Edexcel IAL Geography

Crowded Coasts

Detailed Notes

Classifying Coasts

The coast can be considered as an **open system** as it receives **inputs** from outside the system and **transfers outputs** away from the coast and into other systems. These systems may be **terrestrial, atmospheric or oceanic** and can include the **rock, water and carbon cycles**. Whilst coasts are **open systems**, throughout this topic you will be expected to consider the coast as a **closed system** in some circumstances such as during scientific research and coastline management planning.

Sediment Cells

Coasts can be split into sections called **sediment cells**. These are typically considered a closed-system in terms of sediment. There are eleven sediment cells in England and Wales.

- ➔ **Sources** – Where the sediment originates from (e.g. cliffs, offshore bars).
- ➔ **Through flows** – The movement of sediment along the shore through longshore drift.
- ➔ **Sinks** – Locations where deposition of sediment dominates (e.g. spits, beaches).

Under normal conditions, the coastal system operates in a state of **dynamic equilibrium**. Dynamic equilibrium in a sediment cell is where input and outputs of sediment are in a constant state of change but **remain in balance**. Physical and human action can change this equilibrium.

Sediment cells are **not** fully closed systems, so it is important to remember that actions within one cell may affect another.

Feedback Loops

The coastal system has mechanisms which enhance changes within a system, taking it away from dynamic equilibrium (**positive feedback**) or mechanisms which balances changes, taking the system back towards equilibrium (**negative feedback**).

Negative feedback loop - this **lessens** any change which has occurred within the system. For example, a storm could erode a large amount of a beach, taking the beach out of dynamic equilibrium as there is a larger input of sediment into the system than output. A negative feedback loop will balance this excess of inputted sediment:

- When the destructive waves from the storm lose their energy excess sediment is deposited as an offshore bar.
- The bar dissipates the waves energy which protects the beach from further erosion.
- Over time the bar gets eroded instead of the beach.
- Once the bar has gone normal conditions ensue and the system goes back to dynamic equilibrium.

Positive feedback - this exaggerates the change making the system **more unstable** and taking it away from dynamic equilibrium:

- People walking over sand dunes destroys vegetation growing there and causes erosion.
- As the roots from the vegetation have been holding the sand dunes together, damaging the vegetation makes the sand dunes more susceptible to erosion. This increases the rate of erosion.
- Eventually the sand dunes will be completely eroded leaving more of the beach open to erosion taking the beach further away from dynamic equilibrium.

The Littoral Zone

The **littoral zone** is the area of the coast where land is **subject to wave action**. It is constantly changing and varies due to:
- **Short-term** factors like **tides** and **storm surges.**
- **Long-term** factors like **changes in sea level** and **climate change.**

There are several subzones within the littoral zone:

- **Backshore** – area above high tide level and only affected by exceptionally high tides.
- **Foreshore** – this is land where most wave processes occur.
- **Offshore** – the open sea.

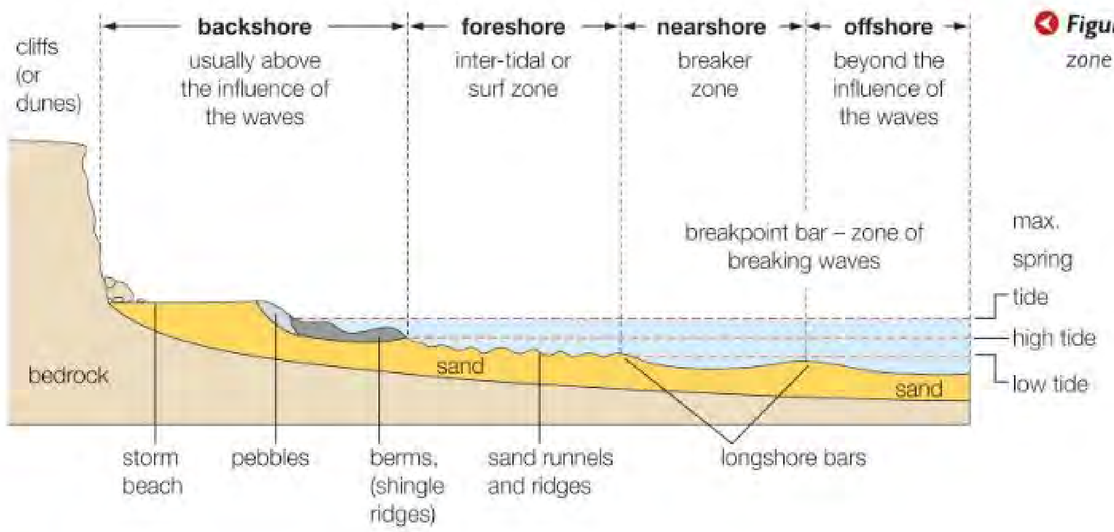
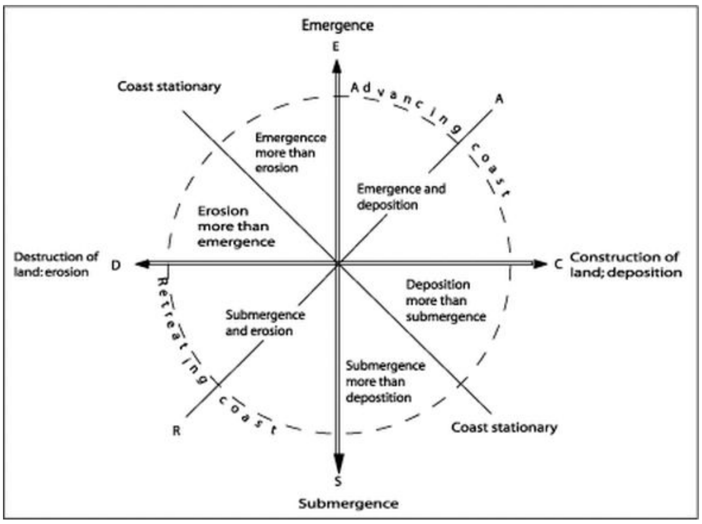


Figure 4 *The littoral zone*

Valentine's Classification

Valentine's Classification describes the range of coastlines that can occur.

