Coasts are dynamic natural systems that are constantly changing. The action of waves and wind creates and destroys many coastal features. These features include stacks, caves, cliffs, arches, beaches and spits.

Coasts are also very popular places to visit and, by the year 2030, it is estimated that 21 million Australians are likely to live near the coast. It is therefore very important that coastal processes and management are understood, and taken into account in all aspects of coastal change.

Geographical knowledge and understanding
- Explain the operation of a major natural system and its interaction with human activities.
- Develop knowledge and understanding of coastal processes.
- Understand and analyse the impact of people on the natural coastal environment.
- Identify strategies and policies to manage coastal environments.
- Analyse development issues.

Geospatial skills
- Interpret maps and photographs at a range of scales to show coastal change over time.
- Read and interpret a coastal vegetation transect.
- Sketch from and interpret an oblique aerial photograph.
- Collect, collate, analyse and present information gathered from coastal fieldwork.

Surfer near Giant Rock. This rock is a giant stack and is much harder rock than the material that surrounded it. The softer rock material has been eroded by the action of wind, waves and rain. The same action will, over time, further erode Giant Rock.
<table>
<thead>
<tr>
<th><strong>Glossary</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>arch:</strong> formed when caves on either side of a headland are eroded further and join up to form one opening</td>
</tr>
<tr>
<td><strong>backdunes:</strong> dunes that sometimes develop behind the foredunes. These may be stabilised by small shrubs and trees.</td>
</tr>
<tr>
<td><strong>backwash:</strong> the movement of water back down the beach to the sea</td>
</tr>
<tr>
<td><strong>bay:</strong> a sheltered part of a sea or lake formed by a curve in its shoreline</td>
</tr>
<tr>
<td><strong>beach:</strong> formed by materials brought to the shore by waves in the swash</td>
</tr>
<tr>
<td><strong>beach renourishment:</strong> the artificial placement of sand on a beach</td>
</tr>
<tr>
<td><strong>berm:</strong> a ridge of sand on a beach</td>
</tr>
<tr>
<td><strong>blowhole:</strong> an opening in the roof of a cave through which water is forced by the action of waves</td>
</tr>
<tr>
<td><strong>cave:</strong> a hollow formed when weak rocks on a headland are eroded</td>
</tr>
<tr>
<td><strong>cliff:</strong> a steep, rocky slope formed by waves eroding the rock face</td>
</tr>
<tr>
<td><strong>coastal hinterland:</strong> the land adjoining the coast</td>
</tr>
<tr>
<td><strong>constructive waves:</strong> waves that carry and deposit sand and other materials</td>
</tr>
<tr>
<td><strong>deposition:</strong> the laying down of material carried, for example, by waves, ocean currents, rivers or wind</td>
</tr>
<tr>
<td><strong>destructive waves:</strong> large waves that carry sand and other material away in the backwash</td>
</tr>
<tr>
<td><strong>erosion:</strong> wearing away of the Earth’s surface by agents such as wind, water and human activity</td>
</tr>
<tr>
<td><strong>estuary:</strong> the tidal mouth of a river where the salt water of the tide meets the fresh water of the river current</td>
</tr>
<tr>
<td><strong>fetch:</strong> the distance over which the wind has blown waves</td>
</tr>
<tr>
<td><strong>foredunes:</strong> sand dunes closest to the beach</td>
</tr>
<tr>
<td><strong>headland:</strong> land jutting out into the sea, usually at the end of a bay</td>
</tr>
<tr>
<td><strong>longshore drift:</strong> the movement of sand and other materials along a beach</td>
</tr>
<tr>
<td><strong>refraction:</strong> the bending of waves caused by their contact with the sea floor and headlands</td>
</tr>
<tr>
<td><strong>rip:</strong> water flowing out to sea in a strong current</td>
</tr>
<tr>
<td><strong>rocky platform:</strong> formed by wave action eroding a cliff, leaving a platform of rock behind</td>
</tr>
<tr>
<td><strong>sand dunes:</strong> dunes that occur when dry sand is blown to the back of a beach and trapped there</td>
</tr>
<tr>
<td><strong>seasonal:</strong> the variation of wind directions and ocean currents according to the seasons</td>
</tr>
<tr>
<td><strong>spit:</strong> a narrow deposit of sand and other material which extends into a body of water</td>
</tr>
<tr>
<td><strong>stack:</strong> formed when erosion causes the rock supporting an arch to collapse</td>
</tr>
<tr>
<td><strong>sustainable:</strong> use of resources and environments that meets the needs of the present population without endangering the ability of future generations to meet their own needs</td>
</tr>
<tr>
<td><strong>swash:</strong> the movement of water up the beach after a wave breaks</td>
</tr>
<tr>
<td><strong>swell:</strong> the movement of the waves</td>
</tr>
<tr>
<td><strong>tombolo:</strong> a spit joining two land areas</td>
</tr>
<tr>
<td><strong>wave-cut notch:</strong> a hollow eroded by the impact of waves at the foot of a cliff</td>
</tr>
</tbody>
</table>
4.1 INTERACTION IN THE COASTAL ZONE

HOW IS THE COAST USED?

About 85 per cent of Australia’s population lives in coastal towns or cities — more than 25 per cent live within three kilometres of the coast. In fact, all urban settlements with populations of more than 500,000 are located on the coastal fringe of the continent.

As well as being a popular place to live, the coast is a major tourist destination. For example, the number of visitors to Queensland’s Gold Coast in the year ending March 2005 was 3,601,000 — an average of 84,555 visitors daily.

WHERE IS THE COASTAL ZONE?

The coastal zone includes the coastal hinterland and the inner continental shelf as well as everything in between. Within Australia’s coastal zone there are many different environments, including mountain ranges, flood plains, rivers and lakes, rainforests, wetlands, mangrove areas, estuaries, beaches, coral reefs and seagrass beds. All these environments must be managed in a sustainable manner to enable future generations to enjoy Australia’s natural beauty.

Most of Australia’s World Heritage sites are located in the coastal zone. For example, the Great Barrier Reef, Lord Howe Island, Fraser Island and Shark Bay are part of Australia’s cultural and natural heritage.

Easy access to transport means that many industries are located in coastal areas. These include service industries, fishing and ports supplying transport for goods and services. Some coastal activities, such as swimming and camping are compatible; others, such as surfing and oil refining are incompatible.
Sustainable development and management means that our use of coastal resources must meet the needs of the present population without endangering the ability of future generations to meet their own needs.

