

# Coastal landscapes

Coasts are very dynamic places – they are constantly changing. Crashing waves, strong currents, tidal waters and hazards (such as **tsunamis**) all transform coastal landscapes. Along the east coast of England and Scotland the coast is under constant attack from the sea. In some places large waves wear away the coast at the rate of about 2 metres every year. Roads, buildings and farms tumble slowly into the sea and many villages dating as far back as ancient Roman times have disappeared.

People, too, bring about changes to coastal landscapes. These changes range from small human activities, such as walking across a sand dune, to large activities, such as building ports and sea walls.



chapter

# 4

## 4A

What forces shape coastal landscapes?

- 1 What evidence is there in Source 3.1 that this coast is changing?
- 2 What changes do you think will take place here over the next 20 years?

## 4B

How are coastal landscapes used and managed?

- 1 How is this coast being used by people?
- 2 What could be done to control this erosion to protect these homes?

## 4C

Are coastal landscapes hazardous places?

- 1 How could people be injured or killed by coastal erosion in this place?
- 2 What other natural hazards are present in coastal areas?

**Source 1** A section of road on the Holderness coast in Yorkshire, England, shows the devastating effect that coastal erosion can have on communities. Many villages in this region have already been lost to the sea.

# 4.1 Coastal landforms

Constant movements of water and wind carve coastal landscapes into an amazing variety of shapes. Geographers, who refer to these shapes as **landforms**, are particularly interested in exploring the forces that create them. To begin your own investigation into coastal landscapes, you should start by finding out the names of the most common landforms, shown in Source 3. Some of them you may have heard before but others may be new to you.

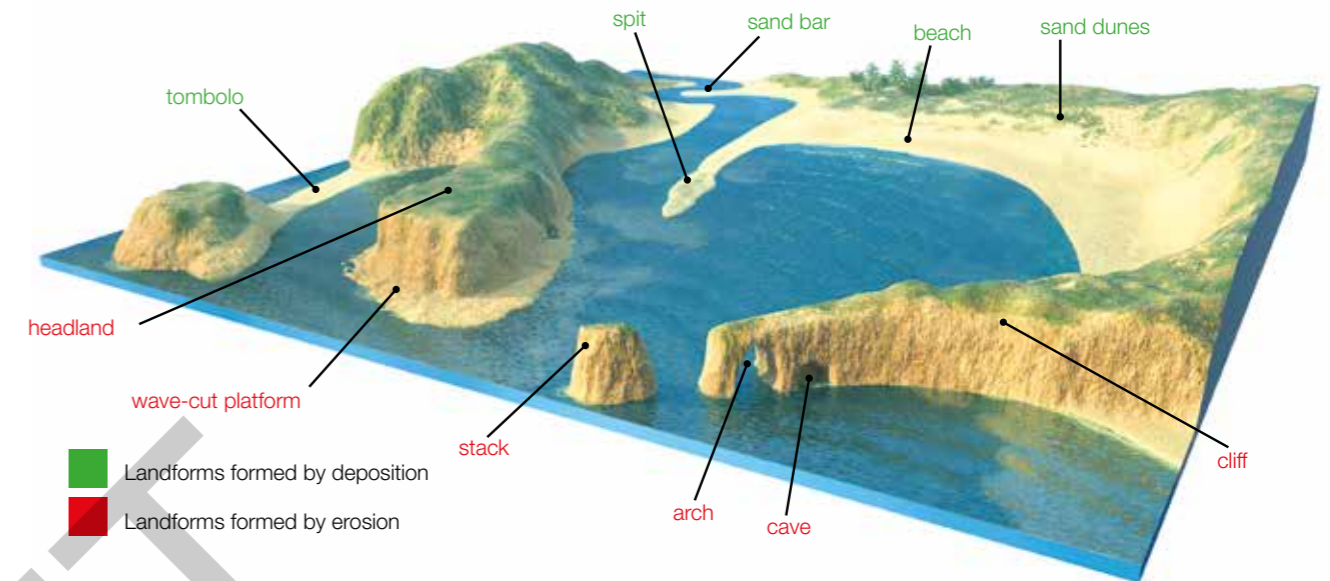
Coastal landforms can be formed in two different ways, either by **erosion** (the wearing away of land by waves and wind) or by **deposition** (the building up of land through deposits of sand and other materials). Because of these processes, there is no 'typical' or 'average' coastal landform: every **arch**, **stack**, **cave** or **headland** will be unique. There are, however, common features for each type of landform. Geographers examine and describe the similarities and differences of these features and use them to explain how they were formed. For example, Sources 1 and 2 show two Australian coastal landforms. Geographers would describe both of these landforms as headlands, despite the fact that they look quite different.



Source 1 A headland at Esperance, Western Australia



Source 2 Headlands at Port Campbell, Victoria



Source 3 Some common coastal landforms

## keyconcept: Change

### A day at the beach at Point Peron

Like all landscapes, coasts are constantly changing. During a five-hour visit to a beach, about 2500 waves hit the shore. Each wave picked up millions of grains of sand and moved them.



Source 4 Point Peron headlands

Some grains were moved further inland, some along the beach, some out to sea, and some were picked up and put back in the same place. The wind picked up millions of particles of dry sand and blew them onto the dunes. People walked through the dunes, trampling the plants and creating a wind tunnel that sped up erosion. In the course of the day, the sea level rose and fell about 2 metres as the Moon's gravity pulled the oceans towards shore and away from it, creating tides.

What makes beaches perfect for geographers to study is the rapid rate of change that takes place there. This is mainly because:

- one wave crashes about every 8 to 10 seconds and each of them changes the coast
- sand is easily eroded and deposited
- people use the coast in many ways, constantly changing it.

For more information on the key concept of change, refer to page xx of 'The geography toolkit'.

## Check your learning 4.1

### Remember and understand

- 1 How do beaches change?
- 2 What natural forces are working continuously on the coast carving new landforms?

### Apply and analyse

- 3 Describe a stack. How do you think stacks are formed?
- 4 Sketch the image in Source 2 and label four landforms.

### Evaluate and create

- 5 How have people used the headland in the foreground of Source 4? Why might this be a hazardous place to live?
- 6 Each of the three photographs in this section shows headlands. Examine each of these photographs.
  - a Based on these photographs, give a definition of a headland.
  - b What features does each share?
  - c In what ways is each unique?
  - d In pairs, discuss some geographical questions you would ask to explore why the headlands are different.
  - e Where would you find some answers to the geographical questions you have discussed?

# 4.2 The power of waves

Waves are the main force that shape coastal landscapes. Waves begin at sea when the wind blows across the surface of the water. The water surface rises along with the wind, but then is pulled back down by the power of gravity. This tug-of-war between the drag of the wind and the pull of gravity creates an **orbit** – a circular movement of water (see Source 4) beneath the surface. This orbit creates what we see as a wave.

<p><b>Spilling waves</b></p> <p>These are sometimes called 'surf breaks' and are generally found where there is a gently sloping beach. These are categorised as constructive waves because they carry sand or sediment to the shore.</p>	
<p><b>Plunging waves</b></p> <p>These are found where the shore is steep and are known for curling over as they break.</p>	
<p><b>Surging waves</b></p> <p>There are sometimes called 'dumpers' and are generally found where the bottom slope is so steep that the wave doesn't break until it is right at the shoreline. These are categorised as destructive waves because their strength can cause erosion.</p>	

Source 1 Types of breaking waves

As waves move into the shallower waters near the coast, the bottom of the orbit comes into contact with the sea bed. Friction generated on the sea bed slows the bottom of the wave more quickly than the top. The top (or crest) of the wave continues moving and finally falls forward onto the shore (much as a person can stumble and fall over, head first). The water that falls forward and moves up the shore is called the **swash**. The **backwash** is the water that runs back to the ocean.

## The impact of waves on coastal landscapes

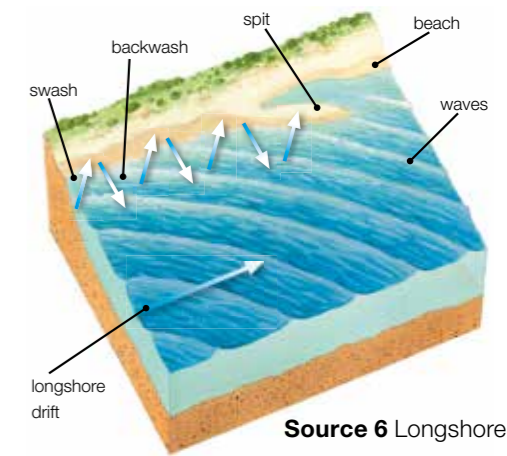
The energy in waves can travel thousands of kilometres before it is released on the coast. This energy then changes the coast in three important ways. Firstly, it erodes the coast by breaking down the rocks of cliffs and headlands into small pieces of stone or sand, eventually forming a beach. Secondly, along with tides and currents, the wave energy transports the sand out to sea and along the coast. Thirdly, the waves deposit the sand in new places, forming new beaches, spits and sand bars.

