AQA Geography A-level

3.1.3 - Coastal Systems and Landscapes

Detailed Notes

The Coastal System

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. The coastal system is impacted and impacts upon processes which occur in the **five oceans** of our planet and the **smaller seas** of which they are part of. You should be aware of the **different habitats and activities which are affected by and affect the coastal environment**. Some of these are demonstrated in the image below:

Source: National Institute of Water and Atmospheric Research New Zealand

Sediment Cells

Coasts can be split into sections called **sediment cells** which are often bordered by **prominent headlands**. Within these sections, the **movement of sediment is almost contained** and the flows of sediment act in **dynamic equilibrium**.

Dynamic equilibrium refers to the maintenance of a **balance** in a natural system, despite it being in a **constant state of change**. The system has a tendency to **counteract any changes** imposed on the system in order to keep this balance, which is achieved by **inputs** and **outputs** constantly changing to maintain the balance. Dynamic equilibrium in a sediment cell is where input and outputs of sediment are in a constant state of change but **remain in balance**.

The dynamic equilibrium may be upset in the **long term** by **human interventions**, or in the **short term** it may be interrupted by **natural variations**. Within each sediment cell there are **smaller subcells**. Often the smaller subcells are used when **planning coastal management projects**.

There are many features to the coastal system and most are listed below - there is more detail on each throughout these notes. Most of the questions in your exam will **focus on how these features and processes affect the coastal system**, though this will not always be explicit in the question title. When you are learning something in this unit, always **link it back to the key features** below:

Inputs: May refer to **material or energy** inputs. Coastal inputs are not limited to but include three main areas:

- **Marine:** Waves, Tides, Salt Spray
- **Atmosphere:** Sun, Air Pressure, Wind Speed and Direction
- **Humans:** Pollution, Recreation, Settlement, Defences

Outputs: May refer to **material or energy** outputs

- Ocean currents
- Rip tides
- Sediment transfer
- Evaporation

Stores/Sinks: Refer to stores and sinks of sediment and material. The formation of each of these stores is discussed later in these notes

- Beaches
- Sand Dunes
- Spits
- Bars and Tombolos
- Headlands and Bays
- Nearshore Sediment
- Cliffs
- Wave-cut Notches
- Wave-cut Platforms
- Caves
- Arches
- Stacks
- Stumps
- Salt Marshes
- Tidal Flats
- Offshore Bands and Bars

Transfers/Flows: The processes that link the inputs, outputs and stores in the coastal system

- Wind-blown sand
- Mass-movement processes
- Longshore drift
- Weathering
- Erosion
  - Hydraulic Action
  - Corrosion
  - Attrition
  - Abrasion
- Transportation
  - Bedload
  - In suspension
  - Traction
  - In solution
- Deposition
  - Gravity Settling
  - Flocculation

Energy: The power and driving force behind the transfers and flows in the system

- Wind
- Gravitational
- Flowing Water

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 occured 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:

1. When the destructive waves from the storm lose their energy excess sediment is deposited as an offshore bar.

2. The bar dissipates the waves energy which protects the beach from further erosion.

3. Over time the bar gets eroded instead of the beach.

4. Once the bar has gone normal conditions ensue and the system goes back to dynamic equilibrium.

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

1. People walking over sand dunes destroys vegetation growing there and causes erosion.

2. 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.

3. Eventually the sand dunes will be completely eroded leaving more of the beach open to erosion taking the beach further away from its original state.

Sediment Sources

Rivers:

- **Most of the sediment** in the coastal zone is a result of an **input from rivers**, especially in high-rainfall environments where significant river erosion occurs. This is demonstrated by the image of the Gulf of Mexico and the sediment flowing from a **river delta** (Source: NASA)
- Sediment may be **deposited in estuaries** which are **brackish (salty)** areas where rivers flow into the sea. They are **important wildlife habitats**. The sediment is then **transported** throughout the coastal system by waves, tides and currents

Cliff Erosion:

- Very important in areas with **unconsolidated (uncompacted and therefore unstable)** cliffs that are eroded easily. In some areas, coastlines can retreat by **up to 10m per year**, providing a **significant sediment input**. **Most erosion occurs during the winter months** due to **more frequent storms**

Wind:

- The wind is a **coastal energy source** and can cause sand to be blown along or up a beach
- Sediment transport by winds may occur where there are **sand dunes** or in **glacial and desert environments** which provide sediment inputs

Glaciers:

- In some coastal systems such as in **Antarctica, Greenland, Alaska and Patagonia**, glaciers flow directly into the ocean depositing sediment that was stored in the ice
- This occurs when **glaciers calve**, a process where ice breaks off the glacier

Offshore:

- Sediment is transferred to the coastal zone when **waves, tides and currents erode offshore sediment sinks** such as **offshore bars**. The sediment is transported onto the beach, helping to build up the beach
- **Storm surges or tsunami waves** may also transfer sediment into the coastal zone

Longshore Drift:

- Sediment is moved along the beach, due to **prevailing winds** which alter the **direction of the waves**. This allows sediment to be transported from one section of coastline (as an output) to another stretch of coastline (as an input). This is a very important process. The **swash approaches the coast at an angle due to the prevailing winds**, transferring sediment along the beach. The **backwash pulls the sediment directly back down the beach**. The swash then transfers the sediment along the coastline and the process repeats

Source: USGS and West Hawaii Today

The images show how the process of longshore drift occurred to block off the Pohoiki Boat Ramp in Hawaii when the Kilauea volcano erupted in 2018. Volcanic material was **transported along the coastline by longshore drift, leading to deposition and beach formation**. This formed a **spit** off the breakwater before eventually blocking the entire boat ramp. It demonstrates how quickly the process of longshore drift can have an impact on shaping the coastal environment.

