Coasts

A: Stoer, Scotland.

B: Morston Marshes, Norfolk.

C: Sennen Beach, Cornwall.

D: The Seven Sisters, Sussex.
The big picture
This chapter is all about the coast, where the land meets the sea. These are the big ideas behind the chapter:
- The coast is shaped and changed by the waves – and by humans!
- The waves shape it by eroding, transporting and depositing material. This gives special landforms.
- We humans change it by how we use it. (For example, for seaside resorts.)
- Along some of the coast, where the rock is soft, the sea is eroding land and homes away.
- There are ways to slow down this erosion. But they all cost a lot.

Your goals for this chapter
By the end of this chapter you should be able to answer these questions:
- What causes waves?
- How do waves shape the coast?
- What do these terms mean? 
  *erode*  *transport*  *deposit*  *longshore drift*
- What are these, and how are they formed?
  *beach*  *bay*  *headland*  *cave*  *arch*  *stack*  *stump*  *wavecut platform*  *spit*  *salt marsh*
- In what ways do we use the land along the coast? Give at least five examples.
- Why is the coastline eroding fast, in some parts of the UK?
- What can we do, to protect land and homes from coastal erosion?
- Why can’t we protect all the places that are at risk of erosion?
- What is the government’s strategy, for fighting coastal erosion?

And then …
When you finish the chapter, come back to this page and see if you have met your goals!

Your chapter starter
Page 12 shows places on our coast.
What’s the coast?
What can you do there?
How far do you live from the coast?
Why does it look so different in different places?
Waves and tides

In this unit you'll learn what causes waves and tides, and begin to find out how waves affect the coast.

What causes waves?
Waves are caused by the wind dragging on the surface of the water. The length of water the wind blows over is called its fetch.

Did you know?
- The prevailing (most common) wind in the UK blows in from the south west.

When waves reach the coast

Out at sea, the waves roll like this. In a gale they can be over 30 metres high!

They break in shallow water, like this. The water that rushes up the sand is called the swash.

The water rolling back into the sea, like this, is called the backwash.

If the backwash has more energy than the swash, the waves eat at the land, dragging pebbles and sand away. (This happens with high steep waves.) But if the swash has more energy than the backwash, material is carried on to the land and left there. (This happens with low flat waves.)
Tides
Even when the sea is calm and flat, the water level is always changing. That’s mainly because of the moon. As the moon travels around the Earth, it attracts the sea and pulls it upwards. (The sun helps too. But it is much further away so its pull is not so strong.)
The rise and fall of the sea gives us the tides. Look at these photos:

Tuesday 9.00 am. The tide is in, here at Wells in Norfolk. In fact the sea has reached its highest level for today. This is called high tide.

Same day, 3.20 pm. Now the tide is out, leaving the boats resting on the mud. The sea has fallen to its lowest level for the day. This is called low tide.

High tides occur about every twelve and a half hours, with low tides in between. The drop in sea level from high to low tide is called the tidal range. It keeps changing, because the pull on the sea keeps changing as the moon moves around the Earth, and the Earth around the sun.

Your turn
1 Which three factors determine how high the waves in a place will be?
2 The arrows are winds blowing onto island X.

Which wind will produce:
a the largest waves  b the smallest waves at the coast of X? Explain your answers.
3 Now think about the waves around your own island.
a The prevailing wind in the UK is a south west wind. What do the terms in italics mean? (Glossary?)
b Explain why the south west tip of England gets some really high waves. (Check pages 140 –141.)

4 Using a full sentence, explain what these terms mean:
a swash  b backwash

5 Look at the photos on page 12.
a Which beach do you think has stronger backwash, C or D? What is your evidence?
b Which of the four places probably gets hardly any waves? How did you decide?
6 a What are tides, and why do they occur?
b Photo B on page 12 was taken at low tide. How would the scene look different, at high tide?
c Now repeat b for photo C.
d Look at photo D. Was this taken at high tide? How can you tell?

7 Now look at photo A on page 12. You are on holiday in Scotland. Two days ago you were scrambling around on the rocks – and got trapped at X by high tide! Write a really exciting entry for your diary saying how you felt, and how you were saved.
The waves at work

In this unit you'll learn how waves shape the coastline.