## Longshore drift

Although some waves can hit directly onto a shoreline, most waves hit the coast at an angle. This occurs because of the varied shape of the land and the varying direction of the wind that produces the waves. When the waves hit the coast at an angle, the swash picks up the sand and carries it along the beach rather than just dumping it directly forward onto the shore. The next wave that comes along will also move the sand along the beach until eventually, after hundreds of small zigzags, many grains of sand are moved to one end of the beach. They may pile up to form long deposits of material, such as **spits** and **tombolos** (see Source 3 on page xx), or the wind may change direction, causing new waves to carry sand back in the opposite direction. This movement of sand along a coast is called **longshore drift**. It is a major contributor to the shape of the coastline.

Longshore drift is also responsible for many problems faced by those people who live along the coast. The movement of sand can clog harbours and river mouths. Many coastal communities in Australia spend millions of dollars a year digging up the sand moved by longshore drift and putting it back on the beaches where local residents want it.

One of the most dramatic examples of problems caused by longshore drift can be found on England's south-eastern tip, in a town called Dungeness. Here, a nuclear power station has been built near the coast on an ancient and very large spit made of small stones called shingle. For centuries, this shingle has been shifting back and forth along the southern coast. Currently, huge amounts of the small shingle stones have to be moved to prevent the shingle from eroding. Erosion would threaten the station itself, potentially causing sea water to enter the reactor and bring about a nuclear meltdown. A meltdown would result in radioactive contamination – a disaster with devastating effects that could last thousands and thousands of years.



Source 6 Longshore drift

## Check your learning 4.2

### Remember and understand

- 1 What is the difference between swash and backwash?
- 2 How do waves begin?
- 3 Why do waves break?

### Apply and analyse

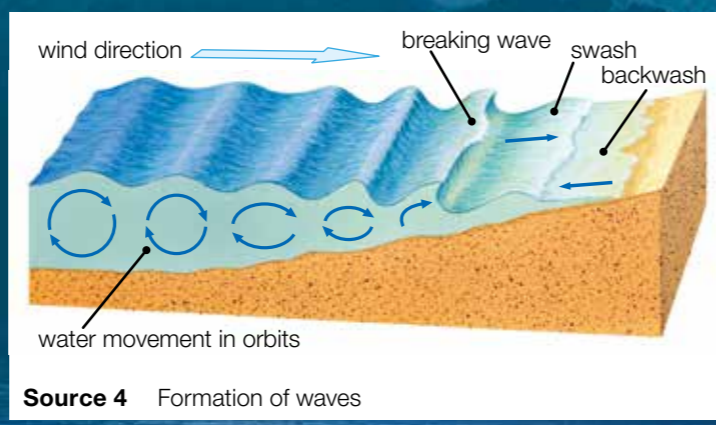
- 4 How do waves change the coast?
- 5 What do you think happens to sand on a beach where the waves strike directly onto the beach rather than on an angle?

### Evaluate and create

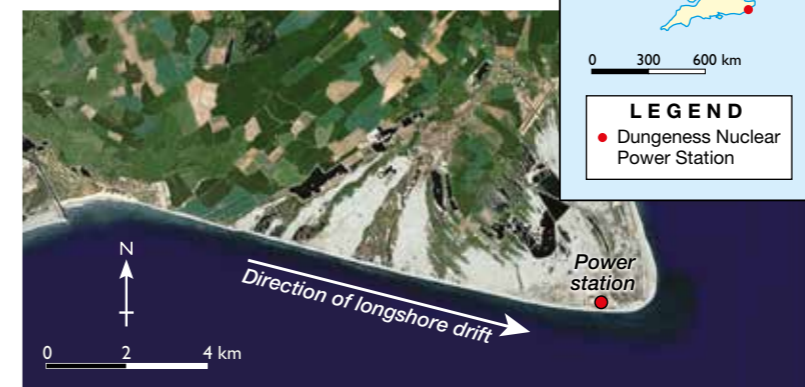
- 6 Describe the journey of a grain of sand on a beach where the waves strike at an angle.
- 7 Like many beaches around the world, Dungeness is being changed by longshore drift.
  - a What are the local authorities doing about this?
  - b Why is this particularly serious at Dungeness?
  - c Discuss with a partner some other possible solutions. Decide on your best solution and then sketch it so that you can present it to the class.
  - d When you have heard all the possible solutions from your classmates, decide on the one you consider to be the most likely to succeed. Explain why you think this would work.



Source 3 A surfer harnessing the energy of a breaking wave



Source 4 Formation of waves



Source 5 Longshore drift is threatening Dungeness Nuclear Power Station

## 4.3 Erosional landforms

Coastal landforms are created in two main ways. This is due to the fact that when waves hit the shoreline their effects can be varied. They can help to create landforms that allow plants and animals to live and thrive, or they can destroy landforms, killing plants and animals or driving them away.

The types of waves that erode and destroy sections of coast are known as **destructive waves**. Destructive waves are tall and frequent, which means they crash into the shoreline, digging out large chunks of land and eroding the beach. Their swash is weaker than their backwash, causing soil and nutrients to be drawn back into the sea rather than deposited on land.

Destructive waves begin in a large, stormy ocean. The waves travel thousands of kilometres, building up energy that is unleashed onto the rocks and sands of the coast. These waves carve the coastline into amazing shapes in much the same way that a sculptor carves shapes from a piece of marble. This process of wearing away is known as erosion, and the landforms created this way are known as erosional landforms.

A stretch of coastline close to the town of Port Campbell in southern Victoria (Source 1) provides a good example of erosional landforms. This part of Australia's coast is constantly being battered by waves from the Southern Ocean. As a result, the limestone cliffs in the area are being slowly chipped away, creating an ever-changing coast.

### 1 Cliff

Cliffs along coasts are formed by the action of waves on rock. The power of the waves erodes softer rock, leaving the more durable rock behind.

### 3 Gorge

Some caves can be hundreds of metres long. Waves entering long caves can wear away the roof, causing it to collapse and forming a deep gorge.

### 4 Arch

As waves erode the back of a cave they may penetrate right through the headland and produce an arch. Waves may pass through the arch, eroding the sides and top. The arch here (inset) has recently eroded and fallen into the sea creating two stacks (main image).

### 5 Headland

Some sections of the coastline are made up of harder rock than other sections. These can resist the energy of the destructive waves longer than the softer parts and remain as headlands – high, rocky outcrops of land.



**Source 1** A section of coastline near the town of Port Campbell in Victoria

### 2 Cave

As waves approach the coast they tend to bend around headlands and islands and attack them from the side in a process known as **refraction**. When waves encounter a weak spot in the cliff (such as a section of soft limestone) they wear away the rock. They create a small opening, which is soon enlarged into a cave. The waves can now enter the cave and erode the sides and top.

### 6 Bay

The softer parts of a coastline wear away more quickly than headlands and become bays.

### 7 Stack

As the soft rock of arches is eroded by the destructive waves, the rock above the arches eventually falls into the sea leaving behind stacks – vertical columns – of rock.

## Check your learning 4.3

### Remember and understand

- 1 Describe what a destructive wave is in your own words.
- 2 Why do some rocks erode more quickly than others?

### Apply and analyse

- 3 Study Source 1.
  - a How many caves, arches and stacks can you identify?
  - b Describe the waves in this landscape. What evidence is there that they are destructive waves?

### Evaluate and create

- 4 Predict what changes might occur in the next few thousand years in the landscape shown in Source 1. On a sketch or copy of the photograph, sketch and label the following features of a future landscape:
  - a collapsed stack
  - a new arch
  - a new stack
  - the shape of the new coastline
  - a new gorge.
- 5 This coastline is moving inland at the rate of about 2 centimetres a year. The Great Ocean Road, which you can see in the background, is about 200 metres from the coast at present.
  - a Estimate the date at which it will fall into the sea.
  - b What other features of the human environment in this region will also change by then?

## 4.4 Depositional landforms

Unlike destructive waves, **constructive waves** have characteristics that help to create landforms that allow plants and animals to live and thrive. Constructive waves are long and low which means they begin far out at sea and gently roll onto the shore, allowing for a smooth and gentle landing. In this way, soil and plants are deposited onto the shore. The swash of these waves is slow and strong, which means that materials from the sea can be brought further inland. The backwash, in contrast, is very weak, which means materials are not dragged back into the sea. In this way, a wide, gently sloping beach is formed. Plants can grow and thrive, and the animals that feed on them will settle there.

When waves are small and gentle, they do not generate enough energy to erode the land or cause great and sudden destruction. This is generally the case in bays and harbours that are sheltered from strong winds, such as Sorrento Quay in Hillarys and the sheltered beaches around Shark Bay. Sandy soil is moved from the base of cliffs and from the mouths of rivers by the action of the water. It is carried by constructive waves to new sites along the shore and gently deposited there.