Sediment Budgets

Sediment budgets are very similar to **carbon budgets** and have the same purpose within different systems. They use **data of inputs, outputs, stores and transfers** to assess the **gains and losses of sediment within a sediment cell**. In principle a system will operate in a state of **dynamic equilibrium** where input and outputs of sediment are equal. However, **human actions and natural variation** in the system can disrupt the state of equilibrium.

The Littoral Zone

The **littoral zone** is the area of land between the **cliff's or dunes on the coast and the offshore area that is beyond the influence of the waves**. It is therefore covered by the sea at different points in time. The littoral zone is constantly changing because of:

- **Short-term factors** like tides and storm surges
- **Long-term factors** like changes in sea level and human intervention

The word **shore** is commonly used and can be used with different terms:

- **Shore/Shoreline** - The boundary between the sea and the land
- **Offshore** - The area beyond the influence of waves
- **Onshore** - The area of land not covered by the sea, but very close to it

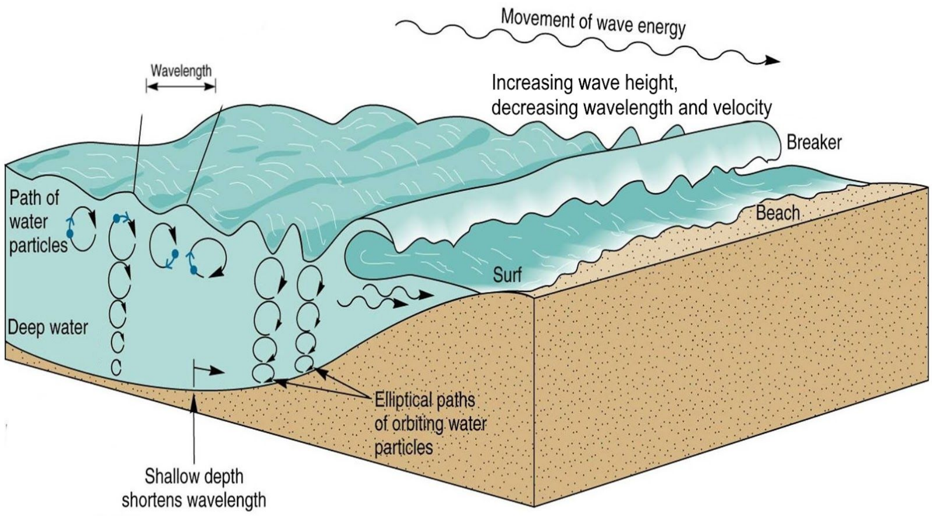
Sources of Energy at the Coast

The **sun is the primary source of energy** for all natural systems. The main energy source at the coast is from **waves which are formed offshore**, which are most commonly **generated by wind**, or less frequently **tectonic activity or underwater landslides causing tsunami waves**.

Wave Formation

The sun has a direct influence on the formation of waves, which occur when **wind moves across the surface of the water**:

- Winds move across the surface of the water, causing **frictional drag** (resistance to the wind by the water) which creates **small ripples and waves**. This leads to a **circular orbital motion of water particles** in the ocean
- As the **seabed becomes shallower** towards the coastline, the **orbit of the water particles becomes more elliptical**, leading to **more horizontal movement of the waves**
- The **wave height increases, but the wavelength (distance between two waves) and wave velocity both decrease**
- This causes **water to back up from behind the wave** until the **wave breaks (collapses) and surges up the beach**



When the wave moves up the beach, it is known as the **swash** and when it moves back down the beach into the sea, this is known as the **backwash**.

Factors Affecting Wave Energy

Strength of the Wind: Wind is essentially air that moves from an area of **high pressure to an area of low pressure**. The different pressure areas are caused by **variations in surface heating** by the sun. The larger the difference in pressure between two areas (**pressure gradient**) the stronger the winds. As waves are caused by the wind, stronger winds also mean stronger waves.

Duration of the Wind: If the **wind is active for longer periods of time**, then the energy of the waves will build up and increase.

Size of the Fetch: The **fetch is the distance over which the wind blows** and the larger it is, the more powerful the waves will be. It could also be thought of as the distance to the nearest land mass in a particular direction.

Wave Types

Constructive waves tend to **deposit material**, which **creates depositional landforms** and increase the size of beaches. **Destructive waves** act to **remove depositional landforms** through erosion, which work to decrease the size of a beach.

	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

The **type of waves** in a coastal environment may vary:

- In summer, constructive waves dominate but destructive waves dominate in winter
- Constructive waves may become destructive waves if a storm begins
- Climate change may increase the storm frequency within the UK
- Coastal management may affect the type of waves that occur

Negative Feedback: Beaches and Waves

The presence of **constructive waves causes deposition** on the beach, which in turn leads to the **beach profile becoming steeper**. **Steeper beaches favour the formation of destructive waves** which are then more likely to occur. The **destructive waves erode the beach**, reducing the beach profile and **leading to the formation of constructive waves**. As constructive waves occur more frequently in summer when there are fewer storms, this means that the beach profile is more gentle in summer and steeper during the winter months when destructive waves are more common. This should lead to a state of **dynamic equilibrium** though in reality this may not occur due to **external factors** such as the wind strength and direction.