**What do the waves do?**
Waves work non-stop, night and day, year after year, shaping the coastline. This shows what they do.

1. They wear away or **erode** the coast. These cliffs are being eroded. (Some of the rock has already been **weathered** - broken down by weather and plants.)

2. They carry away or **transport** the eroded material.

3. They drop or **deposit** it in sheltered areas where they lose energy.

Now we will look at each of these in more detail.

**Erosion**
This is how waves wear away the coast:

They pound at the rock like a hammer. Over time, this breaks the rock up.

They force water into cracks in the rock. That helps to break it up. It's called **hydraulic action**.

They dissolve soluble material from the rock. This is called **solution**.

Chunks of rock get knocked together and worn into smaller and smaller bits. This is called **attrition**. They end up as **shingle** (pebbles) and **sand**.

They fling sand and pebbles against the rock. These wear it away like sandpaper. This is called **abrasion**.

The more energy the waves have, and the softer the rock, the faster erosion will be.
Transport
The waves carry the eroded material away. Some is carried right out to sea. But a lot is carried along the coastline. Like this ...

- This pebble is carried off the beach ...
- ... by the backwash (and gravity) ...
- ... then on again by the swash of the next wave ...
- ... off again ...
- ... on again ...
- ... and so on. Look how far it has moved from A.

In this way, hundreds of thousands of tonnes of pebbles and sand get moved along our coastline every year. This movement is called longshore drift.

Many seaside towns build groynes to stop their beaches being carried away by longshore drift. Look at this photo.

Deposition
Waves continually carry material on and off the land. If they carry more on than off — a beach forms!

Beaches form in sheltered areas. Low flat waves carry material up the beach and leave it there. Some beaches are made of sand, and some are shingle (small pebbles).

Your turn
1 Waves do three jobs that shape the coastline. Name them.
2 Describe three ways in which waves erode rock.
3 These two pebbles are made of the same rock.
   a Which one has been in the water for longer? Explain.
   b Name the process that made Y so smooth.
4 Groynes are barriers of wood or stone, on a beach. Look at the groynes in the photo above.
   a Why were they built?
   b Are they working? How can you tell?
   c From which direction do the waves usually arrive at this beach?
      i from the south west
      ii from the south east
   Give your evidence.
5 This drawing shows part of an island (not Britain).
   a The prevailing wind for the island is blowing. From where does it blow? (Look at the waves!)
   b There is no beach at A. Suggest a reason.
   c There is a good beach at B. Give a reason.
   d Where might the sand at B have come from?
6 Do you think the rock around our coast all erodes at the same rate? Give your reasons.
Landforms created by the waves

In this unit you will learn about the landforms that the waves create along the coast, by eroding and depositing material.

Sculptor at work!
This coast is made of different rocks, some hard, some soft. Once upon a time it was straight. Just look at it now!

1. Hard rock erodes more slowly than soft rock. So now, cliffs of hard rock jut out, forming a **headland**.

2. At the base of these cliffs is a **wave-cut platform**.

3. Here the softer rock has been eroded away, leaving a **bay**.

4. Another headland. Here you can see a **cave**, an **arch** and a **stack**.

**How a wave-cut platform forms**

1. The waves carve **wave-cut notches** into cliffs at a headland. These get deeper and deeper...

2. ... until, one day, the rock above them collapses. The sea carries the debris away.

3. The process continues non-stop. Slowly the cliffs retreat, leaving a **wave-cut platform** behind.

**How caves, arches and stacks form**

1. The sea attacks cracks in the cliff at a headland. The cracks grow larger – and form a **cave**.

2. The cave gets eroded all the way through. It turns into an **arch**. Then one day...

3. ... the arch collapses, leaving a **stack**. In time, the waves erode the stack to a **stump**.
Your turn

1. Make a table like the one started here. Write in the names of all the landforms you met in this unit. Then put a ✓ to show how each was formed.

<table>
<thead>
<tr>
<th>Landform</th>
<th>Created by...</th>
</tr>
</thead>
<tbody>
<tr>
<td>headland</td>
<td>erosion ✓ deposition</td>
</tr>
</tbody>
</table>

2. Make a larger sketch of the landforms in photo A.
   a. On your sketch, label:
      a wave-cut notch an arch a stump
   b. Explain how the arch was formed.
   c. Draw a dotted line to show where there was once another arch.
   d. What will happen to the stump over time?