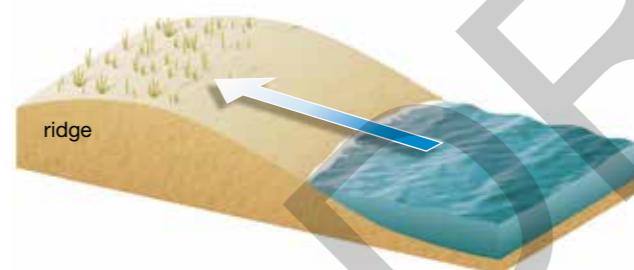
Whereas erosional landforms are the result of the removal of material from the shoreline, depositional landforms are the result of this addition of material. Constructive waves and the shapes they create are called depositional landforms.

The most common depositional landforms are beaches. A beach is formed when constructive waves carry sand, pebbles and broken coral or shells in their swash and deposit them on the shore (see Source 2). These small waves do not have enough energy in their backwash to take the sand back to sea, so it remains as a beach. Storms may bring destructive waves several times a year and wash away parts of the beach, but the slow, gradual process of beach building repairs this damage.

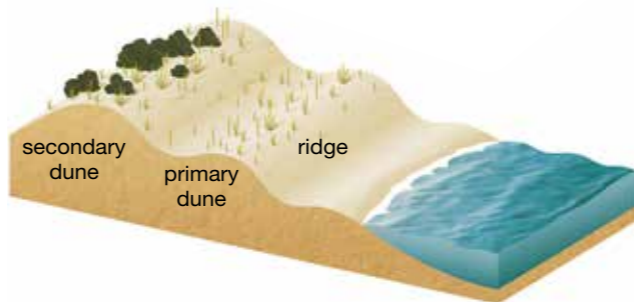
As the tide goes out, the sand dries out and the wind can then pick up individual grains and blow them inland. As the grains move, they may be trapped by an obstruction, such as plants, or they may collect in areas sheltered from the wind. As the sand piles higher it forms **sand dunes** (see Source 3). Plants grow on these dunes and hold them together, which allows even larger plants to take root and grow. But if the plants are removed,



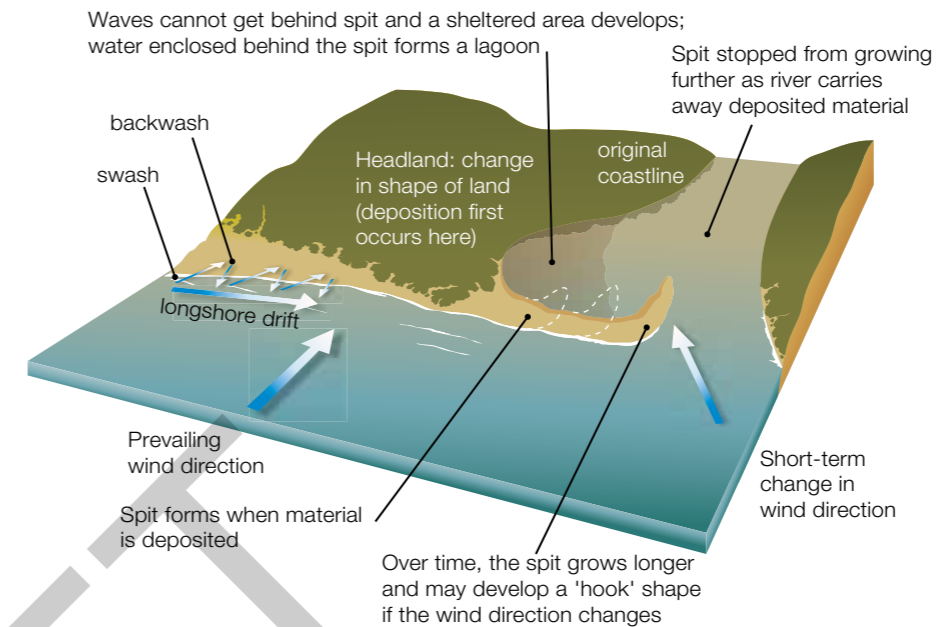
**Source 1** Shark Bay in Western Australia, is an example of a depositional landform.



**Source 2** Constructive waves carry sand onto the shore where it collects and forms a beach. Wind picks up dry sand and blows it inland.



**Source 3** Sand is trapped by plants and collects in dunes. Over time larger plants grow over the dunes, holding them together and making them stable.



**Source 4** How spits form

entire dunes can gradually move further inland, covering roads, car parks, paddocks and plants. These are called **blowout dunes** (see Source 5).

As well as moving inland, sand moves along the coast as a result of longshore drift. As sand is deposited along coasts, other landforms can be created by the forces of water and wind.

A **spit** is a long, curved landform that is built up at the mouth of a river, which is where the river widens and ends. A river carries soil and rocks from upstream in its swiftly moving water. This material is dumped at the river mouth, forming a spit. Over time further soil and rocks collect at the river mouth, making the spit larger and more secure. This more stable environment encourages the growth of plants, which, in turn, provide habitats for animals.

Some spits grow so large that a river may be forced to change its course to reach the sea. Over thousands of years, the river mouth may move hundreds of metres along the coast and a stretch of calm water behind the spit, known as a **lagoon**, is formed. These are often home to communities of plants and wading birds, such as herons and egrets.

A **tombolo** is formed when waves curve around an island close to shore and deposit a bar of sand or other sediment on the lee side of the island (the side closest to the mainland). Eventually, enough material builds up on the leeward side that a permanent connection, or tombolo, is made between the island and the mainland (see Source 3 on page xx).



**Source 5** A massive blowout dune inches its way across Fraser Island away from the beach.

### Check your learning 4.4

#### Remember and understand

- 1 Why do constructive waves tend to add sand to a beach rather than take it away?
- 2 What role does the wind play in the formation of sand dunes?
- 3 What is a lagoon and how does it form?

#### Apply and analyse

- 4 Why are waves important to the formation of a tombolo?
- 5 Is the dune in the photograph of Fraser Island (Source 5) advancing towards the camera or away from it? How can you tell?
- 6 Describe three key steps in the formation of a spit.

#### Evaluate and create

- 7 Draw a sketch map of Shark Bay (Source 1) showing the locations of sand, sea, rivers and forest. (For more information on sketch maps refer to page xx of 'The geography toolkit'.) Remember that a map is a view from above, not on an angle as in the photograph. On your sketch map, use arrows to show the movement of sand.

## 4A rich task

Mandurah,  
Western Australia

The city of Mandurah, south of Perth in Western Australia, is typical of many Australian coastal communities; it has a growing population, with thousands of people flocking to its beach in summer. However, the beaches at Mandurah have a problem – the sand there just will not stay put! For much of the year, winds approaching the coast from the south-west cause waves to strike the coast at an angle. These waves move sand northwards along the beach in the process known as longshore drift. At other times, winds from the north-west move sand away from Mandurah in a southwards direction.



**Source 1** The fieldwork site at Silver Sands beach, Mandurah

## skilldrill

## Measuring longshore drift

The coast is a popular place for geography field trips because it is possible to see and measure many of the changes that are taking place there. There are several ways to measure the forces responsible for longshore drift. You will need some equipment to do this and you will need to record your findings carefully so you can process the data back in the classroom and present your findings.

**Step 1** Measuring wind direction. Stand on the beach and feel the wind. Use a magnetic compass oriented to north (see Source 2) to determine the direction from which the wind is blowing. You may need to drop a few grains of dry sand to help you establish the wind direction. Try to establish the wind's 'average' direction. Draw a line in the sand showing this direction.



**Source 2** A magnetic compass oriented to north



**Source 3** This boy is measuring wind speed with a hand-held anemometer

**Step 2** Measuring wind speed. The device for measuring wind speed is called an anemometer. Your school's sports department may have an anemometer, as they are sometimes used to measure wind speed at athletic events. Set up the anemometer and take regular readings of the wind speed every 5 minutes over a 20-minute period. This will allow you to work out the average wind speed.

**Step 3** Measuring longshore drift. Measure and mark out a set distance of 10 metres on the beach near the water's edge. Stand at the upwind end of your marked-out area and throw an orange out into the water directly from that point. Record the time taken in seconds for the orange to move 10 metres along the coast. Divide this number by 10 to find out the rate of longshore drift in metres per second. Try this at a few different places along the beach and a few different distances from the shoreline in order to work out the average speed of longshore drift. Use your magnetic compass to work out the direction of this drift.

## Apply the skill

- List the equipment you would need to complete the fieldwork activities described.
- Why is measuring wind direction important in understanding longshore drift?
- Source 5 shows a student's notes from a field trip to Silver Sands beach at Mandurah (Source 1). Read them carefully and answer the questions that follow.
  - Calculate the average wind speed by adding together all the recorded speeds and dividing the total by four.
  - What other evidence was provided that it was windy on the day of the field trip?
  - Calculate the average rate of longshore drift. Add together the five observations and then divide the total by five.
  - Why was the sand moving northwards on the day of the field trip?
  - What other trend is apparent in the measurements of the longshore drift?



