10 Coastal landscapes

10.1 Wave types and their characteristics

On this spread you will find out about the formation and characteristics of waves

How do waves form?

Waves are formed by the wind blowing over the sea. Friction with the surface of the water causes ripples to form and these develop into waves. The distance the wind blows across the water is called the *fetch*. The longer the *fetch*, the more powerful the wave.

Waves can also be formed more dramatically when earthquakes or volcanic eruptions shake the seabed. These waves are called *tsunami*. In March 2011 a wall of water up to 40 m high crashed into the Japanese coast north of Tokyo destroying several coastal settlements and killing over 20 000 people (photo **B**).

What happens when waves reach the coast?

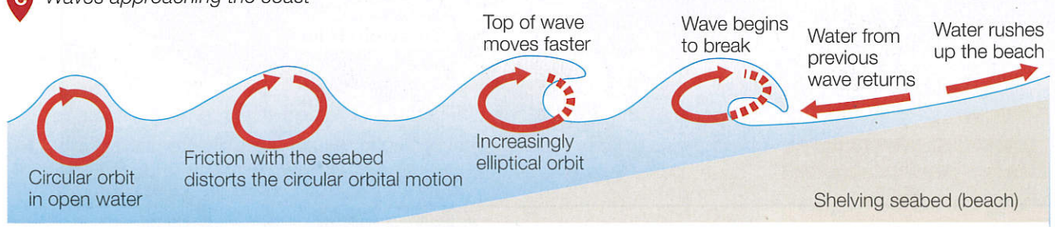
In the open sea, despite the wavy surface, there is little horizontal movement of water. Only when the waves approach the shore is there forward movement of water as waves break and surge up the beach (diagram **C**).

The seabed interrupts the circular movement of the water. As the water becomes shallower, the circular motion becomes more elliptical. This causes the crest of the wave to rise up and eventually to collapse onto the beach. The water that rushes up the beach is called the *swash*. The water that flows back towards the sea is called the backwash.

A *Surfing at Newquay, Cornwall*

B *Tsunami waves hit the coast of Japan*

C *Waves approaching the coast*

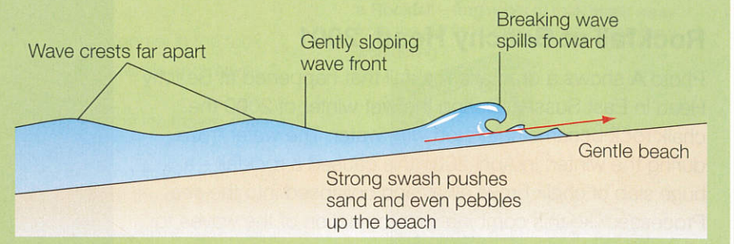


Wave types

It is possible to identify two types of wave at the coast.

Constructive waves

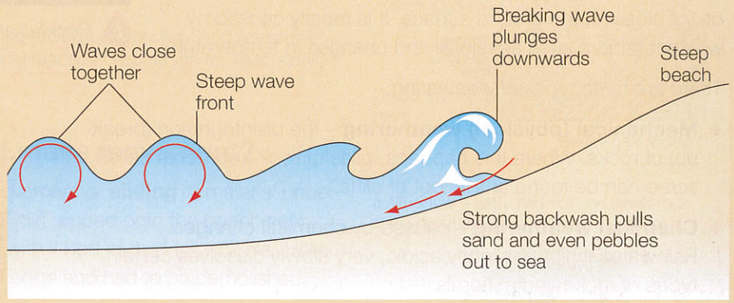
These are low waves that surge up the beach and 'spill' with a powerful swash (diagram **D**). They carry and deposit large amounts of sand and pebbles and 'construct' the beach making it more extensive. Surfers prefer constructive waves because they give longer rides (photo **A**)! These waves are formed by storms often hundreds of kilometres away.



D *Constructive waves*

Destructive waves

These are formed by local storms close to the coast, and they can 'destroy' the beach – hence their name. They are closely spaced and often interfere with each other producing a chaotic swirling mass of water. They become high and steep before plunging down onto the beach (diagram **E**). There is little forward motion (swash) when a destructive wave breaks but a powerful backwash. This explains the removal of sand and pebbles and the gradual destruction of the beach.



E *Destructive waves*

ACTIVITIES

1 **a** Copy diagram **C** and draw an arrow to show the direction of the waves.
  b Add the labels *swash* and *backwash* in the correct places.
  c What causes the waves to rise up and break on the beach?
  d When waves break on a sandy or pebbly beach the amount of backwash is often less than the amount of swash. Why do you think this is?
  e Larger pebbles are found at the top of the beach with smaller ones near the bottom. Use your answer to **d** to suggest reasons why.
2 Why do surfers prefer constructive waves to destructive waves?
3 Outline the characteristics of constructive and destructive waves. Complete a copy of the table below.

Wave characteristic	Constructive wave	Destructive wave
Wave height		
Wave length		
Type of wave break (spilling or plunging)		
Strength of swash		
Strength of backwash		
Net beach sediment (gain or loss)		

Stretch yourself

Carry out some research about the tsunami waves that struck Japan in March 2011.

- Why were the waves so high and so powerful?
- What were the impacts on people and human activities?
- What effect did the waves have on the physical geography of the coast of Japan?

Practice question

Compare the characteristics of constructive and destructive waves. *(4 marks)*

10.2 Weathering and mass movement

On this spread you will find out about processes of weathering and mass movement at the coast

Rockfall at Beachy Head, 2001

Photo **A** shows a dramatic rockfall that happened at Beachy Head in East Sussex. During the wet winter of 2000 the chalk rock became saturated with water. The water froze during the winter. In April 2001 this caused a rockfall – a huge slab of chalk broke away and collapsed into the sea. Processes like this combine with the action of the waves to shape the coastline.

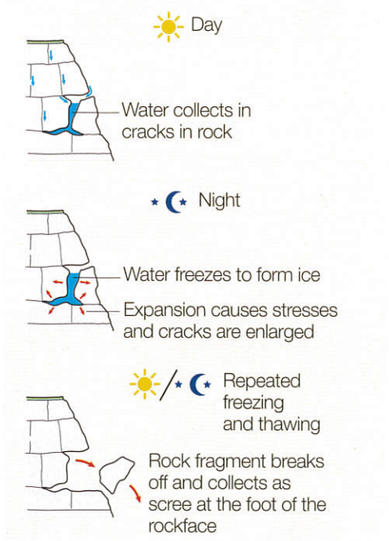
A *Rockfall at Beachy Head, Sussex*

What causes cliffs to collapse?

Cliffs collapse because of different types of weathering. This is the weakening or decay of rocks in their original place on, or close to, the ground surface. It is mostly caused by weather factors such as rainfall and changes in temperature.

There are three types of weathering:

- **Mechanical (physical) weathering** – the disintegration (break-up) of rocks. Where this happens, piles of rock fragments called *scree* can be found at the foot of cliffs.
- **Chemical weathering** – caused by chemical changes. Rainwater, which is slightly acidic, very slowly dissolves certain types of rocks and minerals.
- *Biological weathering* – due to the actions of flora and fauna. Plant roots grow in cracks in the rocks. Animals such as rabbits burrow into weak rocks such as sands.