Coastal environments have not always been managed sustainably. In the past, decision makers had limited knowledge about the fragile nature of many coastal ecosystems and they had different views about the use of coastal areas. Their aim was to develop coastal areas for short-term economic gains. This was based on the belief that nature’s resources were limitless. Building high-rise apartments and tourist resorts on sand dunes seemed a good idea — until they fell into the sea when cyclones eroded the shoreline.

Over time, people realised that sustainable coastal management means understanding the processes that affect coastal environments. To manage the coast sustainably we need to understand:

- the coastal environment and the effect of physical processes
- the effect of human activities
- the different perspectives of coastal users
- how to achieve a balance between conservation and development
- how decisions are made about the ways in which coasts will be used.

The stromatolites at Shark Bay in Western Australia are protected at the World Heritage site. Stromatolites are among the oldest forms of life on Earth.

Activities

Understand
1. List three different coasts you have visited and describe the main environment found in each.
2. Work with another person and brainstorm ten ways the coast can be used. Draw these into a grid and mark whether each activity is compatible or not. Share your results with the class.

<table>
<thead>
<tr>
<th>Swimming</th>
<th>Camping</th>
<th>Oil refining</th>
</tr>
</thead>
<tbody>
<tr>
<td>✓</td>
<td>✓</td>
<td>✗</td>
</tr>
<tr>
<td>✗</td>
<td>✓</td>
<td>✗</td>
</tr>
</tbody>
</table>

Communicate
3. Draw a sketch of the Gold Coast coastline. Label the beach, river and marina. Annotate (make notes on) your sketch identifying areas you think might have a high, medium or low impact on the coastal environment. Justify.
4. Use your own words and the photograph and data about visitors to the Gold Coast to explain the meaning of ‘sustainable development’.

Think
5. Study the photograph showing beach erosion. What do you think authorities were trying to do? Imagine you own the house in the photograph. Write a letter to the local council about your predicament and list the action you would like taken.

Dig deeper
6. Choose one coastal World Heritage site in Australia. Research the way this site is managed to ensure that the coast is protected. Present your findings in a two-page report, including a location map and photographs.
Coastal landforms are produced by two major processes — **erosion** and **deposition**.

**Erosion** is the wearing away of the Earth’s surface by agents such as wind and water. Wind and waves create the energy that erodes the rocks along coastlines. You will be aware of this energy if you have ever been dumped by a large wave!

**Waves** are constantly striking against a coastline. When the weather is windy, the waves are larger and more powerful. As the waves hit the coastline, the energy in them is used to erode rocks and move sand, pebbles and other material. Some rocks are more resistant to erosion than others and will not wear away as quickly.

Waves carry sand and other material on and off the shore. When a wave breaks, the water from it runs up the beach. This is called the **swash**. The movement of water back down the beach to the sea is called the **backwash**. You may have observed the swash and backwash moving sand, shells, seaweed and other material up and down a beach.

When storms occur and waves are large, more material is carried in the backwash to deep water. These are called **destructive waves**. When the waves are small and contain less energy, sand and other materials are more likely to be carried in the swash and laid down as deposits on the beach. These are called **constructive waves**.

**LONGSHORE DRIFT**

In addition to moving material into and out of beaches, waves move material along the shore. Waves rarely approach a beach at right angles. They usually approach at an angle that depends on the direction of the wind. The swash travels up the beach in the same direction as the breaking wave. Due to gravity, the direction of the backwash and any material it is carrying tends to be straight down the beach. The result is that material is transported along the beach in a zigzag movement. (You may have experienced this when you have ended up some distance along the beach from where you left your towel and entered the water.) This movement of material is called **longshore drift** and is usually in one direction only — that of the prevailing wind.
Along the eastern coast of Australia, the great majority of winds come from the east to south-east, with much less from other directions. This results in more material being moved from the southern to the northern end of beaches and therefore more erosion at the south end of beaches.

Longshore drift can be **seasonal**. When winds blow in a certain direction during one season then change direction during another season, the direction of longshore drift can alter.

### Activities

**Understand**
1. Define the terms erosion and deposition.
2. Describe the difference between constructive and destructive waves.
3. How do storms and strong winds influence the erosion process?

**Design and create**
4. Use different coloured plasticine to build a model to explain the process of longshore drift. Use labels to show what is occurring. Demonstrate your model to your family.

**Think**
5. Study the diagram showing the process of longshore drift. What is the direction of the:
   - (a) waves
   - (b) wind
   - (c) swash
   - (d) backwash
   - (e) longshore drift?
6. Predict what will happen to a beach if longshore drift occurs mostly in one direction.
7. Study the diagram showing seasonal longshore drift at Hampton Beach.
   - (a) What is the direction of longshore drift in summer and in winter?
   - (b) Describe what happens to the sand in each case.
   - (c) What has been the impact of the breakwater on Sandringham Harbour?
   - (d) Predict what might happen if the breakwater or groynes were removed. Show this in a diagram.

---

**SKILLS essentials**

**Sketching from an oblique aerial photograph**

This shingle spit on the English coastline at Hampshire is 2.4 kilometres long. The spit is formed by material moved by the prevailing south-westerly winds. The source material came from eroding cliffs at a place called Barton-on-Sea. The end of the landform is called a recurved spit. Hurst Castle, completed in 1544, was built by Henry VIII as a coastal fortress. Charles I was imprisoned here in 1648 before being taken to London to his trial and execution.

Groynes built at Barton-on-Sea have prevented longshore drift from occurring so material must be brought in to replace the gravel that is lost from the spit.

Hurst Castle is built on a spit on the English coastline.

1. Use tracing paper to sketch the spit, including the low-lying land to the north of the castle. Label the castle.
2. Use coloured pencils to show the following:
   - (a) the direction of the prevailing winds
   - (b) the direction of sand movement forming the recurved spit
   - (c) locations where material is being lost
   - (d) where you think the spit will extend to in the future. Justify.
3. Add this information to your legend.
4. Describe how you think the recurved spit is formed.
5. Summarise how human intervention on one part of the coast can have an impact on another area.
When the energy in waves is high, coastal erosion takes place. There are many examples of coastal features formed by erosion.

