drawing. What evidence do you have for this ? How do surfers get out to the break point? Is there any special pattern to their surfing?
3. Why does the wave slow down near the rocks?
4. Find out and record the difference between refraction and diffraction?
5. Does the tide make any difference to the size and breaking pattern of the point surf?
6. Is the rip at the point the greatest at full tide, half tide, low tide. Why?
7. Look carefully at the waves as they break. Make a note of where sandbanks are.
8. Make a list of the materials that make up the headland. Is there any evidence that the headland is eroding?
9. What is the time between waves? Now calculate the speed at which the waves are travelling and try to determine the distance between wave crests.
10. How many waves are passing a fixed point in 10 seconds?
11. Why do surfers avoid certain waves?
12. Is there any reflection of waves as they strike the headland? If so where does this occur?
13. There are three main types of waves. Spilling, plunging or surging. Observe all the waves that break on or around the headland and record where these occur. Do the same on a beach.
14. Do all waves have the same colour? Record the colours you see and suggest reasons for the colour changes.

Field Study

Wave watchers observations

(1) Do waves have a definite shape? Make a drawing of some of the waves you see.

(2) What happens to waves as they approach the shore? Does their size and shape change? Estimate the size of the waves by using your thumb or pencil and an object of known size (e.g. a Surfer)

(3) What causes the noise as the wave breaks? What is the time between waves ? Is anything carried in with the waves ? If so, what ?

(4) Which directions are the waves coming from? Is there some pattern to this movement and do the waves approach the shore at an angle? Observe a group of surfboard riders. How do these surfers get "out the back" ? Is there any particular area they avoid?

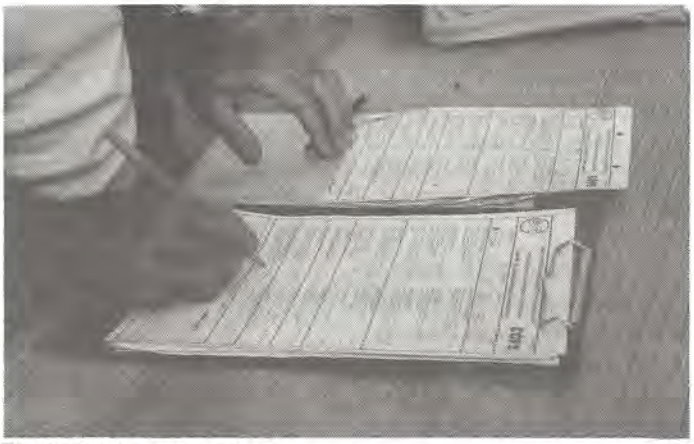


Fig 1.16 Recording sheet

(5) Are all the waves the same height and shape? Can you see a rip? If you can, how can you tell and what steps should you avoid when swimming near a rip?

(6) Do waves approach the shore in sets? If so, how many waves to a set?

(7) Do waves break further out on an offshore sand bar? Are the waves breaking and reforming a number of times?

(8) Make an overall sketch of the area you are observing and mark in relevant features such as headlands, creeks, beach and wave patterns.

(9) Look carefully at the features you have marked. Do any of these have an effect on the way the waves are breaking? Write the effects down.

(10) Look at the waves as they break on the beach. Watch what happens after the wave has broken. Draw a sketch of the broken wave as it would appear from side on. Use the figure on page 17 to help you.

(11) What happens to the shape of the waves as they break on the beach? The wet area of the beach is called the swash zone. Do the waves always reach the highest point on the beach? How far does the water run up the beach? Take a measurement.

(12) Watch carefully as the wave washes back towards the ocean. Does all the water return? If not, what happens to it?

(13) Do waves all rush up the swash zone evenly or are there **crennatures** (cusp like features) on the beach?

(14) Is the tide in or out? Would the same wave patterns appear at a different time in the tide? Give reasons for your answer.

(15) Is there any evidence of pollution? If so what and where? Look in the beach litter and make a description of what you can see. What origins do these materials have? Answer in your note pad.

(16) Is there any beach erosion? If so, note where it is in your note pad.

Wave watchers worksheet - beach

Sample worksheet

Sea conditions:

Date: .... Wind Speed .... Water Clarity in surf zone ☐ murky ☐ clean

Time: .... Water Temperature .... Tide (ebb or flood) ....

Taste of Surf ....

Smell of Surf .... Wave Height (max over 5 mins) ☐ 0 - 0.5 m ☐ .5 - 1.0 m ☐ 1 - 1.5 m ☐ 1.5 - 2.0 m ☐ 2.0 - 2.5 m

Wave Colour ....

Wave Sound ....

Beach conditions ....

Wave Shape ☐ Smooth ☐ Choppy ☐ Broken white caps ☐ Clean lines approaching the shore ☐ Other ....

Wind Direction ☐ On shore ☐ Off shore ☐ Nil

Topic 2

Shoaling waves

Waves that approach the shore and change shape are called **shoaling waves.** These are characterised by the fact that their trough rises as they approach the shore and they lose their energy to the sea floor over which they move.

How much energy do they have and how is this energy lost? What happens to this energy and what effect does it have on the coastline?

When a wave approaches the shore the water above the datum point rises. This rise in a shoaling wave situation is called the **wave set-up.** The water escapes under the wave over the offshore sand bars as indicated in Figure 1.17. A common technique surfers use to get under waves these days is called **duck diving.** If the surfer can position the surfboard into this set up escape region, the surfer can use the set-up escape mechanism to pop out the other side.

Each wave break reforms and breaks again about half its previous height. The height of the wave above this wave set-up decreases as the waves approach the beach as shown by H_1, H_2 and H_3.

Wave set up occurs on the beach by wind and wave action and is the final point at which all the energy given to the wave by the wind is lost.

"Shoaling means wave length and celerity decrease, troughs rise and crest falls above mean sea level until the wave breaks." Smith, S. 1990.

Fig: 1.16 As waves approach the shore they change in shape, direction and speed. Photo courtesy Gold Coast City Council

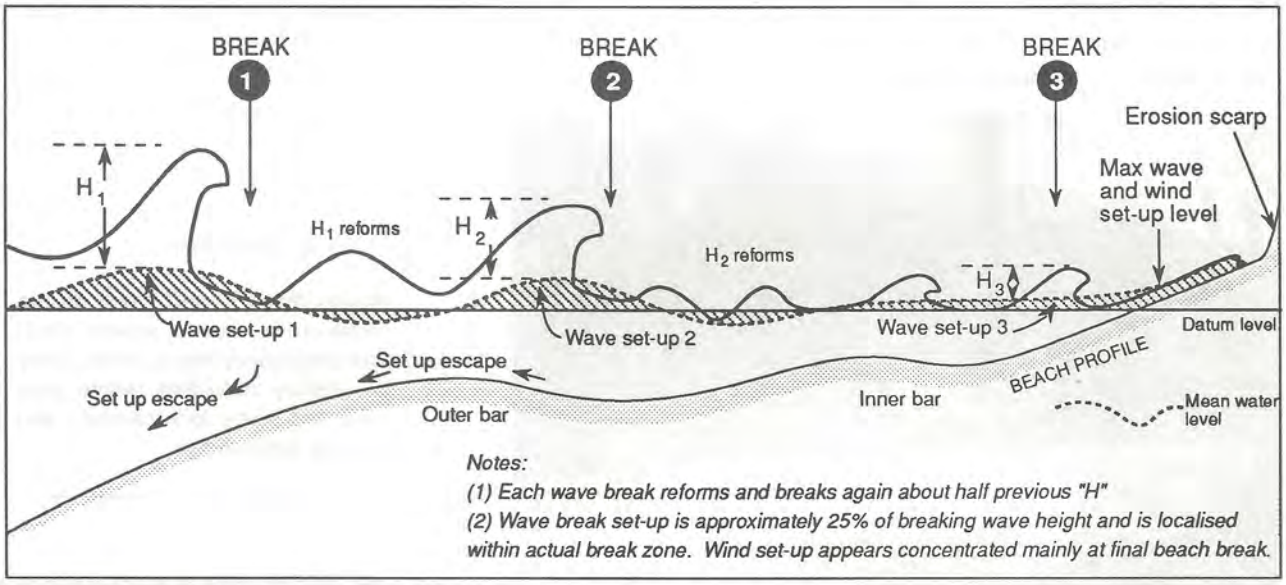


Fig: 1.17 Characteristics of shoaling waves. After Smith, S. 1990.

Generally three types of shoaling wave are recognised and these are summarised in the diagram below:

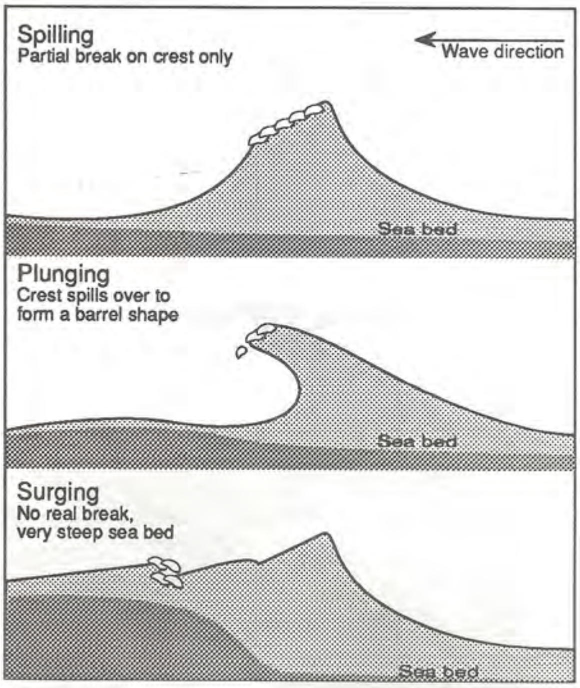


Fig 1.18:- The three common types of shoaling wave

If you stand on the shore and watch waves break, you will notice that no two waves are ever the same. Generally speaking, the way waves break depends the way they were formed and not by the sea-bed over which they travel.

The sea bed shape is determined by the wave form which in turn is determined by the shape left by the previous wave. Where the sea-bed is fixed, such as a rocky headland, there can be some predictability about the wave shape. However the distribution of sand can change around a headland as does the water depth due to tide.

Shoaling waves on one particular day may surge at high tide, spill at half tide and plunge at low tide. In the winter months when waves as big as 7 metres break in Hawaii, the cutlery in the drawers rattles at night.

The Mathematics

These events can be described mathematically in a relationship called the **wave equation.**

If $f_1 = \frac{C_1}{L_1}$ and $f_2 = \frac{C_2}{L_2}$

and $f_1 = f_2$

then $\frac{C_1}{L_1} = \frac{C_2}{L_2}$ or $\frac{C_1}{C_2} = \frac{L_1}{L_2}$

Let us call the celerity of waves in the sea - C_1 and those that shoal close to shore, C_2. As the waves shoal they change shape. The wave trough rises and the celerity decreases. The wave length is narrowed, however the frequency of the waves does not change. We can apply this to our calculations.

Sample problem

A wave at sea has a wavelength of 25 metres and speed of 20 metres per second. As it approaches the shore it is observed to have a speed of 15 metres per second. What is its new wavelength? Ans: The wavelength will be less closer to shore.

We can calculate this as follows using our wave equation.

$$\frac{C_1}{C_2} = \frac{L_1}{L_2}$$

$$\frac{20m/s}{15m/s} = \frac{25 \text{ metres}}{L_2}$$

$$L_2 = \frac{25\text{metres} \times 15m/s}{20 \text{ m/s}}$$

Ans = 18.75 metres

Homework questions

1. If waves in the sea have a length of 30 metres and velocity 28m/sec, how fast will they travel if on entering shallow water they change length to 18 metres? **Ans:** 16.8 m/sec
2. If waves travel at 15m/sec as they approach a shore, and have a length of 16 metres, how long will they be in the sea if they were travelling at 26m/sec? **Ans:** 27.7m/sec

Back to the future

Waves that you see break on the shore are a result of events which took place many hours earlier. They are history unfolding before your eyes and if you look carefully you can see this history.

Fig 1.19: This house was demolished by a huge wave run-up on Hawaii's North Shore.

Water depth and shoaling waves

Waves break at a critical angle and depth. If the crest of the wave forms an angle less than 120°, the water and the height of the wave is greater than one seventh the wavelength, a shoaling wave will start to break.

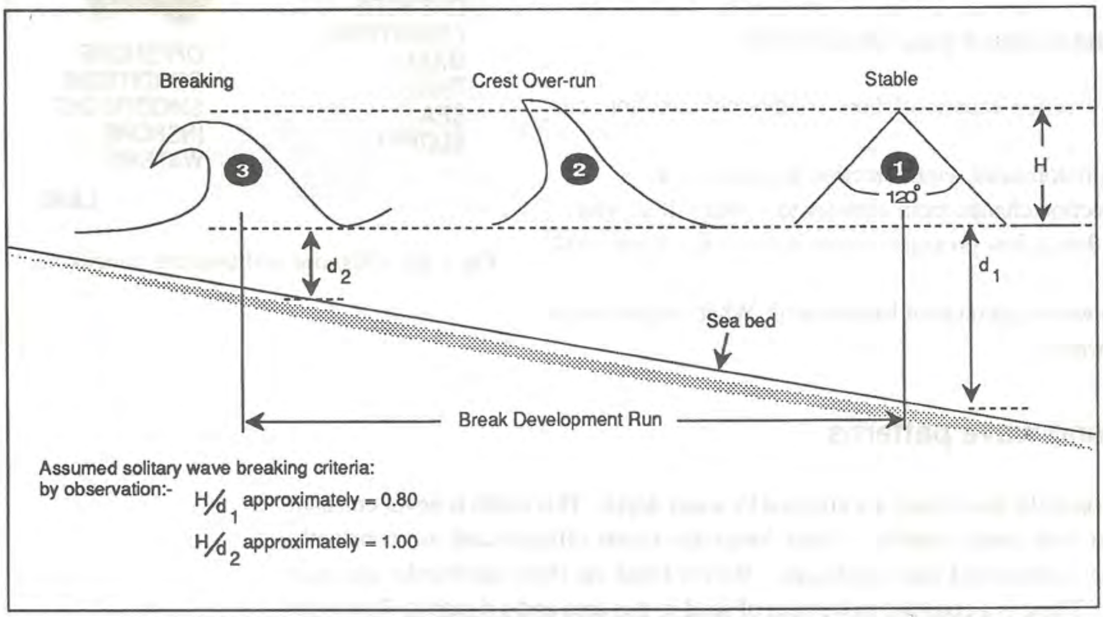


Fig 1.20 :- Stage (1) is a solitary wave at 120° included crest angle. Location (1) is the last point at which the wave can be stable. After Smith, S. (1990)

The most famous plunging wave occurs in Hawaii at the pipeline on Ohau's North Shore. The wave breaks with such force that the air gets squeezed out of the pipe. If you watched the video on waves, you will recall the last wave in the video. This was a plunging wave.

"Riding the wave"

To ride a breaking wave has been a common experience for most Australians. In recent times, many varied craft have been designed to achieve better and faster rides. Ask your grandparents about the surf mats they used to ride or the redwood planks which were the first surfboards to be used in Australia. The break point is the critical part of the wave for the surfer because this is where the final energy is expended. A surfboard gets its energy from the downward face of the wave and is manoeuvred according to gravity and the waves ever changing shape.

If you watch a body surfer catch a plunging wave (dumper) you can see how the initial energy is supplied by the surfer's arms and legs, then the body absorbs the wave's energy and the body is propelled forward and downwards towards the sea floor. The crest spills over and the surfer's body is driven into the water and sand below. The wave rushes over in a circular motion and the surfer is rolled around over the sand. Finally after the wave passes, the surfer's body slows down and comes to the surface. Have you ever experienced that? A surfboard rider can get caught by the crest (lip) of the shoaling wave and the surfboard goes "over the falls" and the rider "wipes out". A boogie board rider can also go over the falls and get dumped. A boat crossing a bar can also get dumped. In this case, breaching is said to occur.

Fig 1.21 A surfboard gets its energy from the downward face of the wave and is manoeuvred according to gravity and the wave's shape

All these things happen at the break point which is greatly affected by wind. The break point can be influenced by winds. The best surfing conditions are when the wind blows offshore. The wind smooths out the secondary local wind sea waves and leaves a pure swell.

Research questions about your local beach

Q1. What wind direction causes offshore conditions? Onshore conditions?
Q2. What is the predominant wind direction at your beach?
Q3. Does the direction change from summer to winter? If so why?
Q4. What effect does a low pressure system have on the wave conditions?
Q5. How big can waves get on your local beach? What conditions can cause these waves?

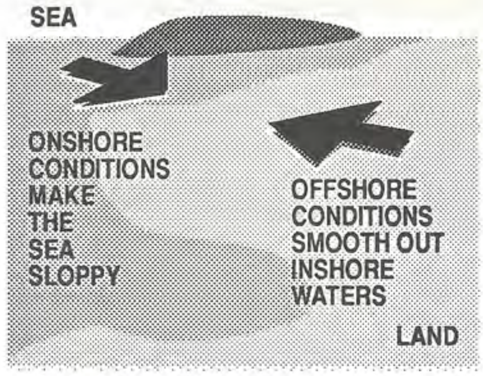


Fig 1.22: Offshore and onshore conditions

Sand banks and wave patterns

As waves approach the beach they are affected by water depth. This depth is never constant near the coastlines with sandy beaches. Sand banks are found offshore and are constantly changing with tide, current and surf conditions. Waves break on these sandbanks and rush towards the beach. There is a constant movement of sand in this area and a dynamic flow is set up between beach and sand bank. The area of beach that contains broken waves is called the **surf zone.** The **surfing beach system** is the area where waves break. Also called the **surf zone,** it is an area of constantly moving sand. **Gutters** and **rips** can form within minutes as the sands are constantly moved around in the longshore current.

Strong currents can be set up in this active beach system by waves approaching the beach at an angle. This oblique wave pattern sets in motion a long shore current which can form rips and gutters along the coastline. A **rip current** soon stops as it passes the breaking wave zone because there is no energy left to drive it. However the **long shore drift current** moves along the coastline. The long shore current will move at right angles to the direction the waves approach the beach. Since wave direction is determined by wind direction, the distance offshore, mid ocean, prevailing winds on our coastline, will shape our beaches. We will discuss this further in Unit 2.

A rip current can be identified by the region where waves consistently do not break.

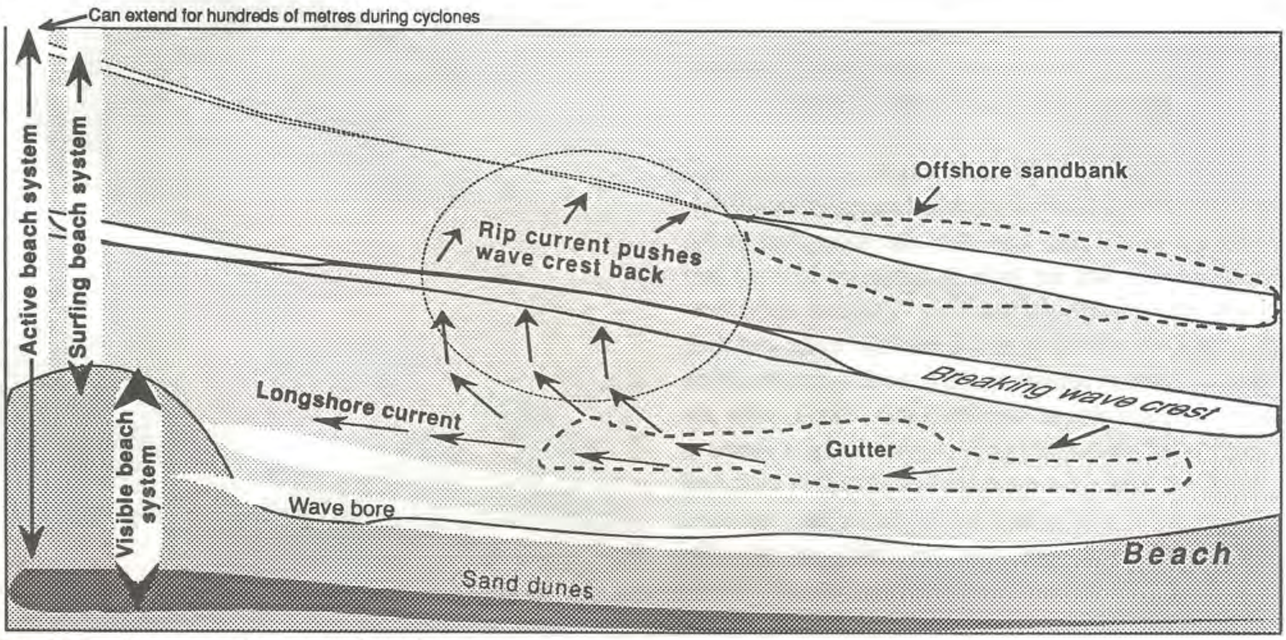
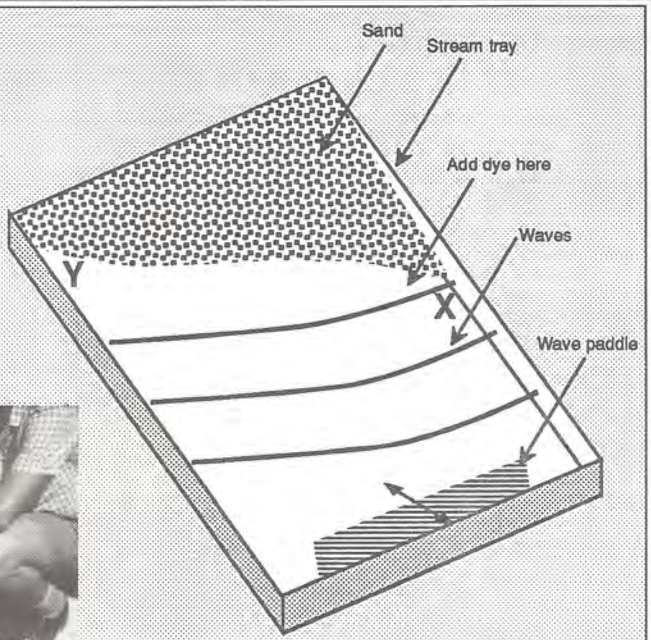


Fig 1.23: : Features of the active beach system

Activity 1.5 Long shore drift

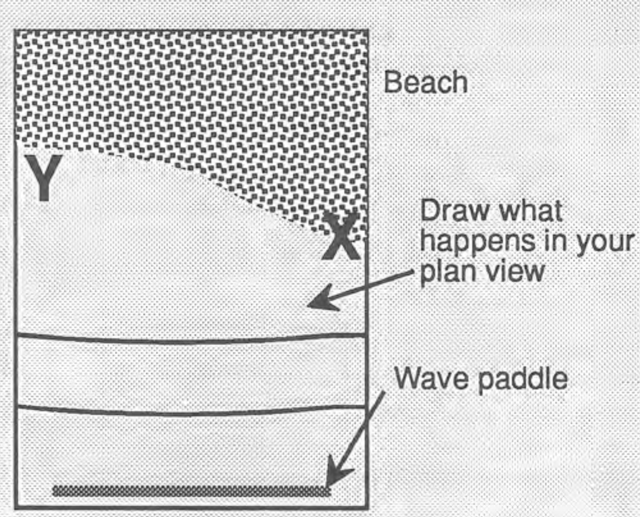


You will need

* a stream tray, wave paddle, some sand and water
* to work outside
* condys crystals liquid in dropper bottle

What to do (You will need to work outside)

1. Fill the stream tray with sand as indicated and shape a beach sloping from X to Y as shown in the diagram above.
2. Add water carefully to half the depth of the beach.
3. Make small waves of a frequency of one per second with a rocking motion of the paddle.
4. Observe what happens to the sand on the beach.
5. Carefully add three drops of condys crystals to the water at point X and observe what happens.
6. Make a "plan view sketch" of what happens like the one opposite.



Save your tank and sand for Activity 1.7, Page 26.

Activity 1.6 Long shore drift field study

(Based on an original idea by Mary Lou Carle)

Purpose

The aims of this project are to:-

(a) discover if long shore drift is consistent in direction and speed along a straight stretch of beach when measured at 15 m intervals at the same time.

(b) find out if long shore drift is consistent at different distances from the shore.

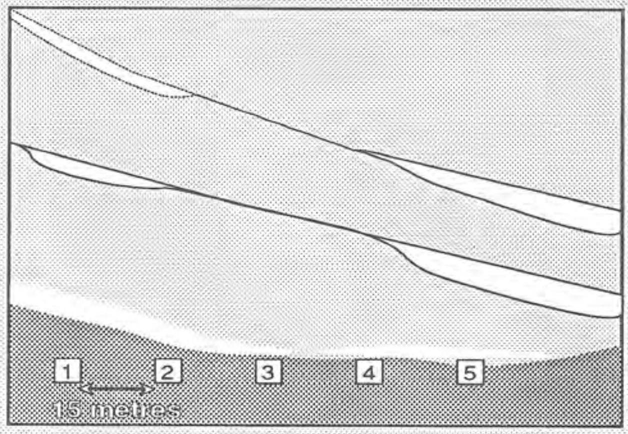
(c) manipulate data in graphical form.

(d) estimate the positions of rip currents and describe some of their effects.

(f) estimate if the long shore drift changes before and after high and low tide (if you have time).

You will need:

* a straight stretch of beach
* two oranges
* data sheet, pencil, hard surface to write on
* watch with second hand



What to do

(1) Pace out 5 stations, 15 metres apart on the beach.

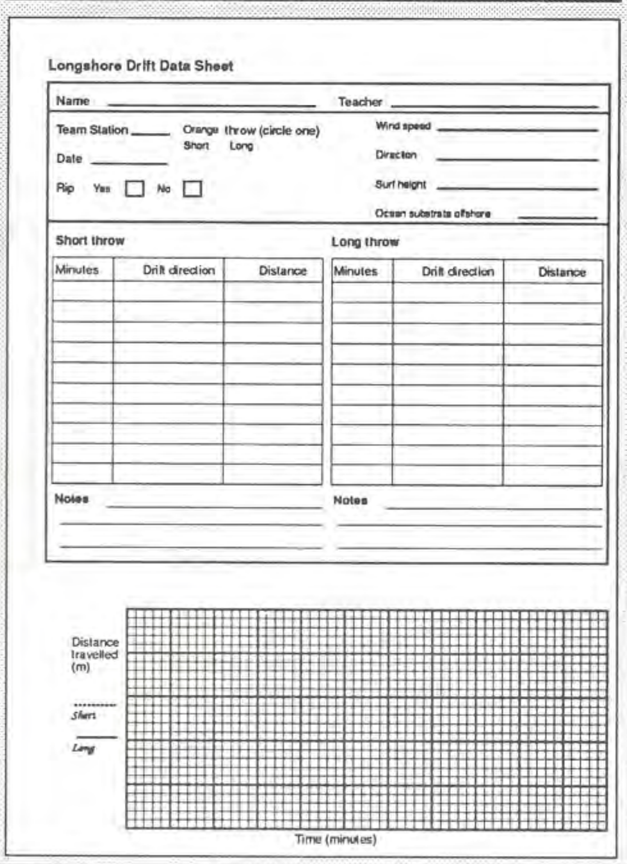
(2) You are going to study long shore drift in close and out far. Decide which partner is going to throw the orange far and which close.

(3) At a pre-arranged signal, such as a whistle, look to your teacher. At the second signal, and it must be emphasised **pre-arranged,** you cast your oranges into the sea and the timekeeper starts the watch.

(4) You then follow your oranges and any variations. If the orange comes in, you should throw it out again.

(5) After one minute the timekeeper signals and you are to mark the position of your orange in the sand opposite where the orange is. After two, three, four and five minutes, recording data accurately in the tables provided.

(6) Draw up a data table like the one opposite and write a short report on your results.


Longshore Drift Data Sheet

Name ______ Teacher ______

Team Station ______ Orange throw (circle one) Short Long

Date ______

Rip Yes ☐ No ☐

Wind speed ______

Direction ______

Surf height ______

Ocean substrate offshore ______

Short throw

Minutes	Drift direction	Distance

Notes ______

Long throw

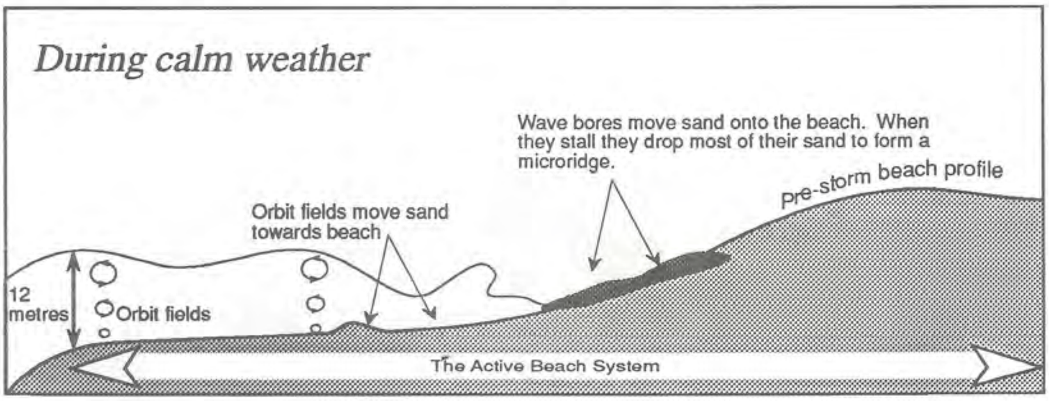
Minutes	Drift direction	Distance

Notes ______

Constructive waves

After a wave has broken it is called a **wave bore** and much of its energy has been released. There is however enough energy to carry sand up the beach. This area is called the **swash zone**. When the wave stops, the sand that was carried by the wave is dropped in a small pile called **a micro-ridge** (see also page 56). Over the time of the tide these accumulate and dry. If there is a strong onshore wind, the sand is blown up the beach where it gets trapped in the dune vegetation. If sea and wind conditions are very calm, the micro-ridges can build to form **berm**. These berms are very unstable and can disappear with the a rising sea.

Fig 1.24: Summary of main features of beach building waves. Can you see the wave bore stall and the wet patch where the water has retreated to become part of the breaking wave? The sand is soft in the swash zone.

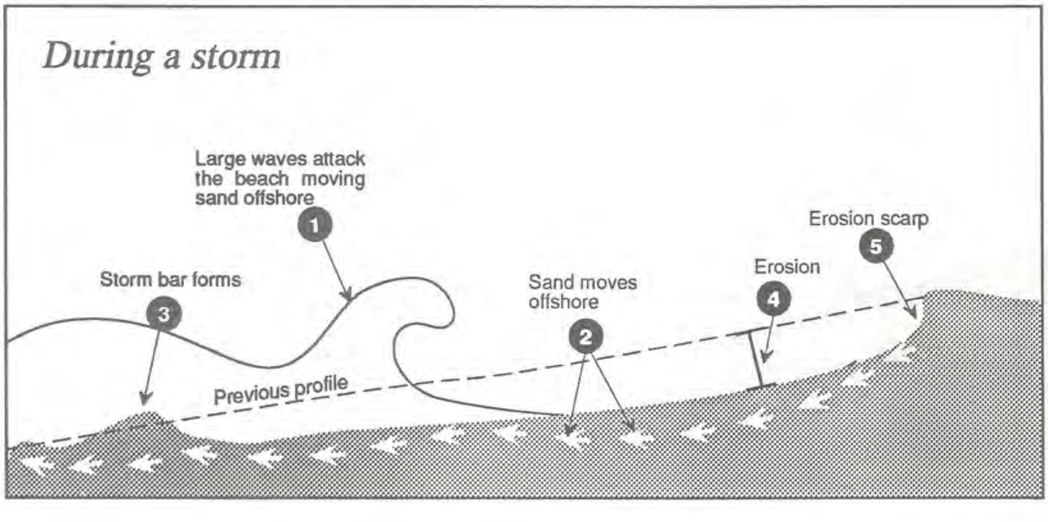


Waves move sand towards the beach by their orbit fields. The broken wave is called a wave bore.

Fig 1.25: Calm seas

Destructive waves

During a storm the energy in the swash zone increases. Wave heights also increase and the effect on the active beach system is dramatic. Large areas of sand are eroded from the beach and move offshore to form a **storm bar.**



During a storm the sea turns grey indicating that large amounts of sediment are now in suspension.

Fig 1.26: Storm seas

The wave bores are now less frequent and tear at the beach face causing erosion of the visible beach profile. The bores carry foam onto the beach and the visible beach decreases in size. Here the high energy of the waves is absorbed and erosion is reduced. The size of the active beach system now becomes greater and a large **erosion scarp** forms on the beach as shown in Figure 1.28 below.

Erosion warning signs

* Grey seas
* Foam in the wave bores
* Black heavy mineral washed to the top of the beach

Storm seas are characterised by foam on the beach, long infrequent wave bores and hard sand. Foam builds up on the beach containing much suspended organic matter.

Fig 1.27: Storm seas

Many factors control the amount of erosion that will occur. The storm bar needs to be fed by the sand bank on the beach. There has to be enough sand in the reservoir of sand to keep feeding the storm bar while the storm seas prevail. The sea will erode the land. Trees and natural vegetation are often sacrificed in the process.

After the storm the wave energy decreases and the smaller more frequent waves move the sand towards the beach. Sand waves can again be seen or felt under the water which advance towards the visible beach. It can take up to 18 months for a beach to recover its original beach profile because many smaller storms may affect the beach during that time. Unit 2 will discuss this further.

Fig 1.28: Erosion scarping during a storm sea

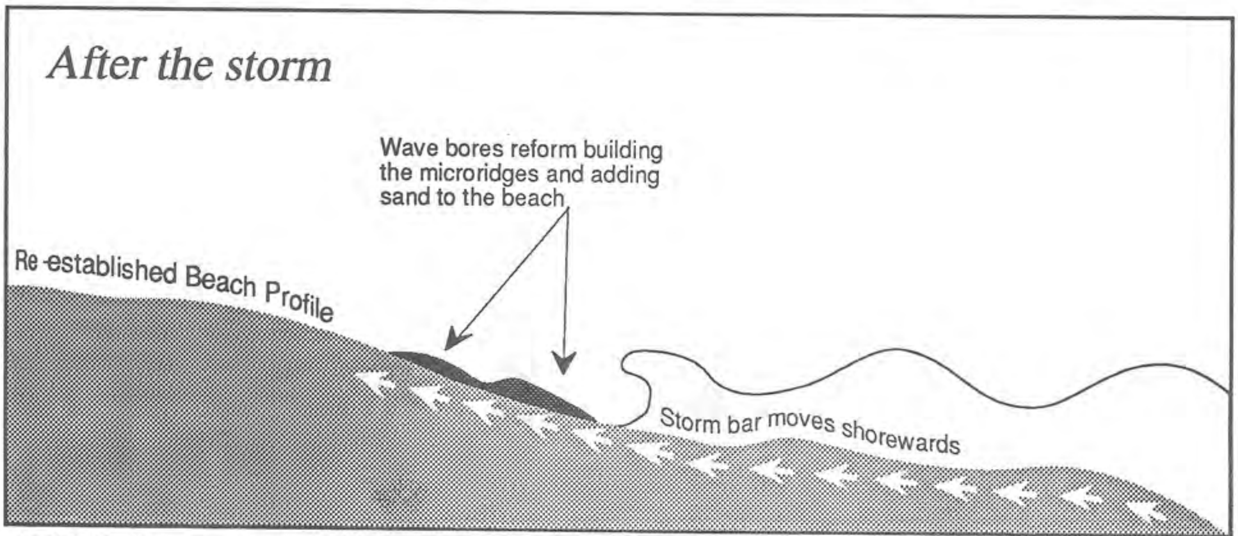


Fig 1.29: After a stormwave size decreases and the beach recovers gradually

Topic 4

Waves and Coastlines

As waves approach headlands the sea floor absorbs the wave energy . However the water depth around headlands slopes off and one part of the wave slows more rapidly than the other.

This causes the wave to bend as shown in Figure 1.30.

When a wave bends as a result of shallow water around a point, **refraction** is said to occur.

A right angle drawn to the crest is called an **orthagonal.** Notice how the orthagonals follow the wave refraction in Figure 1.31 below.

Fig 1.30: Refraction around a point. Note the different angles the waves are approaching the beach

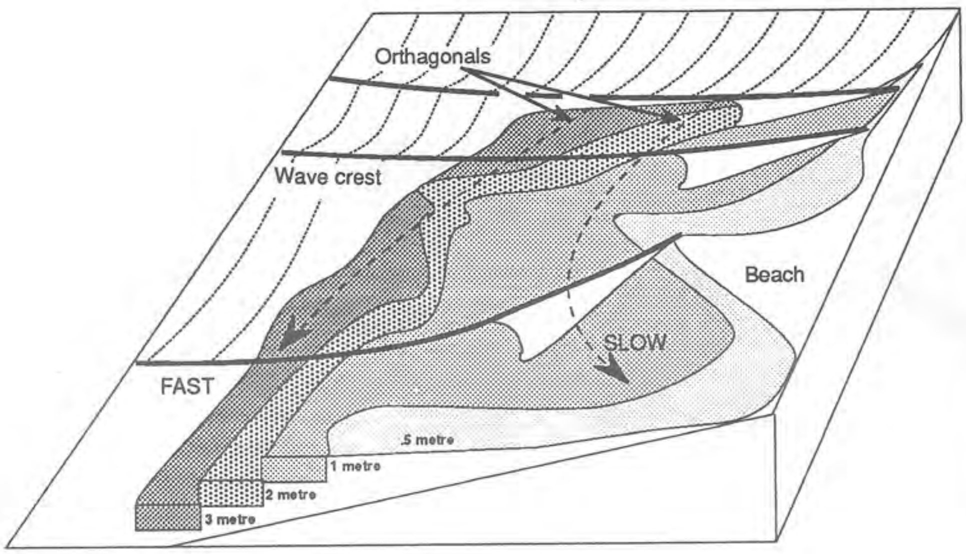


Fig 1.31: Refraction is caused by waves approaching unequal water depths

As the water depth decreases the energy in the wave is absorbed at different rates. This causes the wave to break at an angle. If there is an offshore wind blowing, the air inside the breaking wave gets trapped and a tube forms. When the air pressure increases to a critical point, water and air can be squeezed out of the tube.

If the waves broke directly onto the headland and bounced straight back at the next wave **reflection** would have occurred. If waves came between two very narrow points and spread out in both directions, **diffraction** would have said to have occurred. We will investigate this further in the last experiment in this unit.

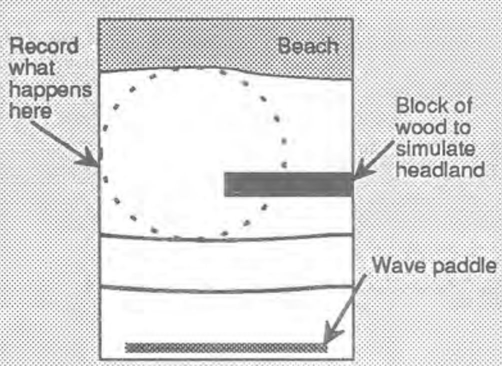
Activity 1.7 Headlands and Bays

You will need

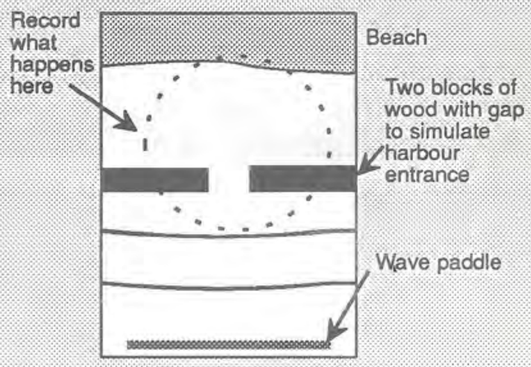
* a stream tray, wave paddle, some sand and water
* to work outside
* small blocks of wood

What to do (You will need to work outside)

Case 1: Simulated headland



Case 2: Simulated boat harbour



Case 3: Simulated groyne

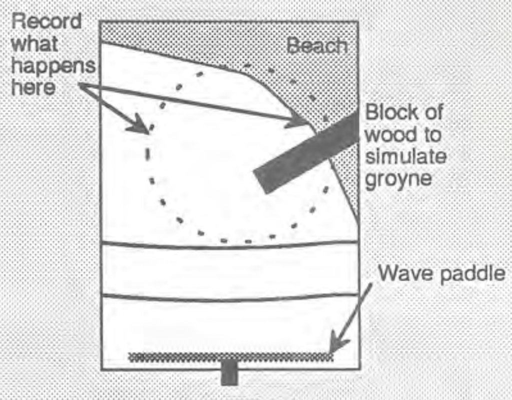


Fig 1.31: A wave tank set up to study a groyne

Extension: Try other shapes and slopes of beaches or the shapes of your local beach system to see if you can simulate wave conditions there.

In each case describe what happens to the wave's shape and what happens to the beach sand.