Tides

Gravity is another key source of energy in coastal environments and is **responsible for tides** which occur when the **gravitational pull of the sun or moon** changes the water levels of the seas and oceans. The difference in height between the tides is known as the **tidal range** and tends to be largest in **channels such as river estuaries**. The high and low tides and therefore the **tidal range** are all impacted by the positioning of the moon and the sun.

The **highest high tide** and the **lowest low tides** occur when the sun and the moon are **in alignment**. Both of their **gravitational forces combine to effectively pull the oceans towards them** to cause the highest high tides. On the other side of the planet, this creates the lowest possible low tides. This is a **spring tide** and it creates the **largest possible tidal range**.

The **lowest high tide** and the **highest low tides** occur when the sun and the moon are **perpendicular** to each other. Both of their gravitational forces **act against each other**, so the **overall pull is minimised** at high tide, but therefore creates a higher low tide. This is a **neap tide** and it creates the **smallest possible tidal range**.

Tides affect erosion and lead to the formation of different coastal landforms.

Currents

Rip currents are powerful underwater currents occurring in areas close to the shoreline on some beaches when **plunging waves cause a buildup of water** at the top of the beach. The backwash is forced under the surface due to **resistance from breaking waves**, forming an underwater current. This flows away from the shore more quickly due to beach features, such as a **gap in a sandbar**, creating a rip current. Rip currents claims lives at beaches every year, though it is possible to escape from them by swimming away from them in a direction parallel to the beach. **Riptides are different to rip currents** as they occur when the ocean tide pulls water through a small area such as a bay or lagoon. Rip currents are an **energy source** in a coastal environment and can lead to **outputs of sediment** from the beach area.

High-Energy and Low-Energy Coastlines

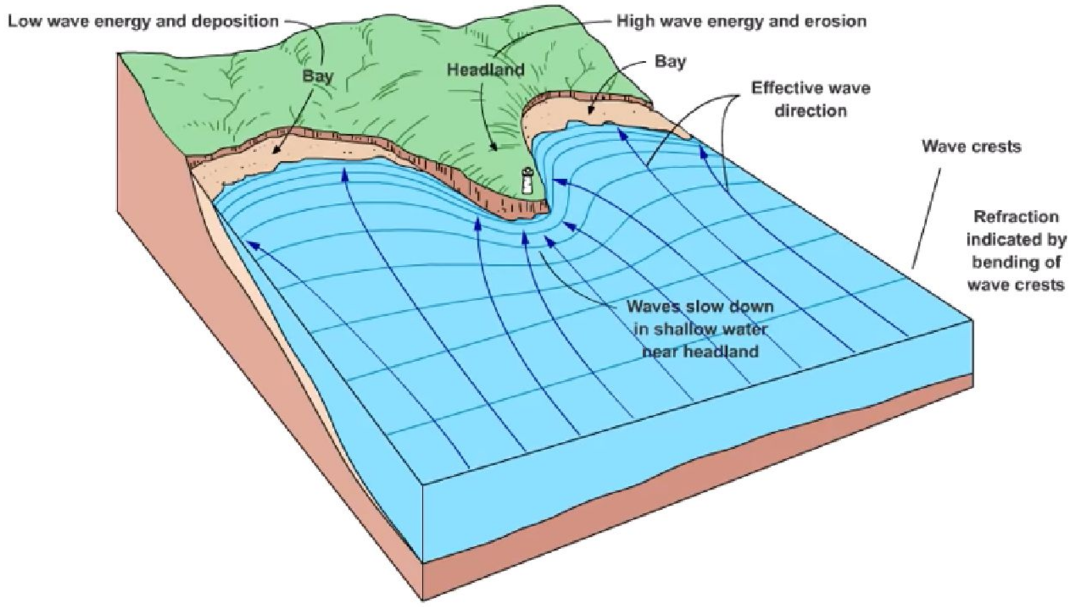
When answering questions in your exam, it is expected that you will include information about the different processes and landforms that may occur in **high and low energy environments**.

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 often 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**.

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.



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

Negative Feedback

Due to the different rock strengths, erosion leads to the formation of **headlands where resistant rock exists** and **bays where unconsolidated rocks and clays are dominant**. This then **increases the forces of erosion on the headlands** and **reduced erosion in the bays** as wave refraction dissipates wave energy and a beach protects the coastline behind. Eventually the **headlands are worn away**, which then again **increases erosion within the bays**. This would lead to **dynamic equilibrium** if conditions stayed constant, but of course over time they will vary.

Marine Processes

Erosion

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 discussed below:

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**.