**HEADLANDS AND BAYS**

Soft rocks are eroded more quickly by wave erosion than harder rocks. **Headlands** and **bays** form along coasts that have alternating resistant (harder) and less resistant (softer) rock. Where there is resistant rock, the coast is worn away more slowly, leaving a headland that juts out into the sea. Where there is softer rock, wave erosion is more rapid and a bay will form.

As a headland becomes more exposed to the full force of the waves, it becomes more vulnerable to erosion than the sheltered bay. As waves approach the coast, the wavefront bends to reflect the shape of the coastline. This bending of the waves is called **refraction** (see the diagram). Wave energy is concentrated around headlands, which are eroded forming landforms such as **cliffs**, **caves**, **arches**, **stacks** and **blowholes**.

**CLIFFS AND ROCKY PLATFORMS**

The photograph below shows cliffs and **rocky platforms** on the Tasman Peninsula in Tasmania. These are formed by waves eroding the rock face between high and low tide. The erosion causes a **wave-cut notch** to form at the base of the cliff. As the notch becomes larger, it undercuts the cliff and a rocky platform develops. This undercut section eventually becomes weak and collapses. Over time, the cliffs retreat inland and the rocky platform extends.

The formation of cliffs and rocky platforms
CAVES, ARCHES AND STACKS

Caves will be formed where weak rocks are eroded on each side of a headland. Over time, the caves will erode enough to join, forming an arch. Further erosion of the rock supporting the arch will cause it to collapse, leaving a stack.

When water rushes into a cave, pressure builds up at the back of the cave. If a section of the roof above the cave is weak, it may collapse, forming a blowhole.

PORT CAMPBELL

One of the most spectacular coastlines in Australia is located near Port Campbell in western Victoria. The rapidly eroding coastline is exposed to the strong seas and winds of the Southern Ocean, and is characterised by sheer cliffs, rock stacks, gorges, islands, arches and blowholes. The oblique aerial photograph of Port Campbell shows part of this coastline. This sensitive coastline is protected within the Port Campbell National Park and managed by Parks Victoria.

(RIGHT) Oblique aerial photograph of the Port Campbell coastline

(BELOW) Water spurting from a coastal blowhole in Samoa
A stack forms when an arch collapses.

Caves form where rocks are weak.

An arch forms when two caves join.
Understand
1. Use the word ‘energy’ to describe what happens to a wave as it approaches the coast.

2. Why are headlands more vulnerable to erosion than bays?

Think
3. Cliff faces are likely to start eroding at a weak point in their structure. Study the photograph on page 84 and suggest where weak points might be, and why.

4. What has happened to the material that collapsed when the cliffs on the Tasman Peninsula were formed?


6. Study the photograph of the Port Campbell coastline on page 85.
   (a) Which do you think is the oldest and the youngest stack? Justify your choice.
   (b) Predict where the next cave, arch and stack might occur. Justify your answer.
   (c) Do you think this photo was taken during low or high tide? Explain.

Activities

Design and create
7. Make a line drawing of the photograph of the Port Campbell coastline. Sketch and label the following: erosion occurring; harder rock resisting erosion; undercutting; deposition; next likely collapse.

Communicate
8. Use tracing paper to make a copy of the photograph of the Isle of Purbeck coastline.
   (a) Use coloured pencils to shade the following: headlands, bays, cliffs, caves, arches and stacks. Add this information to your legend.
   (b) Label where you think wave refraction might occur along this coastline.
   (c) Use another colour to show where you think this coastline may have been 200 years ago. How do you know that the coastline was further out to sea?
   (d) Describe what will happen to these coastal features over time. Try to predict which features might be the first to erode further and justify your choice.

9. To see more aerial photographs of Purbeck, visit the website for this book and click on the Isle of Purbeck weblinks for this chapter (see ‘Weblinks’, page vii).

Worksheet
4.1 Coastal processes
Constructive waves are responsible for building up coastlines by carrying sediments to the shore and depositing them. Some of the features formed by deposition include beaches, dunes, spits and tombolos.

**THE FORMATION OF BEACHES**

Beaches are formed when material is brought to the shore by waves in the swash. The material can be sand, stones, pebbles or other coarse substances. Eroding cliffs can be the source of this material as can rivers transporting sediment. Parts of the beach may always be under water; other sections may always be dry. The intertidal part of the beach is submerged at high tide and exposed during low tide. A sand ridge on a beach is called a *berm*.

**SPITS AND TOMBOLOS**

The process of longshore drift moves sand and other material along a beach. If this drift occurs predominantly in one direction, sand may build up and form an extension of the coastline. This extension is called a spit. A spit can sometimes join two land areas. This type of spit is called a *tombolo*.

Longshore drift along the north-eastern coast of Australia is responsible for creating great sand islands such as North and South Stradbroke, Moreton, Bribie and Fraser. These are also known as giant spits, or megaspits.
**SAND DUNES**

Sand dunes are formed by the wind when dry sand is blown to the back of the beach and trapped. The initial dune is called the *foredune*. Behind the foredune, *backdunes* may develop. Grass such as spinifex usually traps the sand. Over time, other forms of vegetation, such as shrubs and trees, will grow and help to stabilise the backdunes.

Stable and well-vegetated dunes are a barrier to erosive waves, stop sand from being blown inland, and act as a buffer zone that protects land and property. Dunes and dune vegetation are easily damaged by human activities such as pedestrian traffic or trail bikes. Board and chain walkways can provide access for people, while allowing dune vegetation to establish or regenerate.

**Activities**

Understand
1. Explain the difference between constructive and destructive waves. How do constructive waves build coastlines?
2. Draw a profile of a beach from the sea to a sand dune. Label the following: intertidal zone; berm; direction of sand movement with constructive waves; direction of sand movement with destructive waves.
3. Describe the difference between a spit and a tombolo.
4. Study the photographs of the spit and tombolo. Draw a sketch of each photograph to describe how longshore drift has formed each feature. Label the likely direction of longshore drift in each case.
5. Study the map. Use information about longshore drift to explain why the Queensland sand islands are all similar in shape.
6. Read the text and study the diagram of sand dune vegetation.
   (a) Explain the role of vegetation in dune formation.
   (b) Describe the conditions with which dune vegetation needs to cope.
   (c) List some adaptations that help plants to survive in dune environments.
   (d) What might be the consequences of removing vegetation from dunes?