**Source 4** Mandurah, Western Australia

## Year 8 Fieldwork: Silver Sands beach, Mandurah

Date: 7 September 2012

Location: Silver Sands beach, Mandurah

Weather: Fine (no rain) a bit windy

Waves: Medium (about 1-2 metres high) and choppy

Wind Direction: South-westerly

Wind speed observation

Time	Wind speed
10.00	22 km/hr
10.15	18 km/hr
10.30	26 km/hr
10.45	14 km/hr

Longshore drift observation

Test no.	Approximate distance from shore line	Time (in seconds) taken to travel 10 metres
1	5 metres	182
2	4 metres	190
3	12 metres	228
4	20 metres	425
5	10 metres	212

Direction of movement:

Northwards

Evidence of sand movement:

I noticed that sand has banked up beside a stone wall that has been built into the sea. There was a lot of sand on one side of the wall but hardly any on the other side. When the wind blew strongly, sand was being blown along and across the beach. Some of this was blowing as far as the car park.

**Source 5** Student fieldwork recorded at the fieldwork site at Silver Sands beach, Mandurah (Source 1)

## Extend your understanding

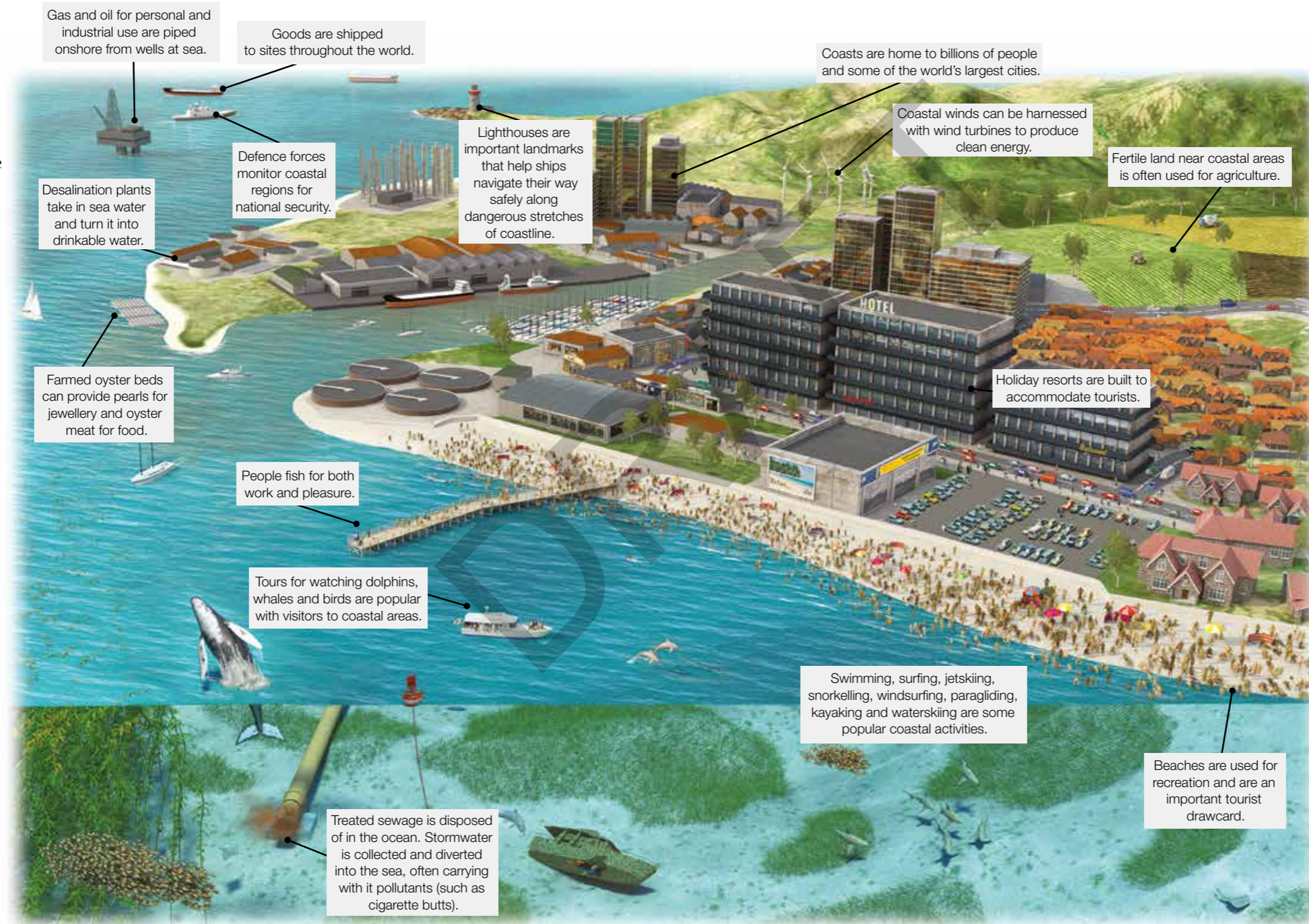
- Is Silver Sands beach being changed mainly by constructive waves or destructive waves? Give two reasons for your answer.
- Look carefully at the oblique aerial photograph in Source 4.
  - In which direction is longshore drift moving sand at Mandurah beaches in this photograph? Give some evidence from the photograph for your answer.
  - How might longshore drift affect the opening of the river in the centre of the photograph?
  - What evidence is there of measures taken to try to limit and control longshore drift?

# 4.5 Coastal landscapes have many uses

Coastal landscapes are some of the most highly populated areas on Earth. About 3.5 billion people – more than 50 per cent of the world's population – live on or near a coast. Some geographers estimate that this number will double over the next 15 years.

In Australia, this figure is already much higher – 85 per cent of us live within 50 kilometres of the sea. Many coastal towns and cities are currently experiencing rapid population growth, increasing this figure even more.

Coastal areas are used for much more than places to live. Source 1 shows some of these uses and their impacts on the environment.



**Source 1** How and why people use coastlines

## Check your learning 4.5

### Remember and understand

- 1 Name two ways in which ships and boats are used in a coastal landscape.
- 2 Which parts of the coastal landscape in Source 1 have attracted the most people? What are these people doing.

### Apply and analyse

- 3 How do you use the coast? Which of the labels on Source 1 describe ways you use the coast?
- 4 Has the artist chosen to show a coast shaped by destructive or constructive waves? How can you tell?
- 5 How does tourism change coastal areas?
- 6 Why do you think so many people live near the coast?

### Evaluate and create

- 7 Can you think of any uses of the coast not shown in Source 1?
- 8 Which activities shown in Source 1 would have no or very little impact on the natural environment? Which three would have the greatest impact?
- 9 Identify one activity shown in Source 1 that you believe has the greatest impact on the environment. Work with a partner to discuss some ways in which people could reduce the impact of this activity on the environment.
- 10 Use a street directory (or Google Maps) to examine a coastal city in Australia. Carefully examine the coastline of this city and list all the ways in which the people of the city have changed the coast or used it in some way. What are some common changes or uses and what are some surprising ones?

## 4.6 Managing coastal landscapes

The forces of nature are constantly changing coastal landscapes around the world. The shapes of beaches are changed; spits are formed; harbours fill with sand; and waves erode the coast, causing houses, roads and other structures to collapse into the sea. Cities and towns built in coastal areas are often affected by these natural processes.

The residents of coastal cities and towns around the world have responded by trying to control or manage the natural processes. Their responses differ depending on the types of forces being dealt with. For example, along depositional coastlines responses are designed to combat the presence of too much sand, while along erosional coastlines the responses are designed to combat the wearing away of the land.

### Coastal management for depositional coasts

The main issue confronting communities along depositional coasts is sand movement. For example, the sand that makes up Adelaide's beaches is gradually moving northwards under the influence of longshore drift. This is causing the beaches in some areas to become narrower, leading to waves eroding land close to roads and houses. In other areas, sand is being deposited in river mouths, blocking boat access to the sea. In Australia, the Department of Sustainability, Environment, Water, Population and Communities is trying a number of measures to address this problem.

Constructing sea walls from large rocks, concrete blocks or sandbags can slow or even stop the movement of sand along the coast. **Groynes** – walls that jut out from a beach into the sea – prevent erosion of a beach by stopping waves from pounding onto the shore, and by directing them away from specific areas of the beach (see Source 1). **Training walls** – walls on either side of the mouth of a river – are built to prevent sand from blocking a harbour or river mouth (see Source 2).



**Source 1** These groynes near Brighton Beach in Adelaide were built to protect the millions of cubic metres of sand pumped onto this beach in the 1990s.



**Source 2** Two training walls and a breakwater have helped to trap sand at the mouth of Glenelg Harbour in Adelaide.

Another method to prevent the erosion of beaches is to move sand from one place to another. This method, known as beach nourishment (or beach replenishment), may involve moving thousands of truckloads of sand every year to reverse the effects of longshore drift. In Adelaide, millions of cubic metres of sand have been dredged from the sea floor or taken from dunes in other places and trucked onto the eroding beaches.

### Coastal management for erosional coasts

In places where destructive waves are eroding the coast, communities have responded by building barriers, parallel to the coast, to prevent waves from reaching the coastline. These barriers are usually made of concrete or piles of rocks or rubble. Walls that are built out in the sea are called **breakwaters**. Walls that are built close to the coast are called **seawalls**. These barriers are designed to direct the water's force at the solid walls made of hard materials rather than the soft and easily moved sands and dunes.