Factors Affecting Erosion

There are several factors which affect coastal erosion, which can be **marine or land based**:

- **Waves:** This is the main factor affecting the **rate and type of erosion**. As a result, most erosion occurs during the winter months when waves are more likely to be destructive and more powerful due to frequent storms
- **Beaches:** If there is a beach in front of a cliff then this will **absorb wave energy** and thus reduce the effects of erosion. Therefore if **coastal management such as groynes** are used which trap sediment, this can lead to beaches not building up in other areas. Instead it could increase the rate of erosion there
- **Subaerial Processes**: **Weathering and mass movement** processes such as landslides weaken cliffs. Rock fragments as a result of these processes may lead to increased **corrasion and abrasion**
- **Rock Type: Sedimentary** rocks like sandstone are made up of cemented sediment particles and are therefore are vulnerable to erosion, whereas **igneous and metamorphic** rocks are made up of **interlocking crystals**, making them more resistant to erosion
- **Rock Faults: Fissures, cracks and joints** are are all types of weaknesses within the rock so the more there are, the quicker erosion of the rock will occur. They also i**ncrease the rock face surface area**, further promoting erosion. Large faults within the rock can lead to the **formation of headlands and bays** due to the favourable conditions for erosion that they create
- **Rock Lithology (Rock characteristics):** As shown in the table on the next page, 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

Processes of Transportation and Deposition

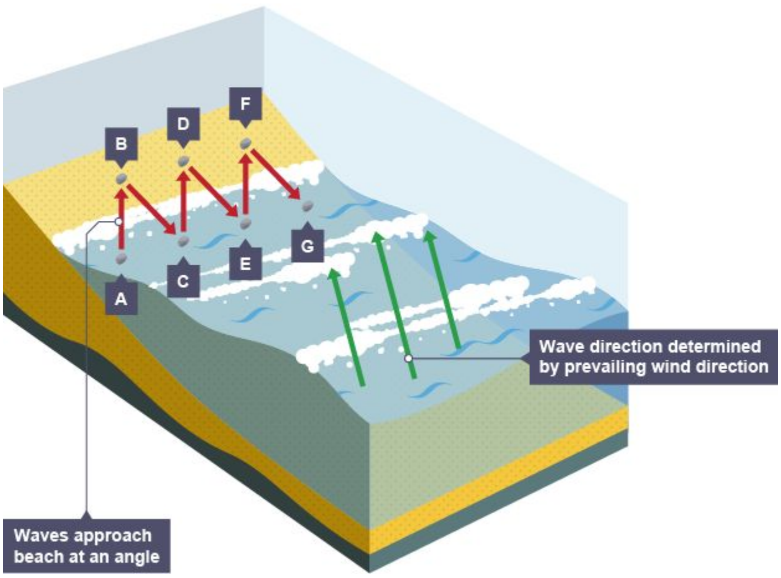
Coastal transportation is responsible for transferring sediment within a sediment cell and between other sediment cells. The four main processes of **transportation** are:

- **Traction** – Large, heavy **sediment rolls along the sea bed** pushed by currents. Think of a big tractor 🚜 wheel moving on the ground (seabed)
- **Saltation** – Smaller sediment bounces along the sea bed, being **pushed by currents**. The **sediment is too heavy** to be picked up by the flow of the water
- **Suspension** – Small sediment is carried within the flow of the water. The **Hjulström curve** shows how **greater velocities of water are able to suspend larger and heavier pieces of sediment**
- **Solution** – **Dissolved material is carried** within the water, potentially in a chemical form. This method of transportation is an important part of carbonation weathering

Longshore (Littoral) Drift (LSD)

Longshore drift may utilise all these methods of transportation to move 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



Source: BBC

Deposition

Deposition occurs when **sediment becomes too heavy** for the water to carry, or **if the wave loses energy**. Deposition tends to be a gradual and continuous process, so a wave won't release all its sediment at the same time. This explains why **beaches are often either sandy or rocky** and these areas are very distinct on the same beach. **High-energy coastlines** continue to transport smaller sediment, so larger rocks and shingle are deposited in these environments. **Low-energy coastlines** have much smaller sediment, which is only deposited in these areas where there is a much **lower water velocity**. As a result, specific landforms of deposition will occur. Two types of deposition are explained below:

- **Gravity Settling:** The water's **velocity decreases** so sediment begins to be deposited
- **Flocculation:** This is an important process in salt and tidal marshes. Clay **particles clump together due to chemical attraction** and then sink due to their high density

Weathering and Mass Movement Processes

Weathering

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**.

Positive Feedback: If the rate of removal of the weathered rock from the base of the cliff is higher than the rate of weathering, then this will promote further weathering as this will **increase the area of exposed rock**. This will increase the amount of erosion that occurs because this will **increase the supply of rocks** which can become part of the **erosive processes of saltation and abrasion**.

Negative Feedback: If the removal of weathered rock from the base of the cliff is slower than the rate of weathering then this will lead to a **buildup of debris at the base of the cliff**, **reducing the exposed cliff area** and therefore **reducing the rates of weathering**. It will also reduce erosion as the cliff foot will be protected from the other forces of erosion.

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

- **Carbonation: Rainwater absorbs CO_2** 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 by **organic activity:**

- **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

Mass movement is the **movement of material down a slope under the influence of gravity**. Mass movement can be categorised into four main areas: **creeps, flows, slides and falls**. Mass movement processes act as an **input into the littoral zone** from the store of the land. The type of mass movement is dependent on:

- Cliff/slope Angle
- Rock Type
- Rock Structure
- Vegetation
- Saturation of Ground
- Presence of Weathering

The Different Types of Mass Movement are:

Soil Creep: The **slowest** but most continuous form of mass movement involving the movement of soil particles downhill. Particles rise and fall due to **wetting and freezing** and in a similar way to longshore drift, this causes the soil to move down the slope. It leads to the formation of **shallow terracettes**.