Refraction and diffraction

From the wave tank experiments you should have observed that as waves pass into shallow water they slow down, increase in wave height and decrease in wavelength.

This effect is called **refraction** and occurs around headlands. If winds are offshore, these make ideal surfing waves as the wave breaks evenly from one side to the other giving the surfer a long ride.

Waves that enter a bay or boat harbour that widens out inside the entrance, tend to speed up, increase in wavelength and spread out. This effect is called **diffraction**. We can trace the direction of spread by drawing lines at right angles to the wave crest called **orthagonals** and are shown inFigure 1.32.

These orthagonals help coastal engineers plan boat harbour designs, rock walls, foreshore developments and beaches. Boat harbours and river mouths have similar effects where wave energy is dispersed as the wave enters.

The wave bends around the rock walls and moves into the boat harbour. Much of the energy is lost and so the wave height quickly decreases, making for an effective boat and ship berthing situation. As we will see later, the slowing effect of the waves drops their suspended sediment. This causes a problem of **siltation.**

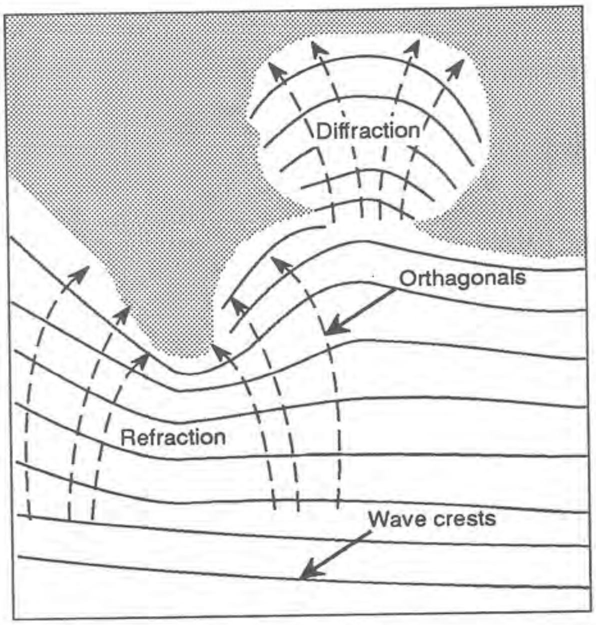


Fig 1.32: Diffraction and refraction

Fig 1.33: A Port has to be specially constructed to avoid the refraction patterns of waves.
Photo courtesy of NSW Maritime Services Division - Port Kembla

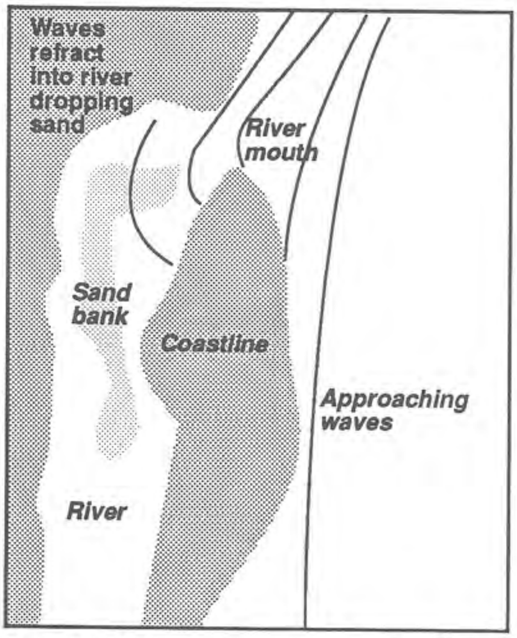


Fig 1.34: Refraction in a river mouth. Waves enter the river for some distance.

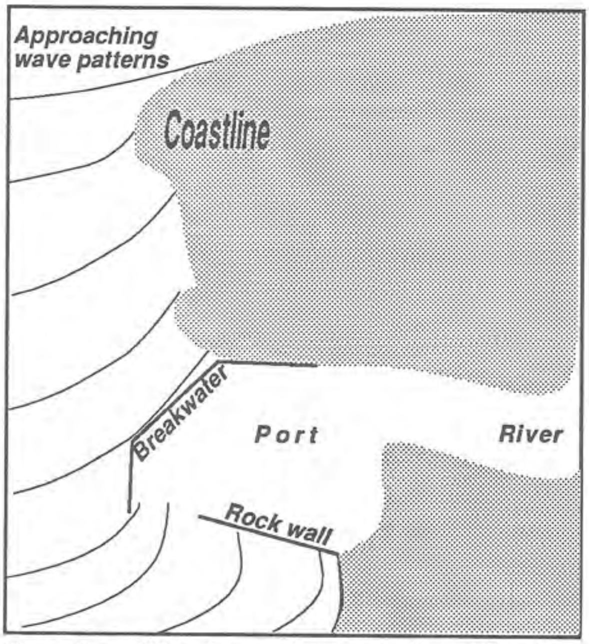


Fig 1.35: Diffraction in a port can be reduced by breakwater design

Studies in wave patterns as they react with coastlines are important for engineers when they design ports and boat harbours. A safe berth should have very little wave action and hence the rates of diffraction need to be reduced to as small as possible.

Reflection

Large storm waves travelling from deep water striking headlands expend a tremendous amount of energy on the structures they hit. Water is thrown up into the air and a wave forms which moves backwards. A wave which bounces straight back on itself after striking an object straight on is called a **reflected wave.** This reflection often results in the shaping of headlands to form wave cut platforms.

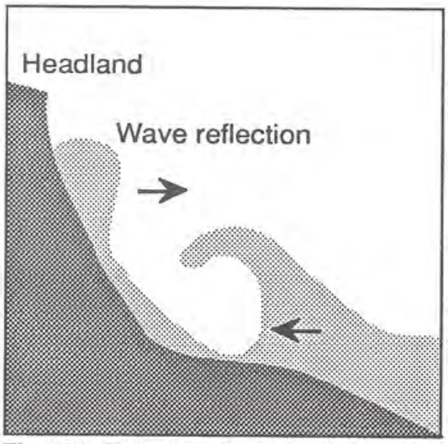


Fig 1.36: Reflection of waves off a headland

Fig 1.37: Wave reflection

Tides

Tides are one big wave. The gravitational force of attraction exerted by the moon on the sides of the earth causes the water to bulge out. Because of distance, the pull on one side is less so the high tides will be at different heights. As the earth rotates, any particular place will experience two high and two low tides. The tide wave has all the characteristics of sea waves. The period will be the time between tides, the height will be the tide height and the length, the distance between crests.

The earth spins through this wave each day, however the wave moves slightly because the moon revolves around the earth. Each tide will be 50 minutes later each day because of this and the heights will change because of the earth's rotation around the sun.

Local conditions also affect the height of the tide. In the deep ocean the tidal rise and fall is about 1 metre. In shallow lakes it is only about 5 - 10 cm. Where deep oceans give rise to continental shelves, the decreased space makes the water pile up and bigger rises and falls occur.

In Broome in Western Australia and Mackay in Queensland, tidal ranges can be as large as 12 metres. This is because they have large areas of continental shelf offshore. At Sydney or Brisbane tidal ranges do not exceed 3 metres because of the rapid fall off in continental slope.

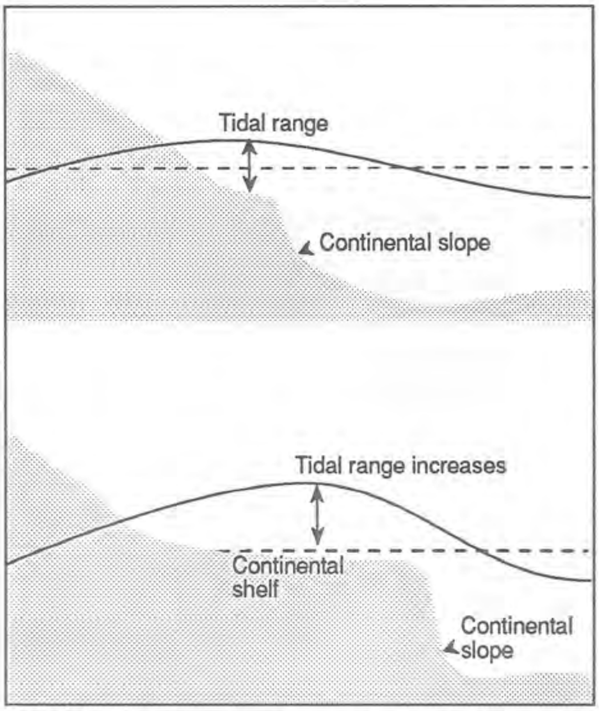


Fig 1.38: Tidal range can be affected by the different type of continental shelf

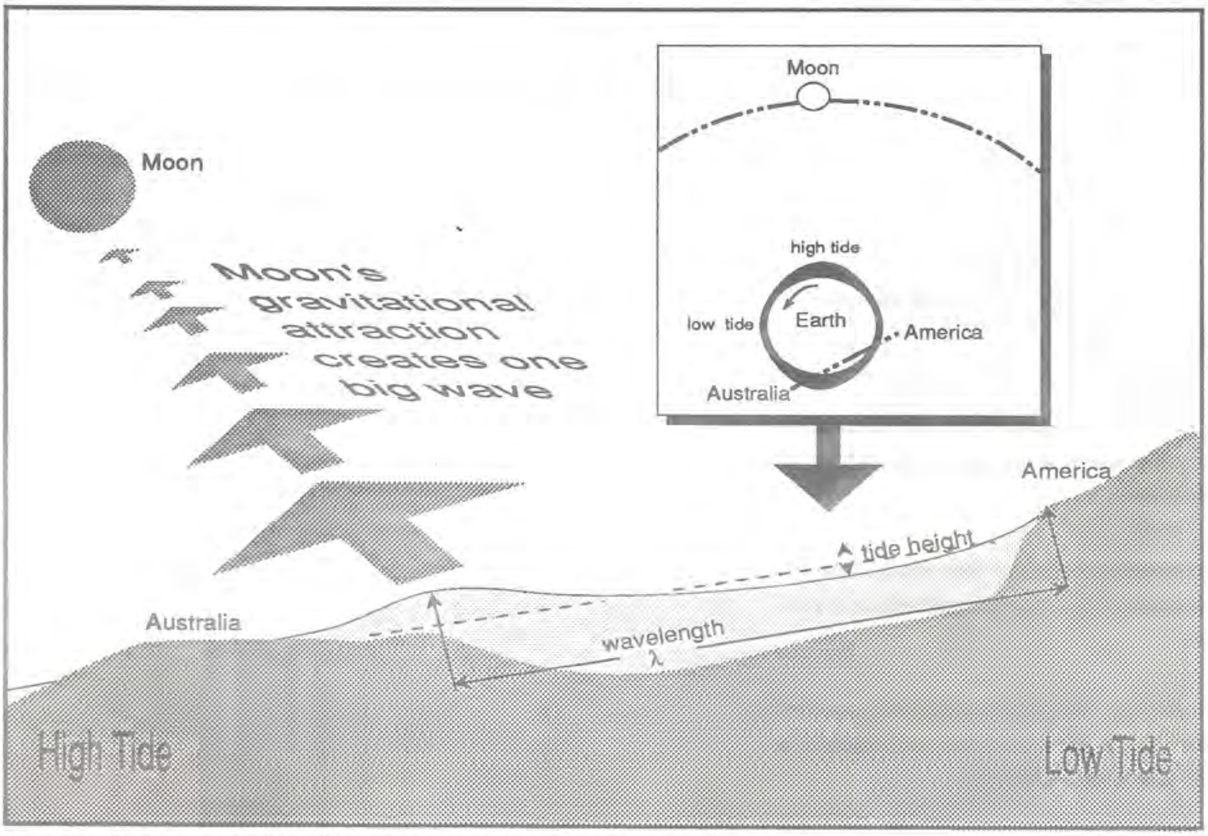


Fig 1.39: Tides are another effect on the coastline. They are really one big wave.

Unit 1

Topic 4

Wave Mathematics

Waves are periodic movements in the ocean's surface caused by wind or oceanic disturbances. A study of waves enables us to understand how the ocean shore is shaped.

Fig 1.40: A ripple tank set up

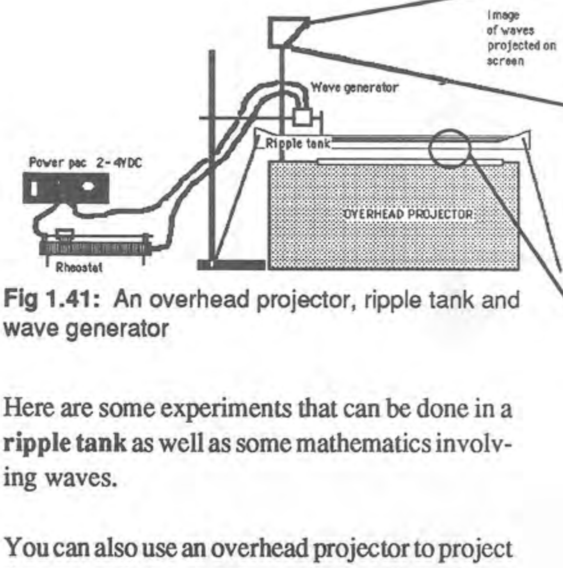


Fig 1.41: An overhead projector, ripple tank and wave generator

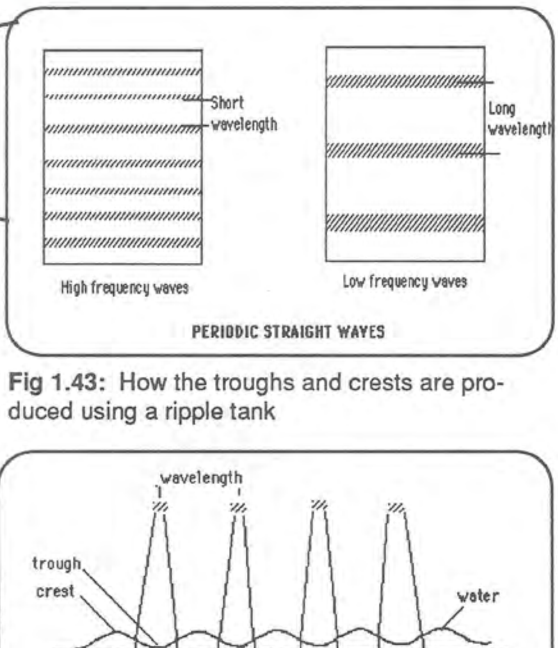


Fig 1.43: How the troughs and crests are produced using a ripple tank

Here are some experiments that can be done in a **ripple tank** as well as some mathematics involving waves.

You can also use an overhead projector to project the waves but a greater understanding will be gained if you work in groups.

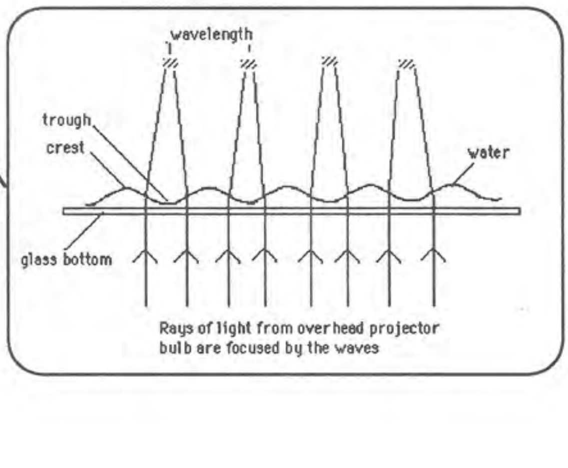


Fig 1.44: Effects on the screen from a ripple tank experiment

Activity 1.8 Ripple tank waves

You will need

* ripple tank and accessories as shown in the photograph
* 12 V power supply
* rheostat
* blocks of wax
* overhead projector (optional)

Hints on ripple tank operation

1. Try out the parts before you assemble the entire apparatus.
2. Try out the motor and the rheostat. The motor must run very slowly to get the best effects when the water is added.

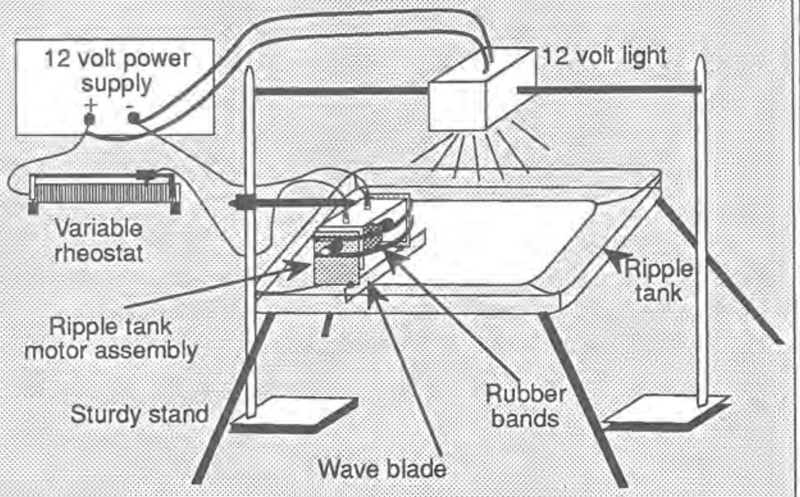


Fig 1.45: A Ripple tank setup

3. Connect the ripple tank assembly and the wave blade so that blade will move up and down in a regular beat. You can make fine adjustments by using the rubber bands as shown in the diagram.
4. When the motor runs well, add about 1.5 cm of water to the tank and hold the motor so that the wave blade touches the water and generates some waves. Adjust the rubber bands so that you get a nice even wave pattern.
5. Now set up the whole structure with light and clamp stands. Add some bricks to the clamp stand to keep them steady and make your fine adjustments. The waves can be studied best in a darkened situation or reverse the light and project them on to the ceiling.

What to do

1. Set up the apparatus as shown in the photograph above.
2. Now start the wave generator and study the effects of the waves on the screen.
3. Identify the following:-

   (a) The trough - the dark parts of the screen
   (b) The crest - the parts between the troughs
   (c) The wavelength- the distance between the troughs or crests.

4. Speed up and slow down the wave generator by adjusting the rheostat and record the changing wave patterns. Make general drawings of fast, medium and slow frequencies.
5. Discuss the term frequency in terms of the number of waves that will pass a point in a given time. See if you can establish the frequencies for different wave patterns.
6. Now use blocks of wax like the ones shown in the photograph to simulate the experiments you did in the stream trays in Activity 1.7.
7. Discuss the terms diffraction, reflection and refraction.

***Note:** You will have to use a piece of glass to make the water shallow at one point to study the effect of waves passing from deep to shallow water. Ask your Physics teacher to help you if you have any problems. Better still invite the expert to give a guest lesson and demonstration of the ripple tank.*

Activity 1.9 The Pendulum

Time is measured by clocks. Any regular repeated motion can be used as a clock. Early humans used sunrise and sunset and later the sundial was used to measure hours. Today, we use a wide variety of clocks to measure time. The unit of time is the **second.**

Units

Revise kilometres per hour. Conversion of Km/hr. to m/sec. Why? Because we need to use in the laboratory, units which we can physically measure. Metres and seconds are such units.

Sample problems:

Convert 60 Km/hr. to m/sec. There are 1000 m in a kilometre and 60 x 60 =3600 seconds in an hour. To convert 60Km/hr to m/sec multiply by 1000 and divide by 3600:-

$$\frac{60 \times 1\ km \times 1000\ m}{3600\ secs} = 16.7\ m/sec\ (Ans)$$

Period and Frequency

When an object makes rapid, repeated motions, one complete motion is called **a cycle.** As the wave generator made one cycle it made one wave, but how fast was this wave travelling? We need to know a few other things.

The time required for one cycle is called **the period.** It has the Symbol (T) and its **units** are in seconds (s)

The number of cycles in one second is called **the frequency.**

Symbol is ***f*****. Units** are hertz, **Hz**

The Pendulum

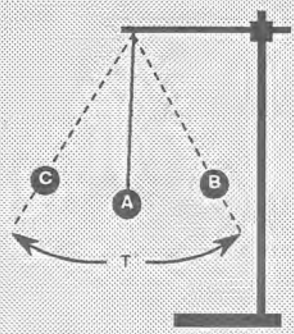
A Class demonstration to explain frequency, period and time.

You will need

A retort stand, clamp, bosshead
A pendulum
A watch with a second hand

What to do

Swing the pendulum from B to C as illustrated. When the pendulum has reached a steady swing, time the number of seconds it takes the pendulum to make 10 swings, divide by 10 and calculate the **period** of the pendulum.



Now calculate the frequency of the pendulum by counting the number of **cycles** (swings) in 60 seconds.

The period is the time for one cycle. In waves it will be the time between crests.

$$T = \frac{\text{time required}}{\text{number of cycles}}$$

The frequency is the number of cycles per second. In waves, it will be the number of waves that pass a point in a given time.

$$f = \frac{\text{number cycles}}{\text{time required}}$$

Sample problems

A pendulum completes 240 cycles in 60 seconds. What is its period and frequency?

Period $T = \frac{60\ s}{240} = 0.25\ s$

Frequency $f = \frac{240\ c}{60\ s} = 4.0\ c/s = 4.0\ Hz$

In the **SI** (System International of Units), the unit for frequency is called the hertz (Hz) and 1 c/s = 1 Hz

From this example it can be seen that the period and the frequency are related by a simple equation. They are reciprocals of one another.

$$T = \frac{1}{f} \quad \text{or} \quad f = \frac{1}{T}$$

Questions

Q1. A surfers guitar string vibrates 750 times in 3 secs. What is its period and frequency? (0.004 secs, 250 hz).

Q2. If a surfer counts 180 waves washing on the beach in 1 hour, what is the time between waves in seconds? Ans (20 s).

Q3. Calculate the frequency and period of a surfers car engine that makes 4800 revolutions in 1 minute. Ans (80 hz. 0.0125 sec)

Q4 Find the average speed for a trip by dividing the total distance travelled by the total time taken. Be sure to use the correct unit for speed.

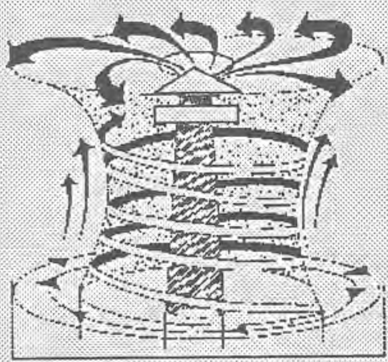
Q5. Draw a distance time graph, with time plotted horizontally and distance vertically. Make the graph as large as possible.

Q6. What is the speed of a Tsunami that travels 6000 km in 8 hours? (750 km/hr.).

Q7. How fast is cyclonic wind blowing when a branch is clocked at travelling 5.8 metres in 2.5 seconds? (2.32 m/sec).

Q8. A wind surfer travels 25 km in .7 hr., then travels 35 km further in the next 1.5 hrs. What is the average speed?

Activity 1.10 Wave rider buoy data analysis



You will need

* Graph paper
* Data from *Cyclone Nancy* over.

What to do

Read the information section and answer the questions below.

Information

Wave rider parameters

Routine special analysis of wave data was performed by a computer to obtain the following parameters.

Energy density spectrum:- *A representation of the distribution of wave energy over the component wave frequencies.*
Significant wave height (Hs Hsig): *The average of the highest one third of waves in the record*
Root mean square wave height (Hrms): *The root mean square of the wave heights from the record*
Maximum wave height (HMax) *The highest individual wave in the record (zero upwards crossing)*
Peak energy period (TP) *The wave period corresponding to the peak of the wave density spectrum*
Significant period (T sig): *The average period of the highest one third of waves in the record*
Zero crossing period (Tz) *The average period of all waves in the record based on upward zero crossings*
Energy density (E.D.) *The value tabulated is M.O. the area of the wave spectrum diagram*
E.P.S. *Spectral width parameter.*

On February 2nd 1990, *Cyclone Nancy* moved down the Queensland coast. The cyclone produced very high waves over a short time. A wave rider buoy moored offshore at a local beach recorded the data printed on the next page. Look at the data over and answer the following questions:

(a) What was the highest wave recorded during the cyclone?
(b) At what time did this wave occur ?
(c) Look at the times between waves. This is the wave period. Do bigger waves have a longer period than smaller waves?
(d) Do bigger waves travel faster or slower than smaller waves ?
(e) How do waves get their energy ?
(f) Which waves have more energy ?
(g) Calculate the **wave power** at any one time with the formula: *Wave Power* $= H^2T^2$
(h) Is this different at different times and how fast does the power of the wave increase?
(i) The data collected over is from cyclone Nancy. Use graph paper to plot the wave heights v's time and then the wave periods, v's time. Can you draw any conclusion from these two graphs ?

Cyclone Nancy Data

For explanation of terms see Page 33

		***************** TIME DOMAIN					*****************		** FREQUENCY DOMAIN ***			
DD/MM/YY	HHMM.SS	Hs	Hrms	Hmax	Tz	Ts	Tc	THmax	EPS	T02	Tp	Hrms	EPS
31/01/90	2300.00	.94	.66	1.65	6.15	7.85	4.05	8.09	.75	6.15	8.95	.72	.74
31/01/90	2330.00	.92	.66	1.73	6.27	7.76	4.05	7.77	.76	6.04	8.77	.69	.69
01/02/90	0000.00	.89	.64	1.45	5.95	7.69	3.93	7.02	.75	6.00	9.07	.67	.65
01/02/90	0030.00	.91	.63	1.44	5.90	7.65	3.90	7.95	.75	6.05	8.01	.68	.65
01/02/90	0100.00	.94	.66	1.53	6.19	7.96	3.81	7.01	.79	6.13	9.41	.69	.68
01/02/90	0130.00	.90	.64	1.50	6.04	7.51	3.99	8.73	.75	5.90	8.84	.68	.65
01/02/90	0200.00	.89	.61	1.61	5.49	7.27	3.73	8.44	.73	5.75	9.54	.67	.65
01/02/90	0230.00	.80	.55	1.48	5.31	6.94	3.73	7.28	.71	5.54	6.94	.60	.63
01/02/90	0300.00	.85	.60	1.45	5.82	7.24	4.08	8.07	.71	5.85	8.80	.65	.64
01/02/90	0330.00	.85	.61	1.26	5.99	7.04	3.80	7.32	.77	5.57	8.41	.63	.67
01/02/90	0400.00	.88	.63	1.65	6.30	8.11	4.18	7.80	.75	5.95	8.71	.65	.70
01/02/90	0430.00	.79	.5[illegible]	1.35	5.34	7.18	3.68	6.49	.72	5.43	7.86	.60	.63
01/02/90	1330.00	.78	.56	1.19	4.55	6.22	3.04	8.57	.74	4.44	7.30	.61	.63
01/02/90	1400.00	-99.90	-99.90	-99.90	-99.90	-99.90	-99.90	-99.90	-99.90	-99.90	-99.90	-99.90	-99.90
01/02/90	1430.00	.76	.54	1.17	4.44	6.20	3.03	8.20	.73	4.45	8.90	.60	.59
01/02/90	1500.00	.82	.58	1.22	4.77	6.51	3.12	5.41	.76	4.71	8.48	.62	.62
01/02/90	1530.00	.84	.60	1.34	4.92	6.75	3.24	6.97	.75	4.81	9.42	.64	.59
01/02/90	1600.00	.85	.59	1.24	4.88	6.41	3.32	6.59	.73	4.80	7.63	.63	.58
		***************** TIME DOMAIN					*****************		** FREQUENCY DOMAIN ***			
DD/MM/YY	HHMM.SS	Hs	Hrms	Hmax	Tz	Ts	Tc	THmax	EPS	T02	Tp	Hrms	EPS
01/02/90	1630.00	.75	.54	1.37	4.79	6.01	3.33	6.76	.72	4.68	8.79	.58	.58
01/02/90	1700.00	.74	.53	1.33	4.98	6.50	3.41	7.12	.73	5.03	8.56	.59	.63
01/02/90	1730.00	.75	.54	1.10	5.05	6.53	3.42	4.76	.74	4.94	7.67	.57	.60
01/02/90	1800.00	.86	.63	1.28	5.43	6.83	3.27	7.31	.80	4.96	8.27	.64	.64
01/02/90	1830.00	.79	.58	1.19	4.80	6.10	3.21	7.71	.74	4.67	6.30	.61	.60
01/02/90	1900.00	.82	.58	1.36	4.59	5.97	3.10	5.76	.74	4.56	7.44	.62	.57
01/02/90	1930.00	.93	.66	1.74	4.50	5.74	3.39	7.12	.66	4.57	5.74	.70	.54
01/02/90	2000.00	.96	.68	1.45	4.64	5.63	3.30	5.83	.70	4.61	6.29	.72	.55
01/02/90	2030.00	1.04	.74	1.71	5.02	6.38	3.48	6.13	.72	4.85	6.09	.77	.57
01/02/90	2100.00	.96	.67	1.64	4.26	5.74	3.05	6.00	.70	4.49	5.38	.75	.58
01/02/90	2130.00	1.07	.76	1.49	4.76	6.04	3.20	5.77	.74	4.68	8.10	.81	.57
01/02/90	2200.00	1.14	.81	1.65	5.17	6.50	3.36	6.26	.76	4.96	6.56	.85	.64
01/02/90	2230.00	1.14	.82	1.79	5.46	6.76	3.40	6.45	.78	5.10	7.49	.85	.61
01/02/90	2300.00	1.09	.76	1.70	4.79	6.44	3.25	6.98	.74	4.97	7.73	.83	.63
01/02/90	2330.00	1.15	.82	2.09	5.33	6.88	3.28	7.34	.79	5.09	7.62	.86	.67
		***************** TIME DOMAIN					*****************		** FREQUENCY DOMAIN ***			
DD/MM/YY	HHMM.SS	Hs	Hrms	Hmax	Tz	Ts	Tc	THmax	EPS	T02	Tp	Hrms	EPS
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02/02/90	0030.00	1.29	.91	1.77	5.41	7.24	3.32	7.62	.79	5.22	7.77	.97	.69
02/02/90	0100.00	1.47	1.05	2.21	5.73	7.45	3.48	8.41	.79	5.58	7.66	1.10	.66
02/02/90	0130.00	1.67	1.20	2.78	6.02	7.81	3.44	5.81	.82	5.81	7.97	1.30	.70
02/02/90	0200.00	1.72	1.20	2.59	5.83	8.34	3.60	8.95	.79	5.66	8.05	1.28	.67
02/02/90	0230.00	2.41	1.70	3.28	7.52	10.45	4.07	15.11	.84	7.27	15.47	1.81	.73
02/02/90	0243.20	3.52	2.43	4.69	9.92	14.03	4.48	14.92	.89	9.52	15.40	2.57	.85
02/02/90	0300.00	2.76	1.93	4.38	8.58	11.75	4.27	11.92	.87	8.35	14.97	2.07	.78
02/02/90	0313.20	3.84	2.76	5.24	10.78	13.15	4.86	14.54	.89	9.81	14.18	2.78	.79
		***************** TIME DOMAIN					*****************		** FREQUENCY DOMAIN ***			
DD/MM/YY	HHMM.SS	Hs	Hrms	Hmax	Tz	Ts	Tc	THmax	EPS	T02	Tp	Hrms	EPS
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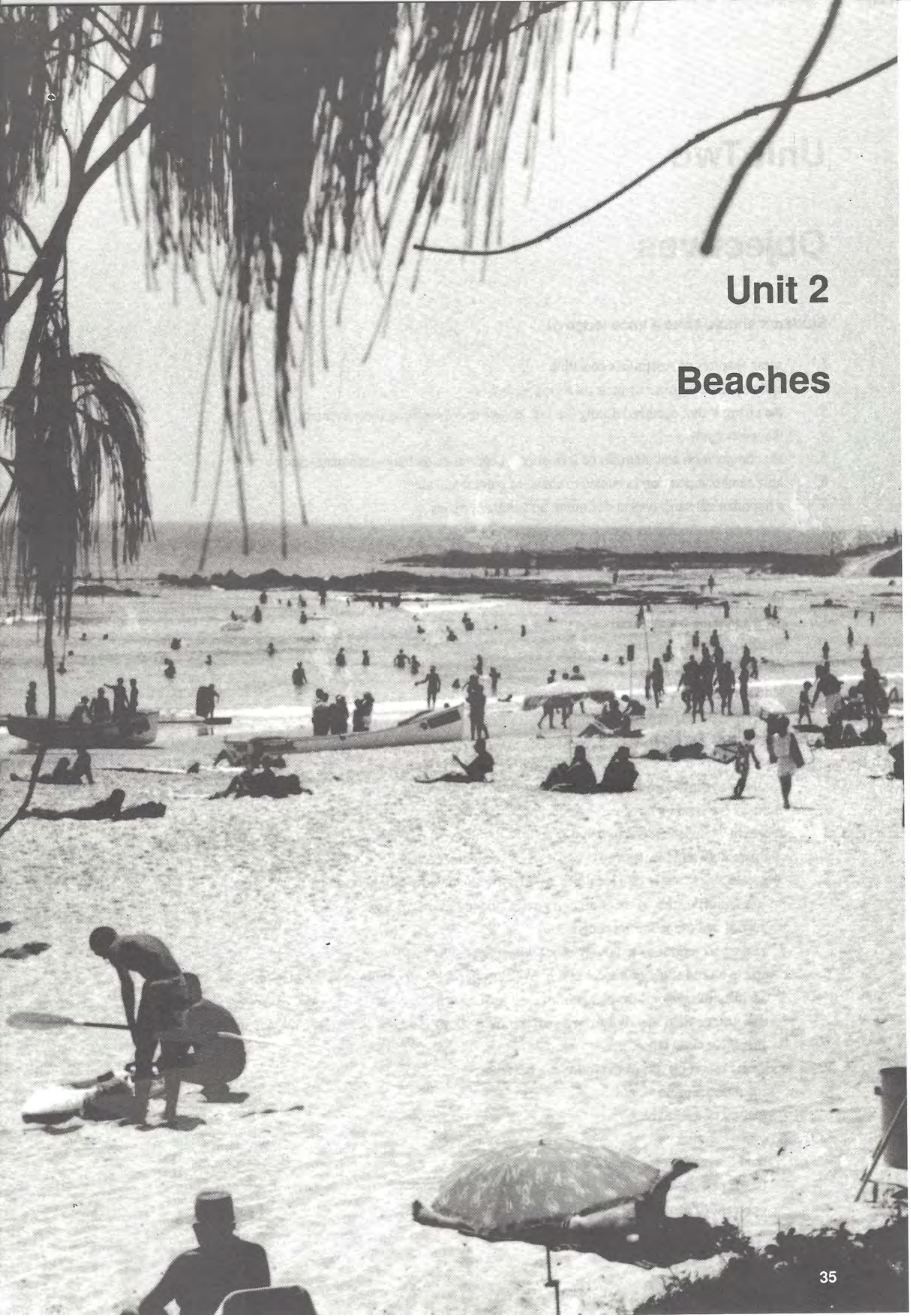
02/02/90	0400.00	4.29	3.01	6.29	10.31	12.16	5.40	12.43	.85	9.10	13.11	3.02	.90
02/02/90	0413.20	4.05	3.02	5.58	10.88	11.78	5.33	12.47	.87	9.12	12.39	2.95	.89
02/02/90	0430.00	4.04	2.76	5.64	9.75	12.30	4.84	12.12	.87	9.32	13.26	2.87	.84
02/02/90	0443.20	3.65	2.56	5.78	9.32	11.76	4.74	11.29	.86	8.79	11.95	2.65	.81
02/02/90	0500.00	3.49	2.45	5.84	8.72	11.48	4.36	11.20	.87	8.21	12.27	2.57	.85
02/02/90	0513.20	3.76	2.68	5.00	9.33	11.09	4.78	11.25	.86	8.65	11.49	2.71	.76
02/02/90	0530.00	3.65	2.51	4.65	8.80	11.05	4.71	11.37	.84	8.60	12.72	2.60	.76
02/02/90	0543.20	3.13	2.20	4.73	8.28	10.62	4.37	10.94	.85	7.93	12.43	2.32	.78
02/02/90	0600.00	3.58	2.56	5.15	9.24	11.02	4.57	9.02	.87	8.48	11.51	2.56	.75
02/02/90	0613.20	3.08	2.16	5.00	8.38	10.56	4.58	10.34	.84	8.16	11.50	2.29	.82
02/02/90	0630.00	3.28	2.32	5.16	8.46	11.07	4.47	10.81	.85	8.27	10.86	2.41	.76
02/02/90	0643.20	3.17	2.30	3.89	8.70	10.76	4.55	8.95	.85	8.18	12.96	2.35	.79
02/02/90	0700.00	3.38	2.38	4.60	9.18	10.52	4.46	10.27	.87	8.38	11.80	2.38	.75
02/02/90	0713.20	2.99	2.08	4.25	7.94	9.90	4.29	11.73	.84	7.86	12.30	2.20	.74
		***************** TIME DOMAIN					*****************		** FREQUENCY DOMAIN ***			
DD/MM/YY	HHMM.SS	Hs	Hrms	Hmax	Tz	Ts	Tc	THmax	EPS	T02	Tp	Hrms	EPS
02/02/90	0730.00	3.22	2.24	4.36	8.06	9.99	4.44	8.69	.83	7.87	11.12	2.31	.73
02/02/90	0743.20	2.93	2.06	4.27	8.24	10.78	4.37	10.46	.85	7.88	12.12	2.13	.79
02/02/90	0800.00	3.07	2.17	4.36	8.17	10.44	4.13	9.80	.84	7.98	11.24	2.27	.77
02/02/90	0813.20	2.82	1.97	4.39	7.87	10.35	4.21	10.38	.85	7.58	11.52	2.08	.74
02/02/90	0830.00	2.62	1.91	3.50	8.63	10.22	4.09	10.85	.88	7.56	11.94	1.90	.76
		***************** TIME DOMAIN					*****************		** FREQUENCY DOMAIN ***			
DD/MM/YY	HHMM.SS	Hs	Hrms	Hmax	Tz	Ts	Tc	THmax	EPS	T02	Tp	Hrms	EPS
02/02/90	0901.28	2.62	1.80	4.77	7.25	10.05	4.27	10.98	.81	7.55	11.13	1.96	.73
02/02/90	0914.45	2.85	2.11	4.20	8.48	10.77	4.45	9.16	.85	7.86	11.55	2.18	.75
02/02/90	0930.00	2.63	1.82	3.59	7.40	9.43	4.15	11.14	.83	7.22	10.47	1.92	.77
02/02/90	0943.20	2.75	1.90	4.75	7.73	9.93	4.03	10.11	.85	7.61	11.64	2.00	.74
02/02/90	1000.00	-99.90	-99.90	-99.90	-99.90	-99.90	-99.90	-99.90	-99.90	-99.90	-99.90	-99.90	-99.90
02/02/90	1013.20	2.73	1.97	4.21	8.14	10.00	4.07	9.24	.87	7.45	10.79	2.02	.77
02/02/90	1030.00	2.75	1.96	5.45	8.19	10.71	4.18	10.24	.86	7.79	11.79	2.02	.75
02/02/90	1043.20	2.35	1.62	3.68	7.37	10.01	4.09	9.41	.83	7.18	11.54	1.74	.75
02/02/90	1100.00	2.36	1.65	4.00	7.40	9.57	3.90	8.40	.85	7.04	10.72	1.72	.72
02/02/90	1113.20	-99.90	-99.90	-99.90	-99.90	-99.90	-99.90	-99.90	-99.90	-99.90	-99.90	-99.90	-99.90
02/02/90	1130.00	2.14	1.53	3.39	7.44	9.23	3.74	9.18	.86	6.87	11.54	1.57	.74
02/02/90	1143.20	2.34	1.66	3.54	7.49	9.60	4.04	9.58	.84	7.07	10.24	1.76	.74
02/02/90	1200.00	2.38	1.67	3.80	7.68	10.07	4.18	9.29	.84	7.55	10.77	1.74	.75
02/02/90	1213.20	2.48	1.69	4.42	7.15	9.75	4.16	9.31	.81	7.58	11.15	1.85	.73
02/02/90	1230.00	2.45	1.72	5.16	7.17	9.72	4.22	10.34	.81	7.78	11.74	1.91	.76

Fig 1.36: Data supplied courtesy Qld Beach Protection Authority

Unit 2

Beaches



Unit Two

Objectives

Students should have a knowledge of

1. some features of Australia's coastline
2. characteristic features of their own local coastline
3. the changes that occurred during the last ice age and the effects these created
4. the water cycle
5. the composition and methods of formation of carbonate and non-carbonate sands
6. how sand composition is related to shape of continental shelf
7. a hypothetical sand system definition and characteristics
8. how sand is effected by waves, wind and water
9. a beach profile and how it is determined
10. definitions and characteristics of accreting and eroding beach profiles
11. local plants found on dune systems
12. plant and dune interactions
13. changing patterns of dunes
14. the sand budget
15. sand spits and river mouth sediment movements

Students should be able to

1. discuss ways in which beaches are important to our economy
2. discuss how sand is moved along beaches
3. debate how close land subdivision should be to dunes
4. compare high and low energy events as they relate to beaches
5. complete a field study of a local beach. As a result students should be able to:-
    * use a profile stick to measure rising or falling levels on a beach
    * record and graph these changes
    * make predictions as to how beaches will change over time
6. complete a field study of a local beach. As a result of this students should be able to:-
    * identify the major dune plants from their local beach
    * construct a field identikit from a poster provided by their local beach protection authority
    * prepare a class report
7. complete report on one of the following headings:-
    * local beach protection
    * history of a local beach
    * video summaries
    * read the results of a scientific report
    * beach pollution
    * open ended research report

Topic 1

Coastal Landforms

The Australian Coastline is long and varied. The photographs in the next few pages are but a glimpse of the different types of coastal environments on our magnificent continent. This unit concentrates on beaches, their importance and how they were formed.