While these walls may help in the short term, they can often create new problems. The energy of the wave may be deflected downwards, for example, eroding the front of the wall, weakening it until it eventually collapses into the sea. The shoreline is then left unprotected.



**Source 3** Lakes Entrance on Victoria's east coast

### Check your learning 4.6

#### Remember and understand

- 1 What are groynes and why have they been built in Adelaide?
- 2 Have the structures built at Glenelg Harbour (see Source 2) been successful in controlling the movement of sand? Give some evidence for your answer.

#### Apply and analyse

- 3 Examine Source 3 carefully.
  - a Is this an erosional or depositional coast? What is your evidence for your answer?
  - b What is the groyne designed to do? Is it working?
  - c What is the training wall designed to do? Is it working?

#### Evaluate and create

- 4 There is a large build-up of sand in the river channel at site A in Source 3. Over time it may build up further and become a danger to small boats using the river.
  - a What does this build-up of sand tell you about the river?
  - b What would you do to try to control this sand build-up? You may like to sketch your solution onto a copy of the photograph.
- 5 Draw a sketch map of a coastline that includes a groyne, training walls, seawalls and a breakwater. (For information on drawing sketch maps refer to page xx of 'The geography toolkit'.) Show these features in your map legend.



## 4.7 Caring for coastal landscapes

Many human activities are changing coastal landscapes in negative ways. Some of these changes (such as the building of new ports or holiday resorts) are deliberate, but many are accidental. A line of litter (such as fishing nets, plastic bottles and household rubbish) can be seen along the high tide mark of some beaches. The fragile vegetation on sand dunes is sometimes trampled and destroyed by thoughtless beach-goers; without the small bushes and trees that hold the dunes together, the wind blows sand further inland. Beaches are eroding, water quality is declining because of pollution and, in many places, coastal animals and plants are endangered by human activities.

Recognising that these threats exist, many people and organisations are working to preserve and protect our coastlines: from large global programs to individual volunteers who donate their time and energy. One such organisation is Coastcare, whose 60 000 volunteer members identify environmental problems in local coastal regions and work to solve those problems. Coastcare volunteers remove invasive weeds, litter and trampled plants from dune areas, and they plant new vegetation to anchor the dunes and keep the sand from blowing away.



**Source 1** Years 9 and 10 students turn a beach into an open-air laboratory as part of the Teach Wild program

**Source 2** Coastcare volunteers planting native vegetation on dunes near Darwin



Another organisation, Ocean Care Australia, is part of a global network that helps school and community groups to clean litter from coasts as part of an 'adopt-a-beach' program. Many schools, particularly those in coastal areas, have become involved in initiatives such as this.

Governments and large organisations have recognised the vital role that schools can play in educating young people about coastal issues. The Teach Wild program is just one of these. A partnership between the Australian Government (through CSIRO), Shell and Earthwatch Australia, this program enlists the help of school students to monitor the health of coastal ecosystems. As part of this program, school students collect and map debris (such as bottles, nets and other litter) found along the coast.

### Case study: saving the Fairy Tern

Many plants and animals that live in the coastal environment are under threat from human activities. One bird that is considered to be at risk of extinction in Australia, New Zealand and New Caledonia is the Fairy Tern. There are about 5000 Fairy Terns in Australia. About half of these live in Western Australia; the rest are found in a few smaller colonies, primarily in South Australia, Victoria and southern New South Wales. Fairy Terns lay their eggs and raise their chicks in open nests in sand dunes, without cover from grasses and bushes. This makes them especially vulnerable to attack from introduced predators, such as wild foxes and domestic cats and dogs. The other major threat comes from four-wheel-drive vehicles, which disturb nesting pairs and destroy nests by driving straight over them.

Those terns that nest in national parks, however, have a helping hand. The managers of national parks can make and enforce clear rules about visitor behaviour. Restrictions on where people can go, and what they can and cannot do, are designed to protect the environment and to make the area safe for terns. In Coffin Bay National Park in South Australia, for example, Fairy Tern nesting sites have been fenced off and all vehicles are banned from these areas. Dogs are forbidden and fox numbers are kept under control through the use of poison baits. The numbers of birds are monitored by park rangers and by volunteer groups, such as Friends of Parks. These measures have seen the numbers of Fairy Terns in Coffin Bay stabilise. Rangers hope they will soon increase.



**Source 3** A Fairy Tern nesting on an open beach

### Check your learning 4.7

#### Remember and understand

- 1 What are some of the problems caused by people in coastal environments?
- 2 How are the individuals and groups in Sources 1 and 2 responding to these problems?
- 3 Why are the Fairy Terns so vulnerable to attack from predators?

#### Apply and analyse

- 4 While Coastcare is a national organisation, each local group can respond differently to issues at the coast. Explain why it is important that responses differ from place to place.
- 5 What could a Coastcare group at Coffin Bay do to help protect the Fairy Tern?
- 6 What could visitors to the coast do to reduce their impact on the natural environment?

#### Evaluate and create

- 7 Parts of Coffin Bay National Park are remote and wild places where access is only possible with a high-clearance four-wheel-drive vehicle.
  - a Why do people visit wild places such as Coffin Bay?
  - b What impacts might human activities have on the natural environment?
- 8 Create a leaflet that encourages people in coastal areas to join their local Coastcare group.

4B rich task

# Gold Coast Seaway, Queensland

A good example of coastal management in action can be seen on Queensland's Gold Coast. Northward sand movement over centuries has caused the mouth of the Nerang River to be pushed north along the coast. This created a long spit sheltering a lagoon (known as The Broadwater). Although this is a natural process, it created several problems in the region. The southern tip of South Stradbroke Island was being eroded by the waters emerging from the mouth of the Nerang River, the spit was unstable and large amounts of moving sand in the mouth of the Nerang River made boating hazardous.

The solution was to build training walls at the mouth of the Nerang River to stabilise the sand and to direct the river flow away from the southern end of South Stradbroke Island. This structure became known as the Gold Coast Seaway. To move the drifting sand from one side of the seaway to the other, a 490-metre-long sand-collection jetty was built. Beneath the jetty are 10 pumps that collect the sand and pipe it to South Stradbroke Island. This sand-bypass system, which can move 500 cubic metres of sand an hour, was the only one in the world when it was completed in 1986.

**skilldrill**

## Drawing sketch maps

One of the most useful skills a geographer can master is the drawing of sketch maps. Sketch maps show the main features of the landscape that you are studying, but do not contain the details you would be expected to include on a formal map. While conducting fieldwork you will probably start with a basic outline map of the main features of the location you are studying, such as a coastline. The steps listed here are for a sketch map that you would complete as part of your fieldwork.

- Step 1** Look closely at the outline map you have been given to see if you can recognise some of the features around you. Orient your map by turning it around so that it is facing the right way.
- Step 2** Decide on the focus of your fieldwork. If you are studying the ways in which people have managed a coastal landscape, for example, you will mark on your map features such as training walls and a sand collection jetty.
- Step 3** Label the features that you recognise. Keep your writing neat and level across the page.
- Step 4** Look around the area you are studying in your fieldwork and find other examples of ways in which people have managed the coast. Locate and label these on your sketch map. You may find it best to shade large areas, such as the training walls, and to add a legend to show the shading and any other symbols you use.
- Step 5** Add carefully labelled arrows to show examples of movement. For example, in the sketch map of the Gold Coast Seaway (Source 4), an arrow shows the direction in which sand is moving. Other examples may include the movement of people, cars and water.
- Step 6** Add any examples you can find of change over time. A build-up of sand on one side of a groyne, for example, shows that sand is moving along a beach.

- A collapsed stack or a pile of rocks at the base of a cliff is evidence of erosion.
- Step 7** Add a title that includes the date, and a north arrow. (You may need to use a compass.)

Apply the skill

- 1 Create a sketch map of the area shown in Source 4. Remember that all maps show a view from directly above. On your sketch map, show how people have managed this coast.

**Extend your understanding**

- 1 Why were training walls built at the mouth of the Nerang River?
- 2 What effect did the training walls have on the direction of water from the Nerang River?
- 3 Name the coastal process that the training walls are designed to manage.
- 4 How successful have the structures been? Give some evidence from the vertical aerial photograph (Source 3) for your answer.
- 5 What evidence is there in the photograph (Source 2) that sand is moving down the Nerang River?