An **advancing coastline** may be due to the land **emerging** or **deposition** being the prominent process. Alternatively, a coastline may be **retreating** due to the land **submerging** or **erosion** becoming the prominent process.



Emergent or submergent coastlines may be due to **post-glacial adjustment** (the land 'wobbles' as the glacier above it melts, causing isostatic sea level change), as well as other causes (discussed later).

Coastal Processes and Land Formations

Erosional processes

Erosion is a collaborative process which involves the **removal of sediment from a coastline** by different types of erosion, not one type acting by itself. The main processes of erosion are:

- **Corrasion** - Sand and pebbles are picked up by the sea from an **offshore sediment sink** or temporal store and **hurled against the cliffs** at high tide, causing the cliffs to be eroded. The shape, size, weight and quantity of sediment picked up, as well as the wave speed, affects the erosive power of this process.
- **Abrasion** - This is the process where sediment is **moved along the shoreline**, causing it to be **worn down over time**. If a watermelon 🍉 was being eroded (theoretically), corrasion would be throwing stones at it and abrasion would be rubbing the stones against the skin of the watermelon. Both will cause damage to the watermelon over time.
- **Attrition** - Wave action cause **rocks and pebbles to hit against each other**, wearing each other down and so becoming round and eventually smaller. Attrition is an erosive process within the coastal environment, but has little to no effect on erosion of the coastline itself.
- **Hydraulic Action** - As a wave crashes onto a rock or cliff face, **air is forced into cracks, joints and faults** within the rock. The high pressure causes the **cracks to force apart and widen** when the wave retreats and the air expands. Over time this causes the rock to fracture. Bubbles found within the water may **implode under the high pressure** creating tiny jets of water that over time erode the rock. This erosive process is **cavitation**.
- **Corrosion (Solution)** - The **mildly acidic seawater** can cause **alkaline rock** such as limestone to be eroded and is very similar to the process of **carbonation weathering**. This is a potential link between the carbon cycle, global warming and coasts. Will increases in rainwater and ocean acidity increase coastal erosion or will the effect by negligible?
- **Wave Quarrying** - This is when breaking waves that hit the cliff face exert a pressure up to 30 tonnes per m^2. It is very **similar to hydraulic action** but acts with significantly more pressure to directly pull away rocks from a cliff face or remove smaller weathered fragments. The force of the breaking wave **hammers the rocks surface**, shaking and weakening it and leaving it open to attack from **hydraulic action and abrasion**.

Erosion rates are the highest when:

- waves are high and have a **long fetch** (the distance the wind has travelled over the wave)
- waves approach the coast **perpendicular** to the cliff.
- **at high tide** - waves travel higher up the cliff so a bigger area of cliff face is able to be eroded.
- **heavy rainfall occurs** - water percolates through permeable rock, weakening cliff.
- in **winter** - destructive waves are the largest and most destructive during winter.

Vulnerability to Erosion

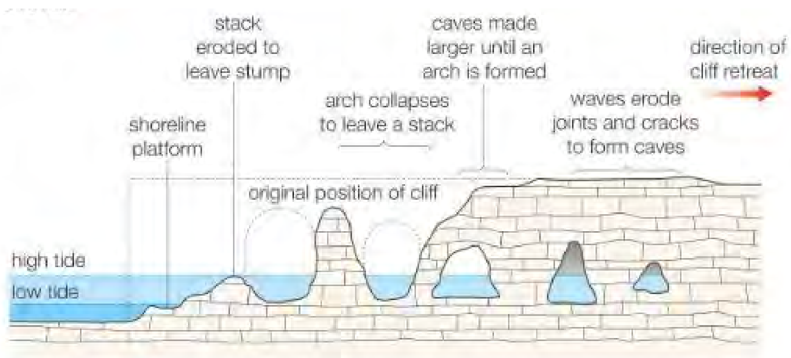
The r**esistance of a rock** will determine its vulnerability to erosion, and is influenced by various factors:

- Whether rocks are **clastic** or **crystalline** – sedimentary rocks like sandstone are clastic as they are made up of cemented sediment particles, therefore are vulnerable to erosion, whereas igneous and metamorphic rocks are made up of interlocking crystals, making them more resistant to erosion.
- The **amount of cracks, fractures and fissures** – the more weaknesses there are in the rock the more open it is to erosional processes, especially Hydraulic Action.
- The **lithology** of the rock - as shown in the table below, the type of rocks and the conditions of the rock's creation directly affects its vulnerability to erosion:

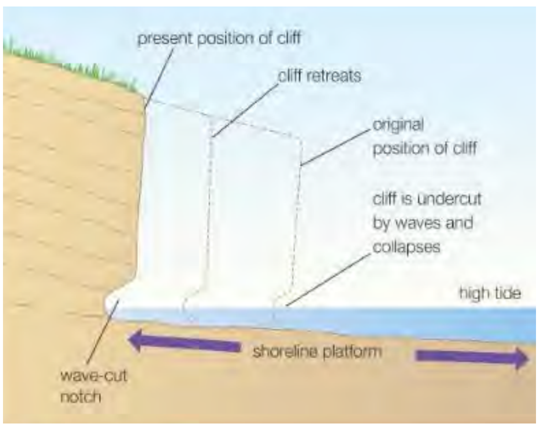
Type of Rock	Examples	Rate of Erosion	Structure of Rock
Igneous	Granite, Basalt	Very slow <0.1cm/year	Interlocking crystals which allow for high resistance to erosion
Metamorphic	Slate, Schist, Marble	Slow 0.1-0.3cm/year	Crystal all orientated in the same direction, resisting erosion
Sedimentary	Limestone	Very fast 0.5-10cm/year	Lots of faults making them weak and vulnerable to erosion

Erosional Landforms

- **Caves, Arches, Stacks and Stumps** - This sequence occurs on pinnacle headlands. Marine erosion widens faults in the base of the headland, widening over time to create a cave. The cave will widen due to both marine erosion and sub-aerial processes, eroding through to the other side of the headland, creating an arch. The arch continue to widen until it is unable to support itself, falling under its own weight through mass movement, leaving a stack as one side of the arch becomes detached from the mainland. With marine erosion attacking the base of the stack, eventually the stack will collapse into a stump.