**Design and create**

7. Create your ideal coastline! Include both erosion and deposition features in your plan. Draw a map of your coastline, making sure you apply BOLTSS. Present your coastline as a 3-D model, a PowerPoint or multimedia presentation, or a poster with photographs.

**Dig deeper**

8. Investigate the sand islands of Queensland and prepare an annotated visual display. To get started, visit the website for this book and click on the Sand Islands weblink for this chapter (see 'Weblinks', page vii).
HOW ARE WAVES FORMED?

Waves are formed in the ocean and may originate thousands of kilometres away from the beach. Waves are usually formed by the wind blowing over the ocean. The size of a wave depends on the:
- wind velocity. Wave height increases exponentially as velocity increases. This is why waves associated with cyclones are larger than normal waves.
- fetch, the distance over which the wind blows
- duration of time that the wind blows.

The largest waves are produced by strong winds blowing in a constant direction for a long time over a wide expanse of ocean.

Waves vary over time and space. This is called the wave climate and explains seasonal variations in the size, character and direction of waves.

WHAT HAPPENS WHEN WAVES REACH THE COAST?

The water particles in a wave actually move in orbits within the wave. This orbital movement is interrupted by the seabed as the wave moves into shallow water. The base of the wave is slowed down by friction against the seabed while the top of the wave keeps going at the original speed. The wave becomes higher and then breaks. Waves approaching the shore break in different ways, depending on the underlying topography offshore.

- Spilling waves occur where the seabed rises gently, and the waves rise and break gently over a distance of several metres.
- Plunging waves are what surfers know as tubing waves because the waves curl over at the crest. They occur where the seabed rises steeply and waves rise and break within a few metres.
- Surging waves occur where waves run up a very steep slope without appearing to break.

RIPS

Rips are localised, fast-flowing currents that run out towards the sea. Rip currents depend on the height and duration of the waves and on the contours and shapes of the seabed. Many Australian beaches have dangerous rips. Many people have died at beaches because they did not swim in a safe area between the flags. Swimmers who are caught in a rip should not swim directly against the current. Most rips are fairly narrow, so if they swim across the main direction of the current they should soon find themselves out of the rip and able to swim back to shore. Rips also move sediments.

The orbital motion of the wave is interrupted by the seabed and the wave breaks.
Surfing using a board, or just your own body, requires the surfer to ‘catch’ the wave. Body surfing and board surfing use the energy of the wave to propel the surfer towards the beach. If you have ever watched waves, you will have noticed that water rises to a wave crest and sinks to a wave trough. In surfboard riding, a surfer stands on a board that skims along the crest of a wave. A body surfer also catches the wave crest. A big wave may bring a surfer up onto the sands of the shore.

A surfer catches the crest and energy of a wave.

The longer the fetch and the stronger the wind, the larger the waves will be. A surfer will go to the beach in the hope of catching good waves if there has been news of a storm far out at sea. The reason is that the waves from the storm are large and have travelled a long way to form a swell, which is ideal for surfing. Experienced surfers use rips to take them out to deeper water where they can catch a wave.

Popular surfing beaches in Australia include Kirra Point in Queensland, Margaret River in Western Australia, North Narrabeen in New South Wales, and Bells Beach and Cape Woolamai in Victoria. Famous beaches in other parts of the world include Jeffreys Bay in South Africa, Pipeline and Rockpile in Hawaii and Mavericks in California, United States.

Riding a giant wave off the north coast of Maui in Hawaii. Maui’s underwater topography combined with Pacific storms produce these giant waves a few times each year at a surf spot called Jaws.

Activities

Understand
1. List the factors that influence the size of a wave.
2. Use the descriptions of different types of waves and draw a cross-section of the seabed for each one. Write notes to explain each wave.
3. Use your knowledge to explain how lifesavers could save a person caught in a rip.

Think
4. Explain how surfers can use rips to their advantage.
5. Which waves and conditions are surfers most likely to chase? Why?

Dig deeper
6. Investigate where the biggest waves in the world occur. Provide some data on these. Why do they occur in these places? To get started, visit the website for this book and click on the Surf weblink for this chapter (see ‘Weblinks’, page vii).
7. Use libraries, surf magazines and the internet to investigate one surf beach in Australia and one overseas. For each one:
   • draw a map to show the location of the beach
   • describe the physical properties that make the beach popular for surfing
   • include photos of the beaches and waves. Present your findings as a poster.
Hampton Beach, in Victoria, is influenced by seasonal longshore drift. People flock to beach environments for recreational activities, modifying them to better serve their needs. The effects of these changes are often dramatic and harmful to the natural environment. The solutions are generally costly. Hampton Beach provides an insight into natural coastal processes and how human interference can both degrade a coastal region and also reverse coastal degradation.

In summer at Hampton Beach, sand moves north-west towards Green Point. In winter, sand moves south-east towards Picnic Point (see page 82). The construction of Sandringham Harbour interfered with this natural process. It caused sand to build up in the harbour during winter, posing a threat to boats moored in the marina. It also prevented sand being redistributed to Hampton Beach during the summer, making the beach less attractive to beach-goers.
Severe storm activity in 1934 caused considerable erosion of the beach and damaged yachts and fishing vessels. At the time, it was feared that Beach Road and nearby homes would be damaged. A stone wall (see page 94) was built to protect the road and residential developments from further threats. In the 1950s, a stone breakwater (see page 95) was added to ensure that Sandringham would be a safe harbour and that vessels within would be protected from storm activity.

These actions, though well-meaning, were disastrous for the beach environment. The eroding foreshore was previously a vital source of sand for the beach. The interruption of seasonal longshore drift meant that eroded material was moved into the harbour and deposited during winter but could not then move in the reverse direction in summer.

By the 1970s, the beach had completely disappeared. The sea wall was also suffering extreme damage, requiring frequent and costly repair. In addition, constant maintenance was needed to prevent the harbour from being choked by sand.

**TECHNOLOGY HOLDS THE KEY**

The local community became alarmed at the range of problems facing Hampton Beach. Those with vision realised that careful planning could see the return of this once popular beach. Several studies were undertaken to ensure that the best possible results were achieved. Every effort was made to carefully think through decisions and thoroughly consider all possible environmental impacts. Mistakes caused by quick decision-making and insufficient attention to long-term environmental effects were avoided. The aim was to restore Hampton Beach as a sustainable beach, while taking full account of aspects such as access, traffic, the marine ecosystem, water quality and stormwater management.