Solifluction: Occurs mainly in tundra areas where the land is frozen (**periglacial environments**). As the top layers thaw during summer (but the lower layers still stay frozen due to permafrost) the **surface layers flow over the frozen layers**. Forms **solifluction lobes**.

Mudflows: An increase in the water content of soil can reduce friction, leading to earth and mud to **flow over underlying bedrock**, or slippery materials such as clay. Water can get trapped within the rock increasing **pore water pressure**, which forces rock particles apart and therefore weakens the slope. **Pore Water Pressure (PWP)** is an important energy source for determining slope stability and refers to the pressure of groundwater held within soil or rock. Mudflows represent a **serious threat to life** as they can be very fast flowing.

Rockfall: Occurs on sloped cliffs (over 40°) when **exposed to mechanical weathering**, though mostly occurs on **vertical cliff faces** and can be triggered by earthquakes. It leads to **scree** (rock fragments) building up at the base of the slope. Scree is a **temporal store** which acts as an input to the coastal zone.

Landslide: Heavy rainfall leads to **water between joints and bedding planes** in cliffs (which are **parallel to the cliff face**) which can **reduce friction and lead to a landslide**. It occurs when a **block of intact rock** moves down the cliff face very quickly along a flat slope. Can be very dangerous.

Landslip or Slump: Contrary to a landslide, the **slope is curved**, so often occur in weak and unconsolidated clay and sands areas. A build up in pore water pressure leads to the **land to collapse under its own weight**. This can create a **scarred/terraced** appearance to the cliff face.

Runoff: Runoff is an example of a **link between the water cycle and the coastal system**, as the water in the form of overland flow may erode the cliffface and coastal area or pick up sediment, that then enters the littoral zone, when it is transported in the water via **suspension**. It may also be responsible for **increasing pollution** in coastal areas if it picks up waste or excess chemicals.

Vulnerability to Sub-Aerial Processes

Temperature and climate can influence the prominence of weathering. In colder climates, mechanical weathering is more common, whereas in warmer climates, chemical weathering is more common.

Coastal Landforms and Landscapes of Erosion

Caves, Arches, Stacks & Stumps

This sequence occurs on **pinnacle headlands**:

- Initially, faults in the headland are eroded by **hydraulic action and abrasion** to create small caves
- The **overlying rock in a cave may collapse**, forming a **blowhole**. The blowhole spurts water when a wave enters at the base, forcing sea spray and air out of the top
- 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 continues 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
- This was seen recently at the **Azure Window in Malta**. With marine erosion attacking the base of the stack, eventually the stack will collapse into a stump
- A **wave-cut platform** will be left afterwards

Cliff Profile and Rate of Retreat

Steep Cliffs: Most common where the **rock is strong and fairly resistant** to erosion. **Sedimentary rocks that have vertical strata** are also more resistant to erosion, creating steep cliffs. An absence of a beach, long-fetch and high energy waves also promote steep cliff development. Most commonly found in **high-energy environments**

Gentle Cliffs: Most commonly found in **areas with weaker rocks** which are **less resistant to erosion** and are prone to sluming. **Low-energy waves** and a **short fetch** will lead to the formation of a scree mound at the base of the cliff, reducing the overall cliff angle. A large beach would also reduce wave energy and prevent the development of steep cliffs by reducing erosion rates. Most commonly found in **low-energy environments**

Rate of Retreat: Dependent on the relative importance of **marine factors** (fetch, beach, wave energy) and **terrestrial factors** (subaerial processes, geology, rock strength). The cliff's most likely to retreat are those that are made of **unconsolidated rock** and sands.

Negative feedback mechanisms can help to protect and restore a coast. For example, during a storm, part of a cliff may collapse so the material produced will protect the base of the cliff from marine erosion, reducing further cliff **recession**. Alternatively, sand dunes may be eroded during a storm, meaning a loss of a sediment on land. However, the sediment produced may be deposited in **offshore bars**, which protect the coastline from further erosion by **dissipating wave energy**.

Wave-cut Notch and Platform

This sequence occurs at steep cliffs:

- When waves erode a cliff, the erosion is mostly **concentrated around the high-tide line**. The main processes of **hydraulic action and corrasion** create a **wave-cut notch**
- 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**
- Over time the same processes repeat leading to a **wave-cut platform** to be formed, which is normally exposed at high-tide

Negative Feedback

The length of a **wave-cut platform** is limited as eventually the waves can no longer reach the cliff, reducing the erosion. Therefore the act of **erosion creating the wave-cut platform has acted to directly decrease the rate of erosion in future** - an example of **negative feedback**.

