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# 2.3 Coastal landscape development

## You need to know

- the characteristics and development of landforms/landscapes associated with coastal erosion, coastal deposition, estuarine conditions and sea-level change
- the impact of climate change on coasts

### Exam tip

Landscapes are the outcome of processes, so you will also need to refer to topic 2.2 Systems and processes here.

### Exam tip

Make sure that you refer to examples from both the UK and other countries.

## Erosional landscapes

A coastal erosional landscape will include all or some of the following.

Cliffs, headlands and bays:

- form when rocks of differing hardnesses are exposed together at a coastline
- tougher, more resistant rocks (such as granite and limestones) tend to form headlands with cliffs
- weaker rocks (such as clays and shales) are eroded to form sandy bays

Wave-cut platforms:

- see Figure 17

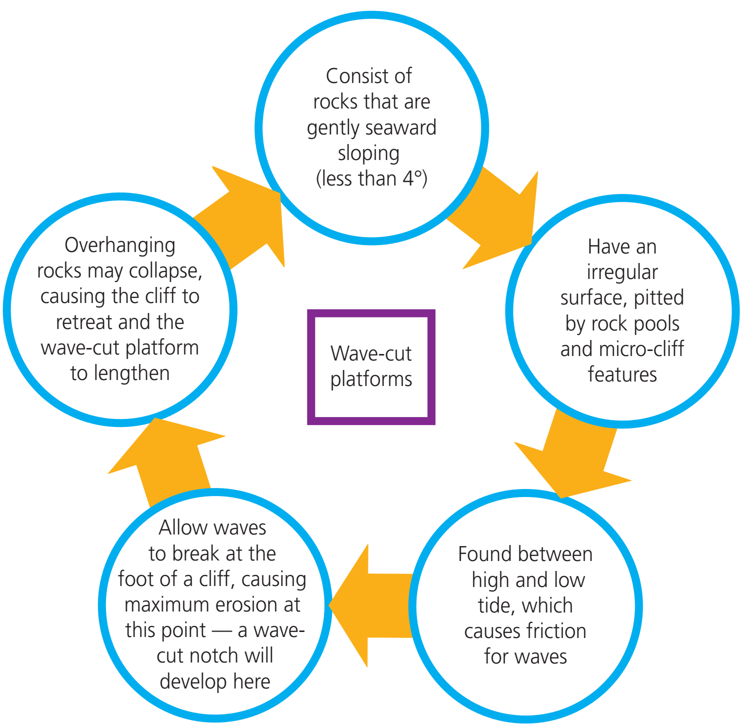


**Figure 17** Wave-cut platforms

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Caves, arches and stacks:

- erosion takes place on a cliff face where there is a weakness, such as joints or bedding planes
- where waves open up a prolonged joint, they form a deep and steep-sided inlet (geo)
- smaller hollows can be excavated to create caves
- where caves are created on either side of a headland and are eroded back, they can 'meet' each other (the back wall collapses) and form an arch
- the sea is now able to splash under the arch, further weakening it until eventually the roof collapses, leaving the seaward side as a separate island (a stack)
- over time the stack erodes to form a stump

# Depositional landscapes

A coastal depositional landscape will include all or some of the following.

Beaches:

- built up by **accretion** in and across bays and made of either sand or shingle, or a mixture of both
- are either
  - swash-aligned, where sediment is taken up and down the beach with little sideways transfer
  - drift-aligned, where sediment is transferred along a beach by longshore drift
- can be sub-divided into different zones (Figure 14):
  - offshore, beyond the influence of breaking waves
  - nearshore — intertidal and within the breaker zone
  - backshore — usually above the influence of normal wave patterns, marked at the lower end by berms, and may have a storm beach further up (Figure 18)