3. Photo B shows the spit at Dawlish Warren in Devon.
   a. Make a sketch of the spit. Don’t forget to show and label the groynes, and salt marsh areas.
   b. Now, a challenge. From which direction does the prevailing wind blow, at Dawlish Warren? How did you decide? Mark the direction on your sketch.

4. This shows some coast before erosion. Make a larger drawing to show how it may look 10 000 years from now. Label any landforms, and annotate (add notes to) your drawing to explain what has happened.
The coast and us

We use the coast in many different ways. Here you can find out about them.

What do we use the coast for?

You saw how the waves change the coast. Now what about us? How do we change it? What do we use it for? Look at these photos.

A. It's great to get away.

B. This used to be a huge industry in the UK. Not now.

C. That lot is just in from China.

D. Baaa.

E. We need to be in a place where oil tankers can come in.

F. We moved here for the view.

G. Atten-shun!

H. We take sand and gravel from the sea bed, off the coast. Millions of tonnes a year... for things like road building.
Who owns it?

So who owns our coastline?

- Over half of it belongs to the state (55%).
- About 3% belongs to the Ministry of Defence.
- The National Trust has bought 1100 km of coastline. To give us all access to it, and protect it from development. It wants to buy more.
- Perhaps 20% is in the hands of private owners. For example farmers. It is hard to get exact figures.
- Local councils own the rest.

Your turn

1. Look at the photos on page 20. They show ways we use the land at the coast, and the sea off it. You have to match each photo to a term in the box below. But the terms are all jumbled. So you must sort them out first. (Start with the easy ones?)

   - mesho
   - deesias stones
   - fragnim
   - Justriny
   - gredding
   - hisginf
   - trop
   - feendec

   Give your answer like this: A =

2. Now look at this list of the UK’s largest cities. Some have ports, which helped them to grow. Which ones? The map on page 139 may help.

   - a. Some have ports, which helped them to grow. Which ones? The map on page 139 may help.
   - b. How many other ports can you name, in the UK? Try for at least two.

4. Most of us love the seaside.

   - a. How many seaside resorts can you name, in the UK? Try for at least four.
   - b. A challenge. See if you can draw a sketch map of the British Isles, from your mental map, and mark those seaside resorts on it!

5. Look again at the photos on page 20. People are at work in all those places – even if you can’t see them. They work in different sectors of the economy. Which of the photos could be used to illustrate:

   - a. the primary sector?
   - b. the secondary sector?
   - c. the tertiary sector?

   Explain your choices. (Try the glossary if you are stuck.)

6. Now see if you can name at least five jobs that people can do on the coast or at sea, but not inland.

7. The UK is one of the world’s richest countries – even if it does not seem rich to you! Its coast has helped to make it rich. See if you can explain how. (Think about what you learned in history?)

8. Are there any disadvantages in having a coastline? See if you can come up with some. Answer in any way you choose. (Spider map? drawings? bullet points?)

9. So, would you like to live on the coast? Yes or no? Explain why.

   (Or, if you live on the coast already, say how you feel about living there, and why.)

The UK’s 10 largest cities:

<table>
<thead>
<tr>
<th>Name</th>
<th>Population (millions)</th>
</tr>
</thead>
<tbody>
<tr>
<td>London</td>
<td>7.17</td>
</tr>
<tr>
<td>Birmingham</td>
<td>0.98</td>
</tr>
<tr>
<td>Leeds</td>
<td>0.72</td>
</tr>
<tr>
<td>Glasgow</td>
<td>0.58</td>
</tr>
<tr>
<td>Sheffield</td>
<td>0.51</td>
</tr>
<tr>
<td>Bradford</td>
<td>0.47</td>
</tr>
<tr>
<td>Edinburgh</td>
<td>0.45</td>
</tr>
<tr>
<td>Liverpool</td>
<td>0.44</td>
</tr>
<tr>
<td>Manchester</td>
<td>0.44</td>
</tr>
<tr>
<td>Bristol</td>
<td>0.38</td>
</tr>
</tbody>
</table>
In this unit you’ll find out about Newquay, in Cornwall, with the help of an OS map.

Meet Newquay

Look at the OS map opposite. It shows Newquay, on the coast of Cornwall.