- **Wave-cut notch and platform** - Marine erosion attacks the base of a cliff, creating a notch of eroded material between high tide height and low tide height. As the notch becomes deeper (and sub-aerial weathering weakens the cliff from the top) the cliff face becomes unstable and falls under its own weight through mass movement. This



leaves behind a platform of the unaffected cliff base beneath the wave-cut notch.

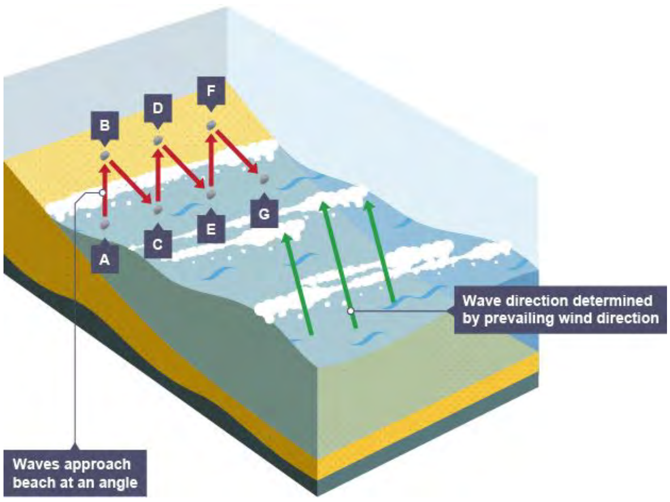
- **Retreating Cliffs** - Through the process of repeat wave-cut notches and platforms, new cliff faces are created, whilst the land retreats.

- **Blowhole** - A Blowhole is a **combination of two features**: a **pot hole on top of a cliff**, created by chemical weathering, and **a cave**, formed by marine erosion. As the cave erodes deeper into the cliff face and the pothole deepens, they may meet. In this case, a channel is created for incoming waves to travel into and up the cliff face (occasionally water splashes out of the top of the blowhole when energetic waves hit the cliff face).

Transport and Deposition

Longshore (Littoral) Drift (LSD) - Sediment is predominantly transported along the coast through the process of **longshore drift**. It transports sediment along the beach and between sediment cells:

- Waves hit the beach at an angle determined by the direction of the **prevailing wind.**
- The waves push sediment in this direction and up the beach in the **swash.**
- Due to gravity, the wave then carries sediment back down the beach in the **backwash.**
- This moves sediment along the beach over time.
- It is one of the reasons why when swimming in the sea, you often move along the coast in a particular direction.



Other processes of transportation include:

- **Traction** – Large, heavy sediment rolls along the sea bed, being pushed by currents.
- **Saltation** – Smaller sediment bounces along the sea bed, being pushed by currents.
- **Suspension** – Small sediment is carried within the water column (a body of water)
- **Solution** – Dissolved material is carried within the water

Effectiveness of Transportation

The impact of transportation depends on the severity of the angle that waves travel onto land.

- **Swash-aligned** – wave crests approach parallel to the coast so there is limited longshore drift. Sediment doesn't travel up the beach far.
- **Drift-aligned** – waves approach at a significant angle, so longshore drift causes the sediment to travel far up the beach.

Likelihood of Deposition

Deposition occurs when a wave **loses energy** meaning the **sediment becomes too heavy** to carry. Deposition tends to be a gradual and continuous process - a wave won't drop all of its sediment all at once.

- **Gravity settling** – the wave's energy becomes very low and so heavy rocks and boulders are deposited followed by the next heaviest sediment.
- **Flocculation** – clay particles clump together due to chemical attraction and then sink due to their high density.

Depositional Landforms

- **Spits** - A spit is a long narrow strip of land which is formed due to **deposition**. **Longshore drift** occurs along the coast line but as the waves lose energy (normally due to going into a sheltered area such as behind a headland) they deposit their sediment. Over time this creates a spit. Periodically, the prevailing wind will change direction causing a **hook** to appear. Over time, the sheltered area behind a spit can turn into a **salt marsh.** The length of a spit is influenced by surrounding currents or rivers. For example, in the diagram the spit is forming in an estuary and the current from the river is preventing deposition to occur across the bay and is instead causing a **recurved spit end**.

- **Bars** - A spit which, over time, crosses a bay and links up two sections of coast (the water within the bay is called a **lagoon**).
- **Tombolo** - A tombolo is a bar or beach that **connects the mainland to an offshore island** and is formed due to **wave refraction off the coastal island reducing wave velocity**, leading to deposition of sediments. They may be covered at high tide if they are low lying.
- **Cuspate forelands** - Only occurs with triangular shaped headlands. Longshore drift along each side of the headland will create beaches, which where they meet, will form a cuspate foreland.
- **Offshore bars** - A region offshore where sand is deposited, as the waves don't have enough energy to carry the sediment to shore. They can be formed as the wave breaks early, **scouring** the seabed and instantly depositing its sediment as a loose-sediment offshore bar.
- **Sand Dunes** - Sand dunes occur when **prevailing winds blow sediment to the back of the beach** and therefore the formation of dunes requires large quantities of sand and a large tidal range. This allows the sand to dry, so that it is light enough to be picked up and carried by the wind to the back of the beach. Frequent and strong onshore winds are also necessary. The dunes develop as a process of a vegetation succession:
  - **Embryo dunes** – Upper beach area where sand starts to accumulate around a small obstacle (driftwood, wooden peg, ridge of shingle)

- **Yellow dunes** – As more sand accumulates and the dune growns, vegetation may develop on the upper and back dune surfaces, which stabilises the dune. The tallest of the dune succession.
- **Grey dunes** – Sand develops into soil with lots of moisture and nutrients, as vegetation dies, enabling more varied plant growth.
- **Dune slack** – The water table rises closer to the surface, or water is trapped between hollows between dunes during storms, allowing the development of moisture-loving plants (e.g. willow grass)
- **Heath and woodland** – Sandy soils develop as there is a greater nutrients content, allowing for less brackish plants to thrive. Trees will also grow (willow, birch, oak trees) with the coastal woodland becoming a natural windbreak to the mainland behind.