Beaches are part of the Australian heritage. The coastal zone provides a place for recreation and tourism, shopping complexes, housing and industrial development, quiet recreation in sheltered waterways, a thrilling ride on a wave or a place for conservation or preservation to protect our fragile ecosystem. The shaping of our coastline has been a long and on-going process. Many different coastal features have evolved as a result of the constant shaping by wind, waves and earth movements. To detail all of these is beyond the scope of this introductory unit into coastal process. However an attempt has been made to give you the big picture so that you can gain an appreciation of how fragile and delicate our coastal zone is.

Today's coastline has been really carved up. Foreign and mostly local investment seeks to put increasing pressure on its use. Legislation on building re-zoning applications, land subdivision, national parks, sand mining and removal of vegetation are but a few of the many aspects of coastal zone management. However before we deal with any of these topics it is important to discuss some of the coastal landforms that need to be managed. The Twelve Apostles found in Victoria shown in the photograph below are part of a national heritage which are managed in a national park. This coastline is exposed to high winds and heavy swells from the southern ocean driven by winds from Antarctica. The coastline is composed of sedimentary rock of variable hardness. This feature has lead to a remarkable diversity in coastal landforms.

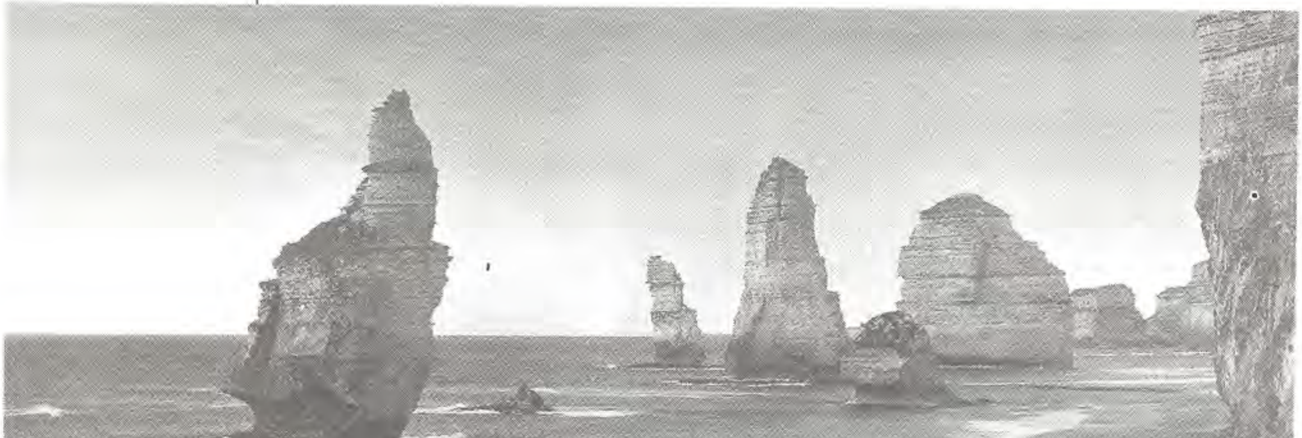


Fig 2.1: The twelve apostles are part of our national heritage. Photograph courtesy Victorian Department of Conservation.

Unit 2

The photographs on this page represent completely different coastlines. In the Northern Territory, winds and currents blow from a different direction compared to the coastline off Broome in Western Australia. The continental shelf is very wide in some places and creates tides of such a height, that ships are stranded at low tide. Further down the coast coral reefs are found and huge cliffs brace themselves from the winds of the Indian Ocean. Further south a local wind called the *Fremantle Doctor* shapes the coastline and many of the sporting activities of south Western Australia.

Fig 2.2: Beaches facing Torres Strait. Photo courtesy Northern Territory Tourist Commission

Fig 2.3: Broome where tides are up to 12 metres. Photo courtesy Allan Nicholls.

The Great Australian Bight is a vast windswept expanse almost totally uninhabited and unsettled. In South Australia, the coastline is extremely varied. Spencer Gulf, the Gulf of St. Vincent, Kangaroo Is and the entrance of the Murray River, all show a great diversity in coastal features. Huge sand dunes adorn the Corong which leads to the Great Ocean Road in Victoria.

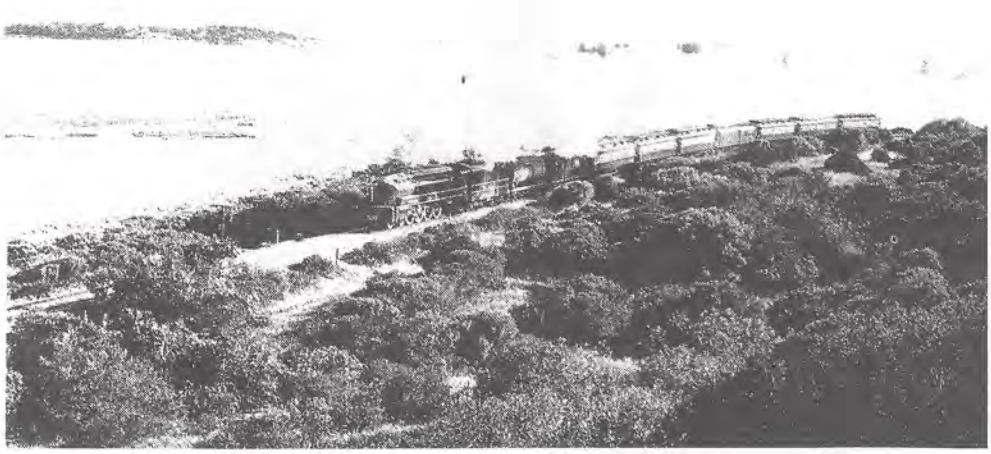


Fig 2.4: The Cockle Train - Victor Harbour. Photo courtesy South Australian Tourist Commission.

The Great Ocean Road leads to Melbourne passing through some of Australians most magnificent coastline. The Twelve Apostles are but one the unique coastal landforms found here. Carved by the icy winds from the Antarctic, these monuments bear testimony to the forces in nature that constantly mould our beaches. Across Bass Strait lies Tasmania. This small island was shaped by the ice sheets of glaciers over 150,000 years ago. High mountain peaks and jagged cliffs in the west give rise to quiet beaches and sleepy coves to the east.

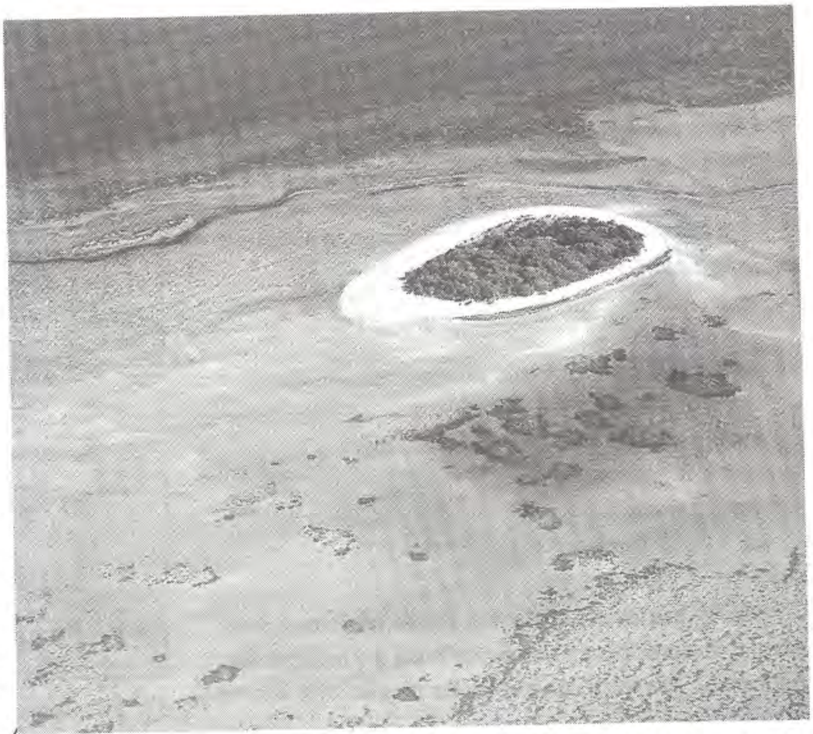


Fig 2.5: Sand cay on the Great Barrier Reef. Photo courtesy Great Barrier Reef Marine Park Authority.

Travelling north from Victoria to New South Wales, the coastline becomes dotted with bays and inlets, evidence of many valleys and rivers that were covered by water. The beaches in New South Wales are famous for the lifestyle that has become Australia's trademark.

In recent times a few have been plagued by pollution and increased public awareness of the need to manage our waste disposal has become apparent.

Fig 2.6: The Hawkesbury. Photo courtesy NSW Tourist Commission.

Fig 2.7: Tasmanian coastline near Hobart. Marine Studies Centre, Woodbridge.

Further north, Queensland lies in the tropic sun. Surfers Paradise is the Australia's second created city (Canberra the first). In creating this city, the coast has been altered dramatically with high rise building and canal estates. This city serves a case study in Unit 3. Large sand islands lie to the north as does the Great Barrier Reef, one of the largest ecosystems in the world to be managed by a Government Authority. In the far north mangroves and rainforest merge at waters edge. The Northern Territory is flanked by the Arafura Sea. Huge expanses of land are managed by Aboriginal populations as is the famous Kakadu National Park.

There are many features of our coastline and some are discussed on this page. During your lifetime you should try to drive around Australia so you can see them all.

Coasts are always changing. Some are retreating under wave action while others are advancing due to the depositing of sediments. There are many different types of coast but the character results from two or more of the following factors:

- wave action
- nature of the rocks found on the coast
- slope of the coastline
- changes in the level of the sea or land
- volcanic activity
- coral formations
- the effects of glaciers

Waves can shape cliffs and create **wave-cut platforms**. In some places these platforms are bordered by high cliffs are very dangerous for people who fish at high tide.

Capes and headlands jut out from the coastline and in some places sea stacks form as shown in Figures 2.1 and 2.8. Caves, arches and stacks are minor features produced by wave and wind action during the process of forming cliffs. A **cave** develops along a line of weakness at the base of a cliff which has been subjected to prolonged wave action. It makes a round tunnel following the line of this weakness and is wider at the entrance. If the joint of weakness extends to a point further up the cliff, the cave will break open or right through and form an **arch**. When the arch breaks off it becomes a **stack**. If the breakthrough occurs further up the cliff, a **blow-hole** is made.

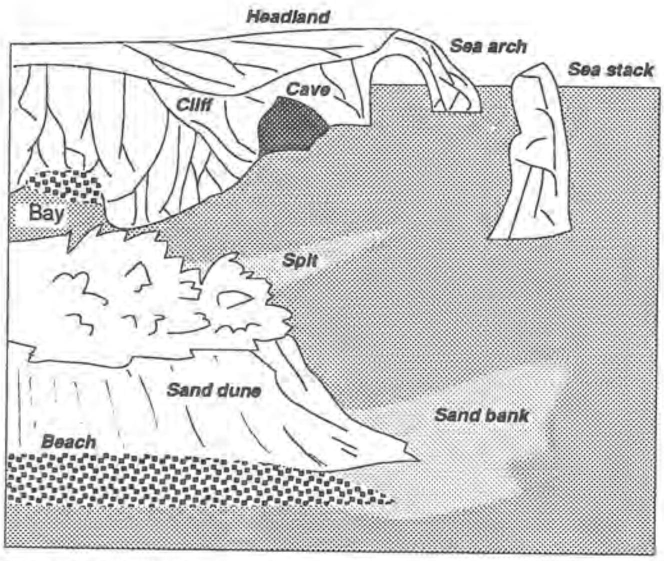


Fig 2.8: Coastal features southern parts of Victoria.

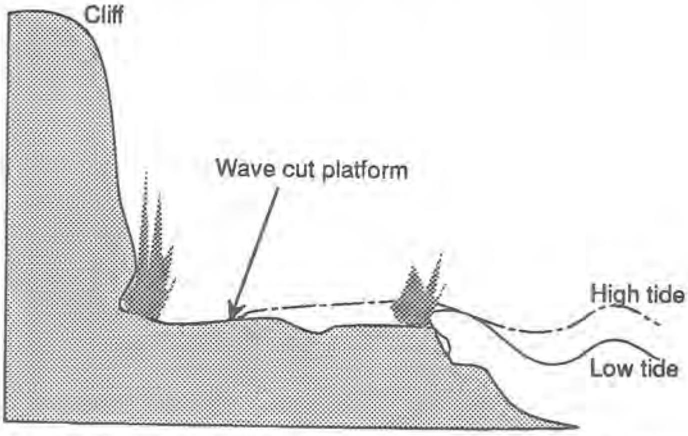


Fig 2.9: Coastal features southern parts of New South Wales.

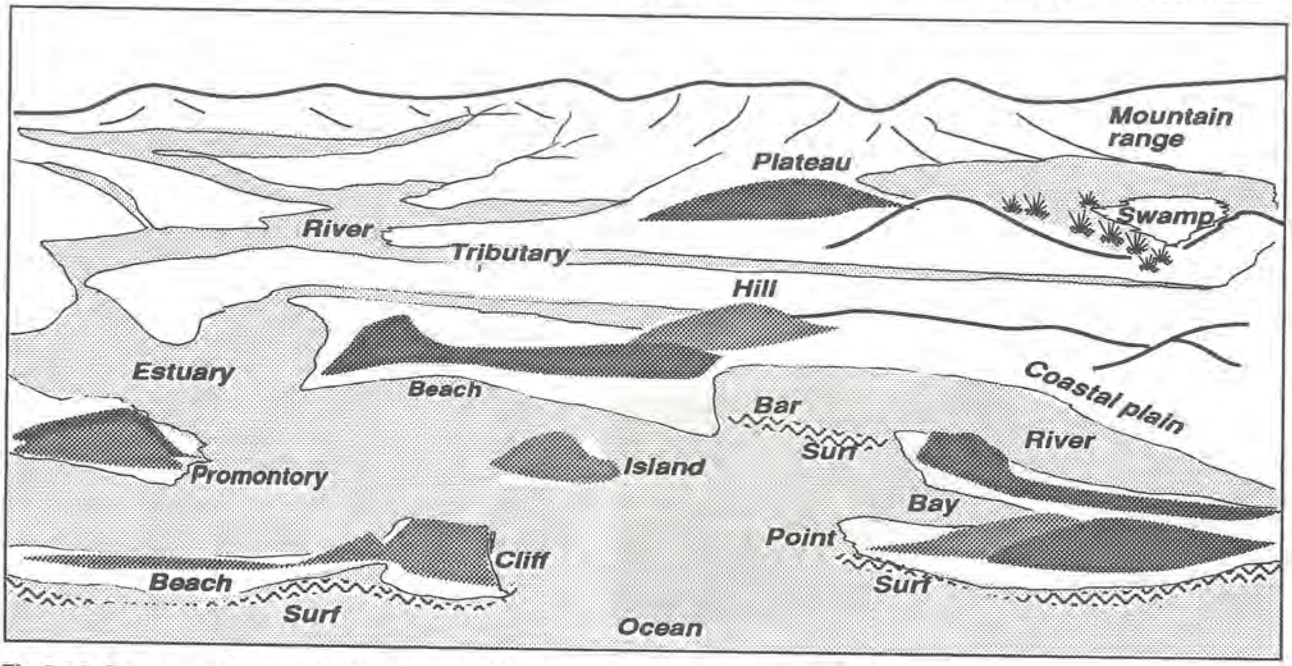


Fig 2.10: Summary of some coastal features. How many of these form part of your coastline?

Activity 2.1 Local coastal features

You will need

A collection of local photographs. (Newspaper adds showing aerial photographs are a good source, alternatively the Department of Lands or Geography Department may have copies)

What to do

Part A: *Use Figure 2.13 over as an example.*

Make a sketch or careful tracing and mark in as many features from the list below. Make an overhead transparency and discuss this as a class exercise.

Part B: *From the photographs supplied, complete similar tracings and mark in the features you identified*

List of coastal features

1 Barrier Islands
2 Bay
3 Beach
4 Brachian dunes
5 Cape
6 Coastal plain
7 Delta
8 Estuary
9 Flood plain
10 Fringing reef
11 Groyne
12 Headland
13 Hill
14 Inlet
15 Island
16 Lagoon
17 Lake
18 Mangrove swamp
19 Mountain range
20 Patch reef
21 Plateau
22 River
23 River valley
24 Salt marsh
25 Sand bar
26 Sand dunes
27 Sea arch
28 Sea cave
29 Sea stack
30 Seif dune
31 Spit
32 Springs
33 Tombolo
34 Valley
35 Wave cut platform

Example map of coast from aerial photograph

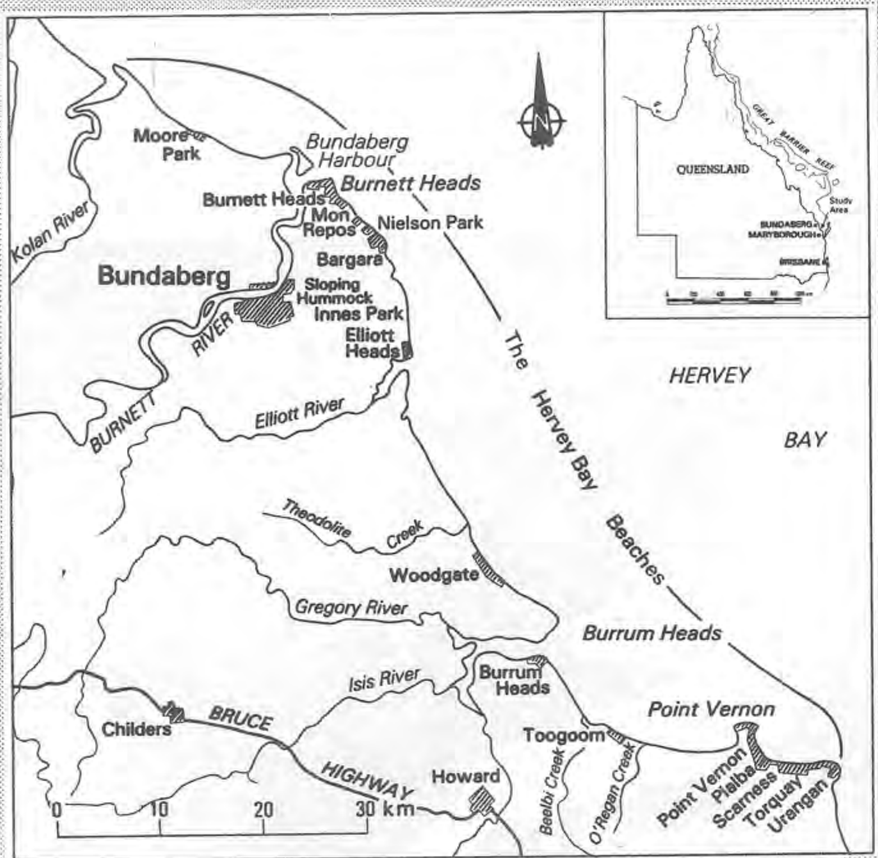


Illustration courtesy of Qld Beach Protection Authority

Where waves cause sediments three types of features can form:-

- Beaches
- Spits and bars
- Salt-marshes and mud flats

Beaches lie between high and low tide marks and are governed by the wave action they experience. High energy beaches have tough sand particles, whereas fine grained particles are found on mudflats and salt marshes.

Spits and bars form where there is a longshore drift created by predominant wave patterns. A **spit** is a low lying narrow ridge of sand or pebbles joined to the land at one end and terminating at the other in deeper water. It may form across a bay or river mouth. The spit is constantly changing because of the wave action. On coral cays in the Great Barrier Reef they are like tails which wag from year to year. A **bar** is very similar to a spit. A common type of bar is that which extends right across a bay. This starts as a spit growing out from one of the headlands and ultimately reaching the other. Many bay bars have a break in them where the tide is too fast to allow sand to be deposited. Sometimes a sandbank is deposited offshore from a beach caused by erosion. This is called a **storm bar** and moves back to the beach in time. It is nourished by the sand dune system as we will see later in this unit.

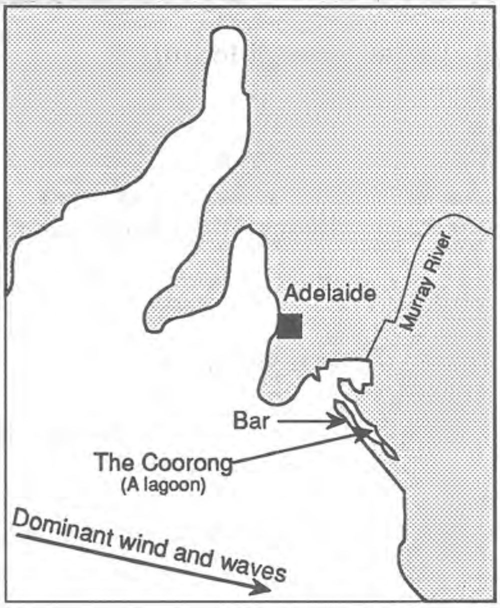


Fig 2.11: Coast of South Australia

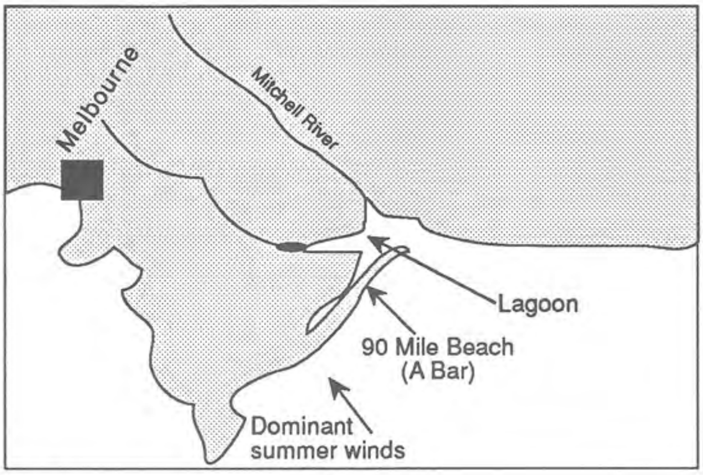


Fig 2.12: Coast of Victoria

Fig 2.13: A sand spit in Queensland. Photograph courtesy Qld Beach Protection Authority.

Activity 2.2 Research Activities

Part A.

Explain the following terms, with accompanying diagrams and or pictures using local examples where possible.

1.	Tombolo	9.	Lagoon
2.	Sea arch	10.	Sea stack
3.	Seif dune	11.	Sand bar
4.	Barrier Islands	12.	Sea cave
5.	Brachian dunes	13.	Patch reef
6.	Fringing reef	14.	Groyne
7.	Coastal plain	15.	Wave cut platforms
8.	Patch reef	16.	Spit

The box of words

sea cave
towards
wind
beaches
sand
lagoon
spits
stack
sand bars
patch reefs

Part B: Local council management.

List three problems your local council has had in developing the coastal zone near your school and state some of the ways in which these have been overcome.

Part C: Which of the following came first?

Of the pairs below, one of the things came before the other. Copy the pair and state which came first.

1. Spit or sand?
2. Rocks or sand?
3. Wind or waves?
4. Sea cave or sea arch?
5. Waves or beaches?

Part D. Complete the sentence.

Complete the sentences from the words in the box above.

1. Shore line currents build ____________
2. Waves move ____________________ the coastline.
3. Most waves are caused by the __________.
4. A sea arch is caused by a _________ wearing through a cliff or headland.
5. A piece of land broken away from the coastline is a ___________
6. Shoreline currents move __________ the coast.
7. Sediment laid down by waves on a shore build ______________.
8. Waves can cave out a cliff face to form a _________.
9. Rising sea level on continental shelves can cause ___________ _____________.
10. A ____________ forms at the mouth of rivers entering the sea.

Part E. Write a sentence.

Write two sentences explaining how wind makes waves and how wind affects wave patterns.

Part F. True or false?

1. Sea arches are carved by waves.
2. Groynes are built to trap sand.
3. Waves follow the coastline.
4. A lagoon is a body of trapped water.
5. Waves only erode beaches.
6. Off-shore bars are built by shore currents.
7. A spit is a trapped body of sand.
8. Only inshore currents erode beaches.
9. Most waves are made by wind.
10. Almost 95%of sand is made in rivers and almost 5% is ex-glacial.

Bays can form in protected areas where rivers enter the sea in places called **estuaries.** A **coastal plain** characterises some parts of Australia's east coast. On this plain mountain ranges provide the source for many of the sediments found on the coast. These were volcanic at various stages of our continents development. **Plateaus and hills** provide relief on this plain and where a river has been cut off from the main stream, a swamp can form. **Mangroves** characterise many of these swamps in northern Australia and are inhabited by a variety of bird life. The coast off Queensland and Western Australia has **reefs.**

In Queensland, the Great Barrier Reef is characterised by three types of reef as shown in Figure 2.16. These reefs have formed on the continental shelf as a result of upward growth of coral from the last ice age.

New coral grew around the fossil reefs exposed during the ice age. Where hills existed, continental islands were formed as a **fringing reef.**

Where the water submerged old reefs, coral grew upwards to form **patch** and **ribbon reefs.** Ribbon reefs grew to the north where the continental shelf comes in close to the mainland. Patch reefs form where there is a wider continental shelf. Here the dominant wind patterns shape the coral islands called **coral cays.**

The reefs to the north are older and thicker than those to the south because of movement north on the **Australian plate.**

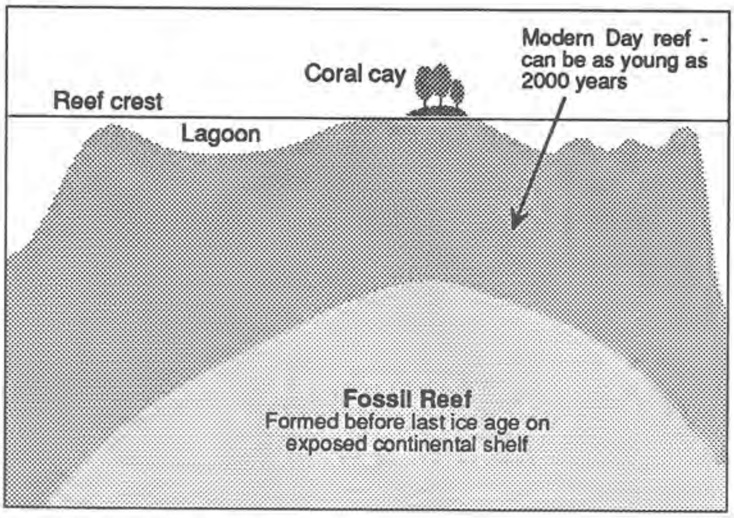


Fig 2.14: Crossection of a coral cay.

Fig 2.15: Ribbon reef. Photo courtesy Great Barrier Reef Marine Park Authority.

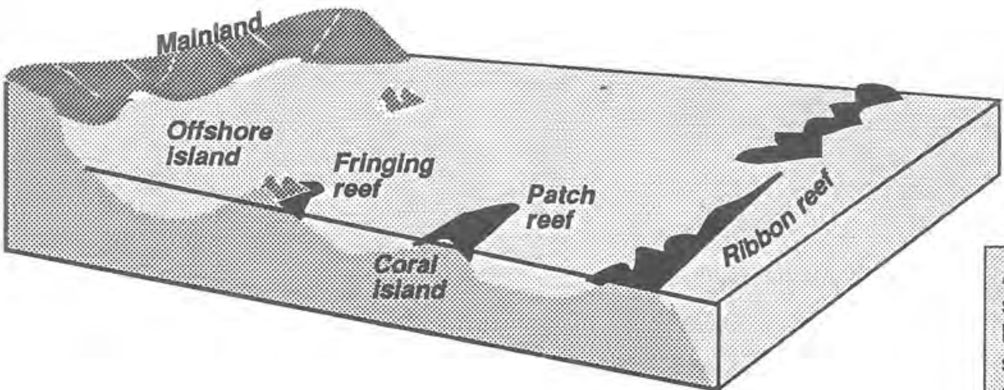


Fig 2.16: Coastal features northern parts of Queensland. After Murdock, 1989.

A separate book in this series called the Barrier Reef World, fully describes the evolution and geomorphology of the Great Barrier Reef. Just write to Wet Paper for a copy.

Topic 2

Sand

Sand is made from rock. Rocks are made of minerals, and minerals were formed a long time ago when the earth was in a state of turmoil. Volcanic activity covered our landscape and mountains were made by the ocean plates of the world pushing together with tremendous force as Australia was carried from the tip of Antartica to where it is today.

To make sand, rock has to be eroded. Wind, rain, ice, earthquakes, chemicals, glaciers and temperature change are some of these forces. Look at Figure 2.17 which is a sand sample from 18 metres of water. It shows that the composition of sand in the active beach system is made up of some very old sand grains.

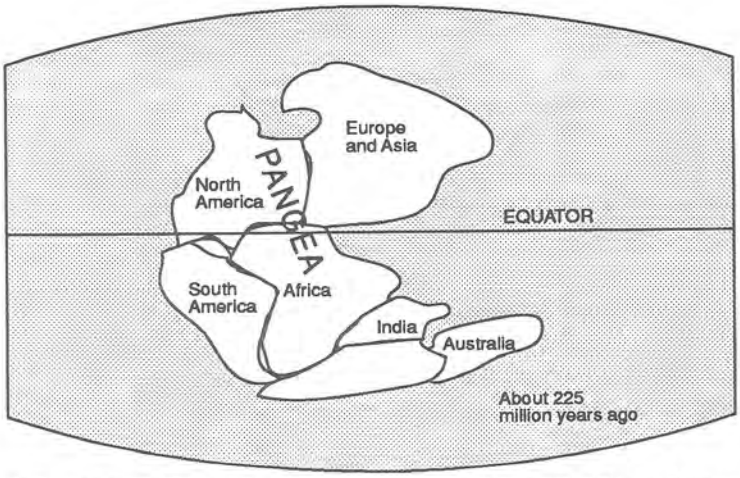


Fig 2.16: Sand on our beaches was being made many millions of years ago when Australia was part of one big supercontinent called Pangea.

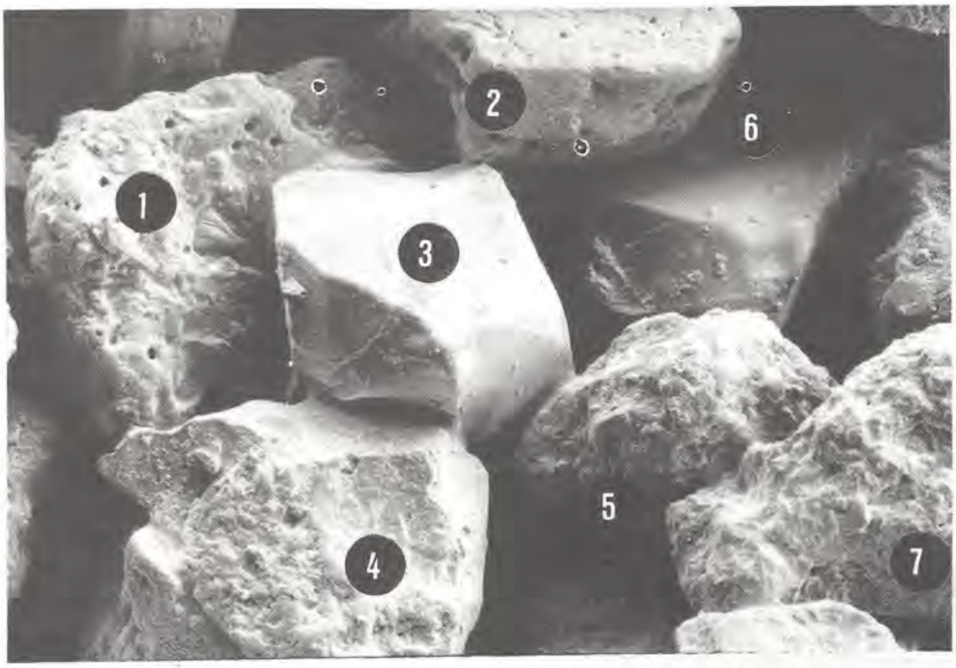


Fig 2.17: Scanning electron micrograph of sand particles in 18 metres of water. Photo courtesy Queensland University of Technology .

The sands of time

Grain 3

has been smashed by ice in a glacier and is over 200,000 years old.

Grains 2 and 6

are rounded and have been washed down to the sea by a river.

Grains 1, 4, 5 and 7

are covered with silt and contain marine borers. They have never been on a beach and have been on the continental shelf for the last 500,000 years.

Wind transport

Deposition of sediments offshore began some 60 million years ago but the sand that moves in our beach systems is controlled by forces in nature that have operated over the past 200,000 years.

At this time there was not as much water on our earth due to the ice age. Large ice caps locked up the water in the seas. The atmosphere was different and so created different wind patterns. In Queensland the strongest wind was from the north on average 120 km/hr. These winds blew over a large coastal plain where the Great Barrier Reef now grows. Sand that had accumulated here blew up into very high dunes creating the large sand islands of Fraser and Moreton. On the Gold Coast no dune has ever reached heights greater than 6 metres in the past 4000 years whereas heights on Moreton Island off Brisbane exceed 70 metres. Off Broome, similar landforms are seen where there is a wide continental shelf. During the last ice age, this was exposed to wind and erosion with the sea hundreds of kilometres out. To the south there was a land bridge between Victoria and Tasmania. In the centre of Australia, high winds blew. Extremes of cold and heat eroded rocks. As the rocks were blown about, they split and gradually became sand. A close examination of sand can tell coastal engineers where it came from. Rough angular sand means it has been blown from offshore. Round smooth sand means it has been washed down river mouths and worked in the surf zone.

The sand budget

20,000 years ago the Victorian Alps and much of Tasmania had glaciers. These solid blocks of slow moving ice, caved out valleys and created rubbles of rock. If the glaciers travelled to the sea, they carved gorges and valleys. Tasmania's coastline has such features. Grain 3 in Figure 2.17 was probably formed in this way.

As the ice sheets began to melt, the water level gradually rose. It covered the sands on the coastal plain and locked them into a sand system that now borders much of Australia. This locked sand system is known as the **sand budget**.

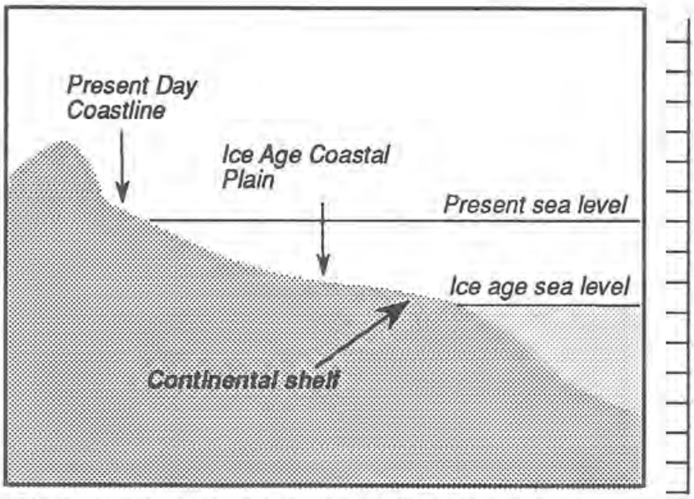


Fig 2.18: Side on view showing shelf and water level

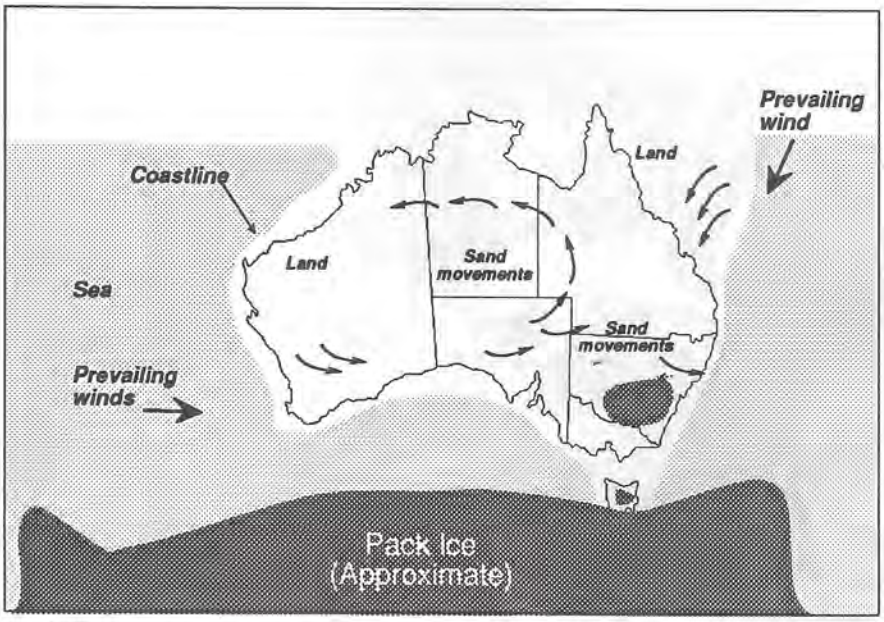


Fig 2.19: Australia with sand patterns during the ice ages. Source:- Perspectives of the Earth.

The wind patterns

With more water over the earth, different wind patterns began and wind speeds dropped.

Wind speeds over water are slower than land due to friction.

Average wind speeds today are between 15-30 knots.

The movement of air from west to east with the characteristic high pressure - low pressure - high pressure systems became a feature of Australian coastal life.

Water transport

The long term erosion of mountain ranges and river transport of sand to the coast has been going on for millions of years. The Murray River System and associated glaciation of the Victorian Alps delivered enormous amounts of sediment into the coastal plain of southern Australia over this time. The Murray -Darling basin accounts for 21% of the area of Australia.

The material transported by rivers and streams is called the **load**. Much of this load is deposited offshore. River valleys became drowned river valleys and the sand on the plains of these valleys became locked in to the sand budget. With more water over the continental shelf, wave patterns began and these started to move the sand as outlined in Unit One. Refraction caused bays to fill in. Reflection broke down cliffs and dune systems. Diffraction transported sand into rivers and bays. More water was moving on earth because of the increased water cycle and sand of different sizes was sorted out.

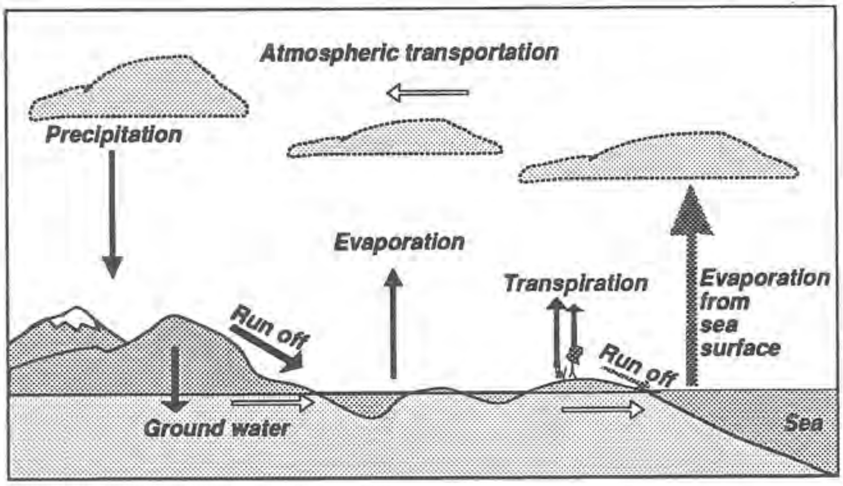


Fig 2.20 The water cycle. (After Clemm, Pottenger, Speitel and Coopersmith, 1990)

Rivers

As a result of the **water cycle**, rivers return water to the sea. Along the way, rivers can create sediment in many ways. Rocks can **roll, slide or bounce** as shown in Figure 2.22 below. The finer grains end up in suspension and the longer the river the greater the suspended materials. The Murray River System adds much to the sand system of the south whereas short fast flowing rivers add little.