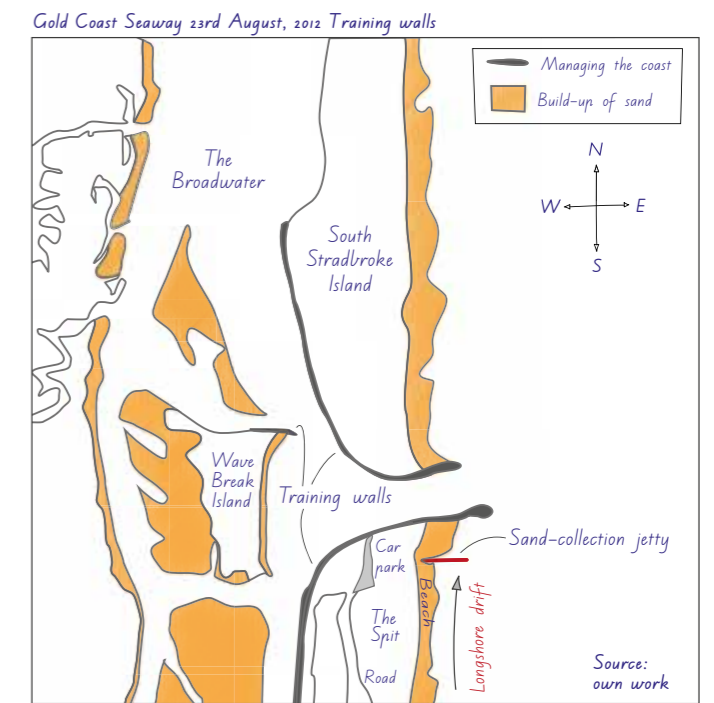
**Source 1** Aerial photograph of the Nerang River entrance, 1984. You can see how the southern tip of South Stradbroke Island has been eroded by the waters flowing out of the river.



**Source 2** An aerial photograph of the Nerang River entrance, 1985, at the beginning of the construction of the Gold Coast Seaway



**Source 3** An aerial photograph of the Gold Coast Seaway, 2002. You can see how South Stradbroke Island has built up and become stabilised with natural vegetation.



**Source 4** A sketch map

## 4.8 Coastal erosion

Waves and currents are constantly changing coastal landscapes. In some places, wave action erodes beaches and cliffs, which can create many problems for people who live in coastal communities. Many built features (such as caravan park facilities, roads, houses, walls and playgrounds) on or near an eroding coastline face the constant threat of collapsing into the sea. Most at risk are communities built on sandy coastlines, as these landforms can change very rapidly – with devastating consequences.

### Case study: Seabird, Western Australia

#### Location

Seabird is a community in Western Australia affected by coastal erosion. In Seabird, located about 100 kilometres north of Perth, structures such as houses have been built beside the beach and are threatened by the eroding coastline. Roads, paths and even the local power and phone lines are close to the beach and are in danger from coastal erosion.

#### Type and extent of damage

Researchers at Curtin University believe that one of the main causes of the erosion along Seabird's coast is the increasing number and strength of storms in recent years. In Seabird, storm waves batter the beach and scour out huge quantities of sand.

Since 2002 the foreshore has eroded by around 20 metres and in 2015 it became so bad that a road running alongside the beach crumbled into the ocean. As a result of the erosion, the town's fishing and tourism industries have declined, forcing people to relocate elsewhere.



**Source 1** Coastal erosion has caused a road to collapse in Seabird, Western Australia.

#### Planning for erosion

The residents of the Seabird community joined together to mitigate (or reduce) the impact of coastal erosion on their town. The local council at Seabird have built a \$2 million sea wall (see Source 2) in front of the threatened structures. This will reduce the strength and impact of waves that break on the shore. However, this solution is only temporary and expected to last 10 years. In the meantime, the residents constructed another short-term solution by laying down concrete matting to hold the beach together. This has not been able to prevent erosion entirely though, with front lawns of some houses still being washed away.

### keyconcept: Change

#### Future changes at Kingscliff

A study of the Kingscliff coastline in northern New South Wales has found that a strip of land 40 metres wide is vulnerable to strong storms and could be eroded to the point where it disappears entirely. This includes much of the caravan park and surf club and the entire bowling club. More alarmingly, the study found that a combination of rising sea levels due to

climate change and the natural process of erosion will threaten much greater areas around Kingscliff in the future. The authors of the study estimated the rate of erosion in this area as about 20 centimetres a year. On the satellite image (Source 3), lines have been drawn that show areas at immediate risk in a storm, areas at risk in 40 years and areas at risk in 90 years.

For more information on the key concept of change, refer to page xx of 'The geography toolkit'.



**Source 3** A satellite image of Kingscliff showing areas at risk of coastal erosion

### Check your learning 4.8

#### Remember and understand

- 1 Why are some coastal communities more at risk from coastal erosion than others?
- 2 How has the Seabird community responded to coastal erosion?

#### Apply and analyse

- 3 Examine Sources 1 and 2 showing Seabird severely affected by erosion.
  - a List any changes as a result of erosion that you can identify in these sources.
  - b Use your understanding of the way in which sand moves to explain these changes.

- c How might these changes affect local residents and holiday-makers in the region?
- 4 The community of Seabird has come up with a number of solutions to mitigate the damage of coastal erosion.
  - a How could they have been more prepared for coastal erosion?
  - b Could the community have prevented coastal erosion?

#### Evaluate and create

- 5 Examine Source 3 showing predicted changes in Kingscliff over the next 90 years.
  - a Describe the area at immediate risk from coastal erosion.

- b Use the scale to estimate the distance the coastline is predicted to move inland in the next 90 years.
- c Describe the changes to this area if this prediction is correct.
- d What natural processes may occur in the next 90 years that will make this prediction incorrect?
- 6 Imagine that you have been asked by the Seabird community to help protect their coast from further erosion by storms. They also want their beach to be attractive to tourists. What advice would you give them?



## 4.9 Rip currents

On Australian beaches the biggest threat to people enjoying the sea is being swept away by a **rip current** while swimming, and then drowning.

At least one-half of all beach drowning deaths in Australia involve rip currents (more commonly known in Australia as 'rips'). During the summer, on average, there is a death related to rip currents every two or three days. Rip currents account for more deaths in Australia than bushfires, floods, cyclones, shark attacks and **tsunamis** combined in an average summer. So what is a rip current, and how can you avoid being caught in one?

A rip current is a channel of water (like a river within the sea) that moves swiftly from the beach out towards open water. This kind of current can develop on any shoreline affected by wave action. When waves are small their swash is slow and gentle, but in rougher water waves coming into shore will push water towards the shoreline. This water needs a place to go, and will move sideways along the shore and then shoot back out to sea at the first opportunity. If there is an opening in a sand bar offshore, the water will head quickly in that direction. The resulting 'river within a sea' will usually travel at about half a metre per second, but can also be several times that speed. Because this

quickly moving water appears to be quite smooth on the surface, swimmers frequently mistake these patches of water for safe, calm waters – and that is when they find themselves in great danger.

In some places, such as at Bondi Beach, rip currents are almost constant features. The rip current at Bondi Beach even has a name – the Backpackers' Express – after the many inexperienced foreign backpackers who are caught in it each year. In other places, rip currents can suddenly appear and disappear. They may stay in place for a few hours or for only a few minutes. On one day they may be at one end of the beach and the following day appear at the other end. Popular surfing beaches around Margaret River and metropolitan Perth also develop hazardous rip currents. These temporary rip currents are generally more dangerous, as beachgoers can be caught by surprise.



**Source 2** A surf life saver pulls a swimmer from a rip current. Surf life savers have patrolled Australian beaches for over 100 years and in that time they have saved more than 600 000 lives.



**Source 1** The 'Backpackers' Express' rip current at Bondi Beach, Sydney, can make this popular beach a dangerous place to swim.



**Source 3** A poster released by Surf Life Saving Australia with advice about avoiding and escaping a rip current

### Staying safe

The best way to stay safe at the beach is to avoid rip currents in the first place. Before you enter the water, watch the surf for a few minutes. Areas of calm, darker or murky water may indicate that a rip current is present. You should always swim between the flags at beaches that are patrolled by surf life savers. Surf life savers carefully inspect the beach and find a safer swimming area away from rip currents. Red and yellow flags indicate where this section of the beach is located and also show that life savers are on duty, watching swimmers and helping when needed.

### Check your learning 4.9

#### Remember and understand

- 1 What is a rip current?
- 2 What is the best way to avoid being caught in a rip current?

#### Apply and analyse

- 3 Why do you think people swim where there is a rip current rather than on a sandbank which is relatively safer?
- 4 Why do you think the Bondi Beach rip current is called the Backpackers' Express?
- 5 There are no flags on the beach shown in Source 1. What does this tell you about this beach? What does it tell you about the people who are swimming?

#### Evaluate and create

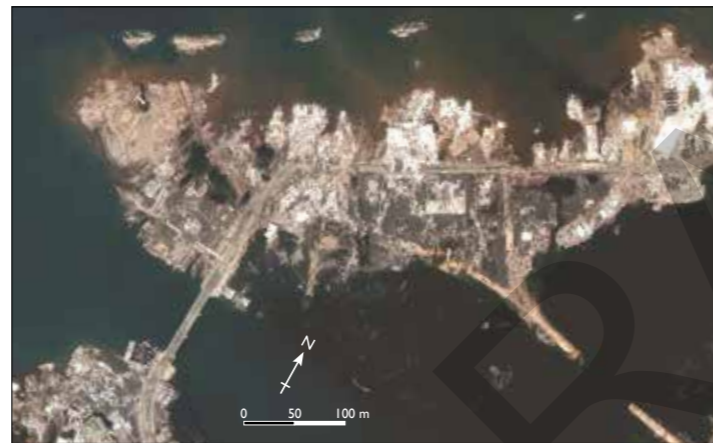
- 6 Design a sign that could be used to warn swimmers about rip currents. Use a symbol or picture rather than words on your sign to explain the danger.