400 years ago, Newquay was just a small fishing village. Then it became a port for shipping tin, and clay, and lead, out of Cornwall. Now it’s a seaside resort – and a surfers’ paradise.

And you are going there on holiday.

Your turn

1. Look at the OS map and photos. What do they tell you about the coast at Newquay? Is it flat? Smooth? Any beaches? See if you can write four sentences about it.

2. Find Towan Head on the map. (It’s at 7962.)
   a. What is Head short for?
   b. How was Towan Head formed?
   c. Find two other examples of this landform on the map. Give their names.
   d. What can you say about the rock in those places?

3. Photo A shows a tiny island. It’s at 811618 on the map, near the aquarium. Do you think it was always like this? Explain.

4. Look at photo B. It shows some of Newquay’s beaches. See which ones you can name, with help from the map.

5. Now, holiday time. You are off to Newquay on a five-day camping holiday, in August, with your friends.

   a. They let you pick a camp site, from the map. Which one will you choose? Give a 6-figure grid reference for it, and say why you chose it.
   b. The map gives plenty of clues about things to see and do, in Newquay. List as many as you can. Then tick the ones that appeal to you.
   c. You will go there by train. Where is the station? Give a 6-figure grid reference for it.
   d. From the station, you’ll go straight to the tourist information office, to find out about surfing lessons. About how far is the office from the station? In which direction will you walk?

6. You book some surfing lessons. They will be at Lusty Glaze beach. (It’s a good place for beginners.)
   a. You will walk to lessons from your camp site. See if you can draw a sketch map of your route. Mark in any landmarks, and say how long the route is.
   b. Lessons will start at 9 in the morning. What time do you think you’ll need to leave the camp site?

7. You see lots of other surfers. They (and other people) fly into Newquay from London, Leeds, Bristol, Dublin, Alicante, Zurich, and other cities.
   a. Find Newquay airport on the map. Give a grid reference for one square of it. (It uses St Mawgan airfield, which once belonged to the RAF)
   b. There are plans for a big increase in the number of flights to and from Newquay, in the future. In what ways will this benefit Newquay? List as many as you can.
   c. What problems might it cause?
   d. A change is sustainable if it helps us economically, and socially, without harming the environment. So we will not regret it later.
   e. Overall, do you think an increase in flights is sustainable? Give your two main reasons.
   f. Would you agree to it, if you were in charge of Newquay?

8. Home again. Now you are going to write a blog about Newquay, for your web page. Say where it is, and what it’s like, and what you did. Make it fun! What photos will you add to your page? And what about a map?
△ Lusty Glaze beach, where you'll have surfing lessons.
How long can Happisburgh hang on?

In this unit you’ll see how erosion by the waves is causing big problems in one coastal village, in Norfolk.

Waiting for the sea to arrive

Diana Wrightson has a great view of the sea, from her home on Beach Road, in Happisburgh, in Norfolk. (Pronounce it Haisbro!)

But she does not know how much longer she can stay there. A few months? A year? A few years? It depends on the sea.

Because the sea is already eating at her back garden. Not so much, in summer. But in winter, when stormy north winds blow, big chunks can disappear. And one day, her house will go too. It’s only a matter of time.

‘We had big plans to do the house up’, said Diana. ‘But now there’s no point. And we can’t sell it – it’s worth nothing! And unless things change, we’ll get no compensation either, when it topples over the cliff. It’s all a big worry.’

The people next door have abandoned their house already. Diana does not want to leave until she really has to. As winter draws near, she will watch the sea nervously. How much longer has she got?

From a conversation with Diana Wrightson, June 2008

Why is erosion so severe at Happisburgh?