In slow moving estuaries, fine **silt** settles out as a result of sand moving down from rivers. Harder sand particles containing quartz and silica move towards the coast unchanged. The Tweed River on the border between Queensland and New South Wales has added no new sand to the system in the last 4000 years, however the Clarence and Richmond Rivers have. This is because of the nature of the land over which they flow as well as their length. On beaches with high wave energy, only the harder sand grains remained. These contain the extemely hard minerals of **quartz and silica.**

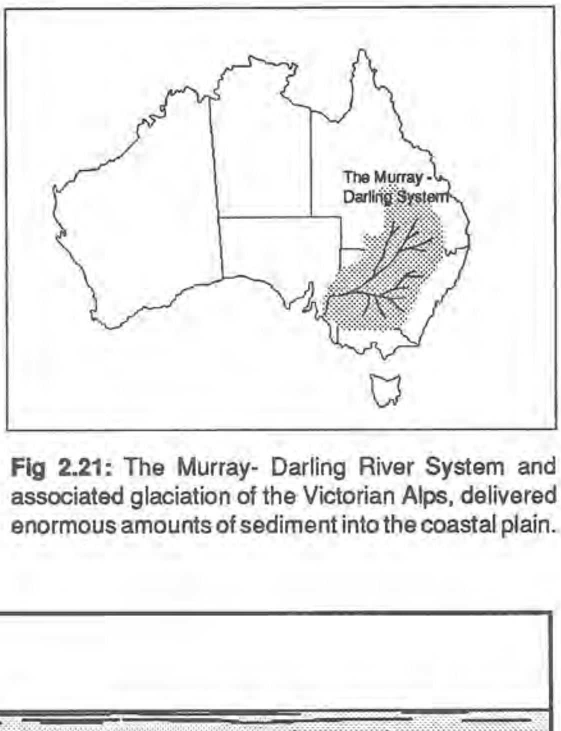


Fig 2.21: The Murray- Darling River System and associated glaciation of the Victorian Alps, delivered enormous amounts of sediment into the coastal plain.

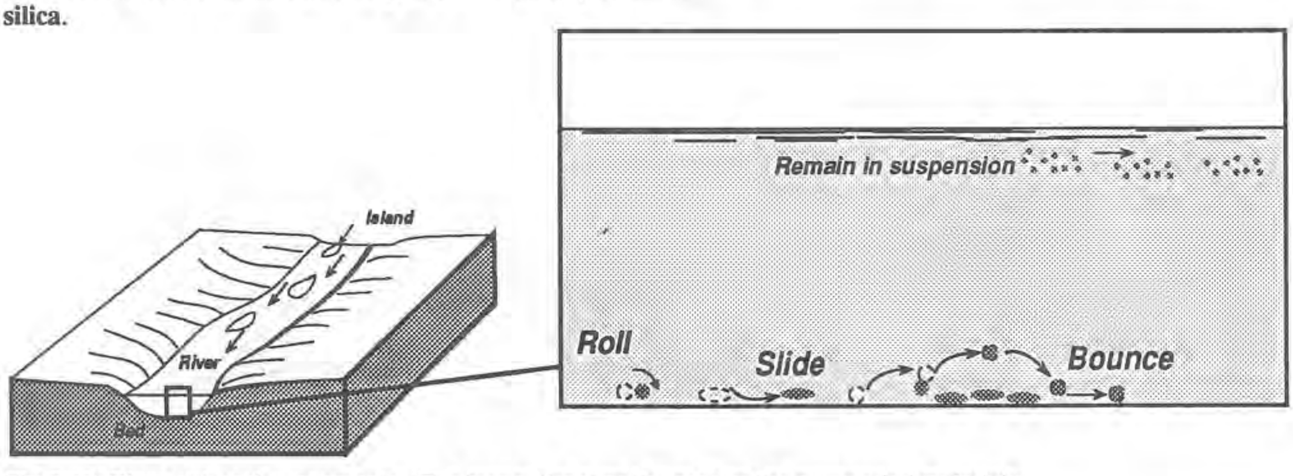


Fig 2.22: River with rock movements. The longer the river the greater the suspended materials

Non-Carbonate Sands

In the next activity you will discover that sand is made of a number of particle sizes. The biggest particle size is a boulder and the smallest clay. Other grain sizes can be classified according to the Wentworth scale of classification.

Table 2.1 The Wentworth grain-size scale of non-carbonate sands related to beach slope

Class	Subclass	Equiv. Diameter	Average slope of beach in degrees
Boulder	-	256mm or more	> 25 degrees
Gravel	Cobble	65 - 256 mm	19 - 25 degrees
	Pebble	4 - 64 mm	13 - 19 degrees
	Granule	2 - 4 mm	11 degrees
Sand	Very coarse	1 - 2 mm	9 degrees
	Coarse	0.5 - 1 mm	7 degrees
	Medium sand	0.25 - 0.5 mm	5 degrees
Mud	Fine sand	0.07 - 0.25 mm	5 degrees
	Silt	0.003 - 0.07 mm	0 degrees
	Clay	0.003 or less mm	0 degrees

After Klemm, Pottenger, Speitel, Reed and Coopersmith 1990

If the sand you examined came from a high energy area, most of the grains would be of silica as well as lesser amounts of shell and mineral. Silica is extremely hard and highly resistant to abrasion, but shell readily abrades and becomes rounded and smooth in the swash zone. On the sea-bed extending past the swash zone, all the particles of all grain sizes are mixed together.

Notice that the particle size on the beach is related to its slope. This can be observed on many Australian beaches and directly relates to the amount of energy the beach is experiencing. Sand cannot form on headlands because the wave energy is too high. As you walk around a headland you can see the boulders turn into gravel and finally sand in areas where the waves are gentle. If two headlands enclose a bay, they capture sand.

However if you live in an estuary, you will see mud and silt accumulating near the mangroves. The mangroves need the mud for support and the mud can only settle in this low energy area. If the coastline was altered to allow high energy waves to enter, the mud would be washed away and the mangroves would die out. Increased tidal flow can also change the composition of sediment on a beach.

Mineral sands

From time to time, usually after a storm, black stains appear on our beaches. These are the mineral sands that were mined on our beaches. It was common to see sand dredges in the early sixties mining rich minerals of zircon, rutile and magnetite. Theses sands were heavier than the quartz and feldspar grains and could be separated by a gravity separator.

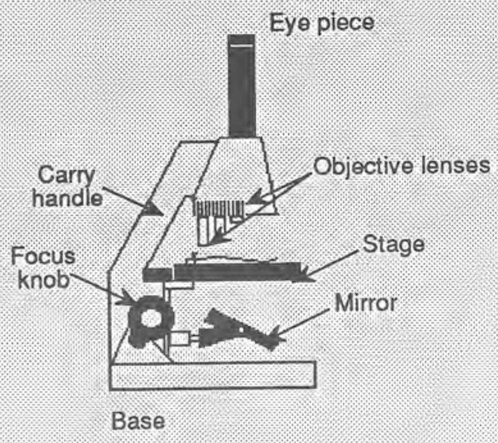
Today it is rare to see sand mining on our beaches because of changing attitudes to conservation of our coastal zone. In hindsight, has sand mining seriously affected an area close to you? Did modern methods of re-vegetation work and was there any environmental disaster because of this type of activity?

Fig 2.23: Mineral sands exposed in front of boulder wall after storm.

Activity 2.3 Sand analysis.

Purpose:

To identify the types of particles that make up sand.



You will need:

* handful of sand
* sieves of various sizes
* sticky tape
* magnifying glass or microscope with slides

What to do:

Carefully sieve the sand and separate out the particles. Now look carefully for shells, minerals and other materials.

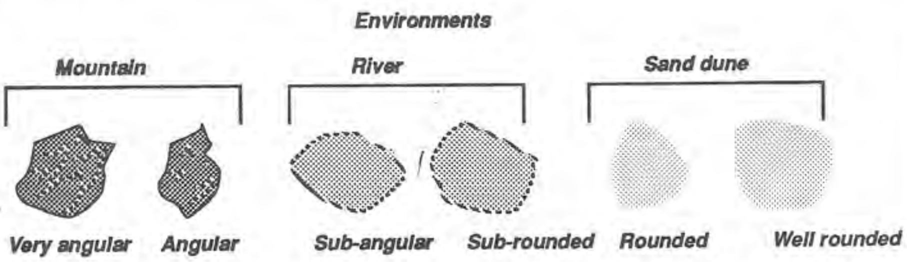
Questions to answer:

1. Look at the classification of particles below. What types does your sand sample contain?
2. Name any one carbonate component and say where it came from?
3. Can you see any minerals in the sample? What do they look like?
4. Use pieces of sticky tape to collect a sample of your sieved sample and stick it into the space below giving them names.

Read this

Carbonate sands are made from the dead remains of animals. They contain calcium carbonate which was extracted from sea water by the animal when it was alive.

Non-carbonate sands are those that formed from rocks. Quartz and feldspar are two very common non carbonate sands..



These all mix together offshore as shown in Figure 2.17

Fig 2.24: Pebble and sand grain sizes of non-carbonate sands

If your sand sample came from a low energy beach you would find that the composition would be different. The non-carbonate sand would be mixed with the carbonate sands discussed over.

Carbonate sands

Sand can be made from living materials as well. Carbonate sands are made from the dead remains of animals that had calcium carbonate in them. Non-carbonate sands are made from minerals that eroded in the hills long ago. On coral cays nearly all the sand is from the dead remains of coral and animals. These sands contain a high percentage of calcium carbonate.

Some animals and plants that make up this sand are summarised below.

When you look at your sand sample, try to identify where particles of this sand have come from.

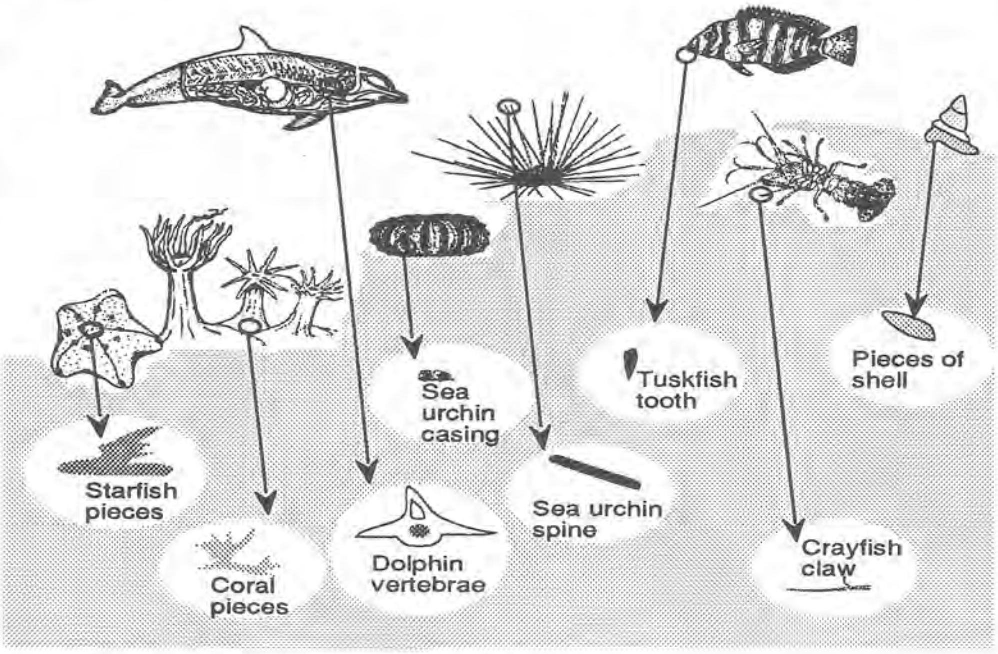


Fig 2.25: Some of the origins of carbonate sand

Sometimes sand can be squashed together to form **indurated sandstone.** This sand comes from carbonate and non carbonate sands that once supported land based animals and plants. When these died, they formed the black parts whose ever increasing layers compressed the mixture together. Chemicals leaching out of the dead remains may also have added to the" cementing" process. **Peat** is formed from organic matter being squeezed together by later deposits laid over them. It is found in the sand because some areas off the coast were once swamps and later a number of beaches existed with distinct beach faces.

On a larger scale sand distribution can be affected by the shape of the continental shelf. A wide continental shelf fed by long flowing rivers will produce different sand than a narrow continental shelf. Islands in the Pacific will also have different sand than continental islands such as Australia.

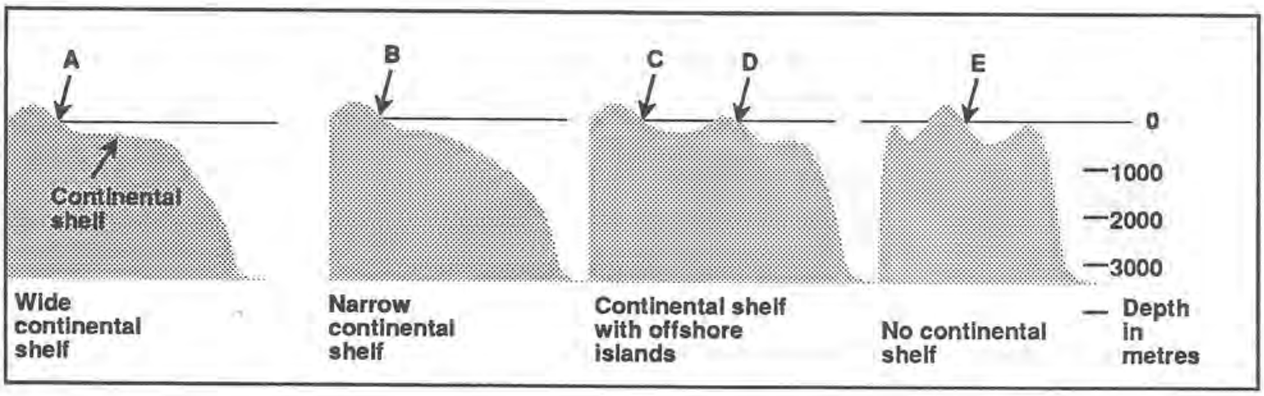
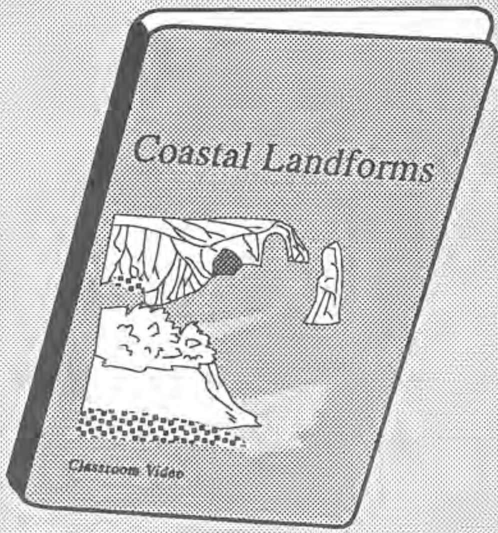


Fig 2.26: Some of the different possibilities for sand development on a larger scale.

Activity 2.4 Coastal Landforms



Purpose:

To review some of the main features discussed so far

You will need:

* The video "Coastal Landforms" by Classroom Video
* A video player and a discussion group

What to do:

Carefully watch the video. Now form a discussion group and answer the questions below.

Questions to answer:

The sand budget

1. Where does sand on tropical islands come from?
2. Where does sand on coastal beaches come from?
3. What would the origin of sand be, that contained..
   (a) calcium carbonate
   (b) quartz
4. How much sand has reached the beach in the last 6000 years?
5. Did the sea level rise or fall during that time?
6. What moves sand along the beach?
7. Name any two structures that capture sand on a beach.
8. What two factors determine whether a beach will form?
9. Complete the sentences below:
   (a) On a beach, the sand particles are just .... enough to be carried in and just .... enough to stay there when the wave goes out.
   (b) A wave's energy is .... as it washes up a beach.
   (c) Storm waves however can .... sand from the beach.

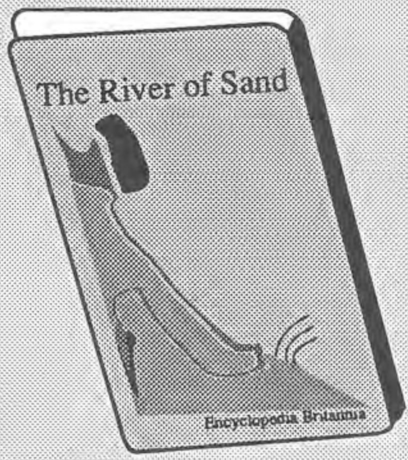
This video is available from:-

Classroom Video
81 Frenchs Forest Rd
Frenchs Forest 2089

Coastal landforms and management video summary

"A sand budget controls the distribution of sand on beaches. Sources of sand are granite, shells, coral, basalt and recycling of sandstone. Some rivers make little contribution to the sand budget while others add considerable amounts of sand each year due to floods. The majority of sand was produced on land, washed down to the sea during the ice age and covered by rising sea levels. Many estuaries have become sinks for coastal sand. Particle size is a factor of water speed or competence. Calcium carbonate and silica are very close in density. A beach is in dynamic equilibrium with its sand which is always mobile. Small waves build the beach and large high energy waves remove it. Sand scarps form on beaches that are eroding. Dunes are the stores of sand and can move. Buildings can be undercut by storm damage if built on dunes or too close to the beach. Sand losses can be accelerated by beach walls. Effects of dune systems and long term recession are discussed. Most of the sand is from another era. To do a mass balance or sand budget we must consider what is already there, what is coming in and what is going out. Sand can be moved in or out by people or currents. Sand can be made by erosion or by marine organisms. Sand can be destroyed by solution or abrasion. There are many sources of sand." John Davis, 1988.

Activity 2.5 The River of Sand Video



Purpose:

To review some of the main features discussed so far.

You will need:

* The video "River of Sand" by Encyclopedia Britannia
* A video player and a discussion group

What to do:

Carefully watch the video. You may have to run it twice. Now form a discussion group and answer the questions below.

Questions to answer:

1. Beaches are made of a variety of materials.
   (a) What are the principal components of a beach?
   (b) What is sand composed of?
   (c) How did the sand get onto the beach?
   (d) Where does the sand come from? What causes solid rock to break down?

2. When a wave crashes up onto a beach the sand grains move. What effect does this movement have over a long time? Your answer should describe the difference between summer and winter waves.

3. If sand moves on and offshore, why does it not form in from in a river entrance? Your answer should discuss
   (a) Waves approaching the beach at an angle (draw a diagram of the surf zone, the beach face and the approaching waves).
   (b) Discuss what happens on the beach face (the red marker and red dye experiments).

4. Where does the sand for a beach come from? What causes solid rock to break down?

5. Waves breaking in the surf zone set up a number of currents. Name two and describe how they operate.

Summary

* The principal sands from sand rocks are feldspar and quartz.
* Sand that moves on our beaches comes from a sand budget.
* Income in the budget comes from a variety of sources.
* Sand may move along a beach when waves approach the beach in an oblique direction.
* Sand can be locked into a captive beach where two headlands form a protective shield.

Topic 3
Wave and Beach Interactions

The sand system

Sediment is added to the sand budget by erosion from mountain ranges as shown by A in the Figure 2.27. Over long periods of time rocks break down to form smaller fragments of either the parent rock or the individual minerals of the rock. The process of weathering is very slow and is dependent on the composition and structure of the rock that is eroded as well as other factors such as rain, wind and temperature change.

Many **minerals** within the rock are fine grained and break down to form **clay and silt**. Other minerals like mica and feldspar are soft and break down to form sand which form from the initial weathering process. Harder minerals like quartz stay the same but gradually become smaller.

The sand particles are washed out of the river mouth at B during periods of heavy rain. They are then moved along the coastline at C by the oblique wave pattern shown as shown in Figure 2.27. Finally the sand leaves the system at D and accumulates in an estuary or bay sheltered by an offshore island. This is called a **"sink"**. Some sand may leak from this sink into another sand system as shown by E. Part of this natural system is shown by the photograph below.

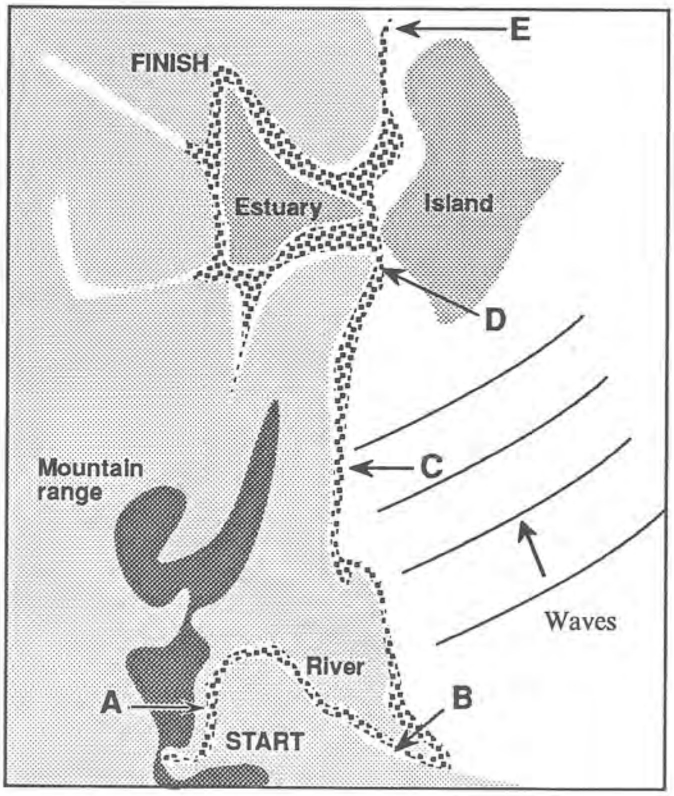


Fig 2.27: A hypothetical sand system

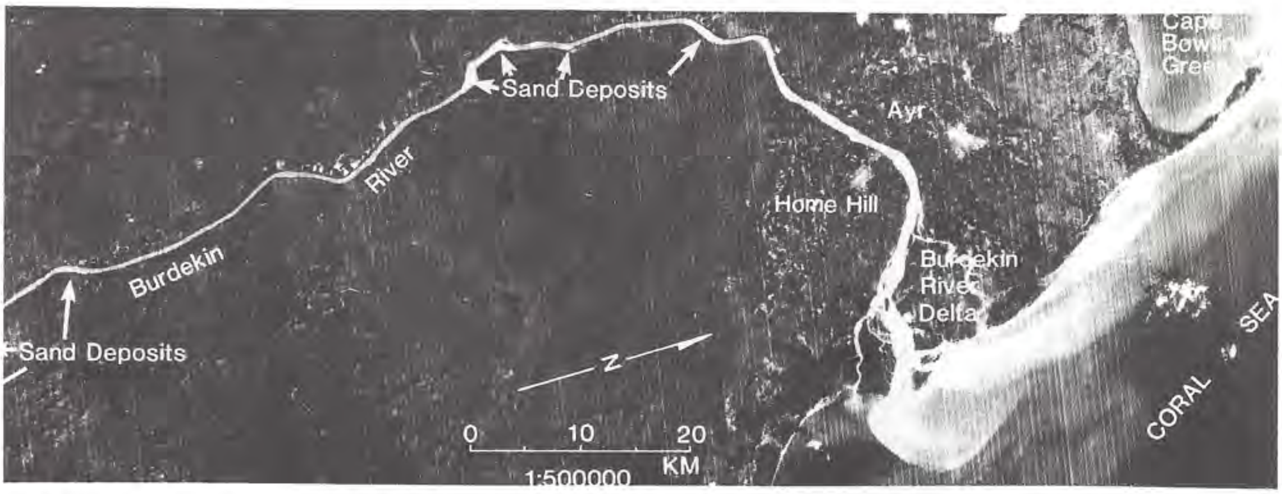


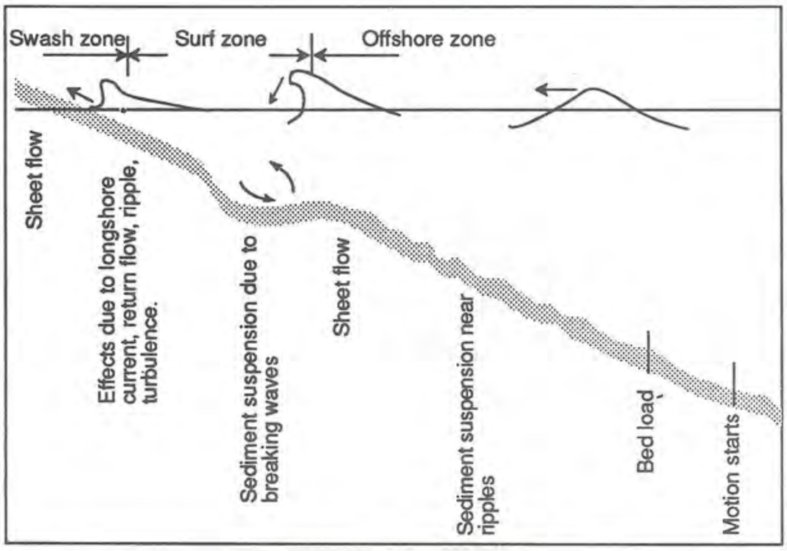
Fig 2. 28: A satellite photograph of part of the Burdekin River System in Northern Queensland. Sand derived from the catchment area is visible in deposits along the river. Sand is deposited at the river mouth and moved north when it strikes wave action from the south. Satellite photograph courtesy Qld Beach Protection Authority.

During floods the sand will be moved rapidly towards the sea. When the rate of deposition at the mouth of the river is greater than that transported north, a delta will form. Where the wave action is high, only the heavier particles will form part of the beach and the clay and silt will remain in suspension.

Only when the wave action decreases or sediment is washed into areas protected from wave action will the fine clay and silt particles settle out.

Once in the beach system, the sand is free to move. It is quickly sorted by wave and ocean currents. The very fine sediments move offshore and are deposited. Eventually thay will roll down the continental shelf to form part of the deep sea ooze.

Fig 2.29: Mud accumulates in estuaries where wave action is less.



Sediment transport

Sediments in the wave zone are sorted more dramatically. A long shore current moves the sand particles back and forth along the beach. Incoming waves also move the sand onto and off the beach as part of a natural process. The figure below shows part of the sea bed profile under the water.

Fig 2.30: Generalised cross section of sea bed opposite a beach.

Profile Stick

A beach profile stick can easily be made from a metre rule, red tape, water level and sticky tape.

Fig 2.31

Activity 2.6 A beach profile

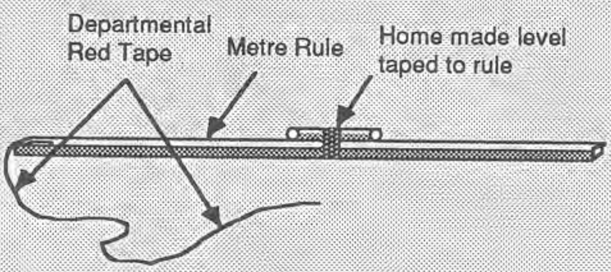
Field Study

Purpose:

To construct a side view - profile of a beach

You will need:

* A profile stick
* Sheet of A4 paper folded twice
* pencil



What to do

1. Make a profile stick like the one shown above and practice on a slope at school to record the change in heights down a slope or bank.

2. Make up your field data sheet by folding a piece of A4 paper twice to record the drop in mm above or below the datum.

3. Start at the top of the bank. Call this your datum point. Now position the stick so that it becomes level. Pull the tape down to the ground and then move it to the stick and read off the fall.

4. Repeat this at a number of stations down the slope so that you continue to record the fall from the datum.

5. When you get to the swash zone (that's the area where water runs up the beach) measure it.

6. Back in class or at home, draw up a data table like the one opposite and recalculate all your measurements so that you can see how far each station is below the datum point. Now plot a profile of the beach slope on some graph paper.

Questions:-

1. Is there any evidence of beach erosion? How can you tell?

2. How wide was the swash zone? How will this change over time?

3. Make a prediction of how this profile will change over the year. What part of the profile is missing?

4. Work out the profile angle and compare it with others in your class. Are all the same?

Time required

40 minutes

Your Measurements

Fall in	Calculated value below datum	Fall in	Calculated value below datum

Note for Activity 2.6

Practice at school first on a grass slope. Use a piece of A4 paper folded twice to make a small A5 notebook. Use a pencil and just record the falls in the slope. When you get back inside transfer this data to a data table like the one shown above.

You may like to make a longtime study of your local beach over a year. If so the profile angles will change from the storm season to calmer conditions.

Some profiles are shown in the Figures 2.36 and 2.38.

How sand is introduced to the beach

Waves move towards the beach. Their orbit fields make sand waves which get closer to the beach. Eventually the wave breaks to form a **wave bore.**

The bore carries the sand up the beach to a point where it stalls. Here the sand is dropped to form a **micro-ridge.**

As the tide recedes, these micro-ridges dry. If the wind is strong enough, sand is blown up the beach. Dune plants reduce the wind velocity causing the sand to drop to the dune. The sand provides a stimulus for the plants to grow and the dune will increase in size. Dune fences achieve a similar result.

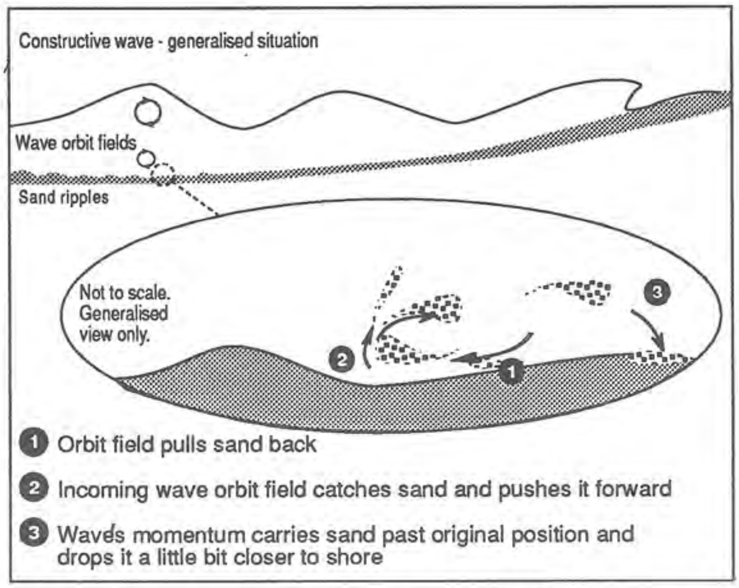


Fig 2.32: Generalised impression of how constructive waves push sand towards the beach.

Fig 2.33: The end result. A micro-ridge formed from a wave bore on a beach that is accreting. The sand is soft in the swash zone.

Some characteristics of beach profiles.

Wave bores - broken waves which carry sand to and from the beach.

Microridges - minute ridges on a beach containing sand dropped by wave bores.

Swash zone - is the maximum distance the wave bore travels up the beach. It can be identified by the "wet bit". The wave bore is the broken part of the original wave as it runs up the beach.

Beach berm - is a small build up of sand near high tide on a accreting beach. It disappears with a storm.

Dunes - mounds of sand covered with vegetation and act as a reservoir for the storm bar during high energy events on the beach. Built entirely by wind of speeds greater than 25-30 knots.

Accreting beach - a beach where sand is moving onshore.

Eroding beach - a beach where sand is moving offshore .

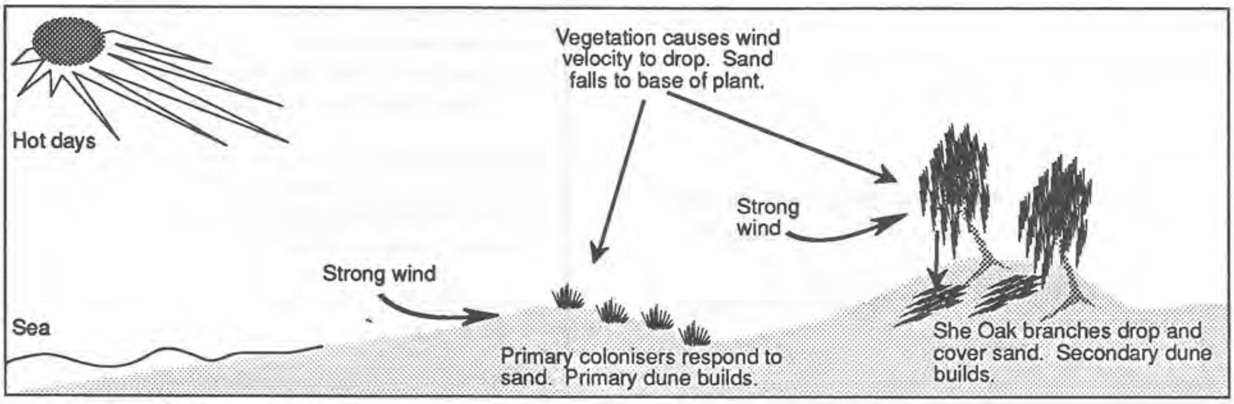


Fig 2.34: Sand is blown up to form a sand dune to form a beach profile

Accreting beach profiles

A beach that builds in size is called an **accreting beach.** For a beach to build, the waves bores need to be frequent. Figure 2.35 shows incoming bores.

There have to be many bores to push the sand towards the beach so that the forward movement of sand is greater than the backward movement. A beach berm can form near high tide if there is little wind.

As wave size increases, bore frequency decreases. The wave orbits do not have the ability to move sand forward and sand moves off the beach. Figure 2.35 shows this.

Fig 2.35: An accreting beach has many wave bores, a low beach profile angle near dunes, sand is soft in the swash zone and micro-ridges visible

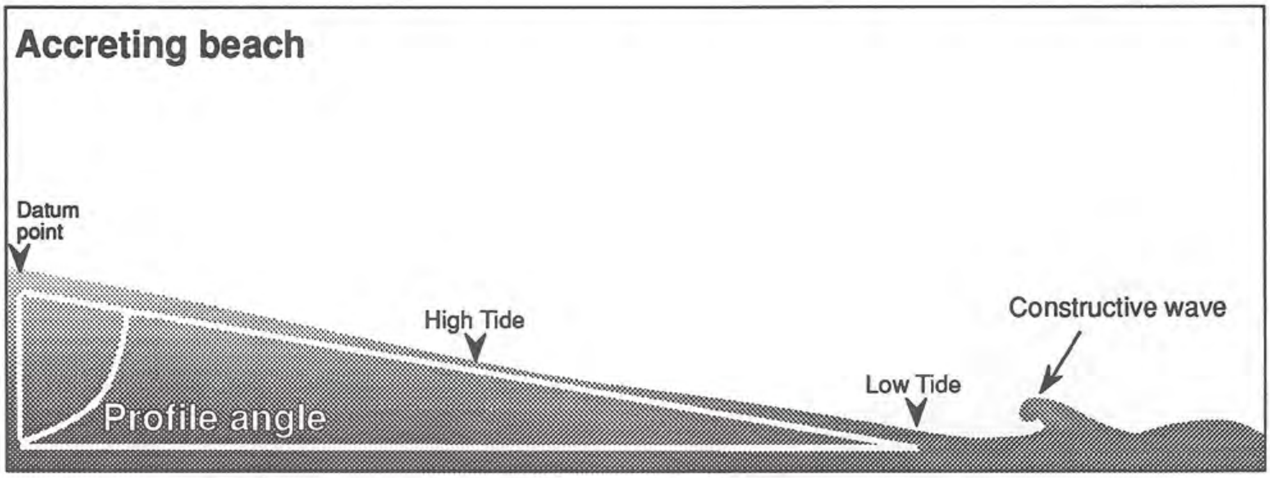


Fig 2.36: Accreting beach profile near dunes. Low profile angle, many high frequency wave bores.

Fig 2.37: Large distances between wave bores are a characteristic of an eroding beach.

It's a strange feature of public awareness that when beaches are in their erosion cycle that there is a public outcry.

When you analyse media reports you should recognise the sensationalism of the report.

Erosion is a natural characteristic of beaches and many critics of beach conservation fail to realise this and stir up public criticism as soon as the erosion cycle starts.

Eroding beach profiles

An erosion scarp is formed as the sand from the dune moves offshore to form a protective storm bar. The micro-ridges no longer form on the beach and are replaced by runnels as shown in Figure 2.40.

Beaches will continue to erode while a storm persists. The sand moves out to an offshore storm bar where most of the wave energy is absorbed. At low tide small waves lap the shore however because of the lowered beach profile, high tide sees more erosion. The sand dune is again eroded with more sand moving offshore. Eventually there will be enough sand on the offshore bar for equilibrium to be established. If there is insufficient sand in the dune reservoir, the sea will continue to erode the land.

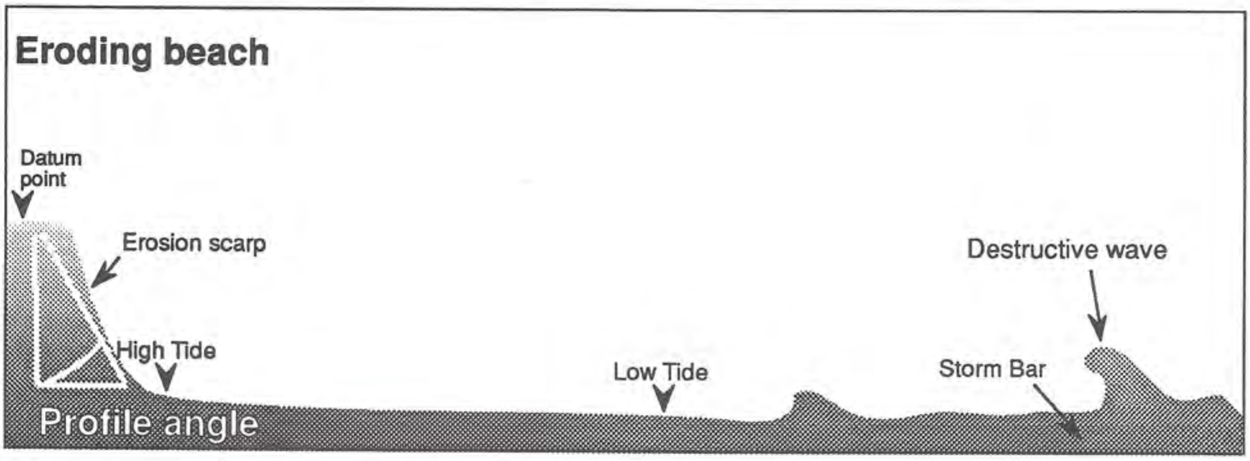


Fig 2.38 Eroding beach profile. Steep profile angle near dune area.

Fig 2.39: Eroding beach profile. Steep profile angle near dune area. Photo by Colin McMurtrie.

After the storm the beach starts to accrete again due to the presence of the smaller constructive waves. These waves start the sand moving towards the shore from the storm bar by the wave orbit fields we discussed on page 56.

The sand is dropped in the micro-ridges by the wave bore and blown up towards the eroded dune and the cycle starts again. It can take up to eighteen months for the beach to fully recover and more erosion may occur due to further storms.

Some characteristics of eroding beaches are:

* distance between wave bores increases
* large profile angle near dune area
* sand is hard in the swash zone
* no micro-ridges visible
* runnels visible in swash zone

When the dunes eroded, the roots of plants and schrubs were left dangling on the erosion scarp. This is called **the fretting**. These roots now trap the sand as it blows up the beach from the dry micro-ridges. It may take up to eighteen months for the original profile to re-establish and it is important that the dune vegetation be protected from damage.

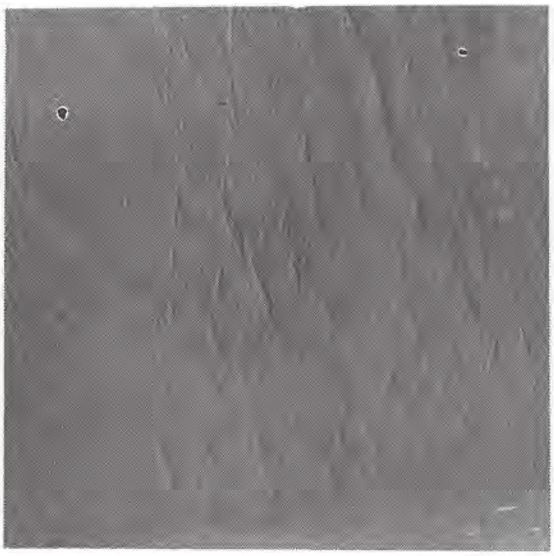


Fig 2.40: Runnels in the swash zone are a characteristic of an eroding beach

The sand budget

We have looked at ways sand forms, how it is moved along the coastline and how it accumulates in dunes on the beach. The sand budget discusses the nett movement of sand into and out of a sand system. Different systems will contain different types of sand but the overall principles are the same. Sand comes in, is moved around and is lost. If the sand visible on our beaches is to stay in quantities necessary for tourist enjoyment, then engineers need to calculate the sand budget.

Every budget has an income and expense. Profit or loss is what is left over after all expenses have been paid. The table opposite summarises some of the parts to the budget. In Queensland, studies have shown that 500,000 cubic metres of sand move in the sand system each year. The amounts will vary and depend on the energy that the beach experiences. High energy beach systems will move more sand than low energy sand systems. Do you know how much sand moves in your local beach system?