B *The process of freeze-thaw weathering*

C *Landslip at Holbeck Hall, Scarborough*

Weathering process	Description
Freeze-thaw (mechanical)	Look at diagram **B**. • Water collects in cracks or holes (pores) in the rock. • At night this water freezes and expands and makes cracks in the rock bigger. • When the temperature rises and the ice thaws, water will seep deeper into the rock. • After repeated freezing and thawing, fragments of rock may break off and fall to the foot of the cliff (*scree*).
Salt weathering (mechanical)	• Seawater contains salt. When the water evaporates it leaves behind salt crystals. • In cracks and holes these salt crystals grow and expand. • This puts pressure on the rocks and flakes may eventually break off.
Carbonation (chemical)	• Rainwater absorbs CO_2 from the air and becomes slightly acidic. • Contact with alkaline rocks such as chalk and limestone produces a chemical reaction causing the rocks to slowly dissolve.

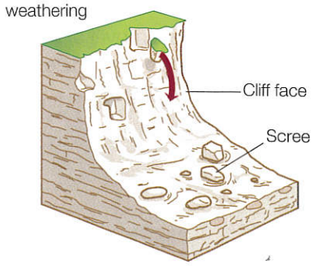
What are the processes of mass movement?

Mass movement is the downward movement or **sliding** of material under the influence of gravity. In 1993, 60 m of cliff slipped onto the beach near Scarborough in North Yorkshire taking with it part of the Holbeck Hall Hotel (photo **C**). The hotel was left on the cliff edge and had to be demolished.

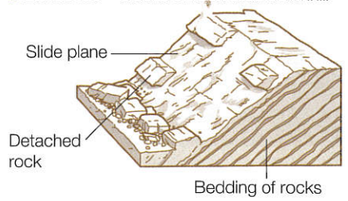
Diagram **D** describes some of the common types of mass movement found at the coast. Both mass movement and weathering provide an input of material to the coastal system. Much of this material is carried away by waves and deposited further along the coast.

D *Types of mass movement at the coast*

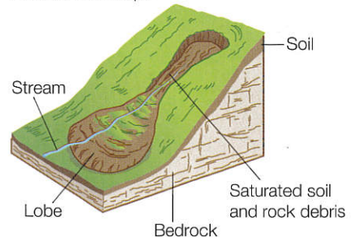
a Rockfall – fragments of rock break away from the cliff face, often due to freeze-thaw weathering



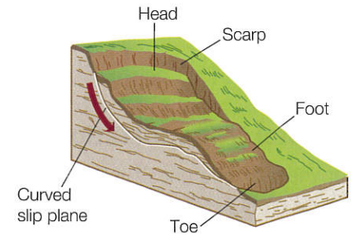
b Landslide – blocks of rock slide downhill



c Mudflow – saturated soil and weak rock flows down a slope



d Rotational slip – slump of saturated soil and weak rock along a curved surface



ACTIVITIES

1 **a** Draw a simple sketch of the coastline in photo **A**. Label the rockfall, the chalk cliffs and the rocky beach.
  b Do you think freeze-thaw is active here?
  c What is scree? Label this feature on your sketch.
  d How might rockfalls be a hazard to people?
2 Make a copy of diagram **B** and add detailed annotations to describe the process of freeze- thaw weathering.
3 Describe the process of mass movement in photo **C** and suggest the causes.

Stretch yourself

Investigate the Beachy Head rockfall in 2001.
- Which weathering and mass movement processes were responsible?
- What impact did the rockfalls have on the shape of the coast?
- Find out how and why the Belle Tout lighthouse had to be moved.

Practice question

Describe the effects of weathering and mass movement on a cliffed coastline. *(6 marks)*

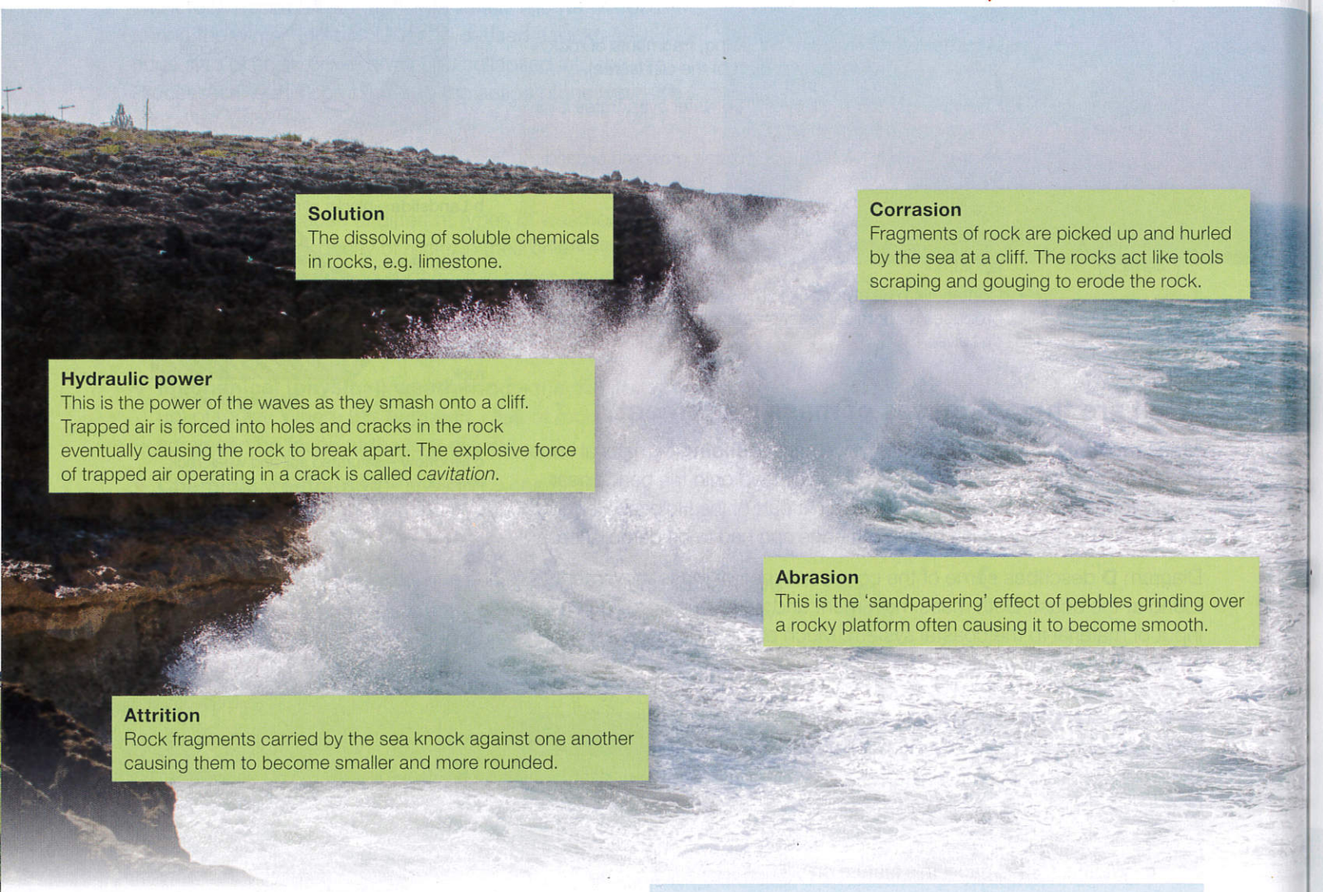
10.3 Coastal marine processes

On this spread you will find out about the processes of erosion and deposition

Coastal erosion

Erosion involves the removal of material and the shaping of landforms. There are several different processes of coastal erosion.