Coastal Landforms and Landscapes of Deposition

Beaches

A beach is a **depositional landform** that stretches from roughly the low tide to the high tide line and is created when sediment is deposited near the coastline when waves lose their energy. It is one of the **most important stores** in the coastal system. **Beach accretion** occurs when the beach is being built up by constructive waves, usually during the summer months. **Beach excavation** occurs in winter when destructive waves remove sediment from the beach. The effectiveness of transportation is dependent on the **angle of the prevailing wind** in relation to the land and leads to the formation of different beach types:

- **Swash-aligned**: Wave crests approach **perpendicular to coast** so there is **limited longshore drift**. Sediment doesn't travel far along the beach. **Wave refraction** may reduce the speed of high energy waves, leading to the formation of a shingle beach with larger sediment
- **Drift-aligned**: Waves approach at a significant angle, so longshore drift causes the sediment to travel far along the beach, which may lead to the **formation of a spit** at the end of a beach. Generally **larger sediment is found at the start of the beach** and weathered sediment moves further down the beach through longshore drift, becoming smaller as it does, so the **end of the beach is likely to contain smaller sediment**

There are different features within a beach. These may include **berms**, which are ridges which mark where the high tide line is at different times of the year, and as a result there may be several berms on a beach characterised by a **small ridge or change in sediment type**. **Cusps** are small **curved dips in the beach** where the swash comes in, and are slightly lower than the rest of the beach. This creates undulations in the beaches profile. **Runnells are smaller ridges** that are often found in smooth wet sand further towards the sea, caused by the tides.

Beach profiles and sediment types **vary dependent on distance from the shoreline**. **Larger sediment is found toward the top of the beach** where it has been left from winter storms. The backwash is often weaker than the swash as the water quickly percolates into the sand. As the backswash isn't as powerful the larger sediment remains at the top of the beach. Some of the smaller sediment will be moved back down the beach, giving a fairly even pattern. Often if you approach a cliff from the sea, the **sediment will become larger** in size. Scree near the cliffs as a result of mass movement processes and weathering means that **angularity increases towards the cliff**, where hydraulic action acts less frequently to round the sediment.

Spits

This is a **long narrow strip of land** which is formed when **longshore drift** causes the beach to extend out to sea, usually due to a **change in direction of the coastline**. This sediment projection can create a **salt marsh due to the sheltered, saline environment** where water flow speed is lower, allowing **deposition of finer sediments** to occur. The length of the spit depends on any changing currents or rivers, which will **prevent sediment from being deposited**. This means a **spit can never extend across an estuary**. A change in wind direction or wave direction can cause the end of the spit to curve (known as a **recurved end**). Over time, the spit may be left with multiple recurved tips, which is known as a **compound spit**. In some areas a **double spit may occur** where the spits from **opposite sides of a bay** reach out towards each other, though are unlikely to touch unless there are no changes to environmental conditions. This could lead to a **barrier beach** being formed.

Barrier Beach/Bars

A barrier beach occurs when a **beach or spit extends across a bay to join two headlands**. This traps water behind it leading to the formation of a brackish lagoon which is separated from the sea. As well as forming from present day processes, some barrier beaches may have formed due to **rising sea levels after the last glacial period**, when meltwater from glaciers deposited sediment in the coastal zone. If a **barrier beach becomes separated from the mainland, it becomes a barrier island**. They are common in areas with **low tidal ranges** and can be very large, as demonstrated by the barrier beaches that have formed in the Netherlands.

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.

Offshore Bars

An **offshore region where sand is deposited**, as the waves don't have enough energy to carry the sediment to shore. They can be formed when the wave breaks early, instantly depositing its sediment as a loose-sediment offshore bar. Waves may pick up sediment from an offshore bar, which then provides an **important sediment input into the coastal zone**. They may also be formed as a result of **backwash from destructive waves removing sediment from a beach**. Offshore bars may absorb wave energy, reducing erosion in some areas.

Plant Succession

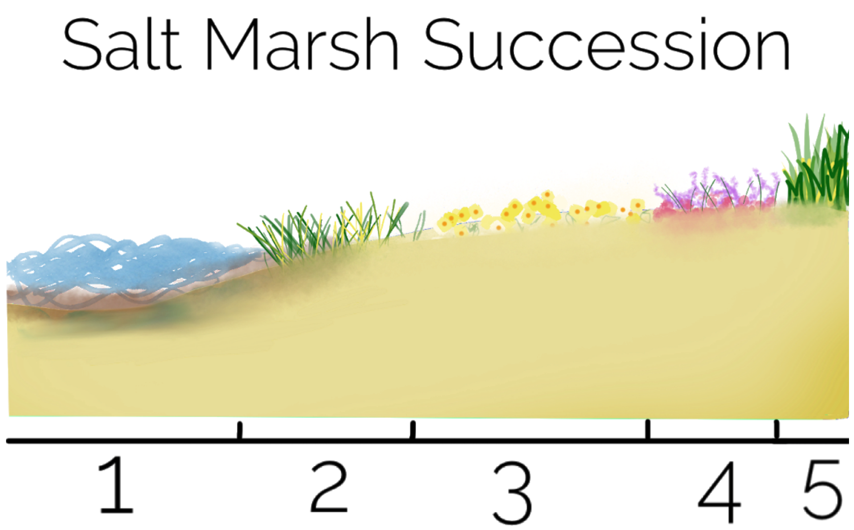
A **vegetation succession is a plant community that changes over time**. On coasts where there is a supply of sediment and deposition occurs, **pioneer plants** begin to grow in bare mud and sand.