Stability of Depositional Landforms

Depositional landforms consist of **unconsolidated sediment** and are therefore vulnerable to change. During major **storms**, large amounts of sediment can be eroded or transported elsewhere removing a landform from one region of the sediment cell. Depositional landforms depend on a **continuous supply** of sediment to balance erosion, which may see some landforms changed as their **dynamic equilibrium shifts**.

Sub-Aerial Processes - Weathering and Mass Movement

Weathering is the **breakdown of rocks** (mechanical, biological or chemical) over time, leading to the **transfer of material into the littoral zone**, where it becomes an **input to sediment cells**.

Mechanical (Physical) Weathering: the breakdown of rocks due to exertion of physical forces without any chemical changes taking place

- **Freeze-thaw (Frost-Shattering):** Water enters cracks in rocks and then the water **freezes** overnight during the winter. As it freezes, **water expands by around 10%** in volume which increases the pressure acting on a rock, causing cracks to develop. Over time these cracks grow, weakening the cliff making is more vulnerable to other processes of erosion
- **Salt Crystallisation:** As seawater **evaporates**, salt is left behind. Salt crystals will grow over time, exerting pressure on the rock, which forces the cracks to widen. Salt can also **corrode ferrous (materials that contains iron) rock** due to chemical reactions
- **Wetting and Drying:** Rocks such as clay **expand when wet** and then contract again when they are drying. The frequent **cycles of wetting and drying** at the coast can cause these rocks and cliffs to break up

Chemical weathering - the breakdown of rocks through chemical reactions. There are different types of chemical weathering:

- **Carbonation: Rainwater absorbs CO2** from the air to create a **weak carbonic acid** which then reacts with **calcium carbonate** in rocks to form **calcium bicarbonate** which can then be easily dissolved. **Acid rain** reacts with **limestone** to form **calcium bicarbonate**, which is then easily dissolved allowing erosion.
- **Oxidation:** When **minerals** become exposed to the air through **cracks and fissures**, the mineral will become oxidised which will **increase its volume** (contributing to mechanical

weathering), causing the rock to crumble. The most common oxidation within rocks is iron minerals becoming iron oxide, turning the rock rusty orange after being exposed to the air.

- **Solution:** When rock minerals such as **rock salt** are dissolved.

Biological Weathering - the breakdown of rocks due to the actions of plants, bacteria and animals

- **Plant Roots** - Roots of plants growing into the cracks of rocks, which exerts pressure, eventually splitting the rocks. Research **Angkor Wat** for more information on this, even though it is not coastal!
- **Birds** - Some birds such as **Puffins** dig burrows into cliffs weakening them and making erosion more likely.
- **Rock Boring** - Many species of **clams** secrete chemicals that dissolve rocks and **piddocks** may burrow into the rock face
- **Seaweed Acids** - Some seaweeds contain pockets of **sulphuric acid**, which if hit against a rock or cliff face, the acid will dissolve some of the rock's minerals. (e.g. Kelp)
- **Decaying Vegetation** - Water that flows through decaying vegetation and then over coastal areas, will be acidic, thus causing chemical weathering

Mass Movement

There are several types of **mass movement**, which tend to be determined by the **weight** of the sediment and its **ability to flow downhill**.

The type of mass movement that occurs depends on:

- the angle of the slope/cliff
- the rock's lithology and geology
- the vegetation cover on the cliff face
- the saturation of the ground/ previous weather patterns

There are two different categories of mass movement: a **slide** and a **flow**. For a slide, sediment keeps its same place within the whole material, simply moves downhill. However, for a flow, all the material flows downs and mixes.

Flows include:

- **Soil creep** - The slowest but continuous form of mass movement involving the movement of soil particles downhill.
- **Solifluction** - Occurs mainly in tundra areas where the land is frozen. As the top layers thaws during summer (but the lower layers still stay frozen due to permafrost) the surface layers flows over the frozen layers.
- **Mudflows** - An increase in the water content of soil can reduce friction, leading to earth and mud to flow over underlying bedrock.

Slides include:

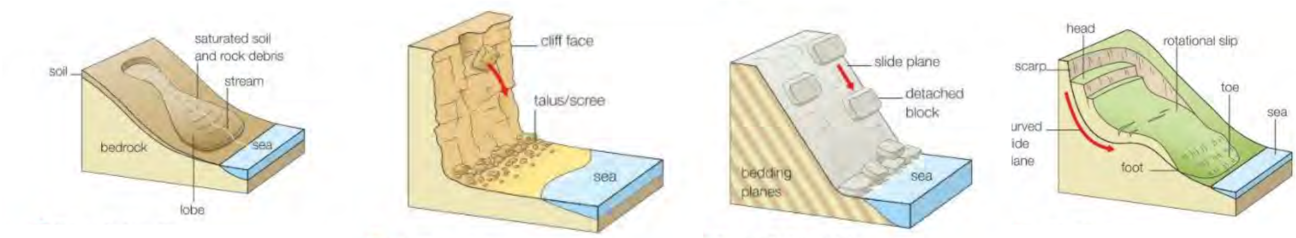
- **Rock falls** - Occur on sloped cliffs (over 40°) when exposed to mechanical weathering.
- **Rock slides** - Water between joints and bedding planes (which are parallel to the cliff face) can reduce friction and lead to more sliding.
- **Slumps** - Occur when the soil is saturated with water, causing a rotation movement of soft materials (such as clay and sand) forming rotational scars and terraced cliff profiles.