Income	Expense
Rivers & streams	Deposition into bays and rivers
Cliff erosion	Longshore drift (out)
Longshore transport (in)	Wind (offshore)
Wind (on shore)	Mining
Beach nourishment	Daming of rivers
Animal and plant remains (Shells)	Animals and vehicle movements

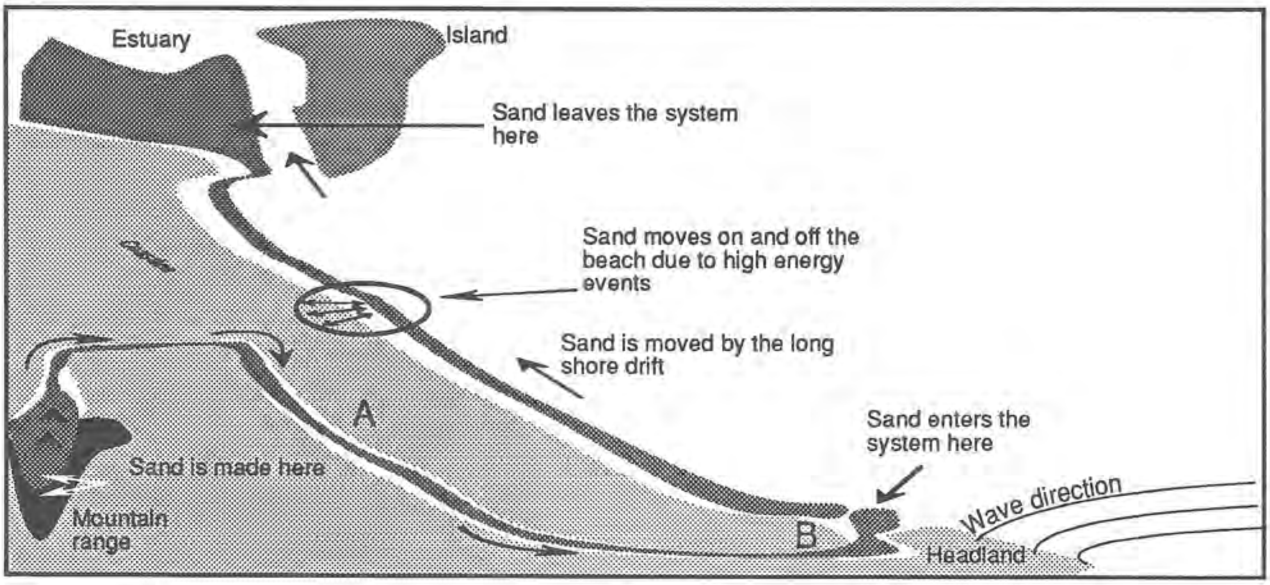


Fig 2.41: Parts to the sand system

Sand spits and river mouths

The movement of sand can be affected by a river within the system. Sand moves in the surf zone until it reaches the deeper water caused by a river mouth. Here, the waves refract, slow down and deposit the sand into a sand spit. This **spit** can vary dramatically because of tide, river currents, prevailing surf conditions and directions. The nett effect however is a gradual lengthening of the sand spit in the direction of the predominant wave pattern.

If the north shore of the river mouth erodes then the southern shore accretes. If left alone, the river mouth will keep moving north. Islands can form. New river mouths can be created. River entrances are very dynamic places for sand movement and as will be discussed later, Australians have done a remarkable job in stuffing them up!!

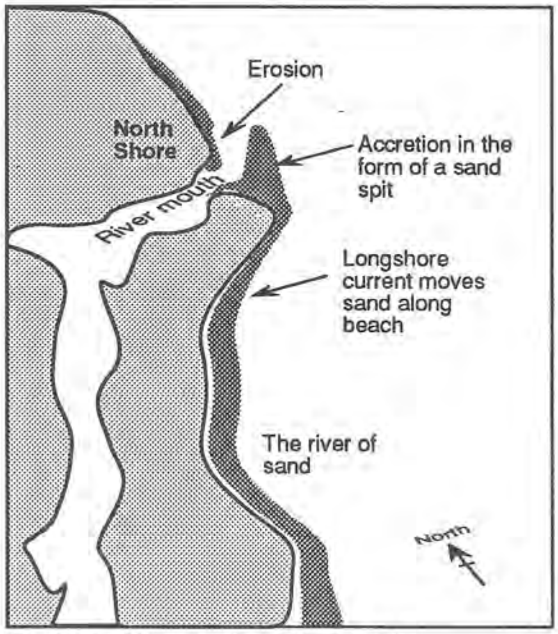


Fig 2.42: River mouth and sand spit

Research Activities

The next unit will look at how humans have interfered with the natural beach system. In preparation for the unit, the following research activities may prove useful in class discussions.

Activity 2.7 Beach Protection

"A good beach is the best form of Coastal Protection" Discuss this very open ended statement in no more than 1000 words.

Activity 2.8 History of your Local Beach

Next time you visit your grandparents ask them to show you old photos of where they had a holiday by the beach. Questions such as:

* How did they get to the beach?
* What accommodation was available when they got there?
* What did they do for recreation?
* What development on the beach occurred during their lifetime?
* What attitude changes have they noticed?

See if you can borrow some old photographs and have them enlarged. Look after the originals and make sure you return them with thanks. Now have the art students make frames and hang them on the wall around the class.

Activity 2.9 They can be Saved

* View the video which shows how an unstable off-shore island was stabilized by sand dune management and re-vegetation. Its available from Administration Officer, Materials Development Section, Schools Sales 417 South Pine Rd., Everton Park. Qld. About $20.

Activity 2.10 Read a Report

Estimate of cyclone erosion and damage on the Gold Coast during early 1974. Report No 65 Gold Coast City Council by Sam Smith. Just how much does a cyclone cost a local community?

"During January and February 1974, the Gold Coast beaches were attacked by two cyclones, and storm conditions persisted for nearly a fortnight. At the peak of the storms, the coast suffered a significant amount of erosion damage; sea walls destroyed, sand was lost and there was much damage to houses, largely from seawater penetration" Just how MUCH did this COST?

Activity 2.11 Open ended questions

Q1. "When a wave washes up on the beach the sand grains move." What effect does this movement have over a long time? Your answer should describe the difference between summer and winter waves.

Q2. "If sand moves on and offshore why does it not form in front of rivers?" Your answer should discuss:
*Waves approaching a beach at an angle.
*What happens to sand on the beach face? (The Red Marker Experiment)

Activity 2.12 Pollution on our beaches

Write to the Director of Transport and Communication Dept., Pollution Prevention Unit, GPO Box 594 Canberra ACT 2601, for the pamphlets on Pollution:- *"Stow It, Don't Throw It"* , *Oil Spill Clean-up of the Foreshore. Field Guide, Protecting Our Seas.*

In the event of an oil spill a special committee has been set up by the Dept. of Transport and Communication. On that committee is an environmental Ecologist whose job it is to identify areas that are ecologically in danger so that clean up can be directed immediately.

Questions:

Q1. How are booms used in an oil spill? What are some of the desirable features of the boom? Find out the difference between curtain booms and free booms.
Q2. List three ways that oil can be mechanically recovered?
Q3. What are skimmers and how are they used?
Q4. What are two types of oil dispersant?
Q5. What role do bacteria play in the use of a dispersant?
Q6. What is a vulnerability index and how is it applied to shoreline types?
Q7. How should a mangrove swamp be cleaned from an oil spill?
Q8. Role play an oil spill on a local beach using the following as a guide:-
1. Have you seen the spill?
2. What is the time/location and source of the spill?
3. Can you tell where the oil is coming from?
4. Can you estimate the direction of movement of the spill?
5. Is the oil escaping or has it stopped?
6. What is the colour of the spill?
7. Does it smell like petrol?
8. Approximately what area does it cover?
9. What are the weather and sea conditions?
10. What is your name and address?

Topic 4

The dune system

The **dune system** acts as a buffer zone between the land and the sea.

Dunes have to erode during storms just as they have to rebuild during calm weather. The photograph to the right shows fretting left behind by pioneer plants in the erosion scarp. The roots are ready to grow again when the wind blows sand back into the base of the erosion scarp.

Dunes provide a place for pioneer vegetation to grow so that more complicated plants can establish themselves further inland. Without this buffer zone the sea would easily claim the delicate land plants which are adapted to soil, fresh water and unsalted air. The dunes provide a place for this transition to occur.

The dune system can have a variety of plants. This topic considers the coastal spinifex as an example of a primary coloniser but there are other plants which perform similar functions in other parts of Australia.

Usually there is a primary or fore dune on which grows the primary colonisers as shown in Figure 2.44 . The fore-dunes become higher and wider as the wind blows more sand up the beach.

Fig 2.43: Plant roots (**the fretting**) left in the erosion scarp play a vital role in the trapping of sand in beach recovery after storms.

Fig 2.44: A dune system consists of primary, secondary and tertiary sand systems.

The wind sorts out the sand grains with the smallest blown further inland. Grain sizes deposited in the dunes vary from 0.15 to 0.30 mm. The upper parts of the sand spinifex absorb the winds energy causing the sand particles to drop. Around the roots, the **wind velocity** is small and the sand can settle. Over time the sand builds up and the grass grows.

The sand acts as a stimulus for plants growth. Long runners extend past the main body of the grass and the matted roots hold this upright plant in place. Male plants produce a terminal cluster of stalked **racemes**. A raceme is a undivided axis containing the flower unit - the anther.

The **anther** produces the **pollen** which blows to fertilize the female reproductive part. This is called **spikelet**, which has an ovary containing eggs. The pollen fertilises the eggs to form a seed. These seeds enclose themselves in a large spine-like bract 10-15 cm long which grows to 20-30 cm and is straw coloured when mature.

Spinifex grass (the local species in New South Wales and Queensland), is the most important of the pioneer grasses because of its tolerance to salt. The beach is a hot, dry and salty environment with very little water. Its upright leafy sheets enable the plant to trap the sand and its ability to grow when covered allows quick vegetation of a dune system. Cycles of sand deposition are important to the dune building process. The spinifex dominates the **frontal dune system** because of these excellent adaptations.

In populated areas the frontal dune is maintained by a fencing program. This allows the vegetation to grow unhindered, allowing the dune to build. Fences can also trap windblown sand. In some parts of Australia, new beach front developments have to, by law, maintain this frontal dune system. In areas where vehicles use a beach, special tracks have been made to allow for vehicle access.

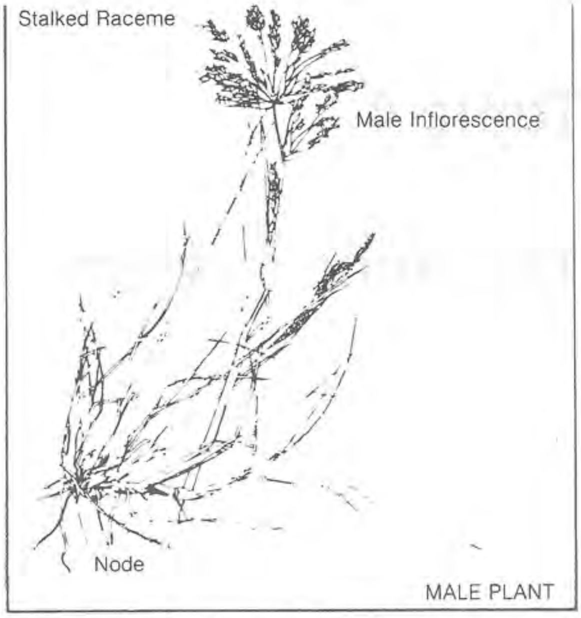


Fig 2.45: Male spinifex. Illustration courtesy Beach Protection Authroity (Qld)

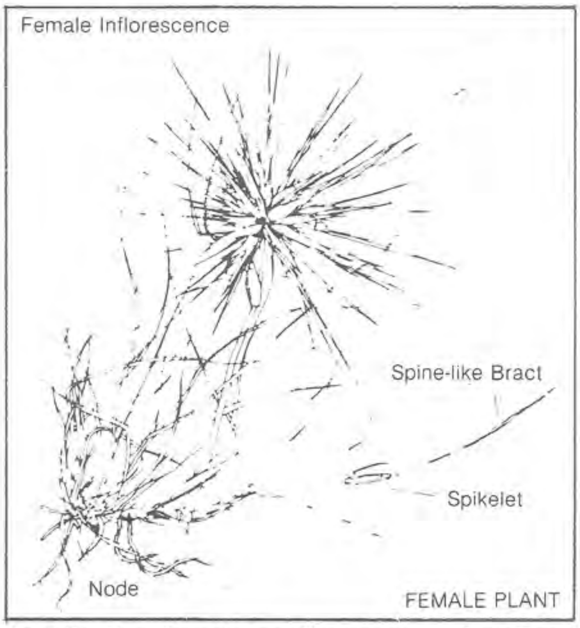
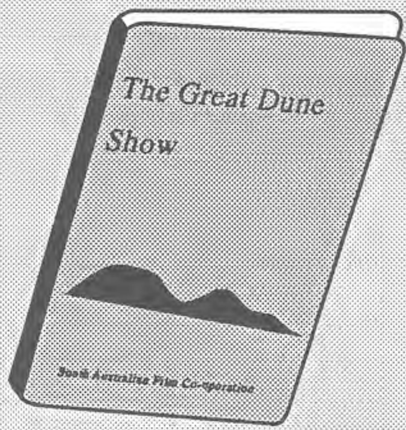


Fig 2.46: Female spinifex. Illustration courtesy Beach Protection Authroity (Qld)

Let's take a rather humourous look now at how these dunes work in the video, The Great Dune Show.

Fig 2.47: Coastal spinifex

Activity 2.13 The Great Dune Show



Aim:
To become aware of the importance of the dune system

You will need:
The Video, The Great Dune Show, Produced by the South Australian Film Co-orporation and available through most Beach Protection Authorities for loan.

Questions to answer (Optional)
Q1. List three factors that make a sick dune.
Q2. List three ways to stop a dune from becoming sick.
Q3. What is an advancing dune?
Q4. What can a dune doctor do to save a dune?

The she oak

The **Casuarina** or she oak, is found close to the beach, on or just behind the frontal dune system. This tree helps the vegetation on the land by cleaning the air of salt before it blows inland. As the salt air blows at the Casuarina, the salt accumulates on the branches. Therefore the air that blows inland is less salty and less able to burn and dry out the leaves of delicate land plants. The Casuarina has a second function. Its roots penetrate deep into the frontal dune. Out from each root is a root hair system which further helps to anchor the tree and bind together the sand. When big storms such as cyclones strike, large waves break on the beaches causing beach erosion. The roots of the Casuarina help to hold the soil together.

Fig 2.48: Spinifex foreground and She Oaks background dominate some beach systems

Fig 2.49: Casuarina trees (She Oaks) play a vital role in the secondary dune system. Photograph courtesy Beach Protection Authroity (Qld)

Secondary dune systems

She Oaks have very long branchlets which are often confused with leaves. The shape of these branchlets and the tree itself reduces wind velocity causing the sand to drop to the base of the plant. In some cases the salt and sand mixture sticks to these branchlets and when heavy enough, the branchlets drop with their sand load. The matting under a she oak forest can be quite thick. The build up of sand gradually increases the height of the secondary dune system.

Plant - Dune Interactions

Nitrogen cycle

All plants need trace elements to survive. Dune systems are very barren environments in this regard and the plants are well adapted by only requiring two main types of element - Phosphorous and Nitrogen.

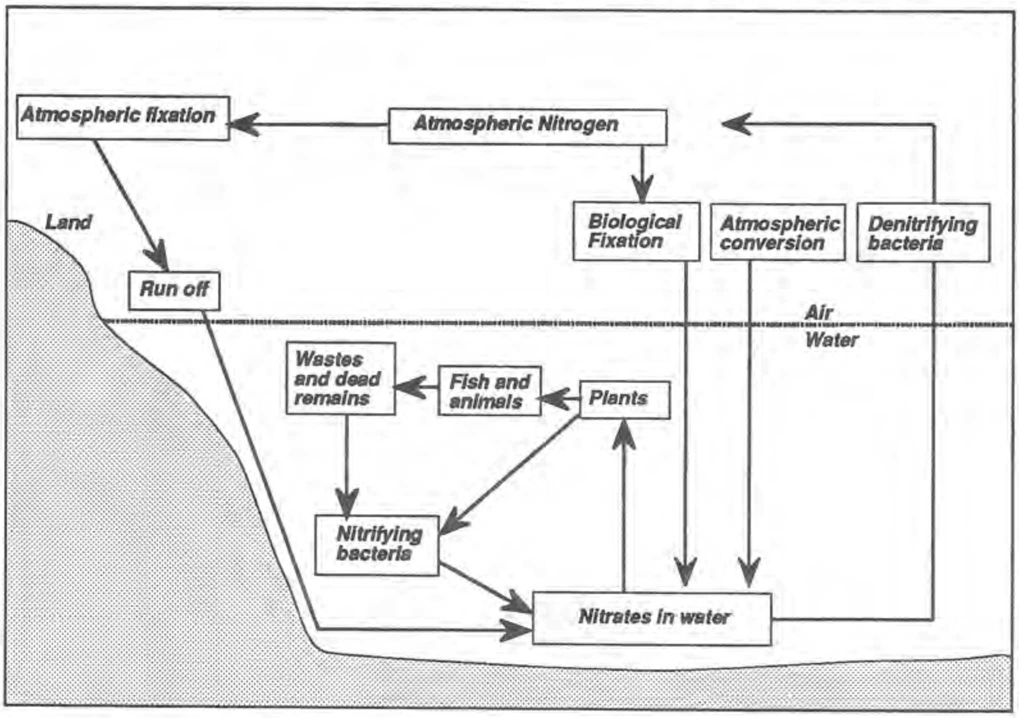


Fig 2.50: The Nitrogen cycle (after Ryan 1991)

The dune system obtains its nitrogen from a process called **nitrogen fixation.** Casuarina trees are able to convert the nitrogen in the atmosphere to a solid form inside the tree. This is done by micro-organisms, called **nitrogen fixing bacteria,** that live in root nodules at the base of the tree. The bacteria absorb the atmospheric nitrogen and convert it to a bound or "fixed" chemical form that can be released as a fertiliser to help the tree to grow. This may be one reason why the tree grows so quickly. This process by which the nitrogen fixing bacteria fix atmospheric nitrogen is called **nitrogen fixation.**

Nitrogen is needed by plants for growth. The spinifex grasses obtain this naturally from the run-off near Casurina trees.

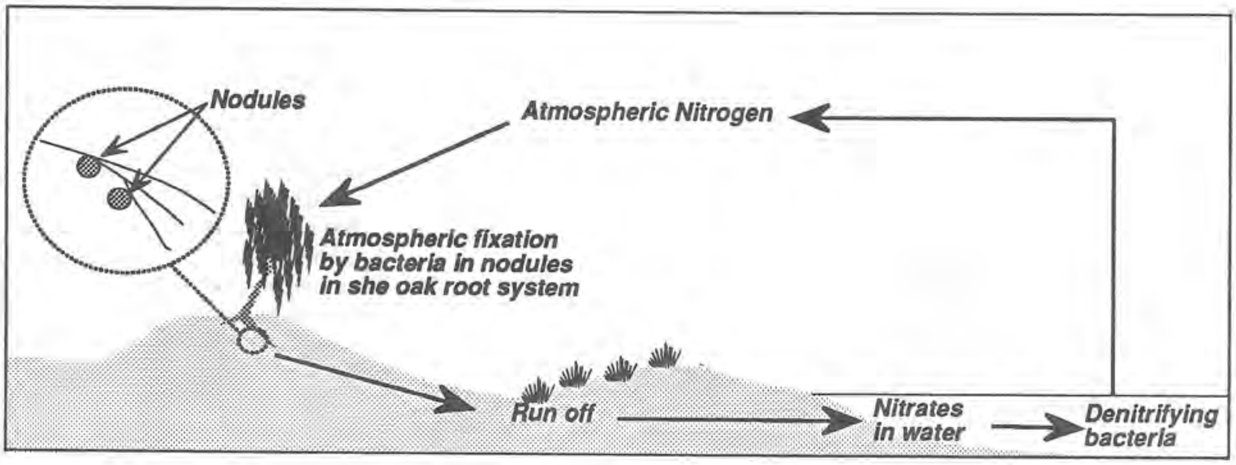


Fig 2.51: The Nitrogen cycle on a dune system

So the humble She Oak is more important than you may have imagined. You should look after it and not use the timber for fire wood when you camp and if you become an owner of a beach front house, *please don't cut it down just for a better view.*

Phosphorus cycle

Phosphorus is another important element for spinifex which has an active root system to seek out this element. When quartz and feldspar are formed, they contain a fine coating of phosphorus which sticks to the sand grain as it moves along the coast. When the sand grains are washed up the beach, they dry and are blown towards the spinifex. The broad leaf of the plant catches the grain by reducing the wind velocity and the grains falls to the base of the plant. Fine root hairs that grow from the main plant then absorb the phosphorus coating from the sand grain.

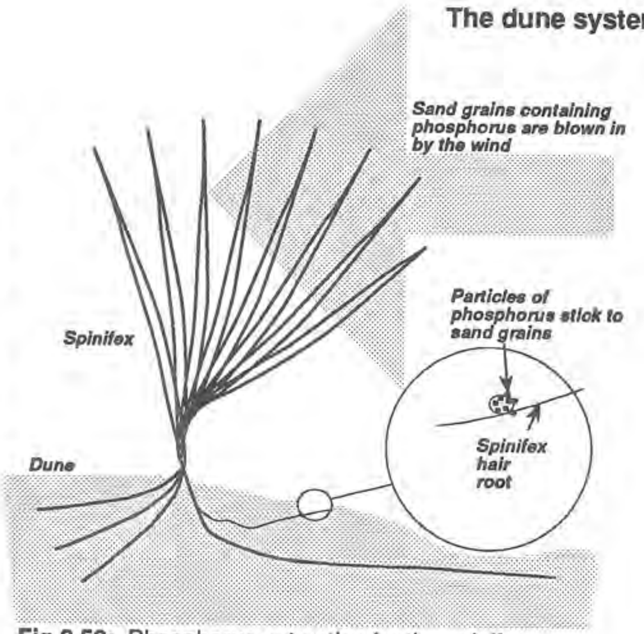


Fig 2.52: Phosphorus extraction by the spinifex

Protecting dune vegetation

Although we have only discussed two dune plants in some detail, it is important to realise that other plants play a vital role in maintaining the dune system. She Oaks and Coastal Spinifex are not found on all Australian sand dunes and other varieties play an equally important role.

To maintain dune plants a number of do's and don'ts can easily be observed by anyone going to the beach. These are summarised opposite.

If dunes disappear then the surf is affected offshore. The offshore storm bars disappear depriving surfers of waves to ride.

Do	Don't
Keep to the walking tracks	Ride trail bikes in the dune areas
Help maintain dune fencing	Break She Oaks and use timber for firewood
Encourage others to stick to the walking tracks	Sunbake on the dune grasses
	Remove sand from the dune system

Fig 2.53: Some simple rules to protect beach vegetation

Changing patterns of dunes

Too much sand on dunes can be a problem also. Dunes can move inland as has happened in South Australia. Vegetation can become eroded in some places and a dune can "**blow out**" into the land. These blow-outs are common in higher dune systems. Primary dunes can be lost altogether in time and the coastline can move inland. If buildings had been established on these fore-dunes they too would be lost.

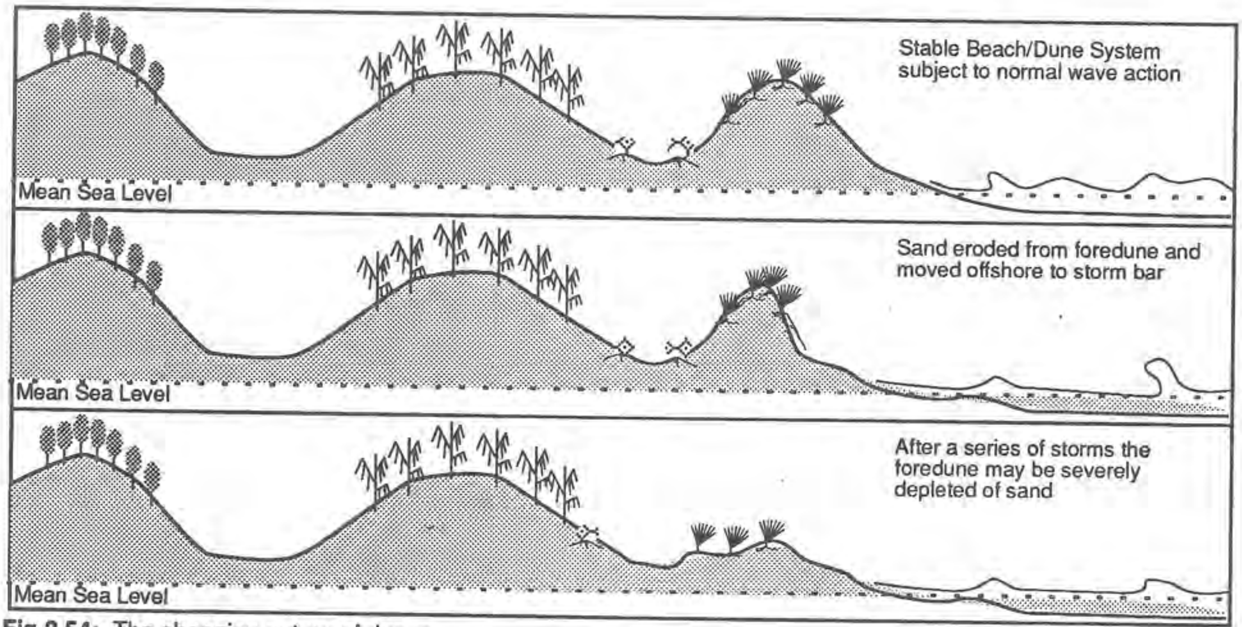


Fig 2.54: The changing nature of dunes

Field Study

Activity 2.14
Identifying Dune Plants

Aim

To identify a number of dune plants from a local dune system

You will need

* stiff cardboard, glue, scissors, plastic self adhesive contact film
* camera and film
* colour photographs of local dune plants and descriptions*

* (Each state has its own beach protection authority. Use the phone book to find the address and write for a set of photographs of local dune plants. In Queensland the Beach Protection Authority has a poster set available from GPO Box 2595 Brisbane 4000

Method

Part A: Make up an identikit card system

Use these materials to make up identikit cards. Cut out the photographs and the accompanying script. Paste the photo on one side of a stiff piece of board and the information on the back. Save the cards for future use.

Part B: Photographing plants

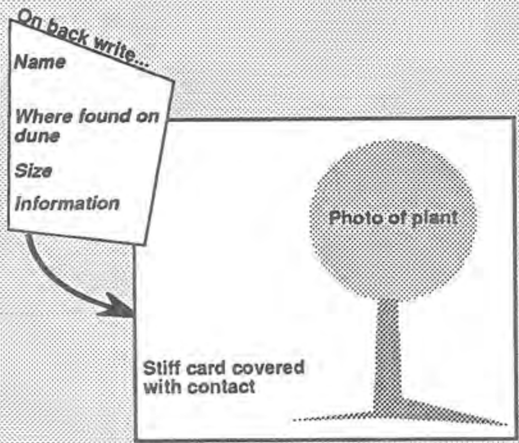
At the beach identify the vegetation in the dune area. Try to do this from the walking tracks provided. If none are available, use walking tracks make by other people. Take your own photographs and make a description of the dominant types of vegetation on a photo list sheet to help you when you get the photos developed. Note on this sheet the size and location of the plant. Use the data collected to write a report on the dune vegetation. Here are some ideas to help you with your report.

1. Develop you photographs to the smallest size possible and set them into a report. For each photograph make a summary sketch of the plant.

2. Make description of plants and note the distribution.

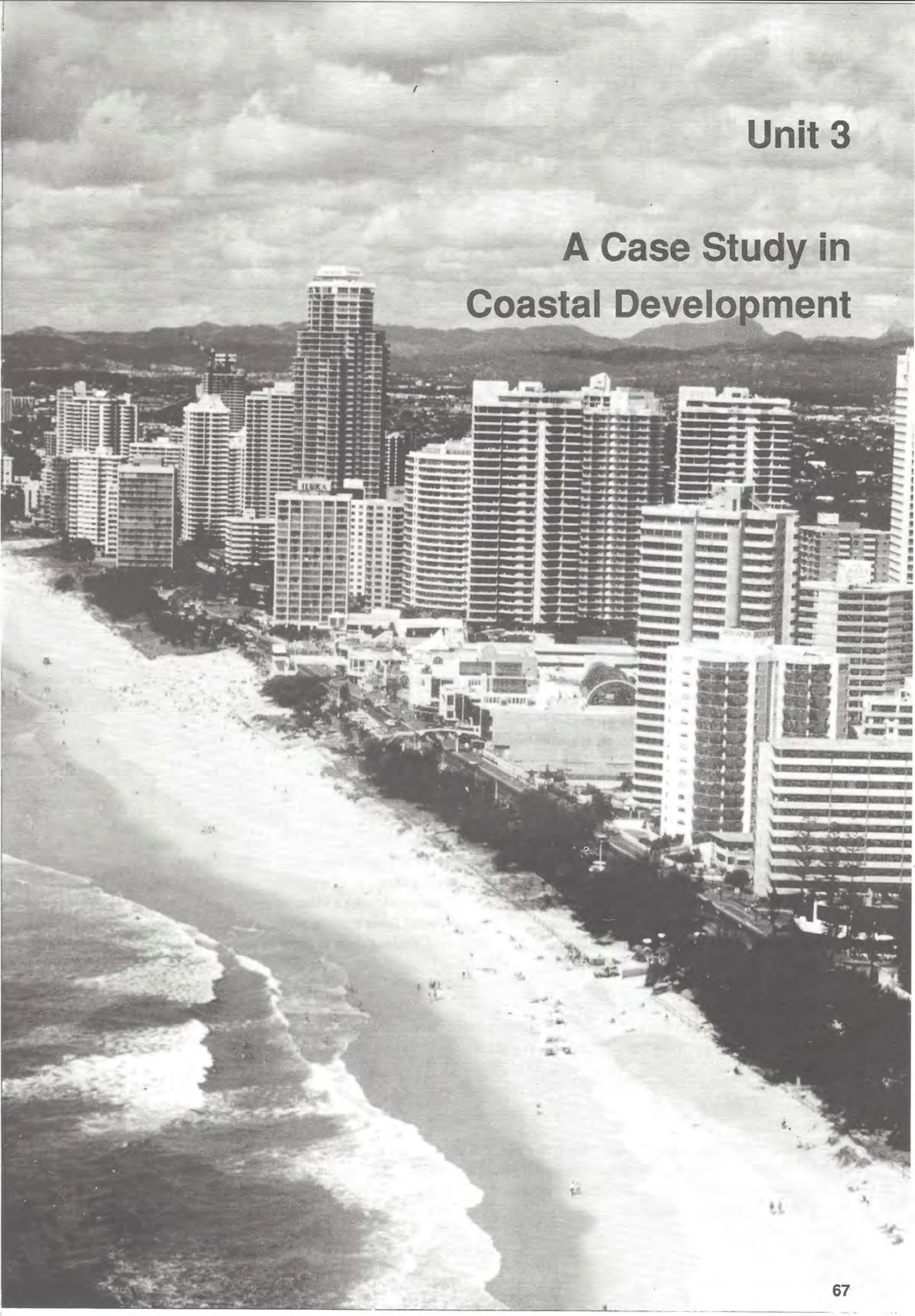
3. Write a few paragraphs on the nitrogen fixing capacity and phosphorous searching capabilities of the spinifex and coastal she oak.

4. Present your report to class.



Unit 3

A Case Study in Coastal Development



Objectives

Students should have a knowledge of

1. Some ways humans have altered the natural flow of sediment along our coastline.
2. Training walls and other engineering structures.
3. The effects damming of rivers on the sediment flow along a coastline.
4. Dune and beach profiles.
5. The boundaries for the Gold Coast sand system.
7. Sand sinks and how they remove sand from the system.
8. Offshore shoals and how these affect wave patterns and sand shadows.
9. Beach nourishment methods.
10. Buffer zones and their purpose.
11. Sand bypass systems.
12. Mangroves in the food chain.
13. Beach Protection legislation.
14. Canals and how they are constructed.
15. Coastal zone management strategies.
16. A local beach system, how it operates and the problems associated with it.
17. Coastal zone management issues of local concern.
18. Re-zoning applications and their use.
19. Some of the Acts of Parliament that manage their local coastal zone.

Students should be able to

1. Discuss the consequences of changing human attitudes to the environment.
2. Relate a hypothetical coastal zone development to their own local experiences.
3. Predict the consequences of development too close to the buffer zone.
4. Become aware of the problems experienced on the Gold Coast by viewing a video discussing the problems caused by the construction of the Tweed River training walls.
5. Discuss any six management issues affecting the coastal zone, ranking them in order of priority and stating why you placed them in this order.
6. Discuss how survey lines are used in research of beach profiles.
7. Write a report on a local beach system.
8. Collect a series of newspaper articles on a relevant coastal issue.
9. Study a local piece of management legislation and comment on its effectiveness in dealing with local management issues.

Extension

10. Debate the development of canal systems as a viable economic venture.
11. Debate the sustainable development issue as it would apply to the development of their local environment
12. Analyse the effective decision making processes of a local council and comment on their effectiveness to deal with a developing local community.

Topic 1

Human Influences

For the last 6,000 years our coastline was allowed to develop shaped only by the forces in nature discussed in the last two units. That was until about 200 years ago. White Australians settled along the coast and quickly used the natural resources to shape a new Nation. Rivers were dammed, ports dredged, mangroves cleared, dunes demolished all in the cause of progress. It is the attitudes of a Nation which determine our environmental fate and the attitudes of our early settlers were different in this respect. A new understanding of the coastal zone is upon us all and the wise use of it lies in your hands. As students, you should now apply the knowledge you have learnt from the mistakes of the past. This unit is not about criticising the mistakes of the past. It is about pointing out the consequences of past actions and looking at some of the ways people have attempted to repair that damage.

The photographs shown here come from the first half of this century. An old resident recalls the following, "we used to all come down the beach in the summer for holidays. I remember the men would chop down the she oaks and use the branches for umbrellas. The other trees were cut for firewood and to make stakes for the tents. We moved the sand from the dunes to fill the swamps so that we could have a flat camping ground and a nice view of the sea."

Fig 3.1: Camping ground Burleigh Heads 1926

Fig 3.2: Kirra Beach 1930's. The she oaks mentioned above can be seen in the foreground

Settlement patterns - a Hypothetical Case

Ninety percent of all Australians live within an hour's drive of the sea. The settlement of our coastline has caused dramatic changes to the natural systems that operated less than 200 years ago. Populations first settle near rivers because they provided a ready supply of water. Consider the development of a hypothetical township over a number of years.

"Water was needed for drinking, bathing, washing clothes, growing crops and dissolving products used in the manufacture of goods. Initially water tanks were installed but as the population grew a dam was built. For trade to occur, shipping needed to enter and leave the river. Access to the town was improved by sealed roads and rail lines. Natural drainage patterns were effected and the river pattern was changed. Damming the river stopped the natural flow of sediments towards the sea. Land clearing caused the natural topsoils to be washed into the river and out to sea.

More sophisticated removal of human waste developed a complicated sewage system with discharge pipes into the sea. Greater use of land meant removal of natural topsoil and with the introduction of exotic species competition with the natural vegetation occurred. These introduced species brought diseases and affected other populations of insect and bird life. Native ground animals moved out of the area and the natural flora and fauna were replaced with completely different types mainly of introduced European stock. It is clear we have settled on our coastal strip and changed it greatly.

Fig 3.3: Coastal steamers using a river mouth early this century

People also made increasing use of the coast. Some built houses right on the sand dunes. Vegetation was cleared for housing and dune heights were levelled for a better view of the sea. People started to holiday by the beach. Trees were cut for wood and shelter. More people used the beach area and sand which was previously held by this vegetation, blew inland and was lost from the system.

Before railways or roads, everything that came to the township came by sea., Boats had to get in and out and the river had to be dredged. Shipping terminals had to be constructed to allow for the easy unloading of goods which lead to mangroves and coastal vegetation being cleared. This meant ships had to negotiate the coastal bars of river mouths. Waves were a problem, so the obvious solution was to build walls and dredge the mud and sand that accumulated in the river mouth. Dredging of river gravel was a profitable business. Sand was needed for concrete and fill so city buildings could be constructed.

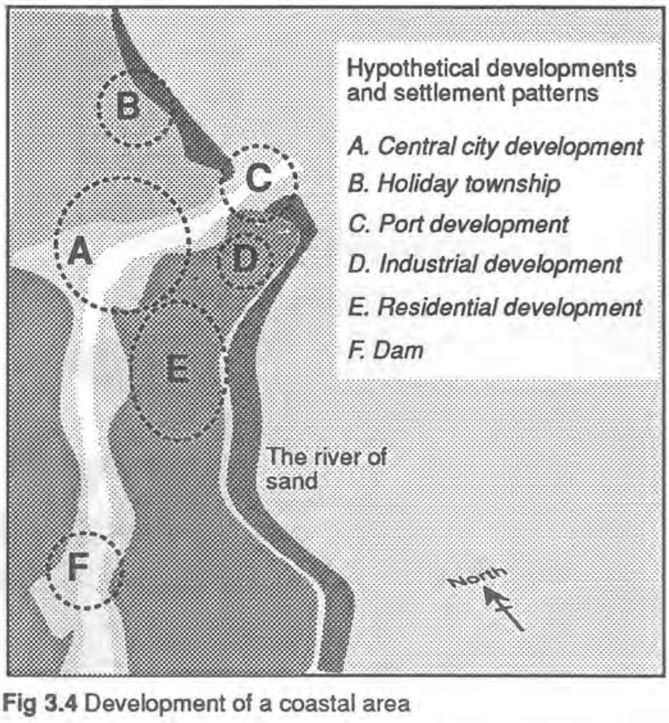


Fig 3.4 Development of a coastal area

But how have these settlement patterns affected the natural sand system and what problems have they created? In the short term all these developments seemed a sensible idea. Employment was created and the town prospered. Nature's resources were boundless and free to use. There seemed no limit to what "Mother Nature" could provide. That was until changes in the coastline were observed.

* *Topsoil washed freely into the river and settled out to sea because the particle sizes were too small to stay in the high energy active beach system. With the removal of trees, salt became a problem because the shallow rooted grasses could not absorb the natural salt levels.*

* *The dam prevented new sand entering the sand budget. Silt accumulated in the river mouth which had to be dredged. With the increased population, more water was needed for the sewage system and a secondary treatment works had to be built. This meant increased rates and charges by the local council and an increase in the cost of labour. Inflation began its insidious cycle.*

* *Sand that normally travelled north, as shown in the diagram, accumulated behind the training walls and sand behind the north wall moved north and was not replaced.*

* *When the sand had filled up behind the training walls, it spilled over around the walls and filled in the river. This meant it was dredged and the sand which normally moved north was now lost to the system.*

Clearly the sand budget had been reduced, with the volume of sand that normally nourished the northern beaches, reduced to a trickle.

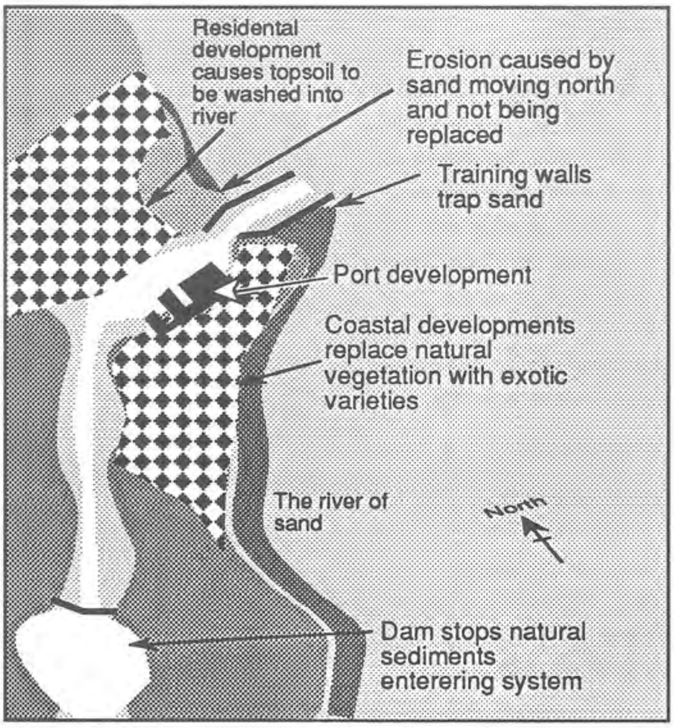


Fig 3.5: Some consequences of development

Fig 3.6: Training walls result in sand being trapped for a time behind the wall on the side of the prevailing winds

The natural sand dunes to the north were starting to erode. This created problems for the housing developments in the holiday township. Before the training walls were built, wide primary and secondary dune systems existed. These were cleared in some places to allow for holiday shacks. As the area became more popular, more holiday shacks were built and swamps were filled in to make way for roads and street lights. With the starvation of sand from the training walls, the sea started to borrow from the foredune areas during storm periods and quickly lowered the beach profile. Sand moved offshore to form the protective storm bars but was never replaced by sand from the south. The nett effect was beach erosion with the houses on the foreshore falling into the sea.