For sand dune succession, **embryo dunes** are first colonised by pioneer plants, which die and release **nutrients** into the sand, increasing the amount of vegetation able to grow within the dune. Embryo dunes and their pioneer plants alter the environmental conditions from harsh and salty, to an environment in which other plants can survive. New species of plants can now colonise the area, which will **change the environment** progressively.
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

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



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

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:

- Pioneer species such as **sea rocket** are resistant and able to survive in the salty sand, with its roots helping to bind the dunes together
- **Decaying organic matter adds nutrients and humus** (organic material comprised of decaying plant and animal matter) to the soil allowing marram grass to grow
- Larger plants are able to colonise the area and the **climatic climax** occurs when trees are able to colonise the area

This leads to a dune structure involving different types of dunes:

- **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

Estuarine Mudflats and Saltmarshes

Deposition occurs in river estuaries because when the flow of water from the river meets with the incoming tides and waves from the sea, causing **water flow to virtually cease**, so the water can no longer carry its sediment in suspension. They may also occur in sheltered areas such as **behind a spit** or other areas where there are **no strong tides or currents** to prevent sediment deposition and accumulation.

As most of the sediment is small, this leads to a **build up of mud**, which over time builds up until it is above the water level. **Deposition occurs as a result of flocculation**. Pioneer plants colonise this area, leading to more sediment becoming trapped. This colonises the transition zone between high and low tide. A **meadow** is formed as sections of the salt marsh rise above the high tide level, leading to the **climatic climax of the vegetation succession** when trees begin to colonise the area.

Stability of Depositional Landforms

Depositional landforms consist of **unconsolidated sediment** making them 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 rely on a **continuous supply** of sediment to balance erosion, which may see some landforms changed as their **dynamic equilibrium shifts**.

Sea Level Change

Sea levels change in short-term period such as day-to-day or minute to minute due to factors such as **high tide and low tide**, **wind strength** and **changes in wind direction** or changes in **atmospheric pressure** (the lower the pressure, the higher the sea levels). Sea level change also occurs over long-term periods, leading to the formation of various coastal landforms as a result of the following processes:

Isostatic Change

Isostatic change occurs when the **land rises or falls relative to the sea** and is a **localised change**. Isostatic sea level change is often a result of **isostatic subsidence** (glaciers weigh down the land beneath, and so the land subsides). When the glaciers melted, this has lead to **isostatic recovery** and the coastline to **rebound and rise again** in the areas that were covered by ice. In the UK, this has caused a see-saw effect. Scotland and the north-west of England are **rising at around 1.5mm per year** as they were previously covered by glaciers, but this has caused the land in the south-east to **subside around 1mm a year**. This links into water and carbon cycles and glaciation units. In some areas of the Mediterranean, some historical ports have been submerged and other raised above the current sea level as a result of this process

Tectonic activity (such as **earthquakes** and **volcanic eruptions**) may cause land subsidence, therefore causing isostatic sea level change. This was seen in the 2004 Indian Ocean earthquake, which caused the city of **Bandeh Aceh to sink permanently by 0.5m**. (This links to the Hazards section of Geography).

Eustatic Change

Eustatic change affects sea level across the whole planet. You can remember this using *Eustatic affects Everywhere*. Eustatic change may be due to **thermal expansion/contraction** or changes in glacial processes. Thermal expansion is the process of water expanding when it gets warmer, and so the volume of water increases leading to rising sea levels. In the last ice age, **sea levels were over 100m lower than they are currently** due as the water was stored in large ice caps as the majority of precipitation fell as snow. When the ice caps melted, this lead to rising sea levels. As a result of global warming, both processes are acting to increase sea levels with the **IPCC predicting sea level increases for 0.3m - 1.0m by 2100**. In Miami, they are currently facing significant problems, with much of the coastal strip flooding regularly during high tides as a result of rising sea levels.

Emergent Coastal Landforms

Where the land has been raised in relation to the coastline, landforms such as **arches, stacks and stumps** may be preserved. **Raised beaches** are common before cliffs which are also raised (**relic cliffs**), with wave-cut notches and similar features proof of historical marine erosion.

Submergent Coastal Landforms

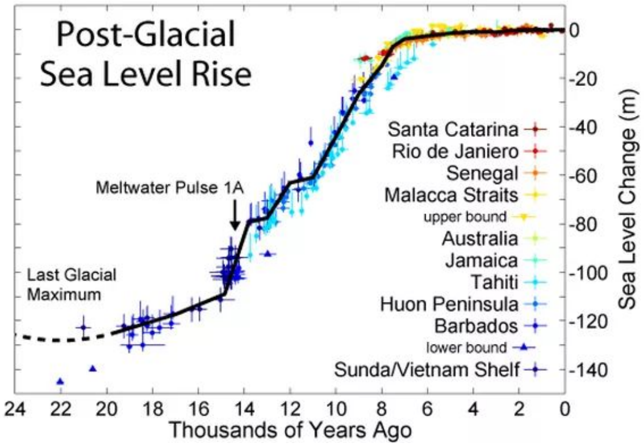
Landforms of submergence occur when the **sea level rises or the coastline sinks** in relation to the sea. An easy way to imagine the effects of rising sea levels is to picture a mountainous area close to the coast and then imagine sea level rising by around 100m leading to some of the valley's being flooded. Rising sea levels leads to the following landforms:

Rias: Rias are formed when rising sea levels **flood narrow winding inlets and river valleys**. They are **deeper at the mouth of the inlet**, with the **water depth decreasing further inland**.