Vulnerability to Sub-Aerial Processes - **Temperature and climate** can influence the prominent process of weathering. In colder climates, mechanical weathering is more common whereas in warmer climates, chemical weathering is more common.

Landforms of Mass Movement - Cliff profiles

Cliff profiles are influenced by many factors but the two main characteristics that dominate are:
- The resistance of the rock to erosion
- The dip in rock strata in relation to the sea

Many cliffed coastlines are **composite** (they have different rock layers) which makes explaining cliff profiles very complex.



Cliff profiles due to solifluction, rock falls, rock slides and slumping.

Concordant Coastlines

Concordant coastlines are where the rock strata run **parallel** to the coast. The rock type varies between different concordant coasts and normally consist of **bands of more resistant and less resistant rock**. For example, limestone may run in parallel bands with clays and sands. These different rock types create different landforms due to erosion

Concordant coastlines can lead to the formation of **Dalmatian coastlines**, where a rise in sea levels led to the flooded widen river valleys between tall headlands. The headlands become islands, running perpendicular to the mainland.

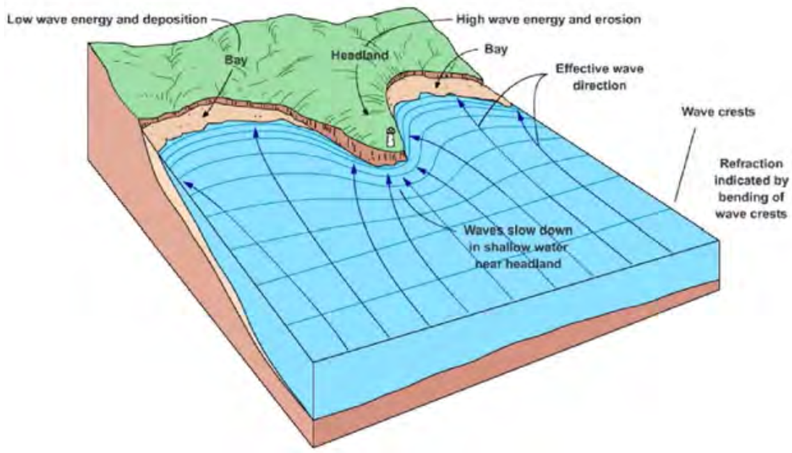
Haff coasts are also dependant on a concordant coastline, where large bays are crossed by spits, creating extensive lagoons.

(Source: https://www.youtube.com/watch?v=G1FIBuybN78)

Discordant Coastlines

This is where the rock strata run **perpendicular** to the sea, which can create successions of headlands and bays; less resistant rocks are eroded faster than the more resistant rocks, which leads to the formation of bays.

Headlands and bays have an effect on income waves and cause **wave refraction**. **Wave refraction** is the



process by which waves turn and lose energy around a headland on uneven coastlines. The **wave energy is focussed on the headlands**, creating **erosive features** in these areas. The energy is **dissipated in bays** leading to the formation of features associated with **lower energy environments** such as beaches.

Coastal Vegetation

Rocks and sediment play a very important role in influencing the shape of the coastal landscape. However, vegetation is essential in **stabilising** any landforms from further change.

Vegetation helps to stabilise coastal sediment in many ways:

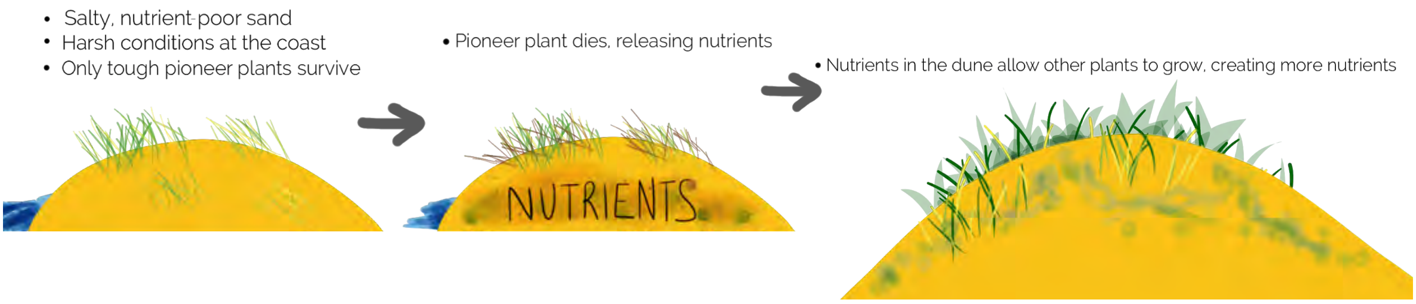
- **Roots** of plants bind soil together which helps to reduce erosion.
- When completely submerged, plants provide a **protective layer** for the ground and so the ground is less easily eroded.
- Plants reduce the **wind speed** at the surface and so less wind erosion occurs.

Plants grow in different coastal environments and are either halophytes or xerophytes

- **Xerophytes** – plants that are tolerant of **dry** conditions.
- **Halophytes (or brackish)** – plants that are tolerant of **salty** conditions.

Plant Succession

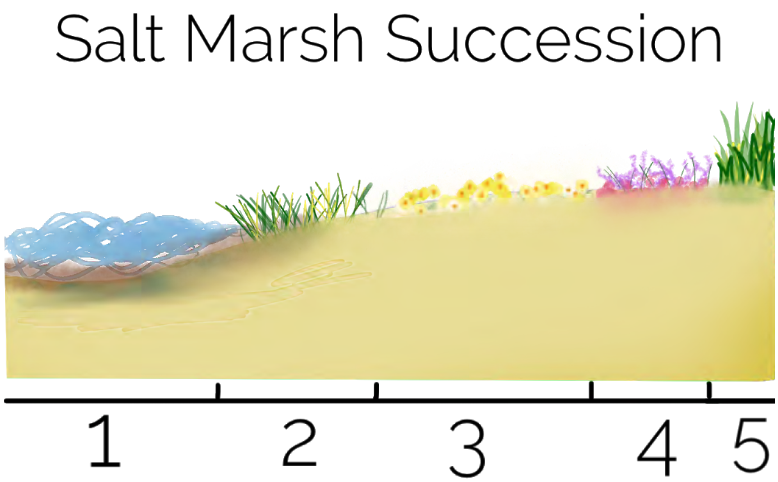
Plant succession is a long-term change in a plant community in an area. On coasts where there is a supply of sediment and deposition occurs, **pioneer plants** begin to grow in bare mud and sand. Due to the salty soil conditions only certain plants can grow there. As more deposition occurs and the vegetation dies and releases **nutrients** into the sand this reduces the saltiness of the soil which means different plants can start growing there. These processes continue over time allowing new species of plants to colonise.