1. The main problem is that the cliffs are soft – sand on top and clay below.
2. Rain soaks into the cliffs and helps to weaken them. (This is one form of weathering.) The more rain they hold, the weaker they get.
3. Meanwhile, the sea erodes the cliffs from below. Not so much in summer, when the weather is calmer …
4. … but winter often brings strong north winds, and storms. Big waves batter the cliffs, and big chunks of them collapse.
5. A line of big rocks, called rock armour, has been put in to protect the cliffs from the full force of the waves. It works – but there isn’t enough of it.
6. Groynes help to slow down erosion. (They stop sand being carried away, and the sand absorbs some of the waves’ energy.) But they can’t prevent it.
7. These wooden barriers (or revetments) were meant to slow down erosion, by making the waves break early. But they were destroyed in a past storm.
Your turn

1. What part does each play in the threat to Diana’s house?
   a. the material the cliffs are made of
   b. rain
   c. strong north winds blowing down the North Sea

   a. What are all the white objects near the top of each photo? (The OS map on the right will help.)
   b. In which compass direction was the camera pointing?
   c. Look at the wooden barriers on both photos.
      i. What are the ones at right angles to the cliffs called? What is their job?
      ii. What are the ones parallel to the cliffs called? What is their job?
      iii. On the second photo, you can clearly see another type of barrier too. What is it called?

3. a. Now list all changes you notice for that stretch of coast, between 1996 and 2007.
   b. From the photos, do you think any of those barriers:
      i. prevented erosion? ii. slowed it down? Explain.

4. Even with barriers, the cliffs at Happisburgh are eroding at a rate of about 2 m a year.

   a. Where there are no barriers, the rate is about 8 m a year.
   b. Suppose the barriers remain as in the second photo below.
   c. Based on this OS map, say how long you think it will be before the sea reaches:
      a. the church
      b. the lighthouse (which is not shown in the photos)

▲ Happisburgh in 1996. Look how far from the sea Diana’s house was then.

▲ Happisburgh in 2007. Look how many houses have gone since 1996 – and the sea won’t stop there.
The war against the sea

In this unit you'll find out where on our coast erosion is a problem, and what we can do about it.

It's not just Happisburgh!

In the last unit you saw that erosion is a big problem in Happisburgh. (Say Haisbro.) But it's not the only place.

The blue lines along the coast on this map show the main stretches that suffer from erosion. Here the sea is busy eating land away, and stealing people's homes.

<table>
<thead>
<tr>
<th>Key</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rock types</td>
</tr>
<tr>
<td>very hard</td>
</tr>
<tr>
<td>hard</td>
</tr>
<tr>
<td>medium</td>
</tr>
<tr>
<td>fairly soft</td>
</tr>
<tr>
<td>soft</td>
</tr>
<tr>
<td>where coastal erosion is a problem</td>
</tr>
</tbody>
</table>

So how can we stop coastal erosion?

Where there are waves, there will be erosion. So we can’t really stop it. But we can slow it down. By building defences that will hold the waves back, or reduce their energy.

Look at these examples. You've met most of them already.

You could build sea walls like this one, to stop the waves reaching valuable land ...

... or a barrier of rock armour (big rocks) to soak up their energy. Less energy means less erosion.

You could even build a reef of rocks out at sea, so that the waves break away from the beach.

You could try wooden revetments. The waves batter them, instead of the cliffs.

You could build groynes to stop sand being carried away. Sand absorbs some of the waves' energy.

You could even add more sand or shingle to a beach, to build it up. It's called beach replenishment.
But it’s not that simple …

So, we can slow down coastal erosion. In that case, why are places like Happisburgh being eaten away so fast? It all comes down to money.

First, coastal defences cost a lot. Rock armour like this costs about £2500 per metre. Sea walls cost about £5000 per metre.

And they don’t last forever. Look at these revetments at Happisburgh, destroyed in a storm. So you have to keep on spending.

Also, global warming is causing sea levels to rise. And causing more storms. So you must keep on building bigger, stronger, defences.

… so Happisburgh suffers

The photo on page 24 shows groynes and revetments at Happisburgh. These were built over 40 years ago. They broke down several times, and the local council repaired them. Now they are in bad shape.

For a long time, the local people have been asking for new defences. But most of the money for new defences has to come from the government. And the government said no!

People have kept on fighting for them. Some emergency rock armour was put down, to gain time. It was paid for by the council, and donations. But it is not enough.

So what will become of Happisburgh now? And the other places at risk from the sea? Find out more in the next unit.

Your turn

1 Look at the map on page 26.
   a Where in the UK is most of:
      i the very hard rock?  ii the soft rock?
   b Does the map show a link between rock type and erosion? Describe what you notice.

2 You need to tell someone (who can’t see the map) where on the coast erosion is a problem. Write down what you will say.