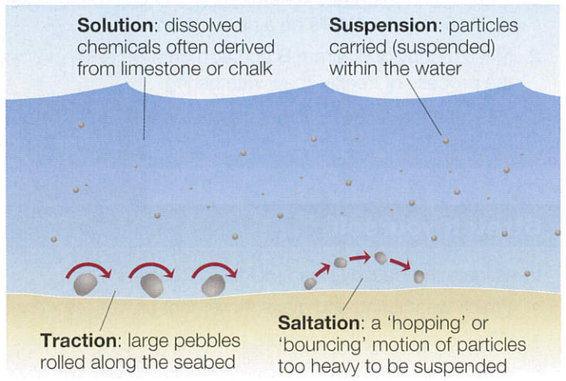
A *Processes of erosion*



Coastal transportation

Sediment of different sizes can be transported in four different ways. (diagram **B**):

- **solution**
- **suspension**
- **saltation**
- **traction**.



B *Types of coastal transportation*

Longshore drift

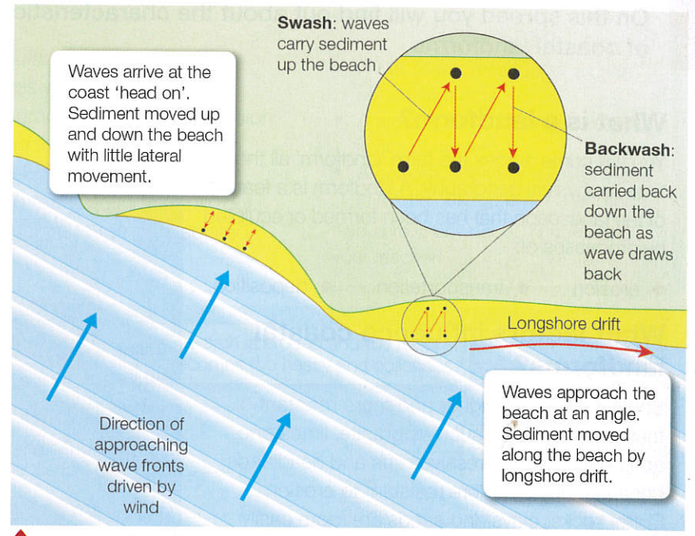
The movement of sediment on a beach depends on the direction that waves approach the coast (diagram **C**). Where waves approach 'head on', sediment is simply moved up and down the beach. But if waves approach at an angle, sediment will be moved *along* the beach in a 'zigzag' pattern. This is called **longshore drift**.

Longshore drift is responsible for a number of important coastal landforms including beaches and spits (pages 100–1).

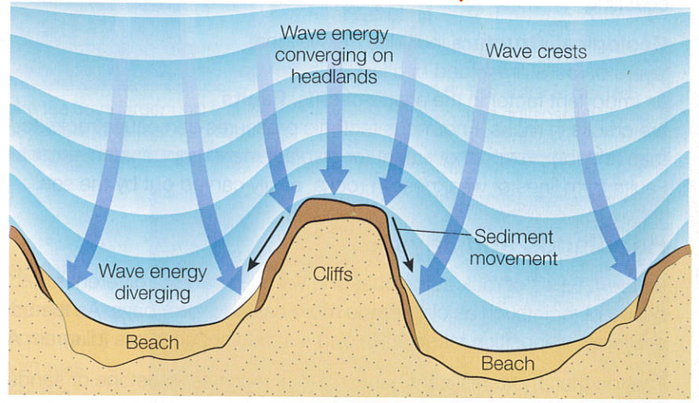
Coastal deposition

Coastal **deposition** takes place in areas where the flow of water slows down. Waves lose energy in sheltered bays and where water is protected by spits or bars (see page 101). Here sediment can no longer be carried or moved and is therefore deposited. This explains why beaches are found in bays, where the energy of the waves is reduced. This is called *wave refraction* (diagram **D**).

Mudflats and saltmarshes are often found in sheltered estuaries behind spits where there is very little flow of water.



C *Longshore drift*



D *Coastal wave refraction*

ACTIVITIES

1 **a** Draw an annotated diagram similar to **B** to show the processes of *erosion*. Show a wave breaking against the foot of a cliff.
b Add detailed labels to describe the *five* processes of erosion.
2 **a** What is meant by the term 'longshore drift' (diagram **C**)?
b Why does this only occur on some beaches?
c Draw a diagram to show the process of longshore drift. Add labels to describe what is happening.
d Imagine you are doing a fieldwork investigation for evidence of longshore drift along a stretch of coast. What evidence would you look for and why?

Stretch yourself

Find out more about the coastal locations where deposition occurs.

- Focus on a stretch of coastline near to your school or one that you have visited.
- Use maps and satellite images to zoom in on locations where deposition has happened. Describe the material that has been deposited and suggest reasons why.

Practice question

What factors affect the processes operating along a stretch of coastline? *(6 marks)*

10.4 Coastal erosion landforms

On this spread you will find out about the characteristics and formation of coastal landforms

What is a landform?

You will come across the term 'landform' all the time in physical geography. A landform is a feature of the landscape that has been formed or sculpted by processes of:

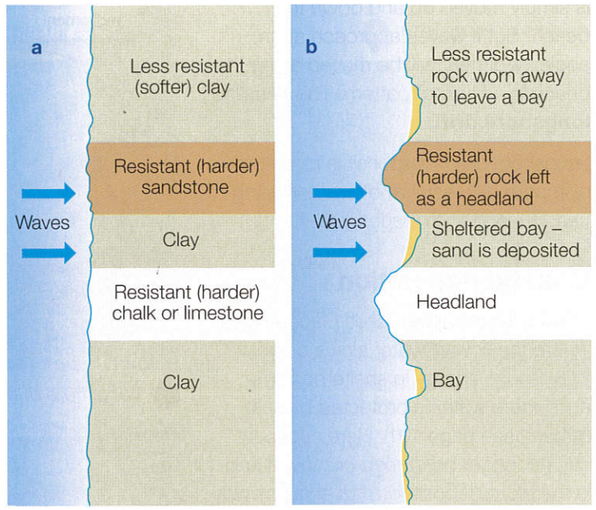
- erosion
- transportation
- deposition.