Computer technology was used to model coastal processes. In this way, known variables associated with wave and wind action in Port Phillip Bay could be taken into account. Using the computer model, planners were able to simulate the redevelopment of the beach. This allowed them to consider alternative strategies and alignments for the construction of groynes and to establish their ideal lengths.

Two rock anchor groynes (see page 94) were built to protect the beach from the seasonal variations in longshore drift. These groynes also housed stormwater drains within them, which were hidden from public view. Two smaller timber groynes (see page 94) were built to provide extra stability for the beach region.

To restore the beach, sand was dredged from a site 350 metres south-west of the Sandringham breakwater. This site was chosen because of its coarse sand, which was more likely to remain in place and not be washed or blown away.

During **beach renourishment**, approximately 160,000 cubic metres of sand was pumped into specially constructed compartments along the beach. This meant sand could be directed to the right area. The process began on 15 September 1997 and continued around the clock for ten days.

**THE END RESULT**

Today, Hampton Beach has been restored, although its appearance is somewhat different to that of 100 years ago. The shoreline is protected, and massive revegetation programs (see page 95) were carried out. Ongoing environmental monitoring confirms that the delicate marine environment has not suffered any adverse effects as a result of the works. With careful planning, people can live in harmony with nature, enjoying all its benefits and beauty. People can also do a great deal to solve environmental problems created by past actions.
The end result of the beach renourishment program at Hampton Beach
One of the two rock anchor groynes constructed at Hampton Beach
Hampton Beach on Port Phillip Bay, Victoria
Stone wall protecting Hampton Beach
One of the timber groynes at Hampton Beach
Revegetation on the foreshore at Hampton Beach
The breakwater at Hampton Beach with the marina in the background
Activities

Understand
1. Describe the seasonal longshore drift that occurs at Hampton Beach.
2. What happened to sand movement before the harbour was built? Outline how this situation changed.
3. Why did people decide to interfere with the natural processes at Hampton Beach? Describe the action taken.
4. Suggest why the problems at Hampton Beach could not be fixed simply by replacing the lost sand.
5. Estimate the current width of Hampton Beach.

Communicate
6. Use the information in the text to develop a timeline of the changes to Hampton Beach.
7. With the aid of a diagram, explain how groynes help to trap sand on a beach.

Use ICT
8. Imagine you are filming a documentary on coastal changes in Victoria. The current episode is the change to Hampton Beach. Prepare a detailed script, including picture boards, describing how Hampton Beach changed over time. Develop this as a multimedia or PowerPoint presentation.

Dig deeper
9. Many beaches around Australia have been altered by human interference. Research another coastal area that has been changed by human activity. Prepare a report, including maps, detailing:
   • the location of the beach and a description of it before it was changed
   • changes people made and how these affected the environment
   • strategies that were used, or could be used, to repair the damage. Evaluate the effectiveness — or likely effectiveness — of these strategies.
All levels of government have some responsibility for coastal management. Traditionally, under the Australian Constitution, the states have the greatest power over the use of the coastal zone. However, responsibilities are fragmented and often overlap.

People have different and often conflicting perspectives about how the coast should be used and managed. There are various stakeholders, including local, state and federal governments, the community, environmental groups, local businesses, and recreation and sporting associations. Before development applications can be approved, an environmental impact statement (EIS) must be prepared. An EIS shows the likely impacts on the physical environment as well as social and economic impacts. The study is distributed and responses invited. The challenge is to resolve the conflicting perspectives of the stakeholders.

**COASTAL EROSION**

Attempts to control erosion can often speed up the process. Constructions such as seawalls interrupt natural cycles of erosion and deposition. Beaches eroded during storms are often naturally replenished in calmer weather with sand coming from:
- nearby beaches
- nearby sand dunes
- eroding cliffs
- deposition from constructive waves.

A number of solutions are available for councils and residents to reduce the amount of erosion along a beach. Some of these are shown in the table on page 98.

**COASTAL POLLUTION**

Australia’s coastline is highly populated and heavily used. As a result, coastal environments and species are vulnerable to pollution. Run-off and discharge from the land includes stormwater, sewage, industrial waste and agricultural fertilisers and pesticides. Ships can cause pollution through oil spills and by discharging bilge water. Sometimes wastes of various kinds are illegally dumped at sea.

Storm erosion claims a house in Wamberal Beach, New South Wales in 1978. A second house on the left was lost later in the evening during high tide. A house to the left of these was saved by being relocated during the storm.

**Litter**

Plastic litter causes a major problem, as it can stay intact for many years. It does not biodegrade. Australians currently use nearly seven billion plastic bags every year, many of which find their way into our waterways. Animals and birds can choke on, swallow or be strangled by plastic litter.

Most litter along Australia’s coasts comes from the land — carried down stormwater drains or carelessly discarded. In recent years, initiatives such as volunteer clean-ups have increased public awareness of the problem, and alternatives to plastic shopping bags are a positive move.

Also needed is a better understanding by the general public that any pollutants poured down a sink or drain will eventually run into the sea.
CHAPTER 4: COASTAL MANAGEMENT

POLLUTION AT GUNNAMATTA BEACH

Gunnamatta Beach is located on the Mornington Peninsula south-east of Melbourne, Victoria. The Eastern Treatment Plant is located at Bangholme and it treats effluent that is then discharged at Boags Rocks near Gunnamatta. About 42 per cent of Melbourne’s sewage — or 450 million litres every day — is discharged at the site.

Reports of sickness from people swimming and surfing at the beach have prompted groups to demand that the facility be upgraded to produce cleaner effluent. A plume of flowing effluent can be seen leaving the pipe. Some people have reported brown-coloured water and an unpleasant smell.

People protesting about pollution at the outfall pipe

Melbourne Water is responsible for the treatment plant and outlet pipe, and the Environmental Protection Authority regularly tests the water from the pipe. Local residents, surfers and swimmers would like the plant to be upgraded to produce cleaner effluent. But Melbourne Water would like to wait for the results of a feasibility study being conducted into building a large effluent pipeline to Gippsland for use as recycled water.

Activities

Understand
1. In Australia, who has responsibility for looking after coastlines? Why might it be difficult to make decisions about the management of coastlines?

2. What is an environmental impact statement (EIS)?

Design and create
3. In groups, design and develop a persuasive advertisement to influence shoppers to stop using plastic bags. Will you shock, amuse or appeal to people’s logic and commonsense?