# 4.10 Tsunamis

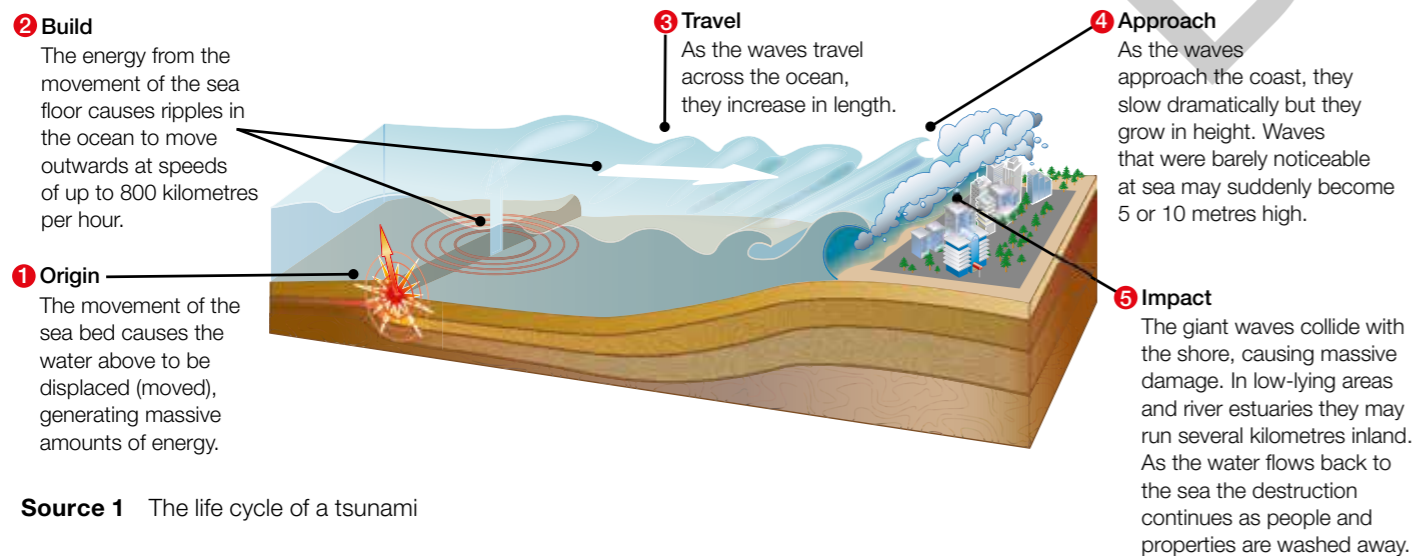
Giant waves called **tsunamis** (a Japanese word meaning 'harbour wave') are perhaps the most terrifying coastal hazard. A tsunami is created when natural events move a huge amount of water in a short period of time. The largest and most common tsunamis are created when the sea floor moves upwards during an earthquake. This causes a series of high, very broad waves to be generated. Other events that can cause tsunamis include underwater volcanic eruptions and landslides. Smaller tsunamis can be created when a large landslide reaches the sea or when large sheets of ice break off glaciers.

## Indian Ocean earthquake and tsunami (2004)

On Boxing Day 2004, a natural disaster of epic scale and force struck many of the countries surrounding the Indian Ocean. A huge earthquake near the southern coast of the Indonesian island of Sumatra triggered massive, broad waves of water that slammed into nearby coastal towns and cities, such as Banda Aceh in Indonesia. The tsunami then travelled across the Indian Ocean, sending huge amounts of water inland with tremendous force wherever it encountered low-lying coastal areas. Indonesia, Sri Lanka, India and Thailand were most affected, but deaths were recorded as far away as Somalia, Tanzania and even South Africa. By the time the tsunami had run its course, much of coastal Asia lay in ruins.



**Source 2** Banda Aceh, Indonesia, before and after the tsunami struck – 23 June 2004 (top) and 28 December 2004 (bottom)



**Source 1** The life cycle of a tsunami

### keyconcept: Space

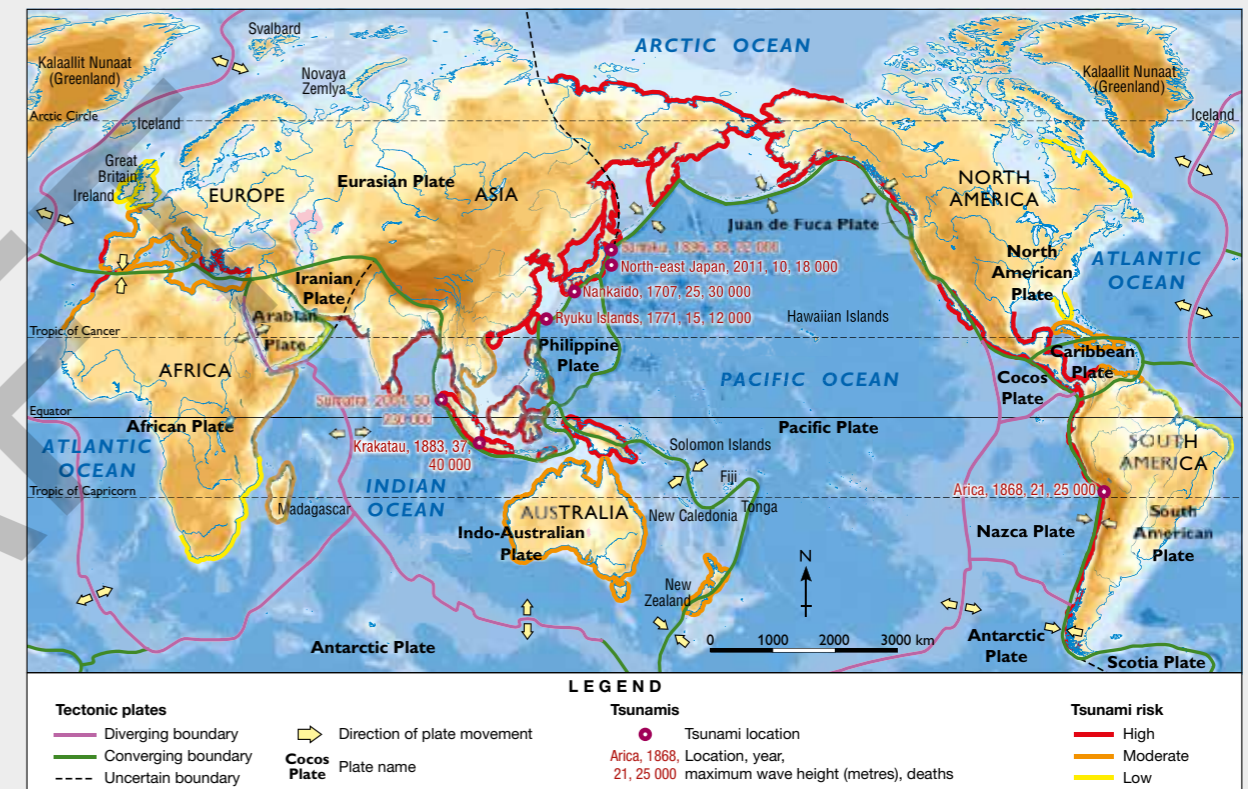
#### Where do tsunamis occur?

Geographers have noticed that some coastal areas are much more at risk from tsunamis than others. By comparing the distribution of tectonic plate boundaries, earthquakes and tsunamis, they found that coastal

areas facing a region where undersea earthquakes occur are most at risk from tsunamis. Japan is the world's most earthquake-prone country, as its east coast lies within 100 kilometres of a very active plate boundary.

For more information on the key concept of space, refer to page xx of 'The geography toolkit'.

**WORLD: TSUNAMI THREAT AND OCCURRENCE**



**Source 3**

Source: Oxford University Press

### Check your learning 4.10

#### Remember and understand

- 1 What are some of the causes of tsunamis?
- 2 In 2004, which countries were worst hit by the Indian Ocean earthquake and tsunami?
- 3 Describe how a tsunami wave changes as it approaches the coast. How do these changes make it more dangerous?

#### Apply and analyse

- 4 Study the map (Source 3). Describe the distribution of the most tsunami-prone regions of the world.
- 5 Describe the relationship between plate boundaries and the level of tsunami threat as shown on the

map. Give the names of specific places and plates in your answer.

#### Evaluate and create

- 6 Sketch the outline of the Banda Aceh coast as shown in the June 2004 satellite image (Source 2 (top)). On your sketch label five changes caused by the 2004 tsunami.
- 7 While the 2004 tsunami caused immediate damage to Banda Aceh, some of its effects will be felt for years. In a small group, discuss how tsunamis affect people and places, and classify the effects as either short term or long term.