What factors influence coastal landforms?

Some rocks are tougher and more resistant than others. Rocks such as granite, limestone and chalk form impressive cliffs and headlands because they are more resistant to erosion. Softer rocks, clays and sands are more easily eroded to form bays or low-lying stretches of coastline.

Geological structure includes the way that layers of rocks are folded or tilted. This can be an important factor in the shape of cliffs. **Faults** are cracks in rocks. Enormous tectonic pressures can cause rocks to 'snap' rather than fold (bend) and movement (or *displacement*) happens on either side of the fault. Faults form lines of weakness in rocks, easily carved out by the sea.

A *The formation of headlands and bays*

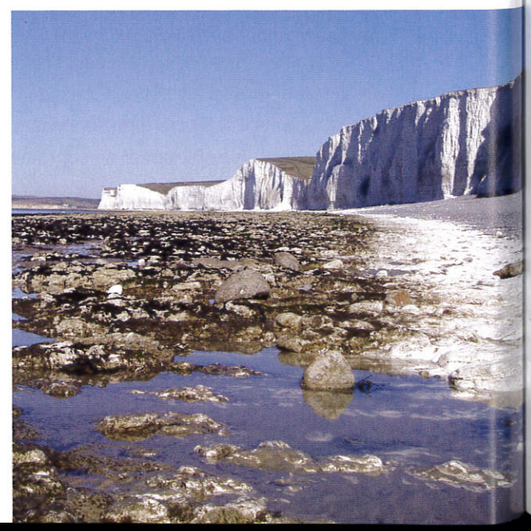


Headlands and bays

Different types of rock at the coastline will be eroded at different rates. Weaker bands of rock (such as clay) erode more easily to form *bays*. As the bays are sheltered, deposition takes place and a sandy beach forms (diagram **A**).

The tougher, more resistant bands of rock (such as limestone or sandstone) are eroded much more slowly. They stick out into the sea to form **headlands**. Erosion dominates in these high-energy environments, which explains why there are no beaches. Most *erosional* landforms are found at headlands.

B *Wave-cut platform and beach near Beachy Head*



Cliffs and wave-cut platforms

When waves break against a **cliff**, erosion close to the high tide line will wear away the cliff to form a wave-cut notch. Over a long period of time – usually hundreds of years – the notch will get deeper and deeper, undercutting the cliff. Eventually the overlying cliff can no longer support its own weight and it collapses.

Through a continual sequence of wave-cut notch formation and cliff collapse, the cliff will gradually retreat. In its place will be a gently sloping rocky platform called a **wave-cut platform** (photo **B**). A wave-cut platform is typically quite smooth due to the process of abrasion. However, in some places it may be scarred with rock pools.

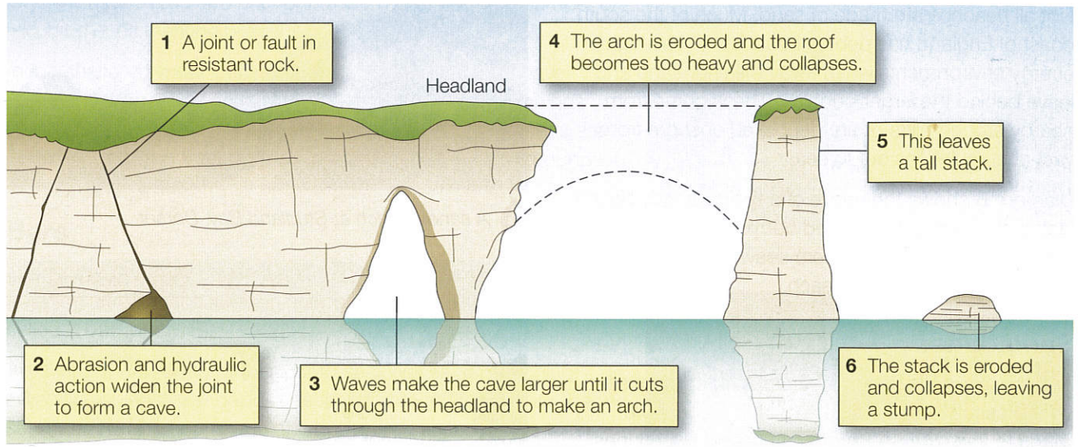
Caves, arches and stacks

Lines of weakness in a headland, such *as faults*, are particularly vulnerable to erosion. The energy of the waves wears away the rock along a line of weakness to form a **cave** (diagram **C**). Over time, erosion may lead to two back-to-back caves breaking through a headland to form an **arch**. Gradually the arch is enlarged by erosion at the base and by weathering processes (such as freeze-thaw) acting on the roof. Eventually the roof will be worn away and collapse to form an isolated pillar of rock known as a **stack**.

Remember!

- A cliff, a river meander or a delta *are* all landforms.
- A process such as longshore drift is *not* a landform.
- A geological feature such as a joint in a rock outcrop is *not* a landform.

If you are in any doubt, check with your teacher!



C *How caves, stacks and arches are formed*

A chalk arch, Bwa Gwyn, Anglesey

Bwa Gwyn (Photo **D**) is an impressive arch formed by erosion in an outcrop of white quartzitic rock on the Anglesey coastline. In the past, Bwa Gwyn was quarried for china clay. Today you can still see the grindstone used to extract the clay on the top of the rocks. It is a stunning climb across the rocks, but it can be dangerous because of unstable cliffs.

Stretch yourself

Find an example of a coastline with headlands and bays. This could be a stretch of coastline near to where you live or one that you have visited.

- Search for a map or satellite photo and add labels to describe the main features.
- Find out about the different types of rock.

Practice question

Use one distinctive coastal landform to illustrate the erosive power of the sea. *(6 marks)*

D *Bwa Gwyn arch, Anglesey*

ACTIVITIES

1. Draw a sequence of diagrams to show the formation of headlands and bays. To test your understanding, draw your coast facing a different direction to diagram **A**.
2. Draw a sequence of labelled diagrams to show how a cliff is undercut by the sea and then collapses to form a wave-cut platform. Use your labels to explain the processes and landforms.
3. Use a sequence of diagrams to explain the formation of a stack (diagram **C**).

10.5 Coastal deposition landforms

On this spread you will find out about the characteristics and formation of coastal deposition landforms

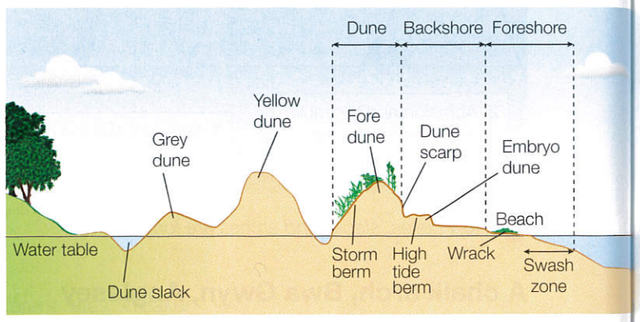
Beaches

Beaches are deposits of sand and shingle (pebbles) at the coast. Sandy beaches are mainly found in sheltered bays (photo **A**). The waves entering the bay are *constructive* waves (see page 93). They have a strong swash and build up the beach.