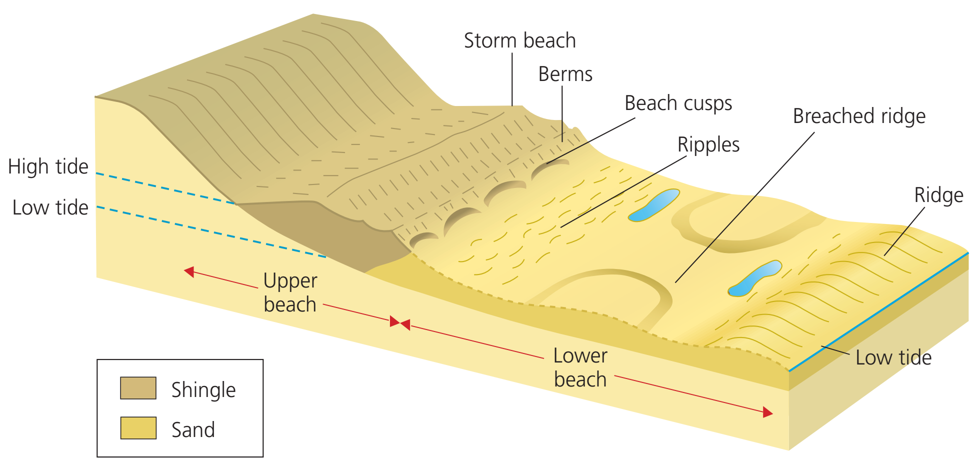


**Figure 18** Beach profile features

## Exam tip

A good way to demonstrate that you know what each of these erosional and depositional landforms looks like is to draw a sketch. Give it a go!

## Key term

**Accretion** The growth of a natural feature by enlargement. In the case of coasts, sand spits and sand dunes grow by accretion.



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Small-scale beach landforms:

- ridges and runnels — alternate raised and dip sections that run parallel to the shore line, exposed at low tide but hidden at high tide. They are caused by strong backwash, and strong tides
- beach cusps — small semi-circular depressions in sand and shingle beaches. Once created they self-perpetuate, especially on swash-aligned beaches
- ripples — micro beach ridges parallel to the shoreline, created by wave action on low-gradient beaches

Spits, tombolos:

- long, narrow stretches of sand or shingle that protrude into the sea or across an estuary
- result from materials being moved along the coast by longshore drift
- this movement continues in the same direction when the coastline curves; where there is an estuary with a strong current that interrupts the movement of material, they project out into it
- the end of the spit is often curved (creating a series of laterals) where waves are refracted around the end of the spit into more sheltered water behind
- a tombolo is formed where a spit joins the mainland at one end to an island at the other

Bars, barrier beaches:

- created where a spit develops across a bay because there are no strong currents to disturb the process — the water behind it is dammed, forming a lagoon
- bars also develop as a result of storms raking up pebbles. This shingle left in offshore ridges creates a barrier beach

Offshore bars:

- deposits of sand and shingle situated some distance from a coastline — these usually lie below sea level, becoming visible only at low tide
- there are two explanations as to where and how they form:
  - in shallow seas where the waves break some distance from the shore
  - where steep waves break on a beach, creating a strong backwash that carries material back down the beach to form a ridge
- when a bar appears above the level of the sea for most of the time it becomes a barrier beach, with a lagoon on the landward side and ocean on the other

**Exam tip**

You may be asked to describe any of these landforms. Refer to size, shape, nature of sediments and field relationship (where the landform lies in relation to the landscape).

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Sand dunes:

- sand is often deposited by the sea under low-energy conditions
- wind may then move the sand to build dunes further up the beach
- these in turn become colonised by stabilising plants (a **psammosere**)

## Key terms

**Psammosere** The succession of plants that develops on a sand dune complex. Plants include sea rocket and lyme grass nearer the sea, with marram grass, fescue and gorse inland.

**Halosere** The succession of plants that develops in a salt marsh. Plants include eelgrass, *Spartina*, cord grass and sea lavender.