Marram grass is a very good example of a pioneer plant:
- it is tough and flexible, so can cope when being blasted with sand.
- it has adapted to reduce water loss through transpiration.
- Their roots grow up to 3 metres deep and can tolerate temperatures of up to 60°C

Salt Marsh Succession

- **Algal Stage** - Gut weed and Blue green algae establish as they can grow on bare mud, which their roots help to bind together.
- **Pioneer Stage** - Cord grass and Glasswort grow, their roots begin to stabilise the mud allowing estuarine to grow.
- **Establishment Stage** - Salt marsh grass and Sea asters grow, creating a carpet of vegetation and so the height of the salt marsh increases.
- **Stabilisation** - Sea thrift, Scurvy grass and Sea lavender grow, and so salt rarely ever gets submerged beneath the marsh.
- **Climax vegetation** - Rush, Sedge and Red fescue grass grow since the salt marsh is only submerged one or twice a year.



Mangroves and Coral Reefs

Mangroves are the shrubbery and trees living at the edge of salty (**saline**) water. Coral reefs are underwater environments home to large populations of marine life. Both mangroves and coral reefs are highly valuable to the local coastline:

- **Natural Defences** - Mangroves and reefs dissipate wave energy, which reduces the risk of flooding due to storm surges and tsunamis for the coastline behind. The roots of the mangroves also bin coastal soils together, reducing coastal erosion.
- **Tourism** - Due to the vast biodiversity, many reefs and mangroves are popular tourist locations, especially for diving, snorkelling and kayaking.
- **Primary Industry** - Local settlements may rely on coral reefs for fishing or mangroves for timber (the wood is resistant to rot, making it extremely valuable).

Source: EcoView/Fotolia

However, mangroves are being cleared for **beach tourist resorts** and coral reefs are declining due to **coral bleaching**.

Waves and Sea Levels

High-Energy and Low-Energy Coastlines

When answering questions in your exam, it is expected that you will include information about the different processes and landforms that may occur in **high and low energy environments**.

High-energy coastlines are associated with more powerful waves, so occur in areas where there is a **large fetch.** They typically have **rocky headlands and landforms** and fairly frequent **destructive waves**. As a result these coastlines are eroding as the **rate of erosion exceeds the rate of deposition**.

Low-energy coastlines have less powerful waves and occur in **sheltered areas** where **constructive waves** prevail and as a result these are often **fairly sandy areas**. There are **landforms of deposition** as the rates of **deposition exceed the rates of erosion**.

The size of a wave depends on various factors including:
- The **strength** of the wind
- How long the **wind** has been blowing for
- **Water depth**
- Distance of **fetch**

There are two types of waves:

	Constructive	**Destructive**
Formation	Formed by weather systems that operate in the open ocean	Localised storm events with stronger winds operating closer to the coast
Wavelength	Long wavelength	Short wavelength
Frequency	6-9 Per Minute	11-16 Per Minute
Wave Characteristics	Low waves, which surge up the beach	High waves, which plunge onto the beach
Swash Characteristics	Strong swash, weak backwash	Weak swash, strong backwash
Effect on Beach	Occurs on gently sloped beaches	Occurs on steeply sloped beaches

Over the course of time, the wave types hitting a beach can vary:
- In summer, constructive waves dominate but destructive waves dominate in winter.
- Constructive waves may turn into destructive waves as a storm begins.

- Climate change could mean that the UK may become more stormier meaning an increase in destructive waves.
- Dams prevent sediment being transported from rivers and entering into the coastal area which means erosion could increase.
- Interference with natural processes along the coast (e.g. through human activity) could affect sediment supply across a coastal area.

Sea level change

Sea levels change can be on a short-term or long-term basis. Short term sea level change can be because of:

- **High tide and low tide** - a daily phenomena due to the gravitational pull of the Moon.
- **Wind strength and direction** - these can change causing a change in sea level for a couple of minutes or longer
- **Atmospheric pressure** - the lower the pressure, the higher the sea levels.

Isostatic - localised sea level change
Isostatic sea level change could be due to **post-glacial adjustment** (glaciers weigh down the land beneath, and so the land subsides until it melts). For example, post-glacial adjustment for the UK after the Ice Age has caused Southern England to subside around 1mm per year and Scotland to rebound and increase around 1.55mm per year.
Tectonic activity (such as **earthquakes** and **volcanic eruptions**) may cause land subsidence, therefore causing isostatic sea level increase.

Eustatic rise - Global sea level change
Eustatic rise is due to **thermal expansion.** Water expands when it gets warmer, and so the volume of water increases which as a result, sea levels increase. This is due to **Global Warming**. However, predicting sea level change is very difficult because various factors could affect changes, and the cause isn't fully understood.

Risks to Coastal Environments

Coastalisation is the movement of people towards the coast. Despite having a high flood risk, may people move to the coast due to **tourism, high-yield agricultural lands,** or **housing pressure**. Coastalisation can increase the environmental vulnerability of these locals to flooding due to storm surges

Storm Surges

A storm surge occurs when there is a short-term change in sea level, which may be due to **low pressure** during a **depression or tropical cyclone**.
The storm surge can be exacerbated through a variety of factors:

- **Subsidence** of the land - through tectonic activity or post-glacial adjustment.
- **Removing natural vegetation** - Mangrove forests are the most productive and complex ecosystem in the world. Mangroves also provide protection against extreme weather events like cyclones which are very common in the Bay of Bengal. However, due to pressure for land space, much mangrove forests are destroyed for tourism, local industry, or housing plains.