Not all beaches are made of sand. Much of the south coast of England has pebble beaches. These high-energy environments wash away the finer sand and leave behind the larger pebbles. These come from nearby eroded cliffs or are deposited onshore from vast accumulations out to sea.

Diagram **B** shows the profile of a typical sandy beach. Notice the clear ridges called *berms*. One of these marks the high tide line where seaweed and rubbish get washed up onto the beach.

A *A sandy beach at Studland Bay, Dorset*



B *A beach profile*

Sand dunes

At the back of the beach in photo **A**, sand deposited on the beach has been blown inland by onshore winds to form *dunes*. Diagram **C** shows how dunes change in form and appearance the further inland.

Embryo dunes form around deposited obstacles such as pieces of wood or rocks.

↓

These develop and become stabilised by vegetation to form *fore dunes* and tall *yellow dunes*. Marram grass is adapted to the windy, exposed conditions and has long roots to find water. These roots help bind the sand together and stabilise the dunes.

↓

In time, rotting vegetation adds organic matter to the sand making it more fertile. A much greater range of plants colonise these 'back' dunes.

↓

Wind can form depressions in the sand called *dune slacks*, in which ponds may form.

C *Development of sand dunes*

D *Hurst Castle Spit, Hampshire*

Spits

A **spit** is a long, narrow finger of sand or shingle jutting out into the sea from the land (photo **D**).

Spits form on coasts where there is significant longshore drift. If the coastline changes orientation and bends sharply, sediment is then deposited out to sea (diagram **E**). As it builds up, it starts to form an extension from the land. This process continues with the spit gradually growing further out into the sea. Strong winds or tidal currents can cause the end of the spit to become curved to form a feature called a *recurved end* (photo **D**). There may be a number of recurved ends marking previous positions of the spit.

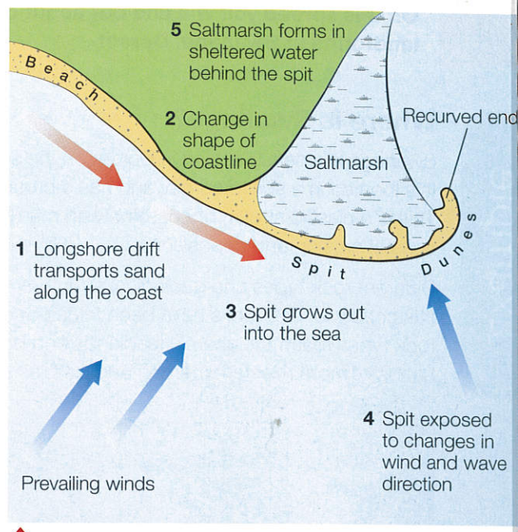
In the sheltered water behind the spit, deposits of mud have built up. An extensive saltmarsh has formed as vegetation has started to grow in the emerging muddy islands. Saltmarshes are extremely important wildlife habitats and over-wintering grounds for migrating birds.

Bars

Longshore drift may cause a spit to grow right across a bay, trapping a freshwater lake (or *lagoon*) behind it. This feature is called a **bar** (photo **F**).

An offshore bar forms further out to sea. Waves approaching a gently sloping coast deposit sediment due to friction with the seabed. The build-up of sediment offshore causes waves to break at some distance from the coast.

In the UK some offshore bars have been driven onshore by rising sea levels following ice melt at the end of the last glacial period some 8000 years ago. This type of feature is called a *barrier beach*. Chesil Beach in Dorset is one of the best examples of this feature in the UK.



E *The formation of a spit*

F *Bar at Slapton Ley, Devon*

ACTIVITIES

1. Describe the processes responsible for the formation of the beach and the sand dunes in photo **A**.
2. Draw a sketch of Hurst Castle Spit. Add labels to describe the characteristic features and the processes responsible for the spit's formation.
3. Describe the characteristics and possible formation of the bar in photo **F**.

Stretch yourself

Investigate the characteristics and formation of sand dunes.

- Why do they only form in certain places on the coast?
- Research 'sand dune succession' to find out the sequence of events in the formation of sand dunes.
- What are the characteristics of marram grass and why does it thrive on sand dunes?

Practice question

How do the processes of deposition lead to the formation of distinctive landforms? *(6 marks)*

10.6 Coastal landforms at Swanage (1)

On this spread you will find out about coastal erosion and deposition landforms at Swanage, Dorset

Example

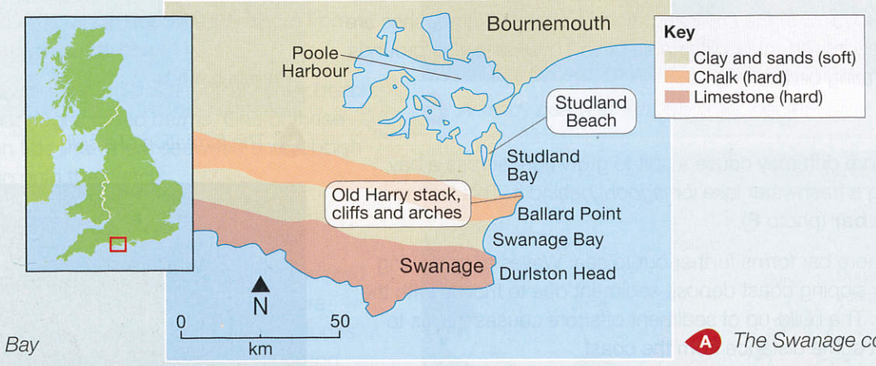
Where is Swanage?

Swanage is a seaside town in Dorset on the south coast of England. It is located in a sheltered bay and has a broad sandy beach (photo **B**). This is a classic stretch of coastline with many impressive landforms of coastal erosion and deposition.

Different rock types and geological structure are important in the formation of this coastline. The rocks have been folded and tilted so that bands of different rock types reach the coast. Headlands and bays form where there are alternating bands of more resistant (harder) and less resistant (softer) rocks (map **A**).

Did you know?

The coast around Swanage is part of what is known as the Jurassic Coast. The 154 km stretch of coast in East Devon and Dorset was made a World Heritage Site in 2001 because of its geological importance. Jurassic is the name of the geological period when the rocks on the coast were formed – 145 to 200 million years ago!



A *The Swanage coast, Dorset*

B *Swanage Bay*

This indented coastline is called a *discordant coastline*. On the south coast there is only one type of rock – limestone. This forms a relatively straight section of coast and is called a *concordant coastline*.

To the north of Swanage is Poole Harbour, one of the UK's largest natural harbours. A great deal of deposition has taken place in this large sheltered bay. You can see two spits at the mouth of the harbour, one on the south side and one on the north.