## 4.11 Japan earthquake and tsunami (2011)

The world's largest **tectonic plate**, the Pacific Plate, is moving slowly westwards towards Japan at the rate of about 80 millimetres a year (see Source 3 on page xx). This movement causes many earthquakes and makes Japan the tsunami capital of the world. Because of the danger, many Japanese towns and cities are protected from tsunamis by high sea walls. There are also many tsunami evacuation centres built on higher ground across Japan. Japanese people, aware of the threat, are educated about ways to prepare for a tsunami event.

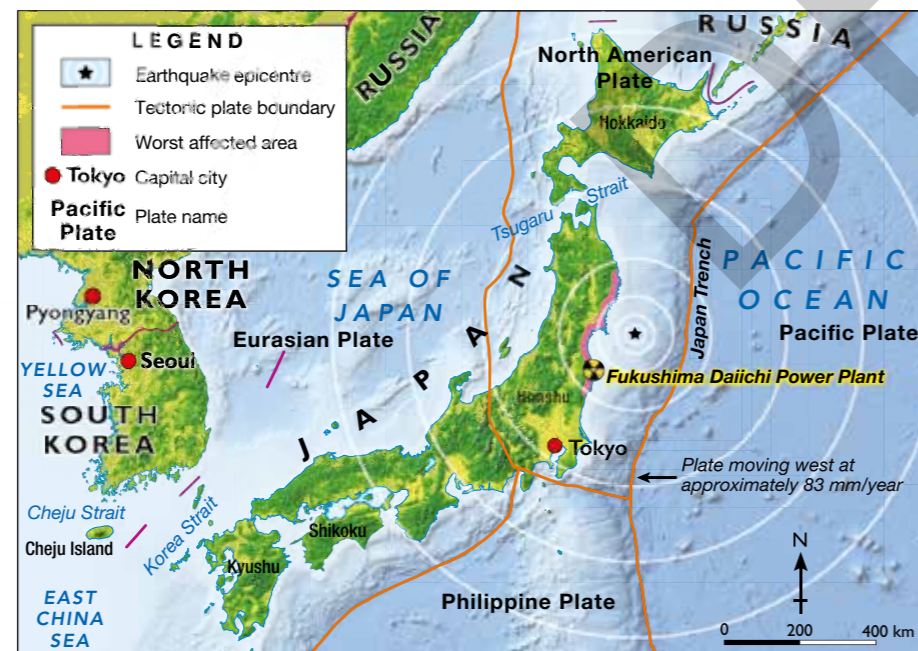
On 11 March 2011, all these preparations were put to the test when one of the largest earthquakes ever recorded sent massive tsunami waves racing towards Japan and eastward across the Pacific Ocean. Within an hour, tsunami waves up to 7 metres high reached Japan's east coast and caused immediate devastation.

The waves in some places pushed several kilometres inland. The water cascaded over the tsunami walls and washed away buildings, cars, roads and people. The damage was worst in areas close to the epicentre of the earthquake; in these areas entire towns were destroyed or entirely washed away. The movement of the tsunami waves was strongly influenced by the shape of the land, as the water tended to be funnelled into estuaries and bays. In one location, researchers found fishing equipment that had been

carried 30 metres up a cliff face, making these waves among the highest ever recorded in Japan.

In some places, the earthquake caused land to sink (subside) and this allowed the waves to travel even further inland. Almost 300 000 buildings were completely destroyed and more than 1 million were damaged. Four large shipping ports were destroyed and a further 300 fishing ports were damaged. Damage to power stations and electricity lines left more than 4 million homes without electricity. An estimated 25 million tonnes of debris was created in the earthquake and tsunami, 5 million tonnes of which was washed into the Pacific Ocean. Items such as boats and soccer balls began washing onto the west coast of North America about a year after the disaster.

JAPAN: 2011 EARTHQUAKE AND TSUNAMI



Source 1

Source: Oxford University Press



**Source 2** The 2011 Japanese tsunami destroyed everything in its path as it moved inland (from left to right)

Eleven nuclear reactors that supplied electricity in Japan were immediately shut down after the initial earthquake, but the safety systems of several of these plants were destroyed in the tsunami that followed.

This caused three of the nuclear reactors at the Fukushima Daiichi Power Plant to overheat and go into meltdown, releasing high levels of radiation into the atmosphere. In response to the disaster, all people living within 20 kilometres of the damaged power plant were ordered to evacuate their homes.

The final death toll may never be known but authorities estimate that nearly 16 000 people were killed by the earthquake and tsunami and more than 6000 were seriously injured. More than 12 months after the disaster, more than 3000 people were still listed as missing.

### Check your learning 4.11

#### Remember and understand

- 1 What event triggered the Japanese tsunami in March 2011?
- 2 What were some of the effects of the tsunami on people within an hour of the waves striking the coast? What were some of the effects that would still be felt a year later?

#### Apply and analyse

- 3 Examine Source 1. Describe the location of Japan relative to tectonic plate boundaries. How does this location make the country the 'tsunami capital of the world'?
- 4 The centre of the earthquake was about 70 kilometres from the coast of Japan. How soon did the tsunami waves reach Japan's east coast? How fast were they travelling? At this speed, how long would they take to reach California, 7800 kilometres away?

#### Evaluate and create

- 5 In the photograph (Source 2), the first tsunami wave can be seen as it moves from left to right. Describe what you think will happen in this place in the 15 minutes after this photograph was taken.
- 6 Japanese children are taught what to do if a tsunami wave is approaching. What do you think they are told to do?

## 4C rich task

## The Twelve Apostles

Victoria's south-western coastline is under constant attack from the water. Large, destructive waves from the Southern Ocean are eroding the soft limestone. Softer rocks are being eroded more quickly, while harder rocks are withstanding the attack a little longer. These harder rocks remain as stacks, arches and headlands, producing one of the world's most spectacular coasts. More than 1 million visitors a year are drawn to the Port Campbell coast, many of whom are secondary-school students who come to see and study coastal erosion in action.



## skilldrill

## Creating a field sketch

Field sketching is an important skill for all geographers. Field sketching is used to show the different geographic features of a landscape in a simple visual form. Being able to sketch the features of an environment is useful as it can provide the geographer with a visual record of their observations while in the field. Outlines, shading and annotations and labels are all used by the geographer to capture all relevant details of the environment being observed in their sketch.

For example, imagine that you are standing on the viewing platform looking at the Twelve Apostles while on a geography field trip. You have been asked to complete a field sketch with a focus on the ways in which this coast is changing. Sources 2 to 4 demonstrate how to build up a field sketch. Here are the steps to take when completing a field sketch.

**Source 1** The Twelve Apostles seen from the visitor's viewing platform

**Step 1** Establish the boundaries of your landscape and draw a border of the correct shape.

**Step 2** With a pencil, lightly sketch the main landscape lines. If there is a horizon in the scene put this about one-third from the top of the frame.

**Step 3** Keeping in mind the features that you want to focus on, add detail to your sketch.

**Step 4** Add shading. Shading helps to establish depth in your sketch and also helps to show the shape of objects.

**Step 5** Add some colour if you wish. Don't try to copy every subtle colour of nature; just give a hint of the right colour. Label those parts of the scene that you consider most important.

**Step 6** Label your sketch with the location and date.

## Apply the skill

1 Complete a field sketch of Bondi Beach using Source 1 on page xx. On your sketch label the following features:

- rocks
- beach
- swimmers
- rip currents.

Use arrows to show the movement of water towards and away from the beach.

## Extend your understanding

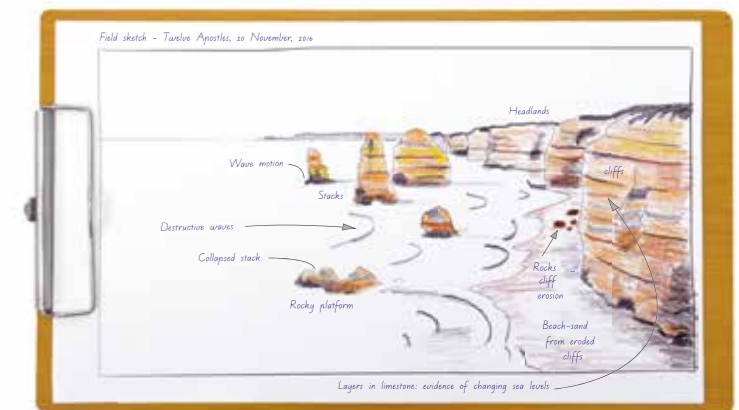
- 1 What evidence is there in the photograph that this coast is changing over time? Give some reasons for your answer.
- 2 What natural forces are bringing about these changes?
- 3 What hazards exist in this place for visitors?
- 4 How could these hazards be minimised?
- 5 If you were visiting a depositional coast on a field trip what could you sketch to show how the coast is changing?



**Source 2** Stage 1 in completing a field sketch of the Twelve Apostles



**Source 3** Stage 2 in completing a field sketch of the Twelve Apostles



**Source 4** Stage 3 in completing a field sketch of the Twelve Apostles