Think
4. Imagine you are planning a meeting about the outfall pipe at Gunnamatta. Make a list of the possible stakeholders and record what their views might be.

5. Should an EIS be prepared for Gunnamatta Beach? Justify.

6. Identify the different perspectives there might be about the storm damage at Wamberal Beach.

Dig deeper
7. Research another coastline that is being affected by pollution. Describe management strategies that could be put into place to reduce the pollution.

Worksheets
4.2 Managing a coastal national park (Hinchinbrook)
4.3 Coastal pollution
# Possible management solutions to reduce the impacts of erosion

<table>
<thead>
<tr>
<th>Solution</th>
<th>Description</th>
<th>Diagram</th>
<th>Advantages</th>
<th>Disadvantages</th>
</tr>
</thead>
<tbody>
<tr>
<td>Beach renourishment</td>
<td>The artificial placement of sand on a beach. This is then spread along the beach by natural processes.</td>
<td><img src="image1" alt="Diagram of Beach Renourishment" /></td>
<td>Sand is used that best matches the natural beach material. Low environmental impact at the beach</td>
<td>The sand must come from another beach and may have an environmental impact on that location. Must be carried out on a continuous basis and therefore requires continuous funds.</td>
</tr>
<tr>
<td>Groyne</td>
<td>An artificial structure designed to trap sand being moved by longshore drift, therefore protecting the beach. Groynes can be built using timber, concrete, steel pilings and rock.</td>
<td><img src="image2" alt="Diagram of Groyne" /></td>
<td>Traps sand and maintains the beach.</td>
<td>Groynes do not stop sand movement that occurs directly offshore. Visual eyesore</td>
</tr>
<tr>
<td>Sea wall</td>
<td>Structure placed parallel to the shoreline to separate the land area from the water</td>
<td><img src="image3" alt="Diagram of Sea Wall" /></td>
<td>Prevents further erosion of the dune area and protects buildings.</td>
<td>The base of the sea wall will be undermined over time. Visual eyesore Will need a sand renourishment program as well. High initial cost Ongoing maintenance and cost</td>
</tr>
<tr>
<td>Offshore breakwater</td>
<td>A structure parallel to the shore and placed in a water depth of about 10 metres</td>
<td><img src="image4" alt="Diagram of Offshore Breakwater" /></td>
<td>Waves break in the deeper water reducing their energy at the shore.</td>
<td>Destroys surfing amenity of the coast. Requires large boulders in large quantities. Cost would be extremely high.</td>
</tr>
<tr>
<td>Purchase property</td>
<td>Buy the buildings and remove structures that are threatened by erosion.</td>
<td><img src="image5" alt="Diagram of Purchase Property" /></td>
<td>Allows easier management of the dune area. Allows natural beach processes to continue. Increases public access to the beach.</td>
<td>Loss of revenue to the local council Possible social problems with residents who must move Exposes the backdune area, which will need protection. Cost would be extremely high. Does not solve sand loss.</td>
</tr>
</tbody>
</table>
Conducting a roleplay and discussion
Open discussion is one way to resolve conflict. Imagine that a severe storm has eroded the coastline north of Hampton Beach. Several houses are now close to the edge of the dunes. You are attending the council meeting where discussion is on the proposal: ‘That immediate action be taken to control erosion and funds be provided from local council rates’.

Seven members of the class select a role from the boxes. The rest of the class play the role of news reporters and record the views heard at the meeting. Use the information in the table on page 98 to help you.

After all the speakers have presented their views, all class members vote for or against the proposal. Record the vote and discuss the following:

1. Are members of the public generally able to evaluate a problem such as the one in the role play? How do personal circumstances affect people’s views?
2. Are there other individuals or groups who should be consulted about this problem? Name them.
3. Do you think a compromise solution could be reached? Give reasons for your answer.

Ellie Elect — Minister for Conservation and the Environment
You are at the meeting to represent the state government. Your presence is important to your party as decisions may affect your government. You are sympathetic to the concerns of the residents and express this in most sincere terms. You also see the value of tourism to this coastal area and understand that it should be preserved. Also, further loss of beach and homes would produce negative publicity for the government nearing election time. However, most of the proposals will cost a lot of money and it is inevitable that the local council will apply to the state for funding under an emergency assistance scheme. Your department does not have the funds to help at the moment. After the election, and with a new budget, you may be able to give a more positive response. At present, you must convince the meeting of the need for further study into the most appropriate scheme and that more time can be taken to reach a decision.

Belinda Builder — engineer
You are an expert in the field of engineering, especially relating to marine projects. You have studied this coastal area extensively and believe it is possible to stabilise the dunes for renourishment projects. This would stabilise the dunes for a combination of a sea wall and beach fill up and a building on the negative publicity the council will receive if more homes are threatened or lost. The attraction for tourists is also important to the council.

Lou Loner — local inland resident
You moved to this area many years ago seeking a quiet, peaceful lifestyle, away from busy Melbourne. Your house is two kilometres inland from the coast and not threatened by erosion. You also take walks along Hampton Beach, which is not under threat of disappearing. You believe that the people who built or bought houses so close to the beach should have considered the question because it means your rates will need to increase to pay for them. You are also concerned about the possible reduction in tourists to the area.

Grant Green — conservationist
You sympathise with residents whose homes are located on the eroding foreshore, but are concerned that most of the schemes proposed will interfere with nature. It is natural for a beach to erode. In doing so, sand and other material is transported to other beaches, which build up material is transported to other beaches, which build up. There is also no guarantee of an environment that will supply the sand, groynes, and offshore breakwaters and environments that will supply the sand, groynes, and offshore breakwaters.

Des Agree — chairperson
You are a local councillor, sympathetic towards the home owners on the dune, but also aware that the council does not have sufficient funds to meet the requirements of the schemes outlined. You will listen carefully to the speakers and ask further questions where necessary. After a brief summary at the end of the presentations, you will conduct a vote among the audience for and against the proposal, arguments presented.

Helena Holliday — regular visitor
This is a location you visit for holidays each year. It is attractive to you because of its proximity to Melbourne and do so twice each day. You are concerned about the erosion, as it destroys the very beach you come to enjoy. You would like the council to undertake any measure to protect the beach. If it is not done, you will stop coming for holidays and think others will do the same.