At Studland there are lagoons, saltmarshes and sand dunes. This area is well known for its wildlife. Photo **C** shows part of the beach and sand dunes at Studland.

C *The beach and sand dunes at Studland*

ACTIVITIES

1 **a** What rock forms the headland at Durlston Head (map **A**)?
  b What type of rock forms Swanage Bay?
  c Explain why headlands and bays have formed along this stretch of coastline.
2 **a** Explain why sediment that has been deposited on the beach in photo **B** (see diagram **D** on page 97).
  b Why has a beach formed in Swanage Bay?
  c Why do you think the beach is popular with visitors?
  d What is the evidence in this photo that the tide is going out?
3 **a** Suggest reasons why sand dunes have formed at the back of the beach in photo **C**.
  b What is the name of the grass growing on the sand dunes?
  c How does this grass help to stabilise the dunes?
  d Describe the characteristics of the barbecue area. Why do you think a specific area has been provided for this purpose?

Stretch yourself

Carry out some further research about Studland.

- What are the main habitats found here?
- Why is it an important area for wildlife?
- Why is it a popular place for visitors?
- Find out how the area is being managed to minimise the harmful effects of visitors.

Practice question

Using evidence from the photos, evaluate any potential conflict between the different uses of the Dorset coast near Swanage and Studland. *(6 marks)*

10.7 Coastal landforms at Swanage (2)

On this spread you will use map and photo evidence to study landforms of coastal erosion and deposition at Swanage, Dorset

Example

Using the OS map extract and photo

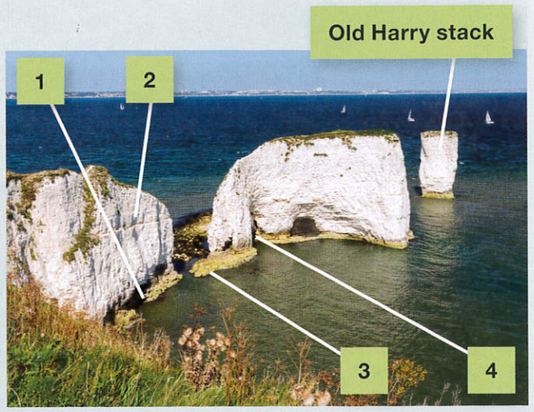
Map **A** is a 1:50 000 extract from an OS map of the Swanage coast. Look back to diagram **A** on page 102 to see how the different rock types form the headlands and bays.

Locate the chalk headland Ballard Point on the map, to the north of Swanage Bay. Photo **B** is an aerial photo of this stretch of coastline. Notice the impressive white chalk cliffs and the many isolated stacks. In the far distance is a well-known local landform, an isolated stack called Old Harry. Photo **C** is a close-up view of Old Harry.

Did you know?

Old Harry had a wife … a stack that stood side by side on the chalk seam that stretched out from Swanage Bay. But, the sea gradually eroded this second stack until her eventual collapse in 1896. Old Harry's wife is now known as a stump.

B *Aerial view of the coastline between Ballard Point and the Foreland*



C *The Foreland and Old Harry*

ACTIVITIES

1 Study map **A** and photo **B**.
- **a** The Foreland, Peveril Point and Durlston Head are all examples of what coastal landform?
- **b** In what grid square is the Foreland?
- **c** In what direction is the photo looking?
- **d** On the map, what local name is given to the stacks shown in the photo?
- **e** Describe the characteristics of the chalk cliffs in the photo.
- **f** Give the six-figure grid reference of Old Harry.

2
- **a** Locate Swanage Bay on the map. Approximately how wide is the bay from Ballard Point to Peveril Point?
- **b** What map evidence is there that deposition is occurring in Swanage Bay?
- **c** How does this deposition help to explain the growth of Swanage as a tourist resort?

Practice question

Use evidence from the OS map of the Swanage coast to suggest how the area's human use has been affected by its physical geography. *(4 marks)*

A *1:50 000 OS map extract of Swanage coast*

ACTIVITIES

3 Study map **A** and photo **C**.
- **a** What are the landforms labelled 1–3 on photo **C**?
- **b** Was the photo taken at high tide or low tide? Explain your answer.
- **c** What additional evidence would you need to confirm that landform 4 is an arch?
- **d** Design an information board to be located on The Foreland to explain the formation of Old Harry.
  - Draw a series of annotated diagrams to describe its formation. Refer to the processes of erosion in your annotations.
  - Remember that your information board is aimed at the general public so make sure it is clear and attractive.

4 Locate Studland Bay and Studland Heath on map **A**.
- **a** Give the four-figure grid reference for Studland Heath.
- **b** What is the meaning of the blue bird symbol at 033850?
- **c** Describe the different types of natural environment in this area.
- **d** Why is this area popular with visitors?
- **e** Why do you think Studland needs to be managed?

10.8 Managing coasts – hard engineering

On this spread you will find out how hard engineering can protect coastlines from the effects of physical processes

Why do coasts need to be managed?

Coasts need to be managed to maintain a balance between the forces of nature and the demands of people. People living or working at the coast need to be protected from erosion and flooding. With sea levels expected to rise in the future, coastal defences will become ever more expensive. In some case the increasing costs may outweigh the benefits and coastlines may be left undefended.

What are the coastal management options?

There are three different management strategies for defending the coast.

Hard engineering – using artificial structures such as sea walls to control natural processes

Soft engineering – less intrusive, more environmentally-friendly methods that work with natural processes to protect the coast

Managed retreat – this increasingly popular option enables the controlled retreat of the coastline, often involving allowing the sea to flood over low-lying land

Hard engineering

For centuries people have used hard engineering structures to try to control the actions of the sea and protect property and land. Sea walls, groynes, rock armour and gabions are the most common hard engineering structures used in coastal management.

Sea wall

Description: Concrete or rock barrier against the sea, placed at the foot of cliffs or at the top of a beach. Has a curved face to reflect the waves back into the sea.

Cost: £5000–£10000 per metre

Advantages:

- Effective at stopping the sea.
- Often has a walkway or promenade for people to walk along.

Disadvantages:

- Can look obtrusive and unnatural.
- Very expensive and high maintenance costs.

A *Sea wall at Dawlish, Devon*

Groynes

Description: Timber or rock structures built out to sea from the coast. They trap sediment being moved by longshore drift and enlarge the beach. The wider beach acts as a buffer to reduce wave damage.

Cost: Timber groynes £150000 each (at every 200m)

Advantages:

- Create a wider beach, which can be popular with tourists.
- Provide useful structures for people interested in fishing.
- Not too expensive.

B *Groynes at Eastbourne, Sussex*

Disadvantages:

- By interrupting longshore drift they starve beaches further along the coast, often leading to increased rates of erosion elsewhere. The problem is therefore shifted rather than solved.
- Groynes are unnatural and rock groynes in particular can be unattractive.

Nowadays hard engineering approaches are less commonly used because they:

- are expensive and involve high maintenance costs
- interfere with natural coastal processes and can cause destructive knock-on effects elsewhere. For example, by altering wave patterns erosion can occur further along the coast, leading to new problems such as cliff collapse.
- look unnatural.