# Estuarine environments

Key features:

- sheltered river estuaries or zones in the lee of spits are areas where there are extensive accumulations of silt and mud (mudflats), aided by flocculation and gentle tides
- these inter-tidal areas are colonised by vegetation, and a succession of plant types may develop over time (a **halosere**), creating a salt marsh (Figure 19)
- the initial plants of a halosere are tolerant of both salt and regular inundation at high tide
- they also have a long root system and a mat of surface roots to hold the mud in place
- the plants trap more mud and build up a soil for the next stage of the succession
- as the mat of vegetation becomes more dense, the impact of the tidal currents reduces and humus levels increase, allowing reeds and rushes to grow and, later, alder, willow and oak
- salt marshes often have complex systems of waterways — creeks
- in some extensive salt marsh areas, hollows of trapped sea water form, which then evaporate and create salt pans

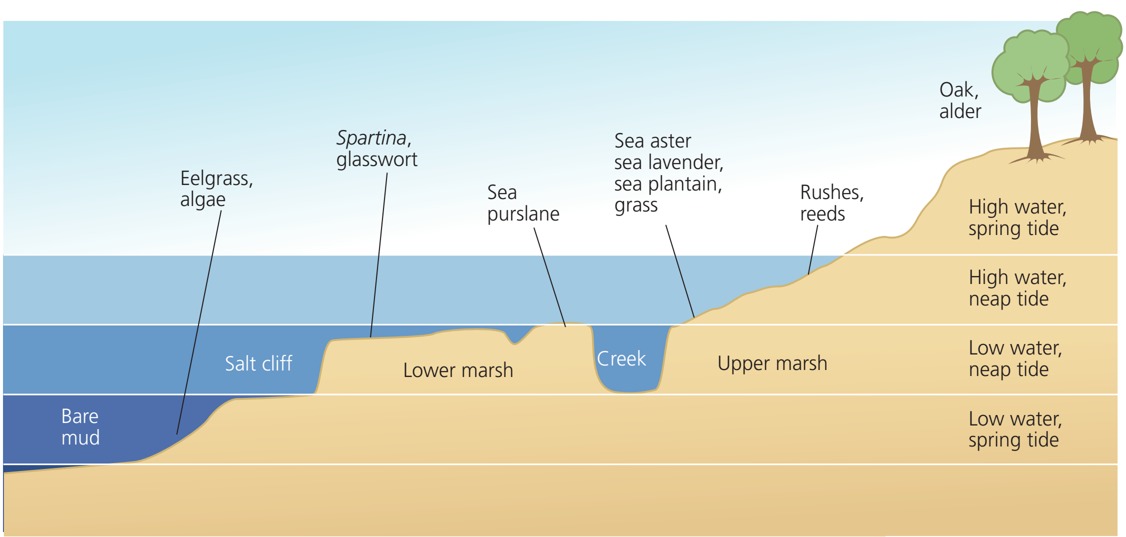


**Figure 19** The structure of a salt marsh

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# Landscapes of sea-level change

Changes in sea level take place over time due to:

- sea temperatures being colder or warmer than the present
- relative changes in land levels

## Eustatic change

Key features:

- results from a fall in sea level due to a new glacial period, when water is held as ice
- results from a rise in sea level when, at the end of a glacial period, the ice on land melts

## Isostatic change

Key points:

- arises from changes in the local relationship of land to sea
- as ice collected on the land during a glacial period, the extra weight pressed down on the land, causing it to sink and sea level to rise
- as the land ice melts, the land begins to move back up to its original position (readjustment) and sea level falls
- depends on the thickness of the original ice and the speed of its melting

## Tectonic change

Other changes of sea level have been caused by tectonic processes associated with plate movement — they too tend to be localised.

## Major changes in sea level

In the last 10,000 years (the Holocene):

- global sea level rose very quickly up to 6000 years ago (the Flandrian transgression)
- it flooded the North Sea, English Channel and Irish Sea
- it flooded many former river valleys to give the distinctive indented coastline of southwest England and Ireland (rias)
- since then sea levels have remained largely consistent, with a slight rise recently due to climate change

### Key terms

**Eustatic change** A sea-level change that affects the globe.

**Isostatic change** A sea-level change that affects a localised area.

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# Coastlines of emergence and submergence

## Coastlines of submergence

Rias:

- drowned winding river valleys with long fingers of water stretching a long way inland, including their tributary valleys
- are widest and deepest nearest to the sea and get progressively narrower and shallower inland
- tidal changes will often reveal extensive areas of mudflats

Fjords:

- straight, glaciated valleys that have been drowned by rising sea levels at the end of the ice ages
- have a shallower area at the mouth (a rock threshold), where the ice thinned as it reached the sea and hence lost its erosional power
- have the typical steep-sided and deep cross profile associated with glacial troughs, and can stretch many kilometres inland