- **Global Warming** - As the surface of oceans get warmer, it is estimated that the frequency and intensity of storms will increase, and so the severity of storm surges and flooding is also expected to increase.

Damaged crops	685 528 hectares
Damaged houses	1 518 942
Dead and missing	4234
People injured	55 282
Cattle and poultry killed	1 778 507
Damaged educational institutions	16 954
Damaged roads	8075 km
Damaged bridges/culverts	1687
Damaged electricity lines	703 km
Tube wells affected	901
Cost of damage to roads, embankments, sluice gates and riverbank protection	US$ 29.6 million

Figure 7 *Some of the impacts of Cyclone Sidr (from Bangladesh's Department of Disaster Management)*

Consequences for Communities

Some areas of the coast may have significantly **reduced house and land prices** (as the area becomes known to be at significant risk). This can lead to economic loss for homeowners and local coastal economies. In the UK, many insurers don't provide home insurance to people living along coastlines that are at extreme risk of erosion or storm surges.
Storm surges also damage the environment by **destroying plant successions** and damaging many coastal landforms. Depositional landforms, due to their unconsolidated nature, are most likely to be destroyed. Also, erosion may take place at accelerated rates or higher up along the cliff face, which can increase the risk of collapse.

Environmental Refugees

Globally, more than 1 billion people live on coasts that are at risk from coastal flooding and 50% of the world's population currently live within 200km of the coast.

As storm surges and erosion along some coastlines are predicted to increase, so too is the volume of environmental refugees displaced **internally or internationally**. People may lose their homes, way of life and culture as they are forced to migrate to avoid the rising eustatic sea level and the rising risk of **coastal flooding**.

Local Factors that Threaten Coasts

Coastlines and marine life is susceptible to local changes on shore.

- **Coastalisation** is the development of urban towns and cities along the coast. In MEDCs, coastalisation is rapidly increasing as coastal towns offer an **attractive lifestyle** - pretty surrounding/ views, local water sports, local source of food. However, increasing the built environment in sometimes **vulnerable locations** (bays at risk from storm surges) can add to pressure on natural coastal defenses ie. mangroves.
- **Unsustainable fishing or resource collection** will reduce the marine population and natural habitats, which can cause further decline along the **food chain**. Occasionally, local fishermen may try to introduce a productive species to a coast. This would increase their catch and so reduce food insecurity. However, **alien species** can threaten other wildlife and increase competition for food within the food chain.
- **Pollution** can greatly degrade the natural environment. **Water pollution** especially affects a coastline, since pollution and chemicals dumped from the coastline can flow outwards into the ocean. **Plastic waste** is particularly threatening to coastlines, since plastic bags are mistakenly ingested by turtles and other marine animals. Also, **nuclear contamination** (by air or water) can spread quickly outwards from coastal stations, as evident in the 2011 Fukushima Disaster.

Coastal Management

Approaches to coastal management have changed greatly due to new knowledge and research about the positive and negative impacts that management can have on a coastline. New approaches have been created, though the specific strategies used can mostly be classified into two types - **hard and soft engineering**. Hard and soft engineering **both relate to traditional approaches to coastal management**. 'There is erosion occurring in this area, so lets build a beach or sea wall to reduce the erosion'. These approaches are a **direct solution** to the problem that is occuring.

There are different approaches to managing coastal areas.

- **Hold the line** – Defences are built to try and keep the shore where it is.
- **Managed realignment** – Coastline moves inland naturally but managed.
- **Advance the line** – Defence are built to try and move the shore seawards.
- **Do nothing** – No defences are put in place and the coast is allowed to erode.

Factors looked at when deciding on which policy to use:

- **Economic value of assets** that could be protected is looked at, for example the important natural gas terminal at Easington would be protected however farmland and caravan parks wouldn't
- The technical feasibility of **engineering solutions**, for example a sea wall may not be possible for a certain location.
- The **ecological and cultural value** of land. For example, it may be desirable to protect historic sites or SSSI.

Coastal Decision Making

Cost-benefit analysis (CBA)

This is an analysis that is carried out before any form of coastal management takes place. The cost involved include construction, demolition, maintenance etc. is then compared to the expected benefits like the value of land saved, homes and businesses protected. Costs and benefits include both tangible and intangible things.

For a project to be given the go ahead, **the expected benefits have to outweigh the costs** (according to DEFRAs 1:1 analysis)

ICZM – Integrated Coastal Zone Management

- A coastal area (sediment cell) is managed as a whole. This often involves management between different political boundaries e.g in the UK different councils will have to work and manage coasts together.
- The ICZM recognises the importance of the coast for **people's livelihoods.**
- The ICZM recognises that coastal management must be **sustainable** whereby economic development is important but this should come at a cost for the environment.

The ICZM must involve all stakeholders, plan for the long term and try to work with natural process and not against them.

Shoreline management plans (SMPs)

For each sediment cell in the UK, an SMP has been created to help with coastline management. Each SMP **identifies all of the activities, both natural and human** which occur within the coastline area of each sediment cell. The sediment cells are considered to be closed for the purposes of management, although in reality there will be some exchanges between the different sediment cells. SMP's are **recommended for all sections of English and Welsh coastlines by DEFRA** (governing body responsible for the majority of environmental protection in the UK). Four options are considered for each stretch of the coastline:

Types of Defences

<u>Hard engineering</u>

Hard engineering is a very traditional and in many ways outdated approach to coastal management and it involves **man made structures that aim to prevent erosion**. They are often very effective at preventing erosion in the desired area, but are high cost and have a **significant environmental impact due to the use of concrete** and other man-made materials. By reducing erosion in one area of the coastline, they may act to exacerbate erosion elsewhere. Therefore their only impact is to change where erosion is occuring.