Maths skills

A local council wishes to defend a 1 km stretch of coastline. Calculate comparative costs for each of the following:

- sea wall
- rock armour
- groynes
- gabions.

Rock armour

Description: Piles of large boulders dumped at the foot of a cliff. The rocks force waves to break, absorbing their energy and protecting the cliffs. The rocks are usually brought by barge to the coast.

Cost: £200000 per 100m

Advantages:

- Relatively cheap and easy to maintain.
- Can provide interest to the coast.
- Often used for fishing.

Disadvantages:

- Rocks are usually from other parts of the coastline or even from abroad.
- Can be expensive to transport.
- Do not fit in with the local geology.
- Can be very obtrusive.

C *Rock armour at Walton on the Naze, Essex*

Gabions

Description: Wire cages filled with rocks that can be built up to support a cliff or provide a buffer against the sea.

Cost: Up to £50000 per 100m

Advantages:

- Cheap to produce and flexible in the final design.
- Can improve drainage of cliffs.
- Will eventually become vegetated and merge into the landscape.

Disadvantages:

- For a while they look very unattractive.
- Cages only last 5–10 years before they rust.

D *Gabions at Thorpeness, Suffolk*

ACTIVITIES

1 a Why is a sea wall an example of hard engineering?
  b What is the purpose of a sea wall?
  c What are the advantages and disadvantages of a sea wall?
2 Draw a simple diagram to explain how groynes cause a beach to become wider.
3 What are the arguments for and against using gabions as a form of coastal defence?

Stretch yourself

Find out about other options for hard engineering. Consider the following:

- revetments
- offshore breakwaters
- artificial headlands.

What is the cost of construction? Outline the advantages and disadvantages.

Practice question

What are the advantages and disadvantages of hard engineering at the coast? *(6 marks)*

10.9 Managing coasts – soft engineering

On this spread you will find out how soft engineering can protect coastlines from the effects of physical processes

How does soft engineering protect the coast?

Photo **A** shows **beach nourishment**, one of the most widely used forms of soft engineering. Sand, or in this case shingle, is dredged offshore and transported to the coast by barge. The shingle is then dumped onto the beach and shaped by bulldozers. This is called **reprofiling**. The higher and wider beach now provides greater protection to valuable land and property and creates a natural amenity for tourism and recreation.

Soft engineering approaches such as beach nourishment try to work with natural coastal processes. Photo **B** shows marram grass being replanted to help stabilise sand dunes. This is called **dune regeneration**.

Soft engineering schemes tend to be cheaper than hard engineering although they may require more maintenance. Every few years beaches will need more sand or shingle and sand dunes may need replanting to replace grass that has died or been trampled. However, these schemes are generally more sustainable and are often the preferred option for coastal management today.

A *Beach nourishment at Eastbourne, East Sussex*

B *Sand dune regeneration at Calgary Bay, Mull, Scotland*

Beach nourishment

Description: The addition of sand or shingle to an existing beach to make it higher or wider. The sediment is usually obtained offshore locally so that it blends in with the existing beach material. It is usually transported onshore by barge.

Cost: Up to £500 000 per 100 m

Advantages:
- Relatively cheap and easy to maintain.
- Blends in with existing beach.
- Increases tourist potential by creating a bigger beach.

Disadvantages:
- Needs constant maintenance unless structures are built to retain the beach.

Dune regeneration

Description: Sand dunes are effective buffers to the sea but are easily damaged and destroyed by trampling. Marram grass can be planted to stabilise dunes and help them to develop. Fences can be used to keep people off newly-planted areas.

Cost: Cost: £200–£2000 per 100 m

Advantages:
- Maintains a natural coastal environment that is popular with people and wildlife.
- Relatively cheap.

Disadvantages:
- Time-consuming to plant the marram grass and fence areas off.
- People don't always respond well to being prohibited from accessing planted areas.
- Can be damaged by storms

C *Dune regeneration at Chichester, West Sussex*

Dune fencing

Description: Fences are constructed on a sandy beach along the seaward face of existing dunes to encourage new dune formation. These new dunes help to protect the existing dunes.

Cost: £400–£2000 per 100 m.

Advantages:
- Minimal impact on natural systems.
- Can control public access to protect other ecosystems.

Disadvantages:
- Can be unsightly especially if fences become broken.
- Regular maintenance needed especially after storms.

D *Dune fencing at Formby, Merseyside*

ACTIVITIES

1 **a** Describe what is happening in photo **A**.
  b Why do you think beach nourishment has been chosen to help defend the coastline at Eastbourne?
  c What other forms of coastal defence have been installed here and what is their purpose?
  d What are the disadvantages of beach nourishment?
2 **a** Why do you think the area of sand dunes in photo **B** needs to be restored?
  b Apart from planting marram grass, what other forms of management will be needed to restore these dunes?
3 Why do you think there is a wide price range for each of the forms of soft engineering?
4 Suggest why *either* hard engineering *or* soft engineering is the best option for defending the coast.

Stretch yourself

Find out more about sand dune regeneration.
- Try to find an example of sand dunes that have had to be regenerated (restored).
- What caused the problems and what solutions have been adopted?
- What are the challenges and opportunities for the future?

Practice question

Identify the differences between hard and soft engineering coastal management strategies. *(4 marks)*

10.10 Managing coasts – managed retreat

On this spread you will find out how managed retreat can protect coastlines from the effects of physical processes

Managed retreat

Managed retreat is a deliberate policy of allowing the sea to flood or erode an area of relatively low-value land. It is a form of soft engineering as it allows natural processes to take place and does not intervene in the way that hard engineering does.

In the long term, allowing managed retreat is a more sustainable option than spending large sums of money trying to protect the coast with sea walls or groynes. As sea levels continue to rise, managed retreat seems likely to become an increasingly popular choice for managing the coastline.

A *The breach of the sea defences at Medmerry*

Medmerry Managed Retreat, near Chichester, West Sussex

Aerial photo **B** shows a stretch of coastline on the south coast of England near Chichester. This flat, low-lying coast is mainly used for farming and caravan parks. For many years the land was protected by a low sea wall but this is now in need of repair. Building a new sea wall to protect the area against future sea-level rise was a very expensive option.

Given the relatively low value of the land, it was decided to allow the sea to breach the current sea defences (photo **A**) and flood some of the farmland that was previously protected. You can see in the photo how this has happened .

The Medmerry scheme cost £28 million and the controlled breaching of the old sea defences took place in November 2013. In the future, this scheme will:

- create a large natural saltmarsh to form a natural buffer to the sea
- help to protect the surrounding farmland and caravan parks from flooding
- establish a valuable wildlife habitat and encourage visitors to the area.

You can see on photo **B** that embankments have been constructed inland to give protection to farmland, roads and settlements. This alteration of the coastline is called *coastal realignment*.