Cliff Tapper — foredune resident
You are one of the many residents who have homes along the eroding dune. You are concerned about the safety of the beach, especially as it is popular with holidaymakers and tourists. You are also concerned that losing the beach amenity will reduce tourism and therefore reduce income for the local area. If the erosion is not stopped, many buildings will eventually be destroyed. You believe the council is partly to blame for granting building permits on these sites. You also feel that local governments have responsibility to protect ratepayers from such disasters.

CHAPTER 4: COASTAL MANAGEMENT

99

SKILLS essentials

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4.8

FIELDWORK: INVESTIGATING A COASTAL ENVIRONMENT

Geographers are interested in where things are, why they are there and how humans interact with the environment. Conducting fieldwork allows us to apply skills and techniques such as observing, measuring, collecting and analysing primary data. By investigating coastal processes and human impacts in the field, we can understand the importance of actively and responsibly managing a coastal area.

Activities

Pre-fieldwork activities
1. Decide on the main focus or aim of the fieldwork, for example:
   - How has the coast changed over time?
   - What impact have people had on the coast over time?
   - How can the coast be sustainably managed?
   - Should development continue in the coastal area?
   - What are the effects on local ecosystems?
   - How can the dunes be restored?
   - Has everyone access to the coastal areas?
   - What are the roles of individuals, groups and governments for a more sustainable coast?
2. Discuss human interactions over time in coastal areas — from indigenous people to a future scenario.
3. Take notes from videos, and research current coastal issues from newspapers, journals, CD-ROMs and websites to obtain perceptions from different groups — for example, sewage outfall and the building of high-rise apartments on foredunes.
4. Complete activities using topographic maps and geographic information systems (GIS). Calculate the density of features, such as homes around coastal areas. Calculate the local relief, identify the aspect of slopes, measure bearings, draw a cross-section, calculate the gradient of slopes, construct a vegetation transect and a land use map. Identify and locate physical features (such as cliffs and beaches) and human features using latitude, longitude, and area and grid references.
5. Read and interpret weather maps. Identify the main effects of the weather on the natural and human elements of the local environment. Investigate local weather patterns and their effects on the formation of constructive and destructive waves.
6. Construct and interpret graphs and statistics, such as population change over time.
7. Collect and use digital images showing the impacts of people on coasts, the changing coastal process (before and after a storm) and how people have improved a coastal area (for example, the Clean Up Australia campaign, revegetation of foredunes).

FIELDWORK

The following activities will help you to observe, collect, record, analyse and interpret information. Just before you begin the activities, record the date and time, and whether the tide is high or low.

Beach environment
1. Determine wind direction with a compass or a wind vane.
2. Determine the temperature on the shoreline and on the foredune. Give reasons for the difference.
3. What fraction of the sky is covered by clouds?
4. Use a camera to record wave and weather conditions and landform and vegetation features.
5. Make line drawings of coastal landforms. Add any relevant details and label all of the features.

Longshore currents
1. Throw a paddlepop stick raft into the waves to determine the direction the current is flowing.
2. Throw in an orange at three different places along the beach. Follow each orange for one minute. Calculate how far each one travels. Compare their movements and give reasons for any differences.

Human interaction
1. List examples of human interaction on the beach.
2. List examples of human interaction in the area inland.
3. Form into groups of five students and collect ten items of rubbish on the beach. Sort it into these categories: glass, tin, paper, plastic and other. Graph the results. Which was the most common type of rubbish? Photograph some examples.
Is there evidence of beach erosion? If so, where? Photo-
7.
5.
4. Which is the best plant to hold the sand together? Explain the relationship between the size of the plant and
3. Sketch four of the plants. Explain how they have adapted to this environment.
2. Sketch the relationship between the size of the plant and its position on the dune.
1. Which is the best plant to hold the sand together? Does the amount of organic matter change as you go inland?
7. Is there evidence of beach erosion? If so, where? Photograph evidence of this.

**Waves.**
1. Are the waves breaking at right angles or obliquely?
2. Use a compass to find the direction the waves are coming from.
3. Use a compass to find the wind direction.
4. Is there a correlation between wind direction and wave direction?
5. Estimate the height of the waves.
6. What is the time between waves?
7. What is the wave shape (for example, smooth, choppy, white caps)?
8. Are the waves spilling, plunging or surging?
9. Do waves break offshore at a sand bar?
10. Can you see a rip? Where is it located?
11. Can you see a group of surfboard riders? Why are they located in that part of the surf?
12. How and why do the surfboard riders make use of wave refraction?
13. Use a thermometer to determine the water temperature.
14. How good is the water clarity (for example, clean, dirty, polluted, sandy)?
15. What evidence can you see that sand is moved in the surf?
16. Do the waves run up the beach evenly or are there any indentations (cusps) at regular intervals?
17. Estimate how far the water runs up the beach.
18. Is the beach patrolled? Where are the flags located?

**Water table on the beach**
Use a small shovel to dig a hole in the sand near the water’s edge until you reach water. Measure the distance from the top of the sand to the water table. Do this every two metres from the water level towards the foredune. Record and explain your results. Replace the sand.

**Sand dunes and vegetation**
1. Observe the plants growing on the sand dunes. Using an identification chart or book, how many of the following can you identify?
   - spinifex
   - marram grass
   - pig face
   - sesuvium
   - snake vine
   - pennyp Wort
   - beach daisy
   - native rosemary
   - pandanus
   - bitu bush
   - banksia
   - coastal wattle
   - beach bean
   - casuarina
2. Sketch four of the plants. Explain how they have adapted to this environment.
3. Draw a sketch of the sand dune showing the distribution of vegetation from the front to the back of the dune. Which plant is dominant near the sea? Which plant is dominant near the land?
4. Explain the relationship between the size of the plant and its position on the dune.
5. Which is the best plant to hold the sand together?
6. Does the amount of organic matter change as you go inland?
7. Is there evidence of beach erosion? If so, where? Photograph evidence of this.

**Headland**
1. Draw a sketch of the headland and label the following: cliff, wave-cut notch, rock platform.
2. What evidence is there that the headland is eroding?

**Sand**
1. Collect a handful of sand close to the shore. Using sieves of various sizes, sieve the sand and separate out the particles. Now look carefully for shells and other minerals. Using a magnifying glass, identify any quartz and felspar (see the sketches). Record what you observe.
2. Repeat the activity above, this time with sand from the foredune. Record what you observe.
3. What differences are there between the sand from the two locations? Give reasons for the differences.