Offshore Breakwater

Source: Concrete Layer

Description: Rock barrier which forces waves to break before reaching the shore

- 👍 Effective at reducing waves' energy
- 👎 Visually unappealling
- 👎 Navigation hazard for boats
- 👎 Can interfere with LSD

Groynes

Source: Tripadvisor

Description: Timber or rock protrusions that trap sediment from LSD

- 👍 Builds up beach, protecting cliff and increasing tourist potential
- 👍 Cost effective
- 👎 Visually unappealling
- 👎 Deprives areas downwind of sediment increasing erosion elsewhere

Sea Walls

Source: Southampton University

Description: Concrete structures that absorb and reflect wave energy, with curved surface

- 👍 Effective erosion prevention
- 👍 Promenade has tourism benefits
- 👎 Visually unappealling
- 👎 Expensive to construct and maintain
- 👎 Wave energy reflected elsewhere, with impacts on erosion rates

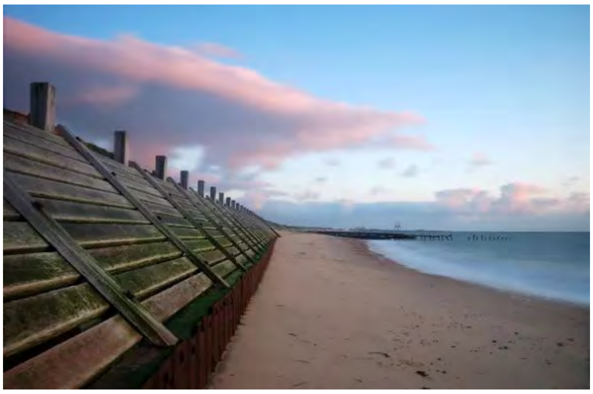
Rip Rap (Rock Armour)

Source: Stacey.Peak-Media

Description: Large rocks that reduce wave energy, but allow water to flow through

- 👍 Cost effective
- 👎 Rocks are sourced from elsewhere, so do not fit with local geology
- 👎 Pose a hazard if climbed upon

Revetments



Source: Geographical.co.uk

Description: Wooden or concrete ramps that help absorb wave energy

- 👍 Cost effective
- 👎 Visually unappealling
- 👎 Can need constant maintenance, which creates an additional cost

Soft Engineering

Unlike hard engineering, soft engineering **aims to work with and complement the physical environment** by using natural methods of coastal defence. They are useful for protecting against sea-level change as well as coastal erosion.

Beach Nourishment

Source: Eastern Solent Coastal Partnerships

Description: Sediment is taken from offshore sources to build up the existing beach

- 👍 Builds up beach, protecting cliff and increasing tourist potential
- 👍 Cost effective and looks natural
- 👎 Needs constant maintenance
- 👎 Dredging may have consequences on local coastal habitats

Cliff Regrading and Drainage

Source: Stacey.Peak-Media

Description: Reduces the angle of the cliff to help stabilise it. A steeper cliff would be more likely to collapse

- 👍 Cost effective
- 👎 Cliff may collapse suddenly as the cliff is drier leading to rock falls which pose a hazard
- 👎 May look unnatural

Dune Stabilisation

Source: Wikipedia

Description: Marram grass planted. The roots help bind the dunes, protecting land behind

- 👍 Cost effective and creates an important wildlife habitat
- 👎 Planting is time consuming

Marsh Creation

Source: DurDoor

Description: Type of managed retreat allowing low-lying areas to flood

- 👍 Creates an important wildlife habitat
- 👎 Farmers lose land and may need compensation as a result

Sustainable Coastal Management

Aspects of managing coast in a sustainable way include:

- **Managing natural resources** like fish, water, farmland to ensure **long-term productivity**.
- Creating **alternative livelihoods** before people lose their existing jobs.
- **Educating** communities about the need and how to adapt.
- **Monitoring** coastal changes and then adapting or mitigating.
- Managing **flood risk** or relocating if needed.

Conflict Over Policy Decisions

When considering coastal management their may be **winners and losers**. Winners can be classified as those who benefit **economically** (e.g. their homes and businesses are protected), **environmentally** (e.g. habitats are protected) and **socially** (community ties still remain in place, people still have jobs so less stress and worrying). **Losers** can be classified as those who lose their property, lose a job, or have to relocate elsewhere. Communities and homeowners have a **strong attachment to a place** so losing their properties and their social networks is a great loss. This will make them **financially worse off** and many people may feel lonely if forced to move and may be angered if areas are not chosen to be protected. Business owners may be angered if nothing is done to protect the area in which they have their business, which could cause them to lose profitability and regular clients. **DEFRA funding has been reduced** by the central government since 2010 so they cannot invest in coastal management in all areas and now have to prioritise their funding in the most important locations. Some people may feel aggrieved by this.

However there may be arguments which supports the decision for no active intervention:

- Coastal managers produce SMP for an entire area so they have to see what kind of impacts other may have if the coast is managed in one specific area
- Local authorities and DEFRA have had their budgets reduced as central government funding since 2010 has dropped and so they cannot invest in coastal management in all areas, they have to prioritise their funding to the most important places

The Impact of Coastal Management on Sediment Cells

Coastal management has a variety of impacts on sediment cells and any form of intervention will cause some kind of impact. **Installing a sea wall would reflect wave energy downdrift** increasing wave energy and erosion elsewhere on the coastline. **Less erosion occurs in these areas with the sea wall**, so there is also **less sediment in the areas with increased wave energy**. **Less sediment reduces the beach size**, so the **cliff is more exposed to erosion** from the higher energy waves. Building groynes has the same effect on downdrift areas as **longshore drift** can no longer transport sediment away from one stretch of coastline.

Land Reclamation

Sometimes, in an effort to **increase the space available** in a coastal city, land is created by dumping vast volumes of sediment off the coastline. This may be successful in providing land for building, farming and industry. However, this reduces **fishing catchment areas**, buildings are prone to **liquefaction** if an earthquake occurs and any local coral reefs may be destroyed.