3 Look at the ways to slow down erosion, on page 26.
   a Which two do you think might work best? Explain your choice.
   b Which one do you think would be best good? Why?
   c Which (if any) will last forever? Explain.

4 Around 850 people live in Happisburgh village. You are one of them. Write a letter to a newspaper, saying why the government should protect Happisburgh.

5 You want to plan new defences for Happisburgh, to show the government. The little OS map on page 25 will help.
   a Show your plan as a sketch map. Mark in the length of each defence you choose. (Check the OS scale.)
   b Add brief notes to your map, to explain your choice.
   c Now work out the cost, using this list:

<table>
<thead>
<tr>
<th>Cost of coastal defences</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Sea wall</td>
<td>£5000 per metre</td>
</tr>
<tr>
<td>Rock armour</td>
<td>£2500 per metre</td>
</tr>
<tr>
<td>Sea reef (42 metres long)</td>
<td>£2 million</td>
</tr>
<tr>
<td>Wooden revetment</td>
<td>£1500 per metre</td>
</tr>
<tr>
<td>Typical rock groyne</td>
<td>£125 000</td>
</tr>
<tr>
<td>Typical wooden groyne</td>
<td>£100 000</td>
</tr>
<tr>
<td>Beach nourishment</td>
<td>£10 per cubic metre</td>
</tr>
</tbody>
</table>
Defend – or let go?

What will the government do, about protecting places from the sea? You can find out in this unit.

The defence dilemma

As you saw, Happisburgh is being eaten by the sea. And it is not alone. Many other places around the coast are suffering too. So they all want sea defences that really work. It’s a big dilemma for the government:

- We’re losing our homes ...
- ... and our land.
- Where can we go?
- It’s not our fault.
- HELP!
- You MUST help us.
- You MUST give us money for sea defences.
- Defences cost a fortune.
- We can’t afford to build them everywhere.
- We need the money for schools and hospitals and stuff.
- Anyway, the sea will win in the end.
- It always does.
- And erosion will get faster, with global warming.
- We’ll just have to let some places go.

So, who will get help?

The government has decided that some places will be protected from the sea. And some won’t.

- So we must consider the huge cost of defences, for years to come ...
- ... as well as people’s well-being ...
- ... and the environment.
- It’s tough. But if defences cost more than what they protect ...
- ... we won’t build them ...
- ... unless there’s a really good environmental or historical reason.
- We must defend the coast in a sustainable way.

What about Happisburgh?

Sadly, Happisburgh will not get money for new defences. It is a small village, with a population of about 850. Defences would cost more than the homes and land are worth. So they will be left to slip into the sea.

Now look for Scarborough on the map on page 26. It is a busy seaside town, with a population of about 106,000. It will continue to be defended. But one day, if sea levels keep on rising, even Scarborough may have to go.

What next for the people of Happisburgh?

The Happisburgh people are angry that their village will be let go. And they think they should get compensation.

- The government won’t defend us from the sea...
- If we knew we’d get money, we would not worry so much.
- We could buy a house in a safer place.
- Now the houses along here are worth nothing.
- It’s only fair.
- And it’s not even our fault.

What do you think?

**Your turn**

1. Do you agree with this person? Explain.

2. The map on the right shows the plans for defending the north coast of Norfolk (where Happisburgh is).
   - a. Some of the coastline will not be defended. What do you think is the main reason?
   - b. Name two villages that won’t be defended.
   - c. Cromer will continue to be defended, at least for now. Using clues from the map, suggest a reason. Say which clues you used.

3. a. Sea Palling has fewer than 600 people. But it will be defended. See if you can find a reason for this, from the map.
   - b. Winterton won’t be defended. What questions would you ask about it, to understand why?

**Key**

- Defend the coastline, at least for now
- Let the sea take over
- Main road
- Secondary road
- Railway
- Town
- Village
- The Norfolk Broads National Park (protected area)

4. a. What is compensation? (Glossary?)
   - b. Suppose the government agrees to compensate people who lose their homes to the sea. Where will it get the money from?
   - c. Here’s one person’s opinion. What do you think? Give your opinion, and reasons.

5. You live on Beach Road in Happisburgh. (See page 24.) You want to sell your house NOW. But no one will buy it, because of the cliff erosion. What will you do? See if you can come up with a plan.