**FIELDWORK REPORT**
Use the information you have gathered to present a report that communicates your findings to other people. Interpret the data and organise the information under headings and subheadings. Describe the weather, waves, landforms, sand dune stability and vegetation, and how people use the beach. Comment on any issues you think could be improved by better management. Include a location map and illustrate your report with sketches, graphs, diagrams and photographs.

**Activities**
**Post-fieldwork activities**
1. Contact the local council in charge of your fieldwork area. Request a copy of the council’s coastal management policy and use it to help you answer the following.
   (a) If erosion is a problem, who is responsible for repairing the damage and which methods (for example, beach renourishment, groynes) have been used? How much money has the local council spent on beach conservation in the last 20 years?
   (b) Does the community have any say in how the beach is managed? Explain your answer.
   (c) Does the council’s coastal management policy reflect an understanding of physical processes?
   (d) Are the council’s future plans for the area sustainable? Give reasons for your answers.
2. Put all of your primary and secondary data together. Process and analyse the data to answer your focus question. Present your report, for example, as a video, poster or PowerPoint. Where appropriate, propose individual and group action.

**Worksheets**
4.4 Record sheets for coastal fieldwork
The Tasman Peninsula is located in south-east Tasmania and is well known for its spectacular coastal features, created by the erosive forces of the waves. Features include very high cliffs, caves, stacks, arches and rocky platforms. The Devil's Kitchen has been formed by the action of waves, carrying sand and rock particles, wearing away at weaknesses in the rock. Vertical cracks have been attacked by waves creating deep sides of an arch. A tunnel may eventually form joining this feature with another — the Tasman Arch.

Activities

1. Name the coastal features located at the following grid references:
   (a) 685 352
   (b) 754 365
   (c) 693 169
   (d) 687 322
   (e) 773 346 (named)
   (f) 775 326 (named).

2. Briefly describe how each of the features in question 1 was formed.

3. The Tasman Peninsula was once separated from the rest of Tasmania.
   (a) What map evidence supports this?
   (b) How did the two land areas become joined?
   (c) What is the name of the feature that now joins them?

4. Describe evidence from the map to show that the eastern coast experiences stronger waves than the northern coast. Locate this area in an atlas. Is there further evidence to support this observation?

5. Use a sketch to help explain how an arch might eventually form at grid reference 698 157.

6. Why does a cartographer use a cliff symbol rather than contours in some places on the map?

7. Study the southern section of the map and give grid references for the following:
   (a) Crescent Bay
   (b) Budget Rock.

8. Locate Crescent Bay on the southern coastline.
   (a) Draw a sketch to show how waves from the south east would refract around West Arthur Head and Standup Point.
   (b) Describe how Crescent Bay would be formed. Draw a sketch to show this.

9. Look at the above photograph of erosion along the coastline.
   (a) Make an outline sketch of the photograph.
   (b) Mark in three different coastal features on your sketch.
   (c) Outline how each feature was formed.
COASTAL PROCESSES AND FEATURES

1. Name the main physical processes occurring on coastlines and one feature produced by each.
2. Describe how different waves can build and destroy coastlines.
3. Port Campbell National Park has many features produced by erosion. Two recent erosion events are shown in the following photographs.

4. Use the photographs and your understanding of erosion and wave energy to explain why these two features collapsed.
5. Name three coastal features that are built by coastal deposition.

Large stack before collapse, Port Campbell National Park

Collapsed stack in July 2005

London Bridge before the collapse of the arch, Port Campbell National Park

London Bridge after the collapse, 1990
1. List five ways that people can alter coastlines. Detail the impact each change might have on natural processes.

2. Study the diagram below showing seasonal longshore drift at Black Rock.

(a) What is the direction of longshore drift during:
- summer
- winter?
(b) Describe what happens to the sand in each case.
(c) Imagine a 1.5 metre rock wall was built at a right angle to the cliff at A, jutting out some distance into the sea. How might the beach either side of this wall change during each season? Give reasons for your answer.
(d) Draw your answer to (c) on a sketch of the diagram.

3. Study the diagrams showing different solutions to erosion on page 98.
(a) Some of these solutions have economic costs and benefits. Others have environmental costs and benefits. Describe the difference between these two types of solutions.
(b) Which solution seems most:
- economically feasible
- environmentally feasible?
(c) Use your knowledge to describe how each of the solutions will reduce erosion on the beach. Use the following terms where appropriate:
- energy
- destructive waves
- longshore drift
- deposition.

4. Conduct a survey of people on their use of the coastline. A sample survey is provided for you.
(a) Conduct a class discussion to decide if there are any further questions to add to this survey.
(b) Each student should survey ten people. Discuss who you will survey. For example, will it be only students in your year level? teachers and parents? other people in the community?
(c) Conduct the survey and pool your results with the rest of the class. Convert the ‘raw’ numbers to a percentage and tabulate the results on the blackboard or a large sheet of paper.
(d) Use these figures to draw bar graphs or pie charts showing the results of the survey. Share tasks among the class. All the data can then be displayed on the wall for the whole class to see.
(e) Use written descriptions of the graphs and maps to summarise how the people surveyed use the coast. Are these people representative of the general population? Give reasons for your answer.

Sample coastal survey

1. How often do you visit the coast?
- first visit
- once a year
- more than once a year

2. For what period do you usually stay at the coast?
- one day
- weekend
- week
- other (please specify) ........................................

3. At what time of year do you visit the coast?
- Jan.
- Feb.
- Mar.
- Apr.
- May
- June
- July
- Aug.
- Sept.
- Oct.
- Nov.
- Dec.

4. What type of accommodation do you use when staying at the coast?
- caravan
- tent
- holiday house
- rented flat/house
- motel/hotel/guesthouse
- other (please specify) ........................................

5. What means of transport do you use to get to the coast?
- car
- bus
- train
- bike
- walk
- other (please specify) ........................................

6. What activities do you participate in during your stay?
(Rank into order of usage: 1 — activity you do most; 2 — next most common activity, etc.)
- swimming
- sunbaking
- surfing
- walking
- boating
- scenic touring
- amusement centres
- sports (away from beach)
- other (please specify) ........................................

7. What attracts you to your chosen coastal location?