Attitudes - what's yours?

Here is one:- "It seems one of those don't touch subjects. Over the years they have changed, but still today some people cut down trees for a better view and drive vehicles over sand dunes, or alter significantly coastal waterways with canal and housing developments.

Who is more guilty of environmental degradation.. the oldtimers who knew no better or the modern day person seeking to improve the economy while ignoring the environmental facts?

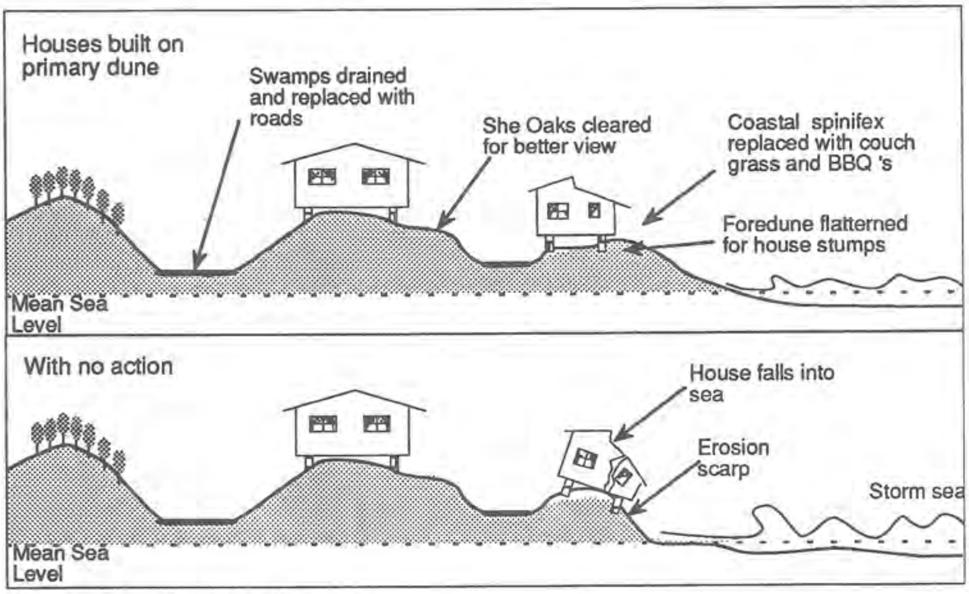


Fig 3.7: Beachfront developments

What about the good things development has done? Modern efficient sewage systems keep our living space free from the deadly diseases of cholera and hepatitis. Well managed surfing beaches and marine parks provide excellent places for holidays. Some would argue that by eradicating the mangroves, the sandfly population has decreased so making eating outdoors a pleasure at the end of the day. This allows people to relax and unwind and be kind and loving towards each other reducing stress and making for a more civilised society.

Fig 3.8: Beach erosion can cause problems. Photograph courtesy Beach Protection Authority

Waterfront homes and houses make great investment opportunities for companies and small businesses to invest funds and make profits. When companies fail to make profits, employment is reduced, donations and community programmes are cut and progress is halted. One could argue that this is a good thing. A slowing in the economy reduces the demand for coastal developments and the need for consumer items.

With less money, people will reuse items they would normally throw away. Recycling will become a fact of life and not a fad. The environment debate will have to come to terms with these aspects and you should always consider the other point of view. If development of the coastline can occur within limits, then we have a sustainable growth. If this growth outstrips the environmental tolerance of an area, we have real problems. What are three main environmental problems of your area and how is your local or state government trying to solve them?"

Topic 2

Our Gold Coast

"The spectacular 42 kilometre stretch of clean, sandy surfing beaches stretching from Coolangatta to South Stradbroke Island is the key to one of the world's largest tourist resort cities - the Gold Coast. Every year, an estimated four million overnight visitors and countless numbers of daytrippers come to the Gold Coast to enjoy its leisure and entertainment facilities, its balmy sub-tropical climate, and its magnificent beaches. Many Australians who grew up by the beach take the coastline of the vast continent for granted. It is, however, an invaluable national asset from the point of tourism, recreational use and the environment.

To protect the coastal zone, careful and often costly management is necessary to make sure the long term stability of this national asset is preserved. The Gold Coast has been a booming growth area over the past few decades, and over the last century development has been focused along the ocean foreshore with the most intensive tourist development pressures of any area in Australia.

Tourism and associated developments have created coastal zone management problems, which nearly always need urgent and costly remedial action, and quite considerable coastal engineering works have been carried out on the Gold Coast. The rolling surf is an undoubted attraction for locals and visitors, but the high average wave energy predominantly from the south-east, also creates a so called longshore transportation - a virtual river of sand moving an average of half a million cubic metres of sand along the coastal region every year. "

Fig 3.9: Surfers Paradise in 1990. This narrow stretch is worth millions to the Australian economy. Above text and photograph courtesy of Gold Coast City Council.

The sand system

New sand is added to the Gold Coast system from the Clarence and Richmond Rivers. These systems produce quartz and feldspar sand grains that are able to stay in the high energy beach zones. Sand dunes as high as seven metres are found within this sand system.

A rich coastal vegetation developed with a wide variety of species. These flooding New South Wales rivers added sand to the budget which accumulated at river mouths. During floods this sand was washed out and added to the system. Very little sand was added from the Tweed River due to volcanic residues left by the now extinct and very eroded Tweed Volcano.

During storms the sand moved off the beach as described in Unit 2. Around the headlands protective offshore shoals developed largely as a result of headland bypassing of sand.

Sand also moved into the Tweed and Nerang Rivers due to tidal influences. Most of the sand entered a large **sink** inside the bays and estuaries between Brisbane and Moreton and Stradbroke Islands.

This sand also filled the Broadwater which was the entrance of the Nerang River as shown in the photograph below.

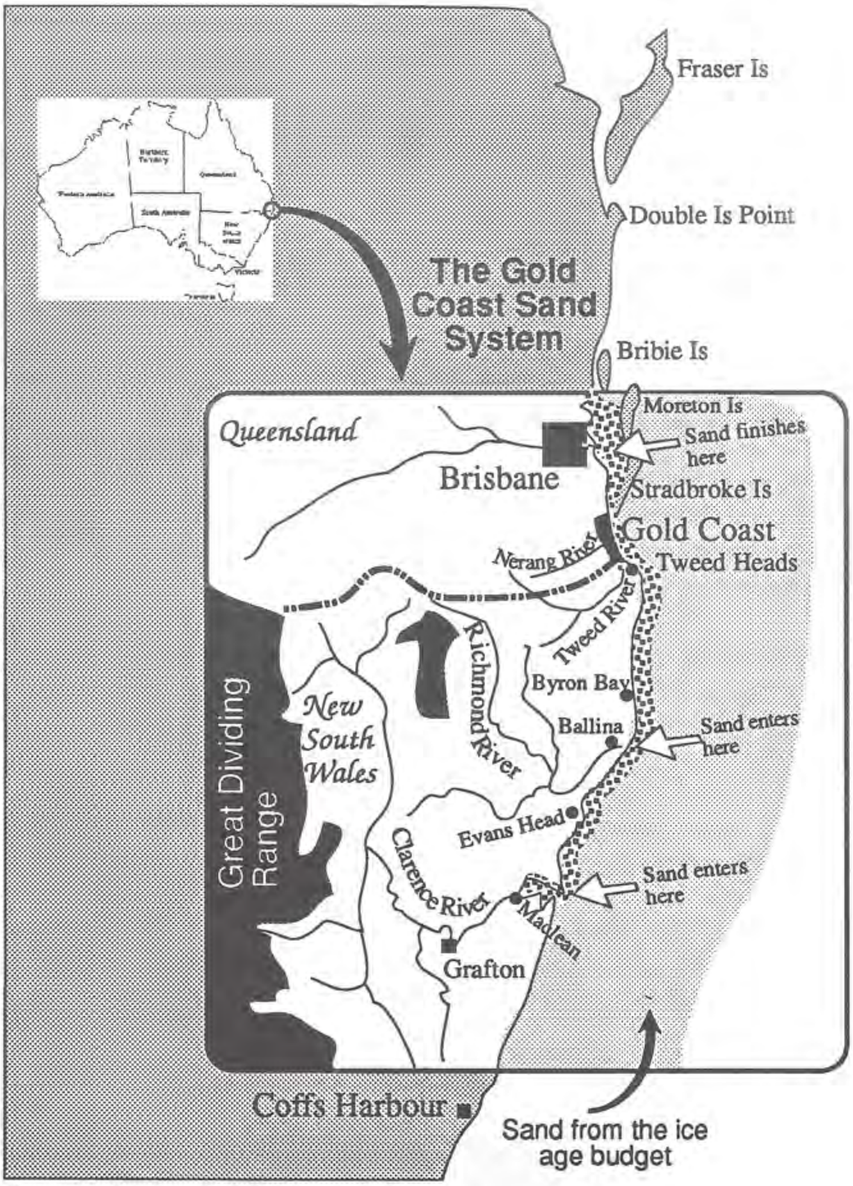
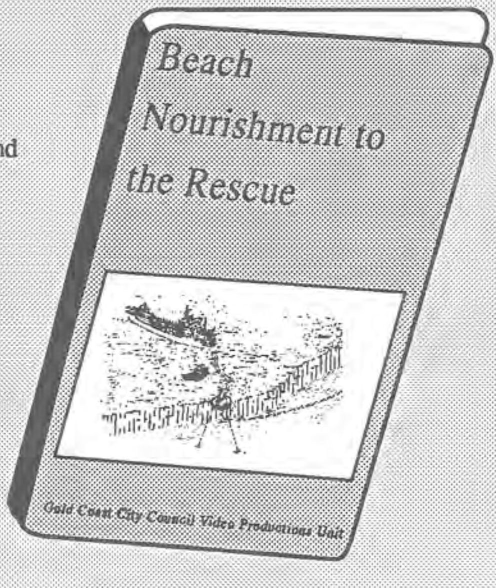


Fig 3.10: The Gold Coast Sand System

Fig 3.11: Photograph courtesy Beach Protection Authority (Qld)

Most of the sand in the system ends up in **sinks**. The sand moving north has refracted into the Broadwater from the Southport Bar.

Activity 3.1 Case Study Video



Aim

To view a video on how beach nourishment has helped manage sand erosion problems of a highly developed coastline.

You will need

* video monitor and VHS player
* beach nourishment video

* This 22 minute video is available from
  Wet Paper Publications
  14 Milbong Terrace
  Ashmore 4214 .

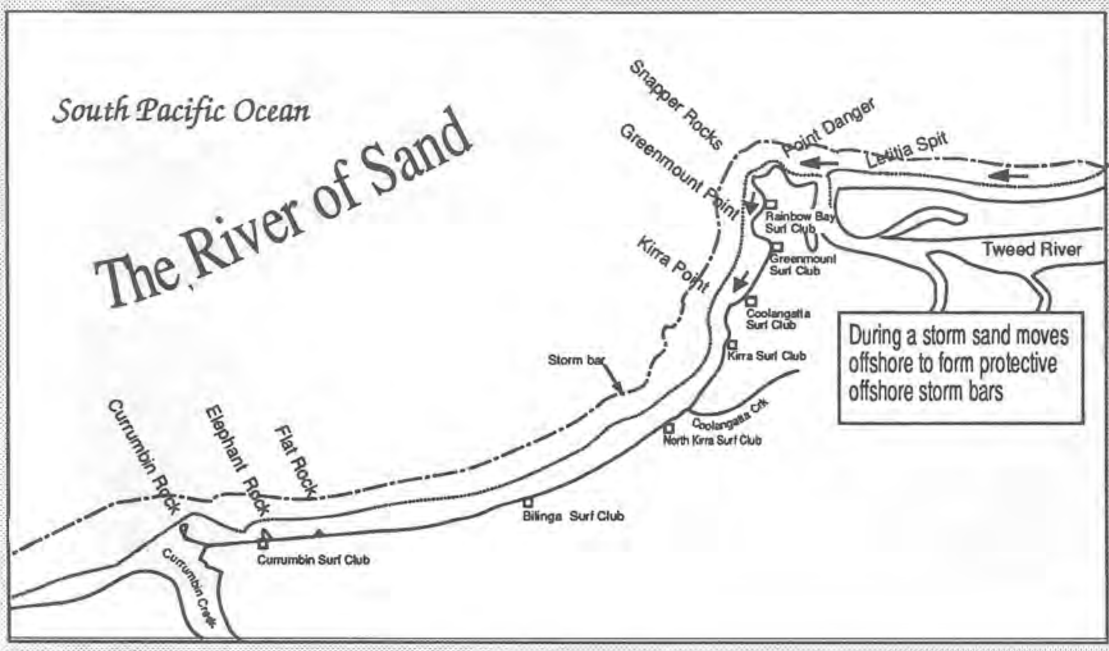
What to do

(1) Trace the map of Kirra below marking in all the features mentioned in the video. Colour in the river of sand before the construction of the Tweed River training walls. Mark in the offshore shoals off Coolangatta and Kirra that were affected. Mark in the dredge area and describe how the trailing suction dredge works. Now mark where the beach will be nourished and where the sand will be placed.

(2) Now answer the questions below

Questions:-

(a) How does a natural beach protect itself during a storm?
(b) Why is beach erosion considered a natural phenomenon?
(c) Name two aspects of settlement patterns that have affected the sand budget on the Gold Coast.
(d) When did beach erosion become a serious problem on the Gold Coast and what immediate steps were taken to manage the problem?
(e) What does the term beach nourishment mean?
(f) If you were transported back to 1940 to live on the Gold Coast, what advice would you give each of the Townships of Kirra, Cooloongatta, Bilinga and Southport in developing their coastline for the next 10 years?



Management problems

However, nature has its own way of protecting the beach, and the sand eroded from the beaches is deposited to form a protective offshore storm bar, reducing the damaging effect of the waves. The Gold Coast beach system is, at times, extremely dynamic. In the long term, evidence from detailed research over the years shows that there generally appears to be a state of equilibrium.

During cyclonic conditions, waves up to 11 metres in height have been recorded, and in these conditions, the active beach extends several kilometres seaward, and can intrude landward temporarily - if unrestrained - for hundreds of metres. During subsequent calmer conditions, sand that has accumulated on an offshore sand bar will move back onshore to restore the beach over a period of up to 18 months.

Of course, extreme conditions don't occur all the time, and it is easy to understand how early settlers built on the active dune areas when there was little to warn them of potential cyclonic erosion. The rebuilding of the beaches in the Kirra - Bilinga area to combat the forces of erosion, has been an ongoing process since the 1970's. Since the extension of the Tweed training walls in 1962, the natural flow of sand along the coast has been greatly reduced. Much of the sand stayed trapped behind the walls and pushed into deep water to form a new delta. As well, the extension of the Tweed training walls pushed the flow of sand further out to sea, denying southern Queensland beaches of much of their natural sand supply. To make up for this lack of sand supply, many projects have been carried out to restore the eroded beach and seafloor again.

In days gone by

Settlement in this area started in the late 1800's and much of the foreshore land was subdivided in the early part of this century, well before the environmental impact was known and local authority controls (as we know them) were in place. So wide were our beaches at times that the Cobb and Co stage coach travelled around Kirra and Greenmount along the beach at low tide.

The small coastal resort settlements gradually merged into a continuous ribbon of tourist oriented development stretching from Coolangatta on the Queensland/New South Wales border to Main Beach in the north. The Tweed River became an important port and steamships regularly crossed the bar. The need for a safe all weather crossing lead to the building of the First Tweed River training walls.

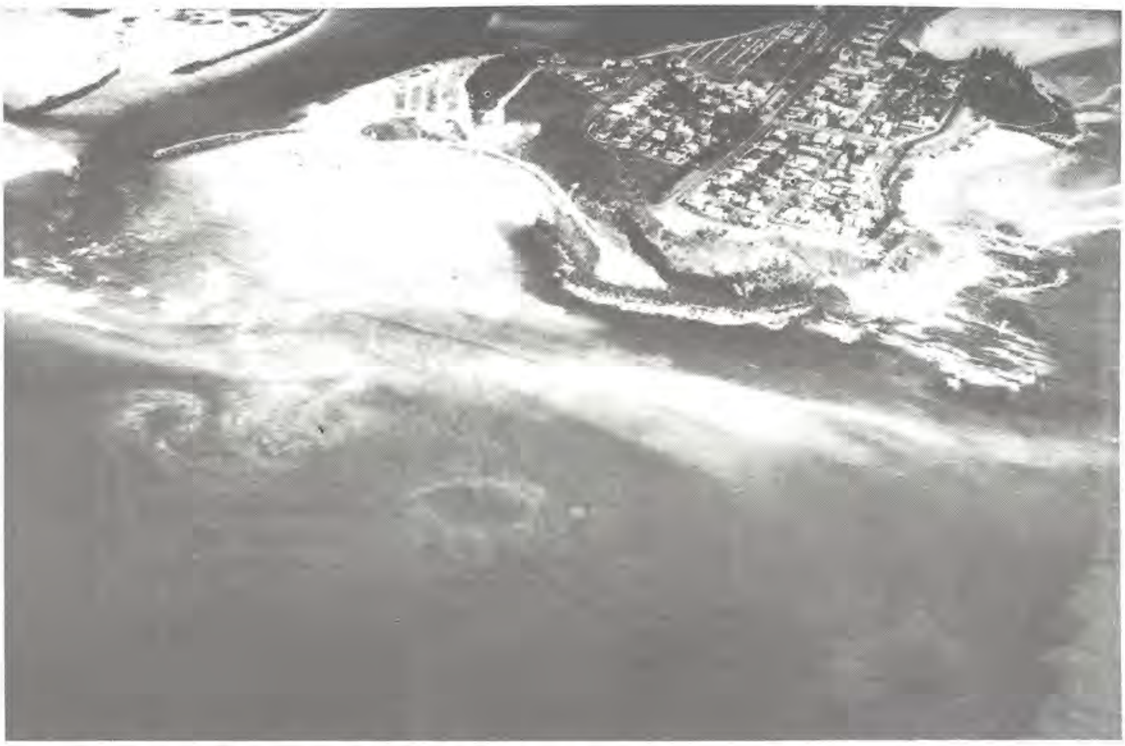


Fig 3. 12: The Tweed River 1963 with the extensions to training walls commencing. Who would have thought that so much controversy would erupt as a result of this engineering project. Photograph courtesy NSW Dept. of Works.

In the 1920's, the population increased and the railway was extended to Coolangatta. The beaches were then in good condition up to the 1930's as can be seen in this early photo taken in September 1930 of Point Danger, Coolangatta, Kirra and Bilinga.

Large offshore shoals were a natural feature which protected the beaches from cyclone damage by dissipating the energy in the wave before it pounded on the beach. As the area developed, erosion became an increasing problem.

Historical records of the beachfront show that cyclones caused severe erosion, particularly in 1936 and 1954. A timber retaining wall was erected at Kirra to protect the Surf Club in 1936.

The Point Danger headland forms a bay to the north. As the normal S.E. waves enter this bay they bend (refract) as they are slowed while travelling over the seabed.

The wave energy is also reduced and in natural conditions large shoals form which further reduce the wave energy reaching the beach.

The shoals and wide beach provided a natural buffer against storm wave attack. Research shows that sand eroded from the upper beach in storms, forms an offshore storm bar which subsequently replenishes the beaches. The sand moving alongshore is supplied by sand in a longshore drift that comes from New South Wales.

By 1950, the beaches were again wide and well stabilized. They again recovered quickly after the cyclone of 1954.

Fig 3.13: A Cobb and Co coach on a beach about 1900. (Photo courtesy John Oxley Library, Brisbane)

Fig 3.14: Beach development on sand dunes at Currumbin about 1929. Photo courtesy John Oxley Library, Brisbane)

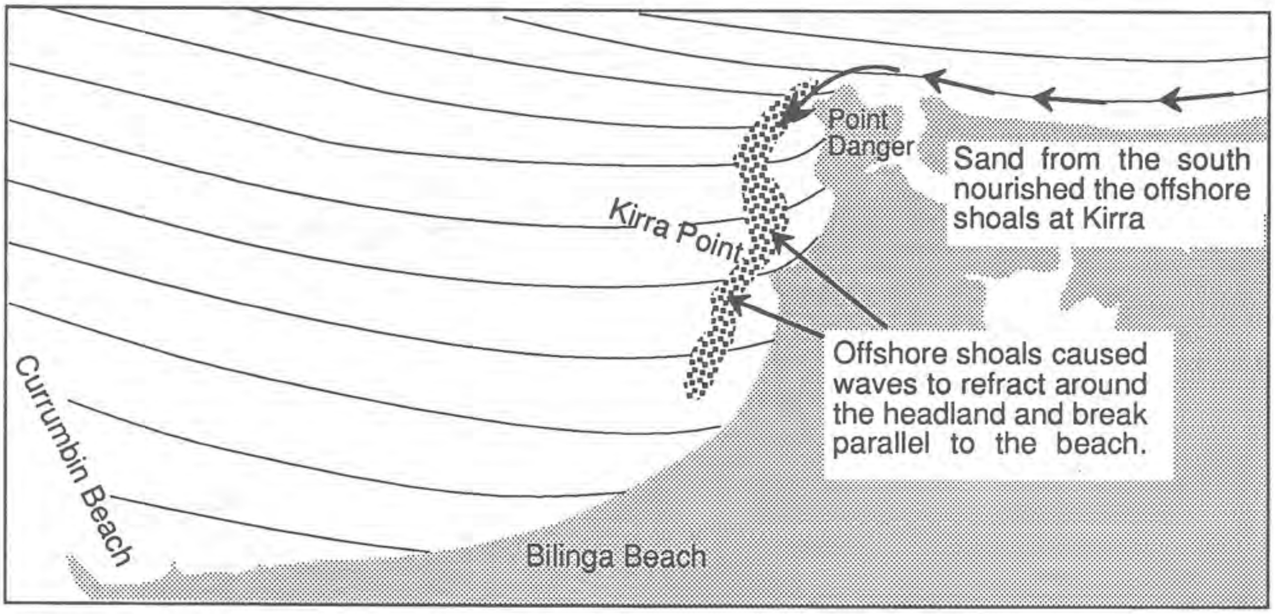


Fig 3. 15: The beaches at the southern end of the Gold Coast were protected by large offshore shoals nourished by sand from the south

Summary of beach system at Kirra and Coolangatta

(1) Sand comes from New South Wales carried by wave action which creates a *longshore drift*. The sand is moved northwards by waves that come from the south east.

(2) When these waves move around Point Danger, the part of the wave in the shallower water closest to the point, slows down. This is because waves in shallower water drag on the seabed.

(3) The part of the wave in deeper water is unaffected by the seabed and keeps moving at normal speed. The nett effect is a bending of the wave. This bending is called *refraction*.

(4) This *refraction* causes the wave to break parallel to Coolangatta and Kirra beaches.

(5) In this area, offshore sandbanks called *shoals* form and feed these beaches in calm weather. These shoals are nourished by sand carried by the longshore drift from around Point Danger.

(6) In storm conditions, the increased wave energy causes erosion of the beach. The eroded sand forms a storm bar(s) which in turn reduce the wave energy reaching the beach until an equilibrium condition is reached.

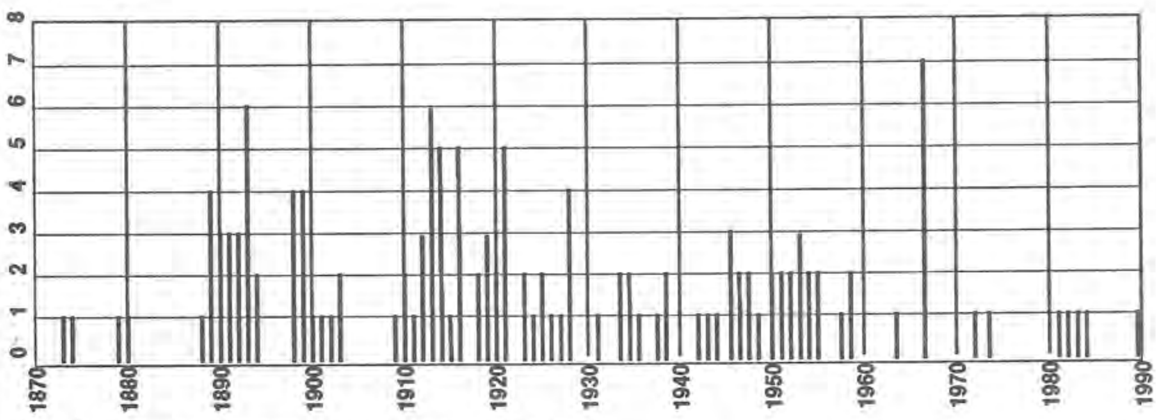


Fig 3.16: Record of cyclones striking the Gold Coast

Training walls built

In 1962, the New South Wales Government extended the rock training walls at the mouth of the Tweed River, interfering with the natural northerly flow of sand and ultimately trapping millions of cubic metres that would have flowed onto the Gold Coast beaches. With the starvation of the sand supply, the shoals off Kirra and Coolangatta beaches were gradually eroded. *Wave refraction* and dissipation north of Point Danger was reduced because the water had become deeper. At this time the waves were breaking on Coolangatta and Kirra beaches at an angle and eroding the beaches further. With the loss of the shoals, higher energy waves could reach the beach during storms and the loss of sand from Coolangatta and Kirra beaches increased.

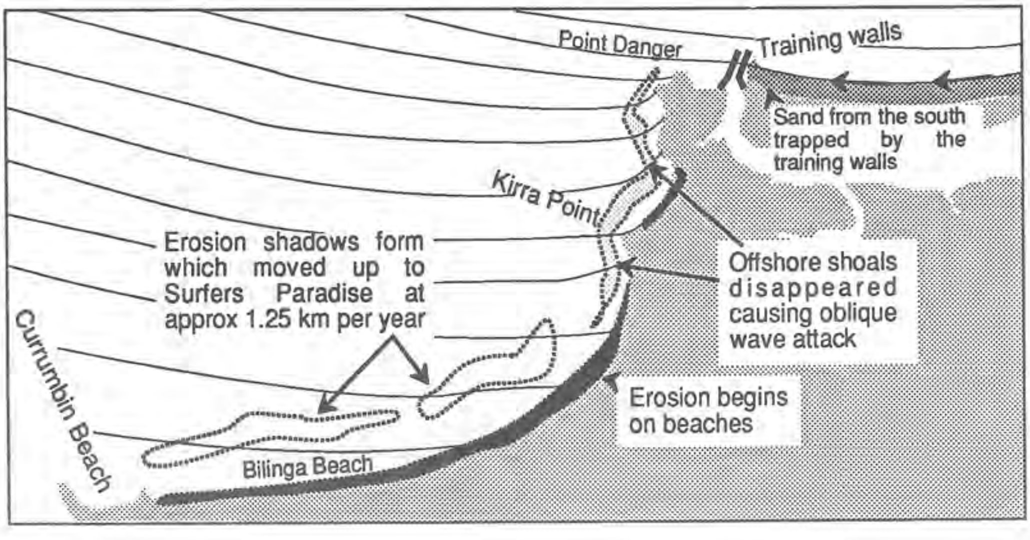


Fig 3.17: The shoals disappearance created erosion shadows which moved up along the Gold Coast beaches from 1962 to 1967.

There was so much concern about the future of the Gold Coast beaches that in 1964, the Delft Laboratories in Holland were commissioned by the Queensland Government to advise on a major study. This included model testing on the causes and expected pattern of future erosion on these beaches. Then in 1967, disaster struck in the form of a series of cyclones each tearing away the beach and threatening the safety of beachfront buildings.

Fig 3.18: In 1967 a series of seven cyclones struck the Gold Coast causing devastation beyond belief. Photograph courtesy Gold Coast City Council.

Massive **boulder walls** were constructed at Coolangatta, Broadbeach and Surfers Paradise forming the last line of defence against storm attack - and narrowly averting total disaster.

In 1970 the **"Delft Report"** was completed providing coastal engineers with the first detailed analysis of what was happening to the beaches, what could be expected in the future and works needed to protect the Gold Coast. Although there was more information and proposed solutions to hand, the funding required for the work was not.

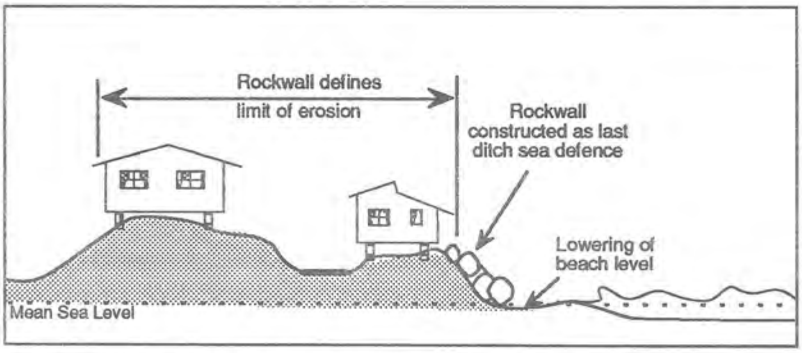


Fig 3.19: Two immediate solutions to the erosion problem.

In 1972, further cyclones caused severe erosion particularly at the southern end of the coast, and the Kirra Point groyne was built to protect Coolangatta beach, and another to stabilise Currumbin.

Due to the effects of the Tweed River walls the shoals eroded during storms were not naturally restored as in the past. This left the southern beaches exposed to more powerful and more oblique wave action.

This new wave attack eroded the beaches further. Rock walls were built to protect property. A year later, the campground at Kirra was washed into the sea, and a boulder wall had to be built to prevent the loss of the Gold Coast Highway.

Another groyne and boulder wall was built at Kirra to stabilise the beach near the surf club, but more cyclones in 1974 caused further erosion problems. Without these boulder walls, major loss of property and damage to sewage, international telephone lines, airport communications and water mains would have occurred.

Fig 3.20: Coolangatta Beach and the famous Kirra Point with its groyne.

The Gold Coast without its beaches was not an economic tourist proposition. People simply would not come to the coast if they could not walk on a sandy beach. This prompted the Gold Coast City Council, with 25 per cent State Government subsidy, to spend more than $2.5 million dollars nourishing the beaches. Initially groynes were built with the limited funds the council had from the ratepayer. A groyne had the effect of trapping sand on one side but allowing the sand on the other to move in the direction of the long shore drift. Sand would erode on this side until the sand on the other filled up behind the groyne and moved around. However a groyne shadow always forms on one side as shown in Figure 3.22 below.

Fig 3.21: Groynes were used to stabilise the beaches as a temporary measure. Long term solutions to this problem were to cost millions of dollars. Photograph courtesy Beach Protection Authority.

By 1973, Coolangatta Beach was realigned by the groyne. The beach was stabilised and protected from strong wave action. By 1981 a second groyne was built at Kirra in an attempt to emulate the success at Coolangatta. However erosion was to occur at Kirra for a further ten years as long-term solution to the problem were researched. In 1974, 900,000 cubic metres of sand was pumped from the Tweed River estuary to Kirra beach. Some recovery of the upper beach occurred in mild conditions from 1976 to 1983 but during 1983 storms caused further erosion damage particularly along the southern beaches. It was also clear that the quantity of sand placed in 1974 was inadequate to deal with the on-going erosion caused by the Tweed Walls. (The sand had now moved onto Palm Beach and Burleigh due to littoral drift). Engineers did their sums and this nourishment work fell well short of the sand budget need for these beaches to operate successfully during normal storm seas.

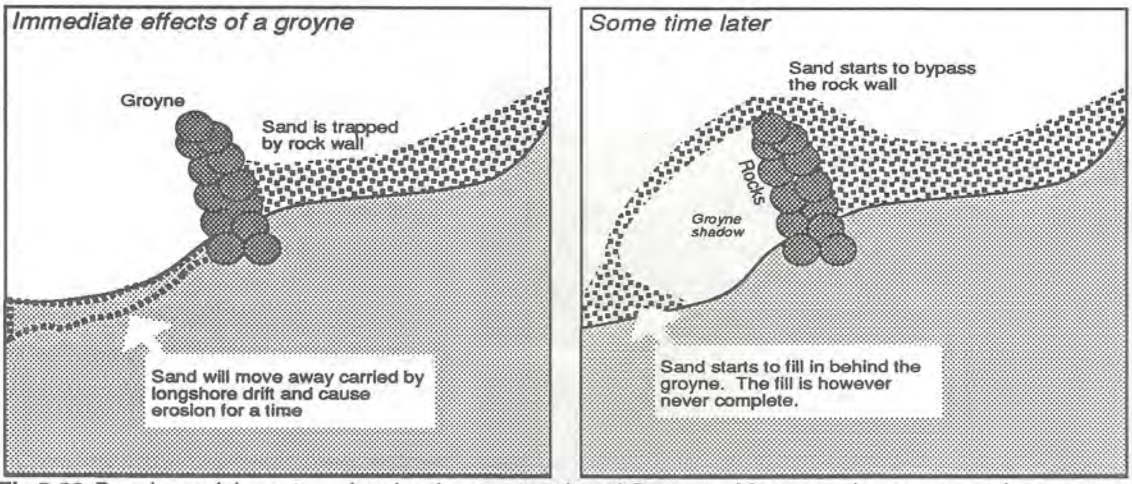


Fig 3.22 Beach nourishment can involve the construction of Groynes. Many people are opposed to groynes because of their unsightly appearance however they are effective in trapping sand. In time sand spills around them however a shadow is always created on one side.

Beach nourishment

Because of these continuing problems, research was initiated in 1985 into achieving a solution. The Point Danger/Tweed River investigation and a detailed study into Kirra erosion began. Further works were carried out in 1985 with a major nourishment programme which saw 1.2 million cubic metres of sand pumped from various sources including the Broadwater, returned to beaches at Narrowneck, Surfers Paradise, Burleigh Heads, Palm Beach and Kirra.

The northern beaches were nourished with sand from channel maintenance works in the Broadwater. The southern beaches were nourished with compatible sand from the stable offshore reserve area, using the Belgian dredge *Vlaanderen XX*. These works incorporated near shore nourishment to restore the eroded sea bed, as well as conventional onshore placement. A dredge was brought in and sand was sucked from a dredge site well offshore. The sand was then pumped ashore using a combination of floating and submerged pipelines.

Fig 3.23 Beach nourishment involves adding sand to the sand budget from outside the active beach system. Here sand is pumped from a river to the beach as is illustrated by method 3 below. Photograph courtesy Beach Protection Authority.

Beach nourishment methods

(in all cases vegetation and walkways follow initial nourishment with sand)

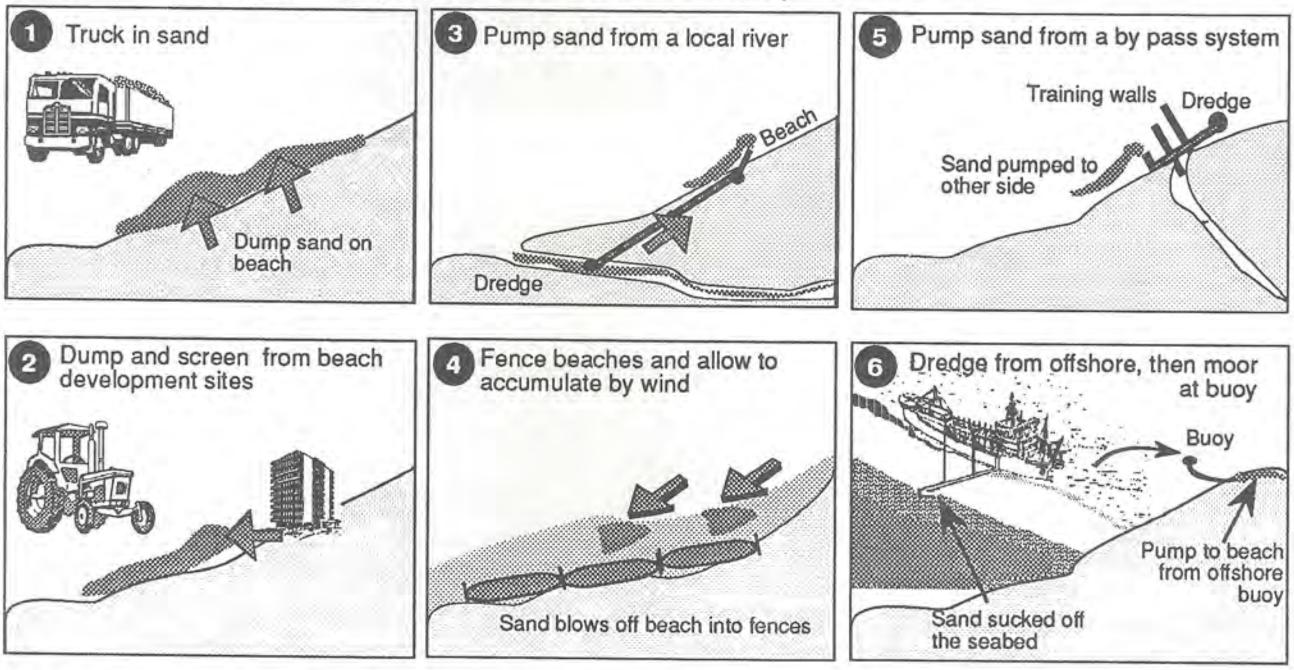


Fig 3.24: Beach nourishment involves adding sand to the sand budget from outside the active beach system. The methods described above are described in the video on beach nourishment.

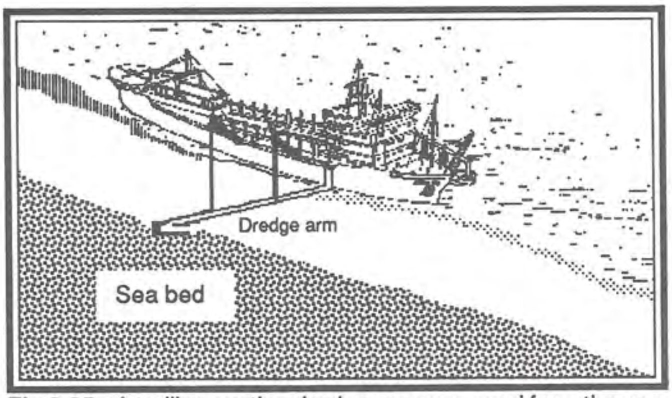


Fig 3.25: A trailing suction dredge removes sand from the sea-bed outside the active beach system and stores it in a hopper.

Fig 3.26: The dredge arms of the trailing suction dredge, Ham 310 off Kirra 1990

This work allowed the concept of **near shore nourishment** to be tested and evaluated. At Kirra, monitoring offshore deposition showed that sand previously deposited in near shore areas moved closer towards the shore and did not run back into the dredged area. By 1986 studies also showed that the sand moved past these groynes and there was no need to shorten or modify their shape. If shortened, this would destabilize areas to the south without significantly improving areas to the north. Mild conditions in 1986 and 1987 gave the beaches some respite, and allowed dune fencing to be done to provide a measure of protection. In 1988, a further 1.5 million cubic metres of sand was dredged from offshore reserves using an Australian based trailing suction hopper dredge. This to deposited sand near shore off Kirra/Bilinga beach to fill the erosion shadows previously mentioned in Figure 3.17. However, summer storms in 1989 accelerated the losses and ripped even more precious sand away to the north of the nourished area and concerned residents held public meetings.

Fig 3. 27: Once the dredge had finished sucking up the sand, it moored at a pontoon where the sand from the hopper is pumped ashore.

In 1989, the Queensland Government made the commitment to a **beach restoration programme** to provide adequate funds to tackle erosion problems. The Queensland Government initiated further works in April 1989 to protect endangered properties by placing 50,000 cubic metres of sand on the offshore bar. The nourishment works already carried out have made significant contributions to reinstating a near shore sand reservoir between Kirra and Currumbin.

Fig 3.28: The pontoon was connected to a pipe to shore and sand gushed forth at a rate of 5,000 cubic metres an hour.

However, after the recent storm period, a **sand deficit** still exists in this area. It is essential to overcome this shortage, otherwise the erosion shadow mentioned earlier, will travel slowly northwards as it did between 1962 - 67, resulting in loss of beaches and damage to seafront properties. The **artificial bar** created, not only protected the beach during the subsequent storm, but also moved shoreward allowing beaches to accrete in front of the boulder wall.

The 1990 beach nourishment project was undertaken, with 75 per cent subsidy from the State Government. It brought 2.4 million cubic metres of sand from offshore to be deposited in the near shore and beach areas.