Dalmation coasts:

- a drowned coastline where the main relief trends run parallel with the line of the coast
- ridges of upland produce elongated islands separated from the mainland by flooded valley areas
- their name originates from the Adriatic coast of Dalmatia (Croatia)

## Coastlines of emergence

The effect of falling sea levels is to expose land normally covered by the sea:

- cliffs that are no longer being eroded become isolated from the sea, leaving relic cliffs
- 'fossil' features, such as former caves and stacks, are left higher up from the coast on raised marine platforms
- raised beaches — common on the coast of western Scotland, where a series of raised sandy and pebble-ridden terraces can be found above the current sea levels

**Exam tip**

Be aware of the links between process and landform and between landforms and landscapes, and of how changes in time may influence both landforms and landscapes.

# Climate change

Sea-level rise associated with climate change is important as increases of several centimetres are predicted in the coming decades, due to:

- the thermal expansion of water as it becomes warmer



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- more water being added to the oceans following the melting of freshwater glaciers and ice sheets, such as those in Greenland

## Do you know?

1 Explain why wave-cut platforms tend to have a maximum width of about 0.5 km.
2 Why can waves erode both sides of a headland?
3 Give two reasons why temperature change causes sea-level change.
4 Describe the impact of isostatic sea-level change on the British Isles.
5 Make three lists: coastal landforms created by erosion; coastal landforms created by deposition; and coastal landforms resulting from sea-level change.

# 2.4 Coastal management

## You need to know

- the traditional approaches to coastal management — 'hard' and 'soft' engineering
- more sustainable approaches to managing coastal flood risk and erosion: the principles of shoreline management plans (SMPs)

## Key terms

**Hard engineering** A form of coastal management that involves the construction of man-made features.

**Soft engineering** A form of coastal management that involves working with nature and natural features.

**Integrated approach** A combination of hard and soft engineering.

## Hard and soft engineering

Traditionally, coastal defence strategies against the risks of coastal flood and erosion are classified into '**hard engineering**' methods (Table 8) and '**soft engineering**' methods (Table 9). Many modern coastal management schemes have an **integrated approach**.

**Table 8** Hard engineering strategies

| Strategy | Description | Commentary |
|---|---|---|
| Sea walls | Concrete or rock walls at the foot of a cliff or at the top of a beach; usually have a curved face to reflect waves back out to sea | Although often effective at the location where they are built, they deflect erosion further along the coast; they are expensive and have high maintenance costs |
| Groynes | Timber or rock structures, built at right angles to the coastline; trap sediment being moved along the coast by longshore drift | The beach created increases tourist potential, and gives protection to the land behind; the process starves beaches further down the coast of sand, however, increasing erosion there |
| Rip-rap (rock armour) | Large, hard rocks dumped at the base of a cliff or at the top of a beach; forms a permeable barrier to breaking sea waves | Relatively cheap, and easy to construct and maintain; the rocks used are often brought in from other areas and hence may not blend in |
| Revetments | Wooden barriers, in a slat-like form, placed at the base of a cliff or top of a beach | Intrusive and very unnatural |
| Gabions | Wire cages filled with small rocks that are built up to make walls; often used to support weak cliffs | Relatively inexpensive; look unsightly to begin with but as vegetation grows they blend in; the metal cages rust and break easily |

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**Table 9** Soft engineering strategies

| Strategy | Description | Commentary |
|---|---|---|
| Beach nourishment | Addition of sand or pebbles to an existing beach to make it higher or wider; the materials are usually dredged from the nearby seabed and spread or 'sprayed' on to the beach | A relatively cheap and easy process; the materials used blend into the natural beach; it is a constant requirement, however, as natural processes may continue to move materials away |
| Dune regeneration | Planting of marram grass and other plants that bind sand together; areas are often fenced off to keep people off newly planted dunes | Maintains the look of a natural coastline and provides important habitats; process requires a lot of time to be effective |
| Marsh creation | Low-lying coastal lands are allowed to be flooded by the sea; the area becomes a salt marsh | Provides an effective buffer to the power of waves, creating a natural defence; creates an opportunity for wildlife habitats; agricultural land is lost, however, and landowners require compensation |