B *Managed retreat at Medmerry, West Sussex*

Coastal monitoring and adaptation

Much of the coastline of the UK does not require expensive intervention in the form of coastal defences. Land may be low-value farmland, forest or moorland. In many cases these coastal zones can be left alone – this is sometimes called the 'Do Nothing' approach. People living or working in these areas have to adapt by relocating further inland. This might involve moving mobile homes on a holiday park, a path, a fence or a hole on a golf course (photo **C**).

Scientists conduct monitoring of these stretches of coastline. This helps to reduce the possibilities of conflict between managing the coast and the needs and views of local people whose lives are affected. This monitoring involves studying marine processes, mass movement and human activity to ensure safety and to make sure this approach remains the most appropriate. If conditions change, for example the risk of flooding increases and threatens property, then a new approach might be adopted.

Another view

Some experts argue that plans for managed retreat strategies may not take into account the impact on coastal communities. There may be longer-term effects on coastal trade, tourism, infrastructure and businesses, as well as rehousing costs.

C *Manage or adapt?*

ACTIVITIES

1 Why is managed retreat a sustainable option for coastal management?

2 **a** Describe the relief of the area shown in photo **B**.

b What are the main land uses at X and Y?

c What is the purpose of the feature at Z?

d What are the advantages and disadvantages of this scheme?

3 Do you think the stretch of coast in photo **C** should be protected or should people adapt to the natural changes taking place? Justify your answer.

Practice question

Examine why a system of managed retreat may not be a feasible option in some parts of the coast. *(6 marks)*

Stretch yourself

Carry out your own research to find another example of managed retreat.

- What were the pre-existing forms of coastal defence and why has managed retreat now been adopted?
- Assess the advantages and disadvantages of your chosen scheme.
- What are the challenges for the future?

10.11 Coastal management at Lyme Regis

On this spread you will find out about the coastal management schemes at Lyme Regis in Dorset

Example

Lyme Regis is a small coastal town on the south coast of England. It lies at the heart of the World Heritage Site known as the Jurassic Coast. This is one of the most spectacular stretches of coastline in the UK and famous for its fossils. The town is a popular tourist destination. In summer, the population of the town swells from 4000 to 15 000!

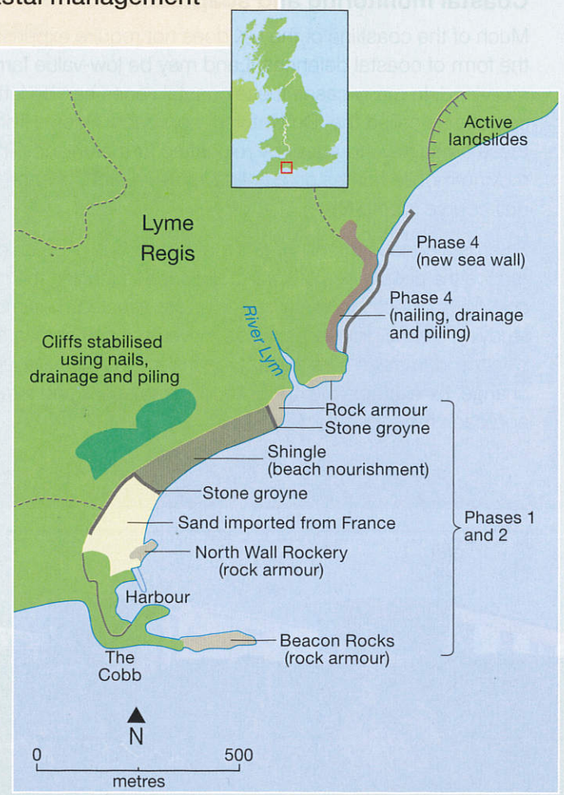
What are the issues at Lyme Regis?

Much of the town has been built on unstable cliffs. The coastline is eroding more rapidly than any in Europe due to the powerful waves from the south west. Many properties have been destroyed or damaged, and there has been considerable erosion of the foreshore. The sea walls have been breached many times.

How has the coastline been managed?

The Lyme Regis Environmental Improvement Scheme was set up by West Dorset District Council in the early 1990s. Its aims were to provide long-term coastal protection and reduce the threat of landslips. Engineering works were completed in 2015.

To reduce conflicts between different interest groups, such as property owners, fishermen and environmentalists, there were consultation meetings and the public were kept informed before and during the construction work.



A *Coastal management at Lyme Regis*

Phase 1 Date: 1990s (completed 1995)

- New sea wall and promenade constructed to the east of the mouth of the River Lim.
- In the winter of 2003–2004 a £1.4 million emergency project was completed to stabilise the cliffs. Hundreds of large nails were used to hold the rocks together as well as improving drainage and re-profiling the slope of the beach.

Phase 2 Date: 2005–2007

Extensive improvements made to the sea front costing £22 million. These included:

- construction of new sea walls and promenades
- creation of a wide sand and shingle beach to absorb wave energy and increase use of the shore; shingle dredged from the English Channel and sand imported from France
- extension of rock armour at The Cobb (map **A**) and the eastern end of the sea front, to absorb wave energy and help retain the new beach.

Phase 3 Not undertaken.

The initial plan to help prevent landslips and coastal erosion to the west of The Cobb were shelved. It was decided to leave this stretch of coast alone as the costs outweighed the benefits.

Phase 4 Date: 2013–2015

This final phase focused on the coast east of the town (photo **B**). It cost £20 million and involved:

- constructing a new 390 m sea wall in front of the existing wall (photo **C**) to provide additional protection
- extensive nailing, piling and drainage to provide cliff stabilisation to protect 480 homes.

B *The Jurassic Coast east of Lyme Regis in 2013 before Phase 4 began*

C *Phase 4 coastal defence works at Lyme Regis*

How successful has the management scheme been?

Positive outcomes ✓	Negative outcomes ✗
• The new beaches have increased visitor numbers and seafront businesses are thriving. • The new defences have stood up to recent stormy winters. • The harbour is now better protected, benefiting boat owners and fishermen.	• Increased visitor numbers have led to conflicts with local people who think traffic congestion and litter have increased. • Some people think the new defences have spoilt the natural coastal landscape. • The new sea wall may interfere with coastal processes and affect neighbouring stretches of coastline, causing conflicts elsewhere. • Stabilising cliffs will prevent landslips that may reveal important fossils – a potential conflict.

ACTIVITIES

1 Complete a table listing the different types of hard and soft engineering used at Lyme Regis (map **A**).

2 Photo **C** shows Phase 4 of the coastal defence work at Lyme Regis.
   - **a** Describe what is happening in the photo.
   - **b** What material has been used to construct the sea wall?
   - **c** Suggest some of the issues associated with carrying out this new defence work.

3 Suggest why both hard and soft engineering have been used to protect the coast at Lyme Regis.

4 How has the management of the coast at Lyme Regis reduced possible conflicts between different groups of people?

Stretch yourself

Investigate the management measures at Lyme Regis. You will find plenty of photos and maps online with 'before and after' images and information about the different measures implemented. Consider how successful these measures have been since 2015.

Practice question

To what extent can the coastal management at Lyme Regis be considered a success? *(6 marks)*