Two dredges were used. One dredge dumped 400, 000 cubic metres of sand in the nearshore area. The other dredge pumped two million cubic metres of sand onto the beach. The **dredge site** was located in depths greater than 18 metres. Research has shown that the sand found there is not a part of the normal active beach. The dredge area is located by electronic position fixing equipment on the dredge. Two dredge arms are lowered either side of the vessel and the sand slurry is sucked from the sea-bed into the hopper with its hinged bottom doors closed. Excess water is allowed to flow overboard through the sides of the ship, allowing the sand to settle and compact at the bottom of the hopper. The hopper can hold about 6,500 cubic metres, which is accurately measured, sampled and recorded as the ship steams ashore.

Future work

A further 4.5 million cubic metres is planned for dredging in later stages to replace all reserves lost from the active system at the southern end of the Gold Coast. This will restore the original stable beach and **sea-bed profile.** This profile will provide an adequate temporary buffer against all but extreme storm wave attack. In simple terms it will fill the hole caused by the starvation of sand. If this hole was not filled it would move north and create problems for the already stabilized beaches at Southport and Surfers Paradise as already happened before.

With the sand back in the system, it will be essential for full bypassing of the Tweed River to ensure sand reserves are maintained and the cycle does not start all over again.

Research presently being carried out with the Delft Laboratories will update the 1970 Delft Report findings and allow the quantity of sand presently bypassing the Tweed River entrance to be quantified. More nourishment works are required, however, to provide an adequate sand buffer against storm wave attack right along the Gold Coast.

The nourished Surfers Paradise beach, for example, has weathered recent storms, but further work is still required to establish the storm buffer.

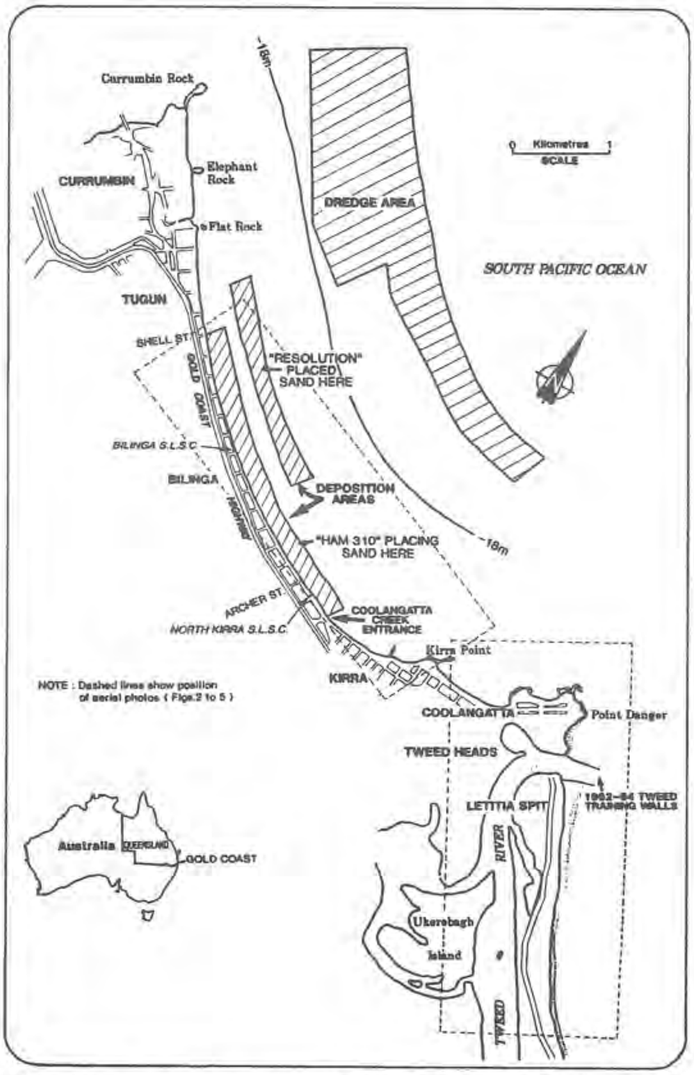


Fig 3.29: The dredge area and deposition site of sand. Illustration courtesy Qld Beach Protection Authority

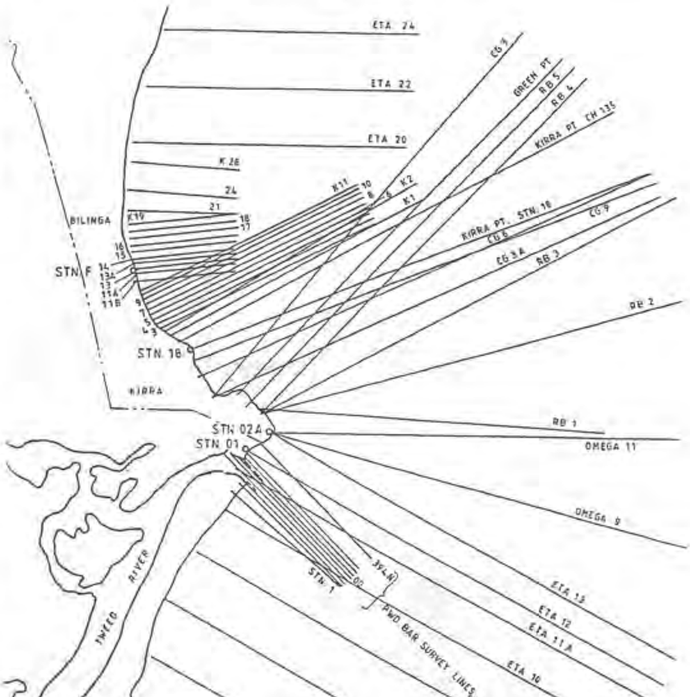


Fig 3.30 Survey lines used to establish beach profile data. Figure courtesy Gold Coast City Council.

In conjunction with the programme of nourishment works, the Gold Coast City Council also requires foreshore buildings to be protected by a boulder wall to limit extreme erosion and for excavated sand from within 500 metres of the beach to be placed on the beach.

Buffer zones

It has been impossible on the Gold Coast to relocate development however coastal engineers have calculated the required beach profile to withstand normal storm conditions. Beach nourishment provides sand for the budget, that has been lost by human influence. It is not a solution, only a supplementary measure which provides sand to the system. Nourished sand to the south will eventually end up on beaches to the north.

Fig 3.31: Surfers Paradise beach after a bad storm in 1989. The beach at high tide is reduced to the fenced buffer zone.

By carefully calculating the sand budget for the beaches at Surfers Paradise and monitoring beach profiles with regular surveys, a buffer zone has been established between rock wall and offshore storm bar.

No buffer zone can withstand the forces of 15 cyclones in a row but management plans are drawn up examining past records of coastal weather patterns. The record number of cyclones to hit the Gold Coast was seven in any one year. The final protection to property will be boulder wall and if all the sand is eroded, the beach will have to be renourished.

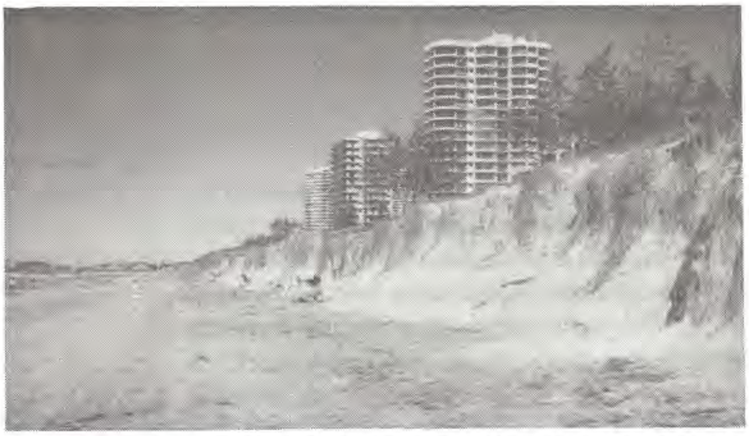


Fig 3.32: Erosion scarping at Surfers Paradise 1989. Photos C. McMurtrie.

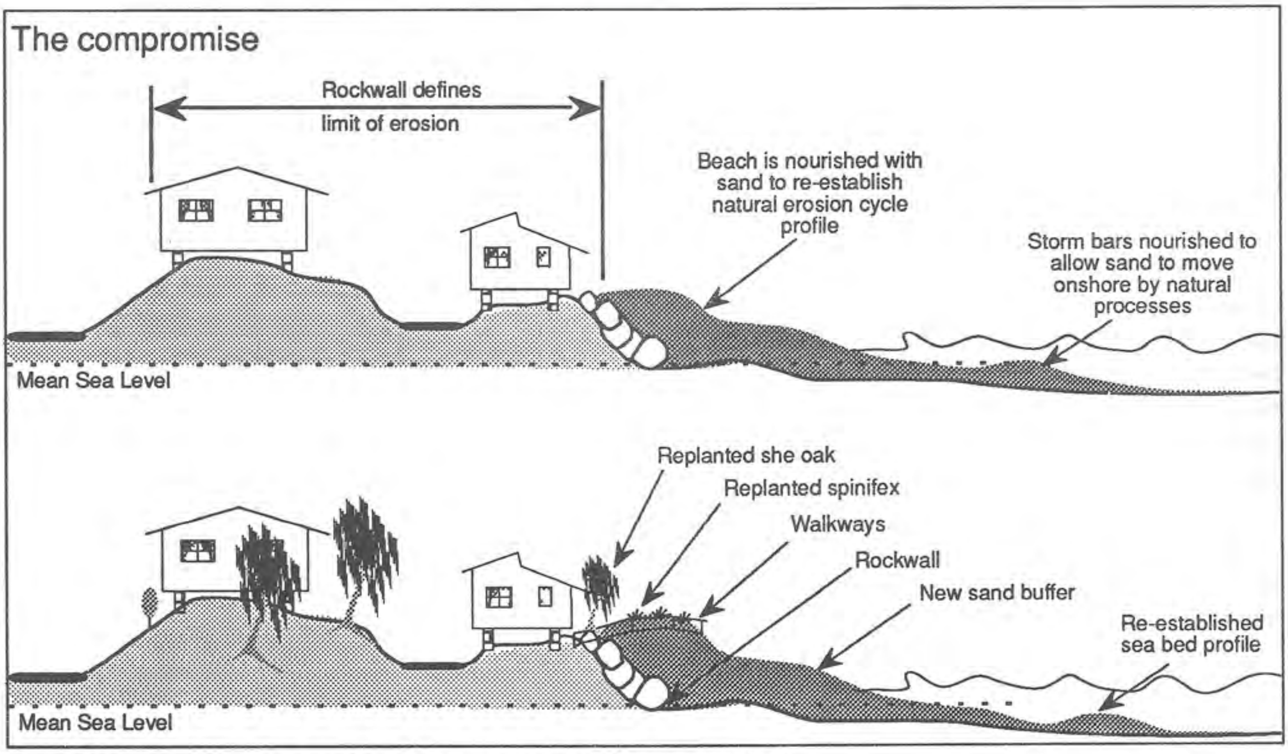


Fig 3.33: The compromise beach profile from beach nourishment methods.

Buffer zones are now part of most undeveloped coastal zones, however in many cases they are poorly defined. Problems exist with freehold or leasehold land. Because beach protection buffer zones are subject to erosion by the sea, pressures are likely to be placed on local authorities and others to protect developments located on such vulnerable land when the sea erodes. There is little that can be done to developed land. The **boulder wall and beach nourishment methods** have proved to be most success for the time being but the cost is large and sand inevitably moves in the longshore drift. Nourishment is an ongoing process. For unoccupied crown land, the buffer zone provides an excellent opportunity for management. If the buffer zone is protected by legislation and managed in accordance with sound conservation principles, the cycles in nature can occur without grossly affecting human activity. The following policy is given as one example of what activities are and are not part of policy in coastal management:-

Beach Protection Authority Queensland

Policy Statement: Beach Protection Buffer Zones

ISSUE

Beach Protection Buffer Zones are contained within areas to which the Beach Protection Authority's declared erosion prone area plans relate, but **they do not include** freehold or leasehold land.

Because Beach Protection Buffer Zones are adjudged to be subject to erosion or encroachment by the sea, pressures are likely to be placed on coastal Local Authorities and others to protect developments located on such vulnerable land when sea erosion threatens. Works designed to protect developments adjacent to beaches, such as sea walls and groynes, almost invariably result in damage to the beach amenity and loss of the beach.

BACKGROUND

For the purpose of this policy statement, Beach Protection Buffer Zones are defined as those areas of **unoccupied Crown land** in erosion prone areas which are located landward of the seaward toe of the frontal dune and adjacent to the sea and which should be specifically set aside and managed as "buffer zones" to help to accommodate fluctuations of the shoreline and erosion by the sea.

The Beach Protection Authority acknowledges that there are some developments already in the buffer zones but seeks to ensure that any such developments are minimized in the future. The Authority does not encourage usage of buffer zones where alternative sites can be made available outside the erosion prone areas.

Under the Beach Protection Act 1968-1989 unoccupied Crown land includes land reserved for or dedicated to public purposes as defined below:

"Unoccupied Crown land" — All land except land which is for the time being:

(a) lawfully granted or contracted to be granted in fee simple by the Crown;

(b) subject to any lease or licence lawfully granted by the Crown.

In this definition "land" includes land below mean high-water mark at spring tides of any tidal water and "licence" includes an authority to prospect, permit or dredging claim under any Act relating to mining.

Within Beach Protection Buffer Zones, Section 47 of the Beach Protection Act provides that:

- grazing or damaging any vegetation is prohibited without the written permission of the Local Authority, and
- interfering with any sand, stone, gravel etc or carrying out drainage works on such land, is prohibited without the written permission of the Beach Protection Authority.

POLICY

1. The Beach Protection Authority **considers** that the provision and proper management of development free and adequately sized Beach Protection Buffer Zones are the most effective means of protection against the loss of Queensland's beaches.
2. The Authority **opposes** the further establishment of permanent development or the replacement of existing development within Beach Protection Buffer Zones.
3. The Authority **supports** the acquisition of land and the technique of beach nourishment to add to or provide adequate Beach Protection Buffer Zones.
4. The Authority **recognises** the value to the State, and particularly the tourism industry, of retaining high quality beaches backed by Beach Protection Buffer Zones.

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ACTION

The Beach Protection Authority will:

1. **Create awareness** of the need to retain, regain, or reclaim and properly manage adequately sized Beach Protection Buffer Zones to ensure the greatest possible retention of usable recreational beaches.
2. **Publicise** through the mass media, and extension and professional publications the need to provide and maintain Beach Protection Buffer Zones.
3. **Permit** and recommend the payment of Government subsidies for the following beach protection works in Beach Protection Buffer Zones:
   - beach nourishment
   - access ways to the beach subject to the control of wind and run-off erosion
   - establishment, nurturing and retention of dune vegetation.
4. **Permit** the following works in Beach Protection Buffer Zones:
   - structures such as picnic tables, barbeques, coastal trails and bikeways that are considered by the Beach Protection Authority, either in isolation or as part of a group of associated structures, to be expendable when threatened by sea erosion.
   - specially designed portable or demountable structures such as S.L.S.C. observation towers and equipment sheds, lookouts, shelter sheds, elevated decks and pergolas that are considered by the Beach Protection Authority, either in isolation or as part of a group or associated structures, to be non-permanent development and capable of being easily and quickly removed when threatened by sea erosion.

   Permits for the above types of works would be granted subject to such structures:
   - NEVER being protected in the event of sea erosion
   - not adversely affecting the amenity of the beach if destroyed or damaged by sea erosion
   - being located in protected areas as far landward as possible in the Beach Protection Buffer Zone
   - not causing wind or run-off erosion
   - not being subsidised
   - being removed, in the case of portable or demountable structures, if threatened by sea erosion.
5. **Not object** to the following activities within Beach Protection Buffer Zones:
   - low level passive recreation in sheltered areas landward of the frontal dune
   - mowing of dune vegetation in sheltered areas landward of the frontal dune
   - occasional burning of excessive vegetation for fire hazard reduction purposes only
   - control of noxious weeds
   - selective clearing of vegetation in sheltered areas landward of the frontal dune

   subject to the prevention of wind and run-off erosion.
6. **Object** to damaging of vegetation, intensive recreation, uncontrolled access to the beach, over-grazing, or any other activity which may lead to wind, run-off or sea erosion in Beach Protection Buffer Zones.
7. **Consider on its merits** each application for a permit under Section 47(1A) of the Beach Protection Act for proposed works or developments in Beach Protection Buffer Zones.

   In Beach Protection Buffer Zones where works or developments already exist the Authority will have due regard to the responsibilities and requirements of coastal Local Authorities to provide services and facilitie for the general public on beachfront land under Local Authority control.

   In Beach Protection Buffer Zones where there are no existing works or developments the Authority, in general, will not issue permits under Section 47(1A) of the Beach Protection Act or support the payment of Queensland subsidies for the following types of works or developments:
   - rock, concrete or other fixed structures (viz. seawalls, groynes) located within the active littoral zone of open beaches unless such structures are required for beach retention or the improvement of navigation
   - buildings, car parks, roads, pipes, drains, excavations, golf courses, power/telephone lines, removal of materials

   or any other types of works or developments which may lead to:
   - wind, sea or run-off erosion
   - damage to the amenity of the beach
   - pressure being applied to the Local Authority and others to protect such works or developments to the detriment of the beach system or the amenity of the beach.

FOR FURTHER INFORMATION PLEASE CONTACT:

The Secretary
Beach Protection Authority
GPO Box 2595
BRISBANE QLD 4001

Beach Protection Authority Queensland

River entrances

These have always been a problem and Figure 3.44 shows an example of the problems management authorities face where the mouth of the Nerang River had been moving north for many years.

As we learnt in Unit 1, waves enter a river mouth and deposit sand by tidal input. In this case during cyclones, waves entered this large river mouth and broke on the foreshores directly opposite. Look at the map opposite and notice that by the year 2000, the river mouth would be opposite the canal estates of Runaway Bay. This would mean that erosion would be a problem during storm seas. In addition, the massive increase in population of the Gold Coast meant some permanent solution to the sewage system had to be found. Studies were done of land disposal but because of the narrow coastal strip, the value of the land and the unsuitability of soil, the ocean outfall was the only option.

But there was the problem of training walls causing an interruption to the northerly flow of sand and focusing storm seas energy at one point directly inside by the diffraction process you learnt about in Unit 1. Research was done into an old idea of **sand bypassing**. Under this idea, sand would be collected from one side of the wall and pumped to the other. To solve the wave diffraction problems a **sacrificial island**, called wave break island, would be built from sand pumped to create channels. The sewage outfall would be located in one side of the wall and allowed to discharge during ebb tides.

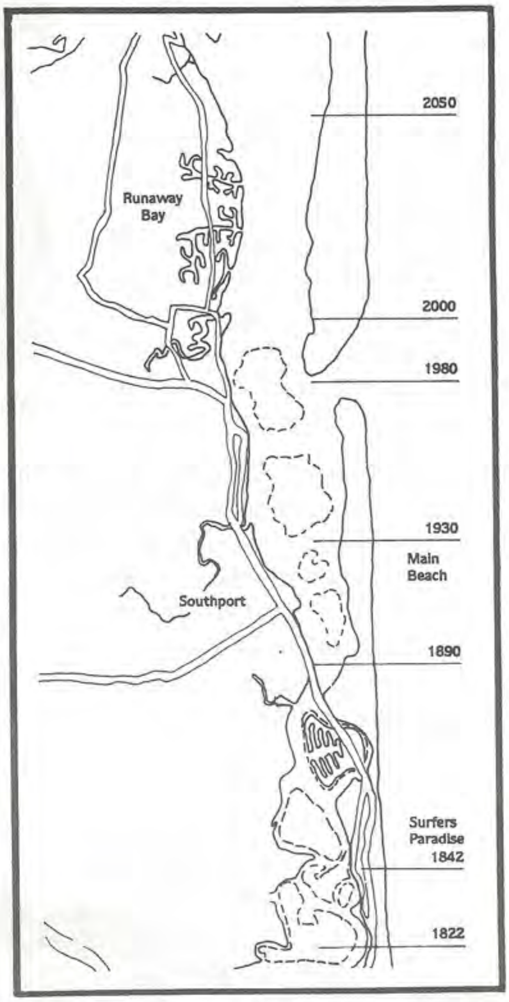


Fig 3.34: The entrance to this river has been moving north for many years. Illustration from Gold Coast Waterways Authority.

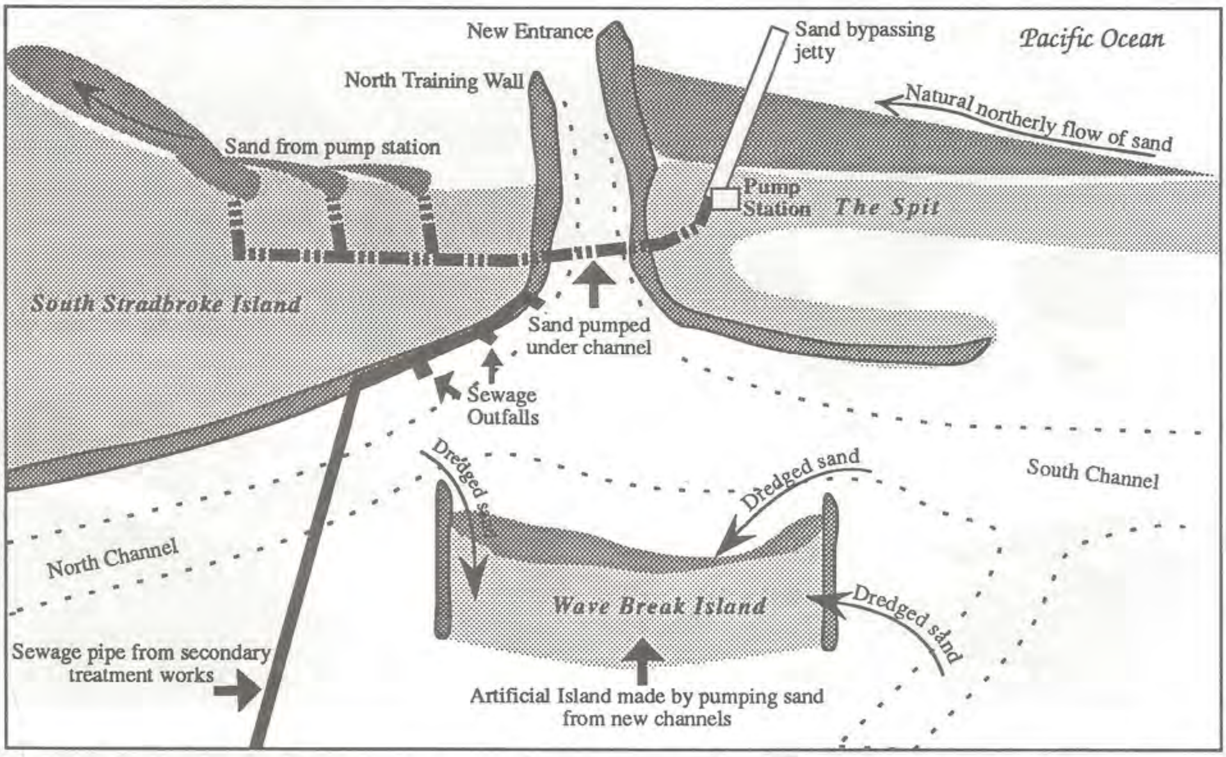


Fig 3.35: Schematic diagram of combination sewage outfall, seaway entrance and recreational facilities Gold Coast Seaway.

The new river mouth is now called a **seaway** and has been very successful. Sand is pumped at night from one side to the other when electricity is inexpensive at a rate of about 500,000 cubic metres a year. This represents the amount of sand that would move north naturally and so the beaches on South Stradbroke Island are unaffected by erosion. **Wave Break Island** was built from sand pumped from the new channels and is now well vegetated. It has however, not yet been exposed to the full fury of a number of cyclones. This is important because if the island eroded here, the sea would break through again exposing the residential developments of Runaway Bay.

Fig 3.36: The sand pumping jetty at the new seaway entrance.

The **tidal patterns** of the river have now changed. The seaway depth increased to a point where the submerged pipeline has been undercut by tide action and has had to be propped up. Current flows near the entrance are very strong mid tides and can catch people unaware. It has been estimated that more sand banks are exposed at low tide making increasing sandfly problems and the new seaway has opened up the spit for a high density tourist attraction increasing pressure on the natural environment. In addition the spit has been stabilised. Vegetation now grows in a green belt that has been established for local residents to observe local dune systems. Lush vegetation also is a problem at night because it creates many hideouts for **muggers**. Selective thinning out of trees and lighting have been installed to prevent this. So there is always a compromise with development and we will have to learn to live with this multi-user idea for many years to come.

Fig 3.37: The new river mouth in November 1985. This photo shows the old entrance as well as the new training walls. The sand pumping jetty is a line to the left of the longest training wall. Photo courtesy Qld Beach Protection Authority.

Topic 3

Management Issues

Management is defined as our "ability to handle or control something properly". In more recent times the term "wise use" has been added to many environmental definitions of management as they apply to our natural resources. Today's environmental watchdogs could be critical of the managers of years gone by but soon realise that these people were working with limited knowledge and different attitudes. Nature's resources then seemed boundless. To exploit these resources was just part of developing our nation into a modern vibrant economy. The filling of swamps with the dune sand seemed a good idea at the time. To make predictions about the effects this practice would have, was not part of the management process. There seemed no need for an environmental study to be done before development proceeded.

One of the key issues to management must be to predict possible consequences of tampering with nature and balancing this with environmental sustainable development.

Some questions and issues in managing the coastal zone are:

* How close to a beach can development take place?
* Can mangroves be removed?
* How much area should be managed? What needs to be banned?
* Who should the management authority be?
* Legislation; how much and by whom?
* Where should national parks, heavy industry and sewage outfalls be located?
* Should high or low rise development occur and where?
* How close to canal estates should wildlife reserves be located? Or is it the other way around? Should wildlife be put before places for humans to live?
* High density affordable units for young home buyers or budget holiday units for families, or both?
* Tourist developments which give young people their first jobs in life?
* An environment where people make more creative use of their leisure activities?

Tree feller might get replanting bill

by GREG STOLZ

Signs of things to come?

There is always an opposing view.

A LABRADOR man who was fined $3000 for clearing mangroves on his Coomera property might also have to pay for replacing the trees.

Primary Industries Minister Ed Casey has called for a full report on the case to determine whether restitution should be sought for the destruction of the mangroves, which are protected under the Fisheries Act.

A 67-year-old Labrador man this week became first person to be prosecuted under the amended Section 71 of the Fisheries Act for destroying mangroves on the Gold Coast.

After pleading guilty in the Southport Magistrates Court, he was fined $3000 and ordered to pay $1776.75 legal costs.

Under the previous legislation the man would have been fined a maximum of $400, but the new Section 71 of the Act allows fines of $6000.

The court was told the man cleared three sections of mangroves on his property, The Diamond Head Sanctuary, where he intended to build a home and plant soya beans.

His solicitor told the court the man was a conservationist, not a rapist of the environment.

The man was not building another Sanctuary Cove, but rather was preparing for his retirement, the court was told.

A spokesman for Mr Casey said the Minister was holidaying in north Queensland but would study a report on the case when he returned in two weeks.

"The Minister is very interested in the case and has called for a report to determine whether restitution for the destruction of the mangroves will be ordered," said the spokesman.

"The restitution would be used to pay for physically going in there and planting more mangroves."

MANGROVES THRIVING, SAYS FORMER MAYOR

FORMER Gold Coast mayor Robert Neumann says mangroves are flourishing in south-east Queensland, despite the public perception that they are diminishing.

"The mangroves are taking over our waterways," said Mr Neumann, who is the managing director of the Neumann Group of Companies and a self-proclaimed environmentalist.

Mr Neumann criticised Environment Minister Pat Comben, who he said was not concentrating on the areas that needed protection.

"True tidal areas need watching, but much of this mangrove blurb is utter rubbish," he said.

Mr Neumann said that while mangroves were killed by dredge spoil the practice allowed many others to grow and was increasing the overall number of mangrove trees.

"It may kill the old trees but the young virile ones thrive in the fresh mud which provides a fertile breeding ground for the mangrove seedling," he said.

His comments followed the prosecution of a Coomera man who knocked down mangroves.

Fig 3.38: Courtesy Gold Coast Bulletin

Management

All management is controlled by the democratic process. Elected members of parliament design legislation that sets out what procedures shall be adopted by the majority of the people at the time. Management is therefore relative to the wishes of the people of the day. There are many competing forces which can be called stakeholders of the day. Some of the stakeholders in the coastal zone are: local residents, industry, manufacturers, teenagers, senior citizens, primary school children, small business men and women, unskilled workers, marine scientists, accountants and so the list goes on. To manage all of these people, each with their own opinion and the user groups they represent with their conflicting ideas and wishes requires a compromise situation.

Ninety five percent of all Australians live in the coastal zone and there has to some form of management. Poor planning leads to a multiplicity of coastal zone problems be it domestic violence caused by the stresses of unemployment and lack of town planning or raw sewage pumped onto our beaches.

If groups of people get together to form a user group with a legitimate claim on an environmental resource, it is hard for management to ignore this claim. With all these user groups staking their claim, environmental management always ends up in a compromise. Three forms of Government facilitate this compromise process. Federal, State and Local governments all have a mass of acts, policies, laws and by-laws which control everything from **sand mineral export licences** to dog faeces in public places.

Federal and State Government Legislation

Acts have been set up to control large areas of coastal lands. e.g. **The Great Barrier Reef Marine Park Act** sets out methods to manage the Great Barrier Reef Marine Park. The act designates control to an authority which is directly responsible to the minister in control of the act. Ministers change with time as departments are restructured according to the wishes of the political party of the day however the act has to be amended so as to cater for changing policies.

Mineral resources acts can also overrule state acts by blocking the granting of export licences. Mineral sand mining has almost ground to a halt in Australia because of federal government bans on **export licences**. A local and state government may allow mining to occur but a company is not going to proceed if it cannot export the minerals.

Traditionally, states have the greatest power over the use of their coastal zone. Under the Australian constitution, power for the development and management in this area is given to the states. Many acts of parliament control this use which makes for a difficult process of management.

Environmental law

Law is merely the means by which the wishes of the people of the day are enacted. Laws can be amended, repealed or made new. **Environmental law** is no different from common law. The idea has arisen due to the growing concern of people throughout the world for their wishes about the environment to be policed. New laws are being made for this purpose.

How these wishes arise?

On a grand scale, international conventions and meetings set global policy. Federal, State and Local governments respond to international policies. Common people are influenced by media, their daily lives and those they communicate with. The **law of the sea** is a good example of how nations have agreed to some common principles of ownership of continental shelf regions and rights in the high seas.

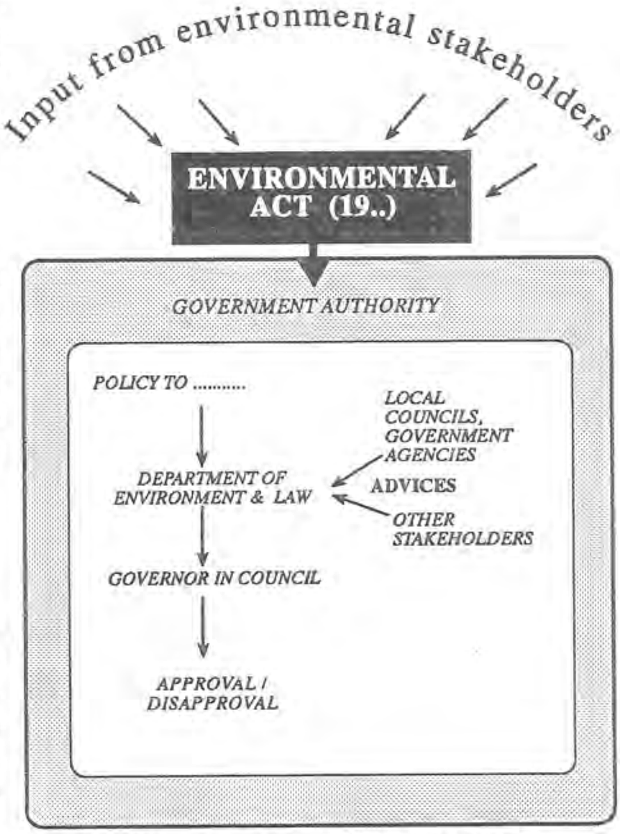


Fig 3.39: General principles of legislation design

Acts of parliament

The following is an example only. In Research Activity 3.3, you will make a study of your own government legislation.

The Beach Protection Act

If you watched the video from the Gold Coast City Council, you should remember the sequence in 1967 where devastation of the beaches threatened homes and property.

Because so many stakeholders were effected, the **Beach Protection Act** was drafted in 1968 to "provide for the protection of beaches against, and for the restoration of beaches from, erosion or encroachment by the sea and for those purposes to establish an authority and an advisory board and to confer and impose upon them certain functions and powers" No 17 of 1968, Qld Government Printer.

Now each state of Australia will have its own coastal zone management act or acts.

Many acts can control many sections of the coast and this is where bureaucracy steps in and people become confused and feel powerless to make changes because of the many different government departments that control different aspects of the coastal zone.

The following is a description of the Queensland Beach Protection Act as it was first presented in 1968.

This acts defines terms:-

*For example, **coast** is defined as " all land including the bed and banks of any river, stream or watercourse, lake or other body of water which is situated above mean high watermark, measured by the shortest distance of that mark and which is situated between high water mark of the main sea and mean low water mark at spring tides of the main sea which is situated between low water mark at spring tides of the main sea within one mile, measured by the shortest distance of that mark"*

The act sets out the membership, powers and duties of the advisory boards set up to administer the act e.g.: A representative from the Brisbane City Council., representative from Department of Mines etc.

An example

In our democratic society we elect the law makers on their political policies. The **environmental platform** has become very popular in recent times, so let's take an example on a controversial issue....sand mining. *e.g. A party says we will ban sand mining on our beaches. The party is voted into power at the next election and then sets to write an act of parliament banning sand mining. It defines where sand mining is banned, who will regulate the phasing out of mining and the monitoring of the ban.*

It will set out what the local authorities have to do to assist with the act and set guidelines for the allocation of money to pay wages and offices to administer the ban. Penalties will be set for people caught sand mining and judges are given the maximum fines they can impose if persons are found guilty of breaching the law as set out in the act. Sand mining can be blocked at many levels. A state may allow the mining to occur, but a federal government may not grant an export licence to allow the product to be exported. The nature of government policies largely determines what will finally happen to the mining of a local beach. Challenges may occur in the state and federal courts and even the high court as to the correct interpretation of the law. If the interpretations of the act are fair and just then sand mining gets phased out, or it may be found that in the long term with proper restoration, it is not harmful and provide essential export income.

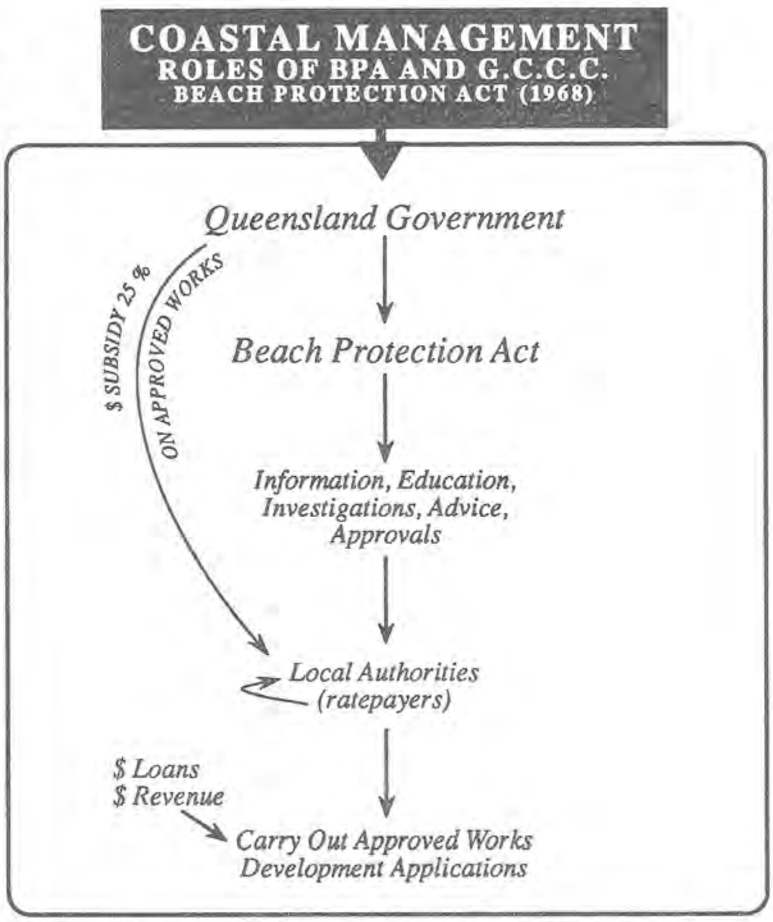
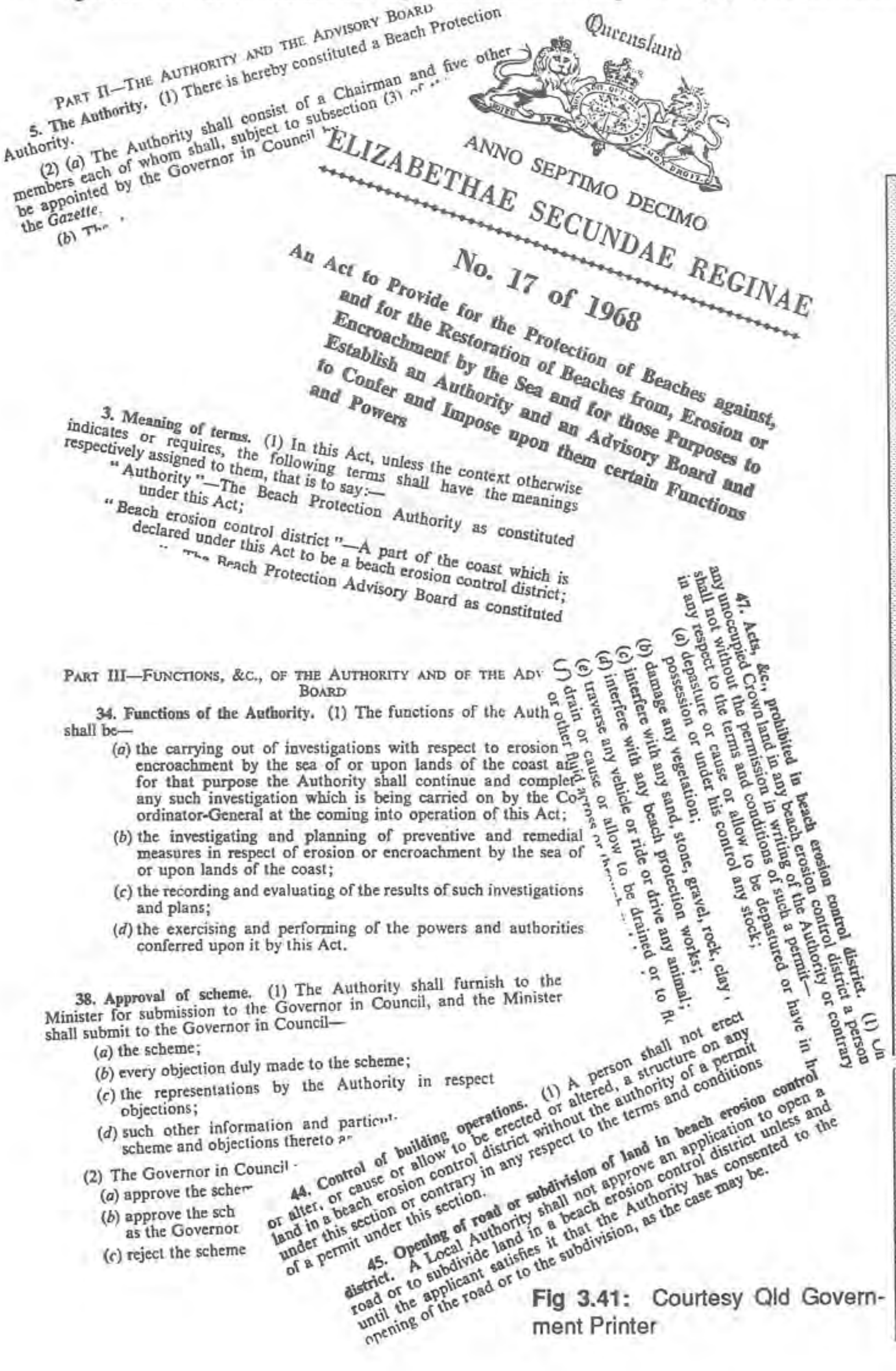


Fig 3.40: Management structures of the Beach Protection Act at one particular point in time under one particular political party.