# Shoreline management plans

Key features:

- SMPs were introduced in 1995, with 22 in England and Wales
- do not exist in Scotland and Northern Ireland, where the devolved governments and local authorities are jointly responsible for coastal protection
- involve all stakeholders in making decisions about how coastal erosion and coastal flood risk should be managed
- aim to balance economic, social and environmental needs and pressures at the coast
- reduce risks to people and to the developed, historic and natural environment in a sustainable way
- predict, so far as it is possible, the way in which a coastline will be shaped in the future (defined as 100 years)

Within the work of SMPs, four policies are often considered (Figure 20).

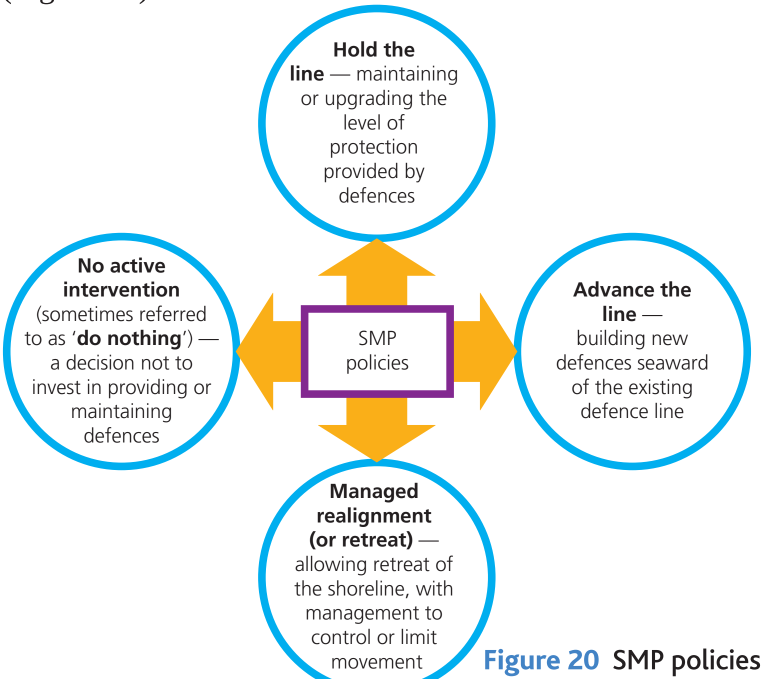


**Figure 20** SMP policies

## Exam tips

- You may be asked to 'evaluate' the effectiveness of coastal management strategies — consider their advantages and disadvantages.
- Be able to name or locate an example of several of these coastal management strategies.
- Good case studies of coastal environments and their management in the UK include the Yorkshire coast (e.g. Flamborough Head, Mappleton) and the Dorset Jurassic coast.
- Good case studies of coastal environments and their management in the rest of the world include the delta region of the Netherlands and the coral reefs of northern Australia.
- Exam questions on these case studies are likely to use one or more of the following words: *sustainable*, *resilience*, *mitigation* and *adaptation*. Make sure you understand these terms.



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## Do you know?

1 Which type of hard engineering interferes most with longshore drift?
2 Compare hard and soft engineering in general terms.
3 Who manages shoreline management plans (SMPs), and why is this important?
4 Which coastal zone management policy option involves 'letting nature take its course'?

## End of section 2 questions

1 Outline the role of wind in affecting coastal energy.
2 Outline how the coast is described as a natural system.
3 Explain how tides are created.
4 Distinguish between eustatic and isostatic sea-level change.
5 Assess the importance of different sources of energy in the creation of coastal landscapes.
6 Evaluate the role of sea-level change over the last 10,000 years in the development of coastal landscapes.
7 Explain how soft engineering could protect a coastline.
8 Hard engineering has been used to protect some coasts. With reference to a case study, explain how hard engineering can protect the coast and comment on its effectiveness.
9 'Coastal flooding and erosion will become a more common occurrence over the coming decades.' To what extent do you agree with this view?
10 Assess the extent to which predicted climate change will present challenges for the sustainable management of a local-scale coastal environment that you have studied.

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