Beach Protection Act

The acts set out the functions and specific provisions which are to;-

* investigate **beach erosion**, plan and prevent further erosion, record and evaluate investigations and exercise the powers given to it.
* set up control districts by declaring parts of the coast as districts, assigning and naming them, amending boundaries and exclude sites
* advertise the schemes and receive objections
* seek approval for the scheme and obtain finance
* implement and maintain the scheme
* control building operations, control roads and subdivision
* compensate persons affected
* police prohibited acts on beaches such as running stock, damaging vegetation, interfering with sand or stones, traversing by any vehicle, draining water or fluid onto the beach
* define areas of restricted access
* define powers of entry, temporary occupation of land, letting of contracts, erection of signs and obstructions
* list general offences and advertise maximum penalty $2000 for any general offence, in any proceeding
* general service of documents, regulations, limitation of liability, publication of orders in council and annual report



PART II—THE AUTHORITY AND THE ADVISORY BOARD

5. The Authority. (1) There is hereby constituted a Beach Protection Authority.

(2) (a) The Authority shall consist of a Chairman and five other members each of whom shall, subject to subsection (3) [illegible] be appointed by the Governor in Council [illegible] the Gazette.

(b) Th[illegible]

Queensland

ANNO SEPTIMO DECIMO

ELIZABETHAE SECUNDAE REGINAE

No. 17 of 1968

An Act to Provide for the Protection of Beaches against, and for the Restoration of Beaches from, Erosion or Encroachment by the Sea and for those Purposes to Establish an Authority and an Advisory Board and to Confer and Impose upon them certain Functions and Powers

3. Meaning of terms. (1) In this Act, unless the context otherwise indicates or requires, the following terms shall have the meanings respectively assigned to them, that is to say:—

"Authority"—The Beach Protection Authority as constituted under this Act;

"Beach erosion control district"—A part of the coast which is declared under this Act to be a beach erosion control district;

"[illegible] The Beach Protection Advisory Board as constituted

PART III—FUNCTIONS, &C., OF THE AUTHORITY AND OF THE ADV[illegible] BOARD

34. Functions of the Authority. (1) The functions of the Auth[illegible] shall be—

(a) the carrying out of investigations with respect to erosion [illegible] encroachment by the sea of or upon lands of the coast a[illegible] for that purpose the Authority shall continue and complet[illegible] any such investigation which is being carried on by the Co[illegible] ordinator-General at the coming into operation of this Act;

(b) the investigating and planning of preventive and remedial measures in respect of erosion or encroachment by the sea of or upon lands of the coast;

(c) the recording and evaluating of the results of such investigations and plans;

(d) the exercising and performing of the powers and authorities conferred upon it by this Act.

47. Acts, &c., prohibited in beach erosion control district. (1) Un[illegible] any unoccupied Crown land in any beach erosion control district a person shall not without the permission in writing of the Authority or contrary in any respect to the terms and conditions of such a permit—

(a) depasture or cause or allow to be depastured or have in h[illegible] possession or under his control any stock;

(b) damage any vegetation;

(c) interfere with any sand, stone, gravel, rock, clay, [illegible]

(d) interfere with any beach protection works;

(e) traverse any vehicle or ride or drive any animal;

(f) drain or cause or allow to be drained or to fl[illegible] or other fluid [illegible]

38. Approval of scheme. (1) The Authority shall furnish to the Minister for submission to the Governor in Council, and the Minister shall submit to the Governor in Council—

(a) the scheme;

(b) every objection duly made to the scheme;

(c) the representations by the Authority in respect objections;

(d) such other information and partic[illegible] scheme and objections thereto a[illegible]

(2) The Governor in Council [illegible]

(a) approve the sche[illegible]

(b) approve the sch[illegible] as the Governor [illegible]

(c) reject the scheme

44. Control of building operations. (1) A person shall not erect or alter, or cause or allow to be erected or altered, a structure on any land in a beach erosion control district without the authority of a permit under this section or contrary in any respect to the terms and conditions of a permit under this section.

45. Opening of road or subdivision of land in beach erosion control district. A Local Authority shall not approve an application to open a road or to subdivide land in a beach erosion control district unless and until the applicant satisfies it that the Authority has consented to the opening of the road or to the subdivision, as the case may be.

Fig 3.41: Courtesy Qld Government Printer

How effective are acts?

The penalty in 1960 for making an un-approved canal changed from $2000 to $100,000 and $2000 for each day the offence continues.

Persons convicted under this act have to restore damage.

The maximum penalty under the Beach Protection Act then was $2000.

Acts are only as good as the power they have to inflict penalties for people who do not abide by them.

Some developments have their own act of parliament. In Queensland, a whole mangrove and wetland swamp was converted into a high class residential development with marinas, shopping village, golf course and tennis facilities.

The Sanctuary Cove Act controlled this development.

How effective are other acts when faced with new legislation which seemingly overturns the philosophies of wetland reserves?

Canals

Many Australians like a home with a waterfront view. Water seems to hold some magnetic attraction and in many places this has lead to artificial waterway developments called **canals or marinas.**

In the past, to make a canal, all that needed to be done was to find a seemingly useless swamp area in an estuary, buy it and have the swamp re-zoned for residential development. Bring in a **dredge** and dig out narrow channels carefully pumping the sand onto an area which can be later reclaimed to build roads, kerb and channelling and building blocks. Subdivide the land and sell it as building blocks letting the new residents plant whatever vegetation they think appropriate with no guidance.

These days canal acts exist as a result of management problems caused by incorrectly designed canals. In Queensland there is a Canal Act of 1958-60 since amended (1979). It sets penalties for illegal or incorrectly built canals and sets limits as to the number and type.

For example the penalty in 1960 for making an un-approved canal changed from $2000 to $100,000 and $2000 for each day the offence continues. Persons convicted under this act have to restore damage. The act also sets approval procedures and final approval provisions.

The act describes how land is to be subdivided and connected to tidal waters and makes provisions for body corporates.

Fig 3.42. Canals are made by draining swamps.

Fig 3.43. Dredge out the sand to make a canal and pump it up into a walled off area.

Fig 3.44. Then build houses on the dredged out sand.

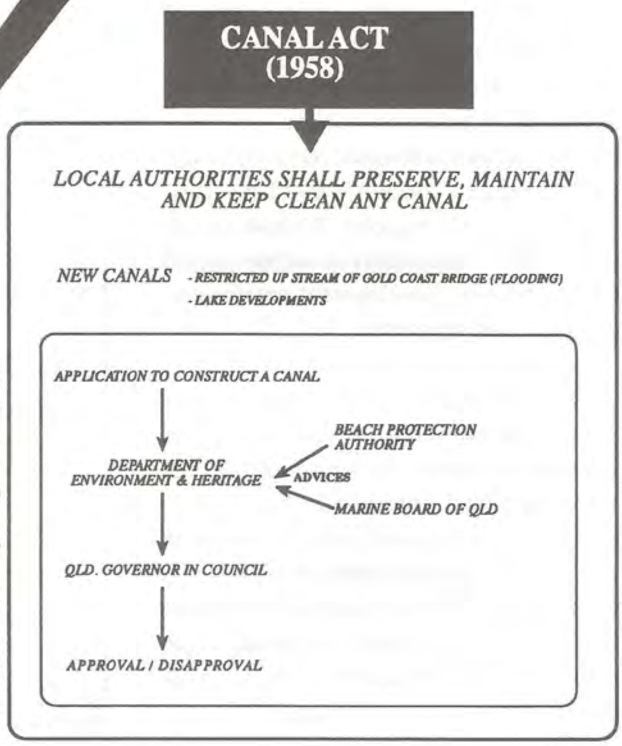


Illustration courtesy Angus Jackson.

Local authority management

Under both acts, mention is made of the **local authority**. Let's take an example of how a local authority has been set up to be part of the management process. From your primary school days you should remember that local council elections are held and the ratepayers elect a council. These councils are regulated by the local government acts which in some cases have the ability to sack councils. Lets have a look at our case study council, Figure 4.37, in particular the Special Projects Division.

There are constant groups of people who work at the council implementing **council decisions** and by-laws. The democratic process sets up systems by which the ratepayers can control the development of their town or city. This is controlled by local government acts which sets out guidelines for the proper conduct of this process. Usually if a development is to proceed an application is made to council. This may be a re-zoning application or a building permit within an already re-zoned area. The council has guidelines as set out by its town plan which is usually developed with the wishes of the people. The developer has to erect a sign on the land indicating his intent to build or re-zone and the ratepayers have a reasonable time to object to the development.

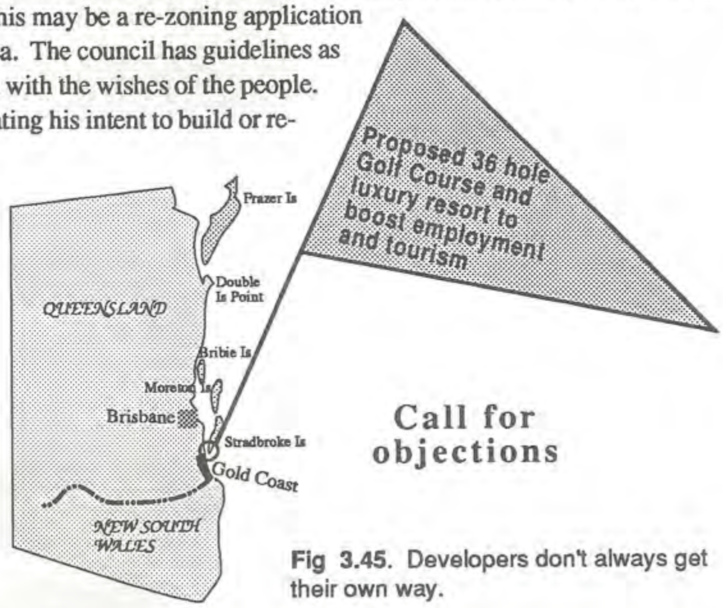


Fig 3.45. Developers don't always get their own way.

Sometimes **resident action groups** form to make public their objections and with the help of media publicity, other people find out about the application for development.

In the meantime, council engineers and environmental consultants will gather their own evidence as to the impact of the application. The economic benefits will be weighed with the weight of public opinion and the reasons they propose for their objections.

Council then has to make a decision based on the guidelines as set out by the relevant acts of parliament, re-zoning by laws and town plan philosophy controlling the development site. Usually the wishes of the majority are met and if the development proceeds, strict contractual guidelines are adhered to. Workers on the site also monitor these guidelines as do union representatives. Many people are concerned about our coastline for economic reasons. Without certain developments, the quality of our lives would change because development creates employment and prosperity.

The challenge lies with the diverse wishes of the general public to make wise and informed decisions studying proposed developments and objections. Responsible media reports and unions play a vital role in making sure agreed guidelines are adhered to and the allocation of suitable government funds to provide research on behalf of the taxpayer is now considered an prerequisite part of responsible government.

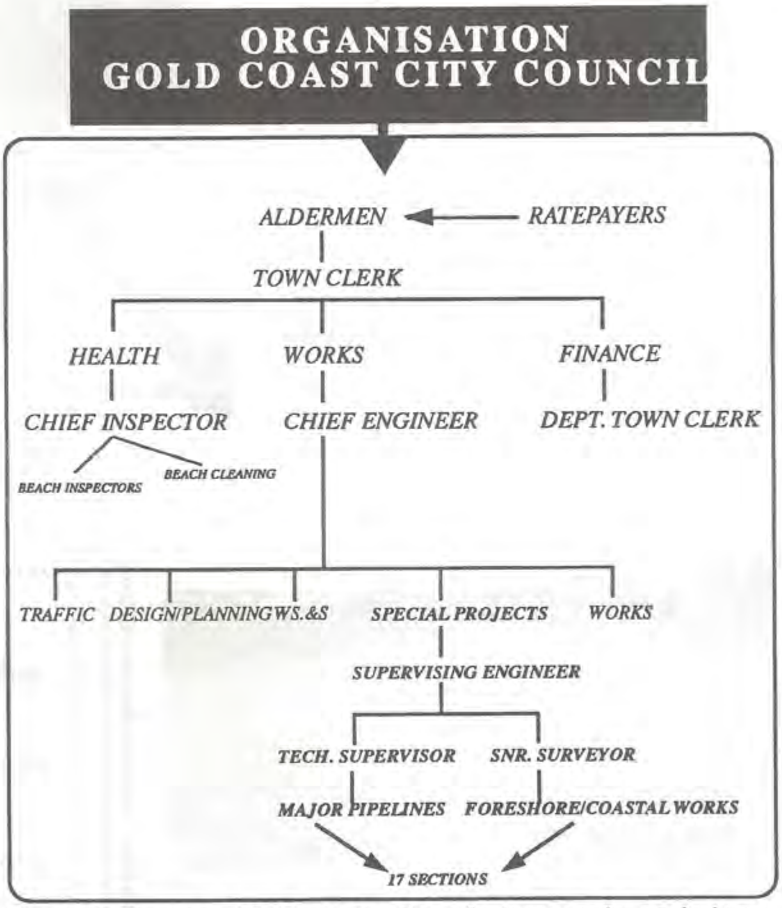


Fig 3.46: Structure Gold Coast City Council, Courtesy Angus Jackson.

Controversial Straddie golf course bid axed

A REZONING application for a golf course and clubhouse on the southern tip of South Stradbroke Island has been rejected by the Gold Coast City Council.

Planning and development committee chairman Alderman Lester Hughes said the council was tying up 'loose ends' concerning a 1987 Gold Coast Waterways Authority rezoning application for a golf course and clubhouse on the land.

"This application raised a great deal of controversy at the time, attracting more than 400 objections and a request by the waterways authority for the matter to be deferred meant it never actually went before the full council," he said.

"Even then it noted council's objective of having the land zoned Public Open Space — Environmental, an aim council is still actively pursuing.

"Despite council's approval of that zoning more than 18 months ago, the State Government has still not reached a decision on the future of this sensitive and valuable 60 hectares on the southern tip of the island."

Speculation

Ald Hughes said the council wanted to ensure the preservation of the island's environment and the continued existence of the waterways authority's old application would only serve to fuel speculation on the island's future.

"South Stradbroke Island is an environmentally sensitive area and the city's rapid growth has placed a greater importance on the need to protect such areas of natural and environmental significance," he said.

Lester Hughes

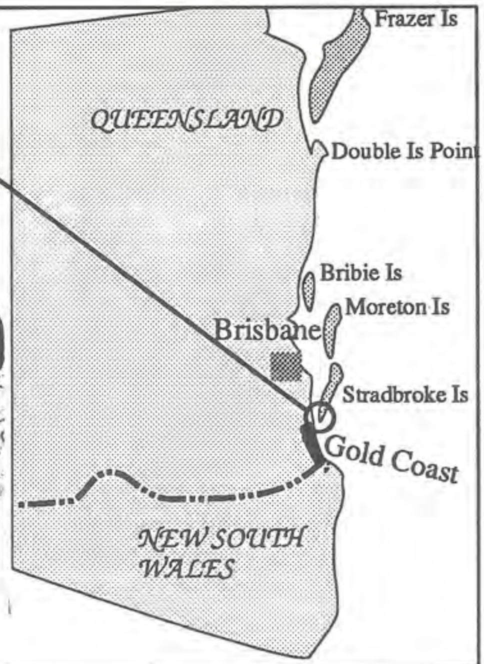


Fig 3.47: Newspaper article courtesy Gold Coast Bulletin.

Planning Gold Coast's Future

Strategy 3

The Tourism Strategy

By the year 2000 the City is expected to accommodate at least one visitor for every two residents throughout the year and substantially more during peak holiday times.

The dynamic nature of tourism requires the application of flexible and responsive planning policies which allow the local industry to respond quickly to new ideas and initiatives and as such maintain its competitive edge.

The tourism strategy plan illustrates, in broad terms, Council's response to the major residential planning issues confronting the City. The main elements of the strategy plan are:

(a) Tourist oriented development confined to the coastal strip primarily within established tourist activity nodes.

(b) A wide range of tourist oriented commercial development will be permitted in areas immediately adjacent to the major tourist activity nodes.

(c) Secondary tourist development zones providing for a smaller range of uses subject to Council approval.

The Council is seeking your views to assist in the preparation of a new Town Plan for the City. This strategy is one of seven to be released in the coming weeks. The strategies are based on information in the document "People, Places and Planning" which is available for direct purchase at a cost of $10.00 or by mail order for $15.00. Your comments on this strategy would be welcomed and should be forwarded to the Town Clerk, Gold Coast City Council, P.O. Box 5042, Gold Coast Mail Centre, Qld., 4217 prior to 30th December, 1990.

For further information phone (075) 31 9227 or call at any Council Office for a free brochure.

Gold Coast City Council

Working for you!

For your copy of "PEOPLE, PLACES AND PLANNING" complete this coupon and send to THE TOWN CLERK, GOLD COAST CITY COUNCIL, P.O. BOX 5042, GOLD COAST MAIL CENTRE, QLD, 4217 with a remittance of $15.00 per copy. The price includes postage, packaging and strategy brochures.

Name: ______________________ Phone: ______________________

Address: ______________________

Number of Copies @ $15.00 per copy: ☐

Part of an application by a local council seeking views on its proposed changes to the Town Plan.

This strategy is part of a seven part plan for the future of a major coastal city

Development now proceeds according to the plan and building applications are processed accordingly. The time to make changes is in the planning phase.

Fig 3.48: This article reproduced with kind permission of the Gold Coast City Council.

There needs to be a balance in the development of our coastal zone. Let's consider some of the issues. If we destroy our mangroves some people would argue we interfere with

- *fish breeding areas*
- *breeding habitats for mosquito and midges*
- *places for birds to roost and nest*
- *mud for crabs to bury*
- *natural river flow patterns*
- *rates of sedimentation of mud and sand that add to the sand budget*
- *rates of carbon dioxide absorption and oxygen production*

however some people would argue we

- eliminate the mosquito and midges that spoil eating outdoors
- remove unsightly swamps that accumulate garbage people dump
- create waterfront building blocks the development of which creates jobs
- create investment opportunities for business to attract overseas investment
- offer a lifestyle for people to strive and work hard for in retirement

The development of our coastline has not been limited to canal estates. Holiday units, beach shacks, national park huts, carparks, ports, marinas, surfing pavilions, sewage works, industrial sites, dumps, small business, fun parks and shops. The list seems endless.

To the **conservationist**, coastal management could mean opposition to those activities that interfere with the natural balance of nature whereas a **developer** may take coastal management to mean using the coastline to make profit and stimulate the economy thus creating employment. Local **long term residents** may wish a total preservation zone with no development whereas people with young families may want coastal management strategies to provide a safe place for their children to play in the sea for fresh air and exercise.

Conflicts must be identified and resolved. There is an urgent need for more coordinated long term planning particularly in relation to the **coastal sediment budget** because these shifting sands of time will inevitably control the destiny of this region.

Albert releases plan for Hope Island canals

by LISA YALLAMAS

HOPE Island's population will increase from 1470 to 18,000 — more than 1200 per cent — if canal estates are built on what have been called 'mosquito infested flood plains'.

The estates would increase the number of homes on Hope Island to 7200, said the Albert Shire Council when it announced its Hope Island Development Control Plan.

The plan was put on public display yesterday.

"The land will be excavated by private enterprise to form a canal system which will enhance the desirability of adjoining land," stated the plan, which is open for public comment for 60 days.

"Hope Island has been historically slow to develop due to major constraints imposed by flooding of the area and poor drainage of sections of the island.

"The construction of a bridge to Paradise Point has greatly improved access to the island and created pressures for both residential and commercial development."

Hope Island is bounded by the Coomera River and the Saltwater Creek.

The island is already the site of two major resort developments: Sanctuary Cove and Shinko's Hope Island Resort.

A colour map in the 73-page plan shows the area of canal development as a thick green line that extends across Boykambil residential areas, from a site near the Oxenford-Hope Island Road roundabout. The line forks into two and runs to the coast.

This Y-shaped future waterway is dedicated as drainage and an access reserve.

It is to be the spine of a development ribbed with canals that will have a minimum width of 75m.

Canal development is expected to act as an efficient drainage system, which will maximise the land area available for development.

Area councillor Col Kleinschmidt said pleasant residential canal development was better than low-lying mosquito-infested land.

"In my opinion, canal development will make it a better place to live and I believe council has taken a brave step in this regard," said Cr Kleinschmidt.

"I know that some residents are concerned and council will hold a public meeting at Boykambil this month to allow public participation and to explain the philosophy behind the Hope Island plan."

Limitations

Several limitations to canal development are mentioned in the plan, including the need for State Government approval for canal development and the need to conserve tidal waterways.

Canal development is also constrained by fragmented ownership of land.

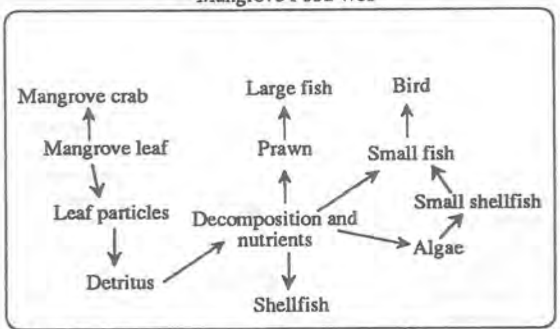
The council intends to encourage comprehensive development by allowing higher-density development on amalgamated properties.

Read this!

Note well

Fig 3.49: Article supplied courtesy Gold Coast Bulletin

Mangrove Food Web



After DPI (Qld) brochure *Our Mangroves*

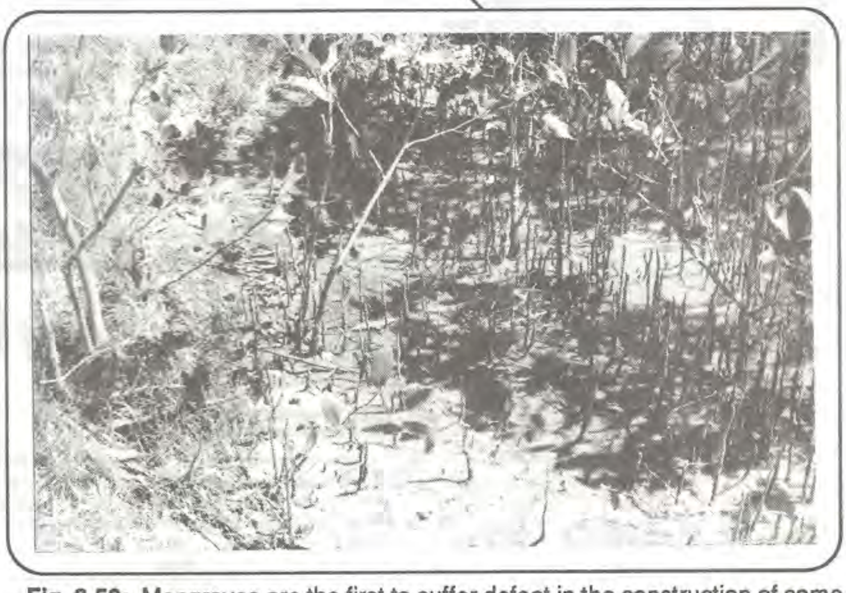


Fig 3.50: Mangroves are the first to suffer defeat in the construction of some canal estates

Topic 4

Your case study

This topic now turns to your local environment and the problems it is experiencing in coping with development.

Firstly you need to make a study of your beach system. Activity 3.2 is designed for this.

Secondly you need to look at the problems and issues confronting your local community. By researching the local newspapers over a period of time (Activity 3.3), from which you can obtain data on public opinion or a media beat up.

Finally, what management schemes are in place already, how effective are they and what areas are they week in or do not cover. Activity 3.4 should help you complete your case study.

How clean?
How polluted?
How much foreign investment?
Beach control districts?
Developed or in natural state?
Sediment flow?
Erosion problems?
Sewage problems?

Local beach pollution raises public concern

The people of Dumbtown on the central coast were given a lesson about pollution this week.

The trees in and around their town were sprayed with agricultural chemicals which had been banned by the world health organisation for the past 10 years.

The sewage system which was designed for a population of 5000 now was overloaded and was totally incapable of coping with the present population of 35,000 during the tourist season.

Fish had been found poisoned in recent months because of chemicals from the local cyanide factory and there had been an increase in child deaths for no apparent reason.

Oil pollution from the local refinery had killed many of the local bird species.

The powerhouse that supplied electricity from the state was also reported having difficulty with its anti pollution apparatus.

Local mayor, Mr. Fred Dimwit, said council policy on environmental issues was lacking because older members of the local community had not been interested in learning at school about environmental issues. Apparently they would rather be off surfing in the now oil slicked beach.

A public meeting would be held next week to stir up interest in environmental issues. It was hoped the teenagers of the town would do something about changing the attitudes of the older surfers who had let the place run down so much.

What is a media beat up?

How much attention should we pay to radical elements of our society and what effects do they have on coastal zone management issues?

What is a foreign investment register and what purpose does it serve?

Fig 3.51: This article not reproduced from anywhere. Hopefully the mechanisms we Australians have set in place now will avoid the environmental disasters of many overseas countries.

Activity 3.2 Your local beach system

This is your opportunity to make a study of a development in your coastal zone. Your study could take a variety of forms and here are a few ideas:-

Note:- Your teacher may restructure these to suit local conditions.

Core activity ideas:-

(1) Find out where your beach system starts and finishes and how much sand moves in it per year. Your local or state beach protection engineers can help you with this.

(2) Draw a map and mark in the natural dune areas, protected dune areas and places where residential or commercial developments have occurred. (Obtain aerial photographs and use them to make tracings of the coastline.)

(3) Mark on the map the areas where groynes, boat harbours, river training walls, beach tracks, car parks, life-saving clubhouses or jetties have been built. Find out the direction of the prevailing winds and the direction of longshore drift. Mark this on your map.

(4) Find out the names of the major dune plants and state the location on fore, mid or hind dune areas. Photograph them and use them in your report.

(5) Draw up a table of these developments and list beside each what effect these structures could have to the movement of sand along the coastline.

(6) Make up a list of coastal zone users. Group under the categories commercial, recreational, professional, tourist, residential and other.

(7) Find out who is responsible for coastal zone management, how the organisations are structured, where "the buck stops" when it comes to beach erosion problems and what steps are taken to manage the coastal zone area.

Extension activities

(8) Research local newspaper articles for controversial coastal zone management issues. Re-zoning applications for beach front developments, location of carparks and groynes. This could be a prelude to Unit four on Coastal Zone management.

(9) Use your camera to take photographs of your local beach system. Include the whole system showing natural and developed areas. Include typical human activities within the system which you have identified above.

(10) Use information from the local council to quantify coastal zone usage. Find out the percentages of residential verses commercial developments and what guidelines and policies are pursued in the enactment of these.

(11) Who owns what? Is ***foreign investment and the great Australian land sell out***, fact or fiction?

Activity 3.3 Newspaper file of local management issues

Aim

To collect a series of articles in the local press about management problems or issues

You will need

To collect newspapers over a set period of time
A scrap book, scissors and some sticky tape
Local newspapers for a week

What to do

1. Decide as a class on a number of areas from the set of newspapers collected. Cut out the articles and stick them on the walls of your classroom. Headings could be:-

   Resident problems - fines for littering beaches, removal of sand, local action groups demanding changes to laws controlling coastal zones

   Regulatory body announcements - new schemes to be undertaken using taxpayers money, new laws to be made to control aspects of beach development

   Development proposals - proposed developments by private companies, new schemes to change to coastline

   User group problems - Air-sea rescue, coastguard, local surfing or fishing club issues, conservation group statements and issues

2. You may choose other headings or sub-divide the users groups. Now collect articles over time and paste them into a scrapbook.

3. Share them with other members of your group in a group discussion at the end of the month.

4. Appoint a group reporter to make a verbal summary at the end of the discussion.

Questions

1. Did there appear to be any bias to any one type of articles in the newspaper? If so, can it be identified?

2. Which part of the community seemed to be most vocal and what was the type of issue discussed?

3. Is there any way to analyse mathematically the data you have collected? If so how would you go about it and what would be the constraints involved?

Extension

If you have identified a method of analysing the newspaper reports, set about a more detailed study as a major optional piece of assessment and present the results to the newspaper editor.

Activity 3.4

Study of a local government act, its implications and the system by which management is enacted

You will need

* A copy of a government act that manages some aspect of the coastal zone e.g.: Beach protection acts, waterways act, beaches act, marine act .. Try to choose an act that is not too long and has few amendments as it will be easier to follow.

* To form a group of 3-5 to make a detailed study of a section

* A copy of the act's annual report

What to do

1. Find out when the act was presented to Parliament, by which political party and for what purpose. A telephone call is all that is required here to the authority that manages the act. You can ask for the annual report to be used in 3 below.

2. Copy down the headings of the main sections of the act and form groups of 3-5 to make a detailed study of three or four sections.

3. What authority or government department will manage the act? Find out their address and get one member of the class to write for a copy of their annual report. When this arrives, divide up into groups to make a study of the relevant sections.

4. Make a detailed summary of the sections your group has been allocated.

5. Make contact with the authority and find out if there have been any breeches under the act and, if so, what types of infringements occurred. Don't ask for names, dates and respect privacy. Make a list.

6. Present your report to the class under the following headings:

   (a) Section/s of act researched
   (b) Aspects covered and relevance to coastal zone management
   (c) Recorded breeches under the act
   (d) Your opinion on the usefulness of this section -
       - What you think the strengths are and what are the weaknesses
       - What changes you would make
       - The reasons for the changes.

7. Compile these summaries and present them to your local parliamentarian and find out when aspects of coastal zone management are next to be debated in parliament. Alternatively, arrange a visit to the local council or shire meeting to hear how environmental issues are debated and proposed developments are discussed. Arrange an excursion to see how the **members of parliament debate** these aspects and the processes by which **coastal zone legislation** is drafted.

Extension

* Find out just how many people have been prosecuted under environmental law and what were the penalties. Are Australians a mob of wimps when it comes to real environmental prosecutions?

1. White Australian settlement has drastically altered the coastal zone by exploiting coastal resources. Some of these are
   * *the beaches and back shore areas for tourism and recreation*
   * *access to the sea via marinas, boat harbours and seaways*
   * *commercial access for ships and port development*
   * *foreshore and sea bed minerals and sea fisheries*
   * *supplies of water for residential and industrial purposes*
   * *coastal habitats for flora and fauna*

2. The development of these resources has created many problems, one of which involves the sediment flow along our coastline. Queensland's Gold Coast can be used as an example to see what types of developments occurred and the problems these created.
   * *in the past, people had little knowledge of conservation or natural coastal long term processes*
   * *sand was removed from the natural system by a variety of means principally the erection of the Tweed River Training Walls and the construction of building on sand dunes*
   * *with a decrease in natural sand flow nourishing the beaches, beach erosion occurred and threatened beach front developments*
   * *boulder walls were initially constructed to stop homes falling into the sea*

3. As a result of these problems, management procedures developed in the form of Acts of Parliament and management by means of a democratic process. For this process to be fair and just, the values and needs of various user groups had to be taken into account.
   * *the beach protection act and associated amendments resulted from the beach erosion problems of 1967. This Act provided money for research and beach nourishment methods based on research evidence form Australia and Holland.*
   * *the act also set in progress a series of management procedures to avoid similar disasters occurring in other parts of the state*
   * *disasters such as these cost the taxpayer money and it is wise use of Government funds to set in place preventative measures*
   * *co operation at three levels of government is required in the management process and there are many different Acts of Parliament controlling aspects of the coastline*
   * *beach nourishment has been successful in maintaining beaches on the Gold Coast and is now the preferred method provided that sufficient money can be found each year to make up losses in sand due to interruption of littoral drift on the beaches such as erosion shadows*
   * *the profile of the active beach system is constantly monitored by survey lines to record data on the movement of sand in the system. Extensive survey line exist at Kirra, Greenmount, Rainbow Bay and Letitia Spit on the Tweed coast*
   * *canal development is another example of altering the coastal zone. Mangroves and natural vegetation are removed and replaced with waterfront homes, marinas and tourist resorts.*
   * *mangroves are important because they*
     - provide habitats for fish and other animals
     - trap, concentrate and recycle nutrients
     - protect the coastline from erosion
     - provide homes for birds, insects and crabs
     - support recreational activities
     - provide a place for educational and scientific activities

The removal of mangroves needs to be carefully thought out and researched before any new development proceeds. Responsible government needs to recognise this so that the effects on the overall coastal ecosystem is considered.

4. Sometimes development is halted to provide for natural areas of coastline to act as a buffer zone to allow the natural processes of nature to occur.
   * *local councils can reject building applications*
   * *lobby groups can halt development of certain areas*
   * *sometimes state governments can overrule local councils*

5. The future of coastal development will be shaped by an informed public who makes the best use of the resources and professional information and advice supplied by local and state governments. Rational informed debate is required, not knee-jerk political decisions based on overzealous lobby group pressure.

Resources required

Activity	Name	Page	Equipment required
Unit 1:	**Waves**		
1.1	Waves in the ocean ...	11	Video player and monitor, Video "Waves in the Ocean" Classroom Video
1.2	Weather and waves. ..	11	Video player and monitor, Video "Weather" Classroom Video
1.3	A long wave tank ...	13	Wave tank custom made by Manual Arts Department
1.4	Wave Watching ...	15	Pencil, worksheet, camera, compass
1.5	Long shore drift ...	21	Stream tray, wave paddle, condys crystals, sand, hose
1.6	The Long shore Drif t...	22	Worksheet, pencil, compass
1.7	Headlands and Bays ...	26	Stream tray, wave paddle, block of wood, sand, hose
1.8	Ripple tank waves. · ...	31	Ripple tank and stands, wave motor and blade, rubber bands, blocks of wax, light, variable resistor, 12 volt power supply, stands (2), bricks (2), white paper, pencil
1.9	The pendulum ...	32	Pendulum, watch, string and stand
1.10	Wave rider buoy analysis..	33	Cyclone Nancy Data, graph paper
Unit 2:	**Beaches**		
2.1	Local coastal features ...	41	Aerial photographs, newspaper cuttings of aerial shots of coast-line, collection of local photographs or slides
2.2	Research Activities ...	43	Worksheet
2.3	Sand analysis. ...	49	Microscope and slides, sand samples from various locations with various sand compositions (labelled), sticky tape, small sieves
2.4	Coastal Landforms ...	51	Video player and monitor, Video "Coastal Landforms" Classroom Video
2.5	The River of Sand Video...	52	Video player and monitor, Video "River of Sand" Encyclopedia Britannica
2.6	A beach profile ...	55	Profile stick, ruler, level, red tape, sticky tape, worksheet
2.7	Beach Protection. ..	60	Library research
2.8	History of your Local Beach	60	Library research, interview sheets
2.9	They can be Saved ...	60	Video player and monitor, Video "They can be saved" Queensland Education Department
2.10	Read a Report. ..	60	Report #65, Gold Coast City Council
2.11	Open ended questions ...	60	Library research
2.12	Pollution on our beaches...	60	Brochures from Department of Transport, Canberra
2.13	The Great Dune Show ...	63	Video player and monitor, Video "The Great Dune Show" South Australian Film Corporation
2.14	Identifying Dune Plants...	66	Local Beach Vegetation Colour Charts, contact paper, scissors and card
Unit 3:	**Case studies**		
3.1	Case Study Video...	75	Video player and monitor, Video, "Beach Nourishment to the Rescue" Wet Paper Publications.
3.2	Your local beach system...	98	Camera
3.3	Newspaper file of local management issues ...	99	Collection of local newspapers for a month
3.4.	Study of a local government act ...	100	Local government acts of parliament from Government Printer

References

Beach Protection Authority Brochures 1-75

Clem, B., Pottenger, F., Speitel, T., Reed, A., and Coopersmith, A. The Fluid Earth, Curriculum & Dev. Group, Uni of Hawaii, 1990.

Gold Coast City Council, Unpublished Reports, 23-46.

Ross, D. Introduction to Oceanography, Prentice Hall, 1982.

Weihaupt, J. Exploration of the Oceans, Macmillan, London, 1979.

Addresses for videos and brochures

Classroom Video, 81 Frenches Forest Rd, French's Forrest 2089

Beach Protection Authority, GPO Box 2595, Brisbane Q 4001

Gold Coast City Council, Special Projects Division, Bundall Rd, Bundall 4217

Dept. of Transport, Canberra, GPO Box 594 Canberra, ACT 2601

Britannica Films, Private Mail Bag 33, Castle Hill, 2154.

Wet Paper, 14 Milbong Terrace, Ashmore 4214.

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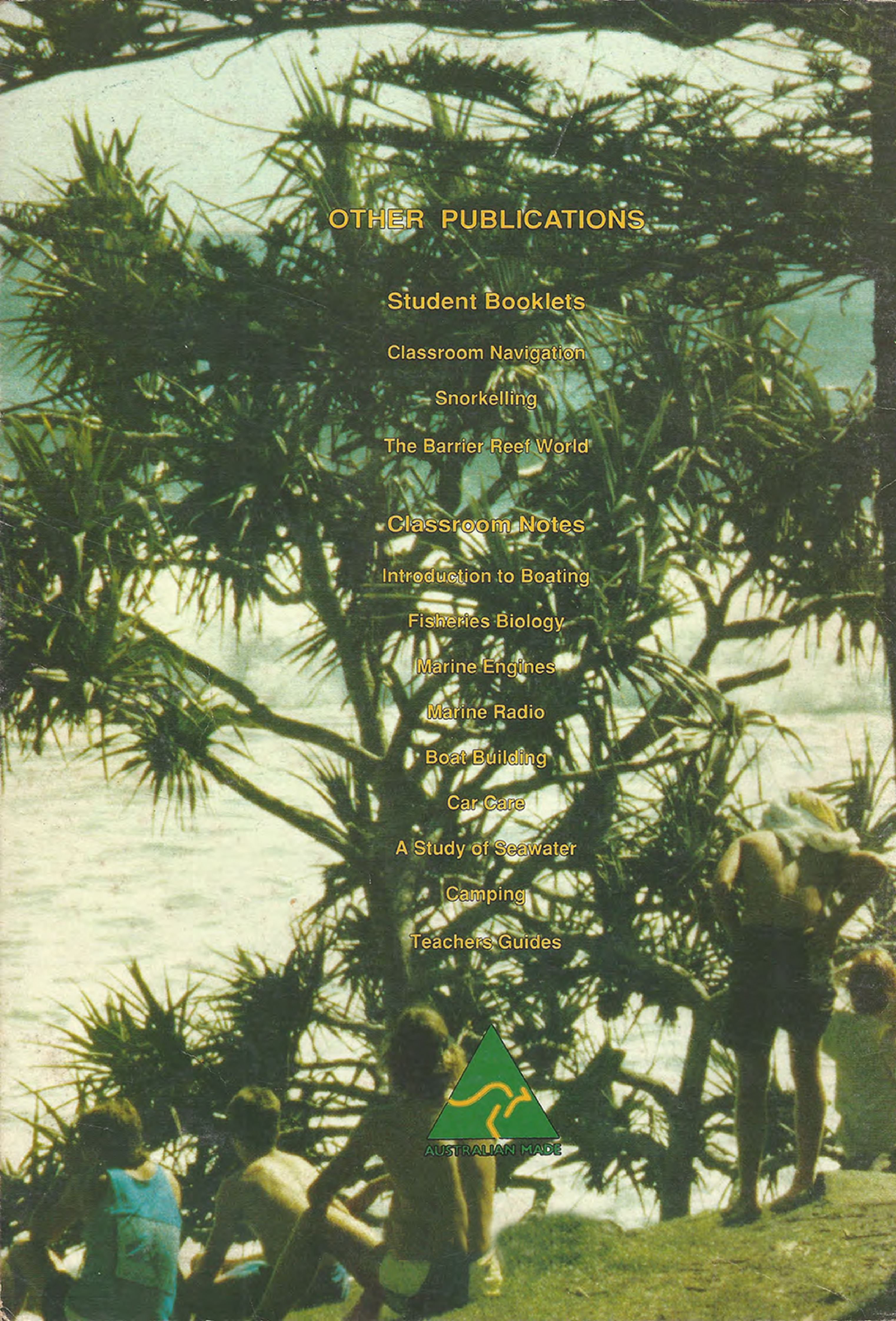
THE AUTHOR

Bob Moffatt is a Science graduate of the Queensland University majoring in Marine Zoology and has completed a Graduate Diploma in School Administration from the Brisbane College of Advanced Education specialising in Marine Management Systems.

He began teaching marine studies programmes in 1973 in the Wide Bay Region where he developed a programme for Senior Zoology students. Since then he has been subject master in science at Gladstone and Benowa State High Schools.

Bob is a keen surfer and shares a love of the coastal zone with his family. The book started many years ago as a set of notes produced by the Science Teachers Association and developed as part of the Brisbane South Marine Studies Project. After many years of research and agony over content, this is the current version. No doubt it will change with further revisions.

At present Bob has begun a small publishing firm called Wet Paper, which specializes in producing and promoting marine studies curriculum materials.



OTHER PUBLICATIONS

Student Booklets

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