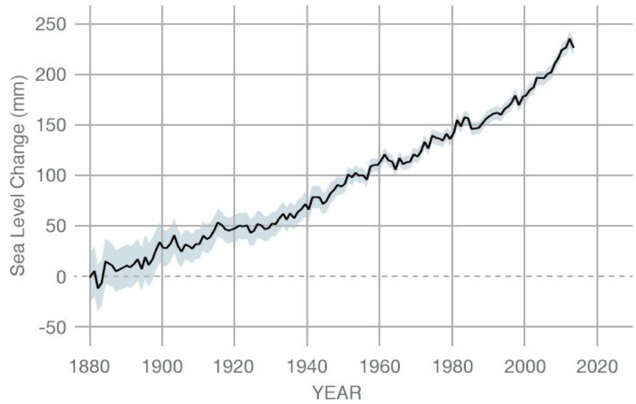
Fjords: Fjords are formed when rising sea levels **flood deep glacial valleys to create natural inlets and harbours**. Fjords can be found across the world though in some countries such as New Zealand they may be referred to as sounds. They are **deeper in the middle section than they are at the mouth**, with the shallower section identifying where the glacier left the valley.

Dalmatian Coasts: This type of coastline occurs when **valleys running parallel to the coast become flooded** as a result of sea level change. This leaves a **series of narrow, long and rugged islands** and the best examples can be seen in Croatia. They may also be referred to as Pacific coasts.

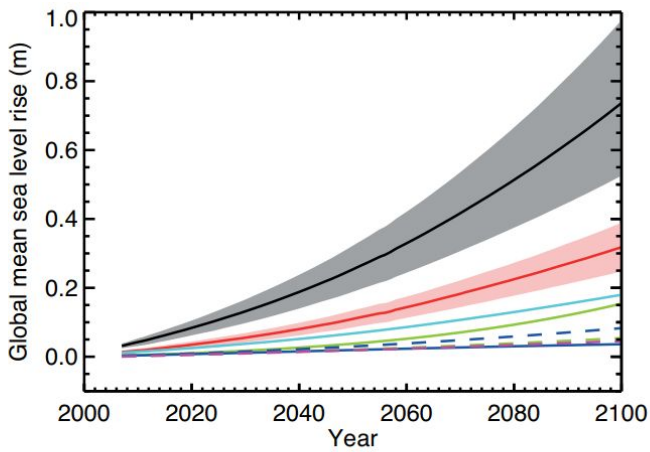
Contemporary Sea Level Change



Since records began around 20,000 years ago, sea levels have always been rising from 120m below the levels which they are now at today. The graph clearly shows that sea level increase **slowed around 8,000 years ago**, and **levelled at the current height around 3000 years ago**.



Since 1880 and the industrial revolution, **sea levels have increased by around 235mm**. That may not sound significant, but it is **enough to overwhelm some sea defences**, when **combined with higher than expected storm surges**. It also affects the drainage system in coastal cities increasing the flooding risk.



The **International Panel on Climate Change (IPCC)** predicts that sea levels may rise between **0.3 - 1.0m by 2100** and the graph shown on the left shows the **different models and climate predictions** that they have created. This could **cause aquifers to be polluted in low-lying atoll islands** (coral reefs protruding from the sea) affecting the residents who live in them. It may also **inundate many coastal cities** and significantly increase the risks from tropical storms and Tsunamis. In some areas turning the coastal area into recreational land as a method of **adaptation** to climate change is proving to be a popular option.

Risks to Coastal Environments

Coastalisation is the process by which the **coast is being developed and people are moving to the coast**, increasing the number of people at risk from marine related environmental activity. It may be a **by-product of urbanisation** in which people are **moving to cities** as the **majority of large cities are coastal**. This is not a required term for the specification, but may be useful to include when discussing the risks of sea level change in future.

Storm Surges

A **storm surge is a result of the low pressure** created by large weather events such as tropical storms. It raises the sea level and therefore poses a significant flooding risk as it has the **potential to inundate flood defences**, making the other impacts of a tropical storm more potent. The risk from a storm surge may be exacerbated by:

- **Removing Natural Vegetation**: Mangrove forests are the most productive and complex ecosystem in the world. Mangroves also **provide protection against extreme weather events such as cyclones** which are very common in the Bay of Bengal. However, due to pressure for land space, **many mangrove forests are destroyed** to make space for tourism, local industry, or housing. Mangroves are an excellent method of coastal management as they can also **keep up with global sea level rises of up to eight times the current rate**. They **trap sediment leading to accretion** on the coastline, helping protect communities from the potential impacts of climate change
- **Global Warming**: As the surface of oceans get warmer, it is **predicted that the frequency and intensity of storms will increase**, and so the **severity of storm surges and flooding is also expected to increase** - there is **no agreed scientific consensus**

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) leading 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**, may potentially be destroyed as was seen in 2013, when the spit 'Spurn Head' was partially destroyed by a large storm surge. If depositional features are destroyed then erosion may occur more quickly closer to the cliff face, which can increase the risk of collapse of cliffs and threats to land owners.

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 60km** of the coast (and this figure is increasing daily). Around **75% of all of the world's large cities are coastal**.

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 sea levels** and the rising risk of flooding. In low-lying countries such as Bangladesh where the coastline is made up of clay sands many people may be displaced due to the potential impacts of climate change on the coast.

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.

Hard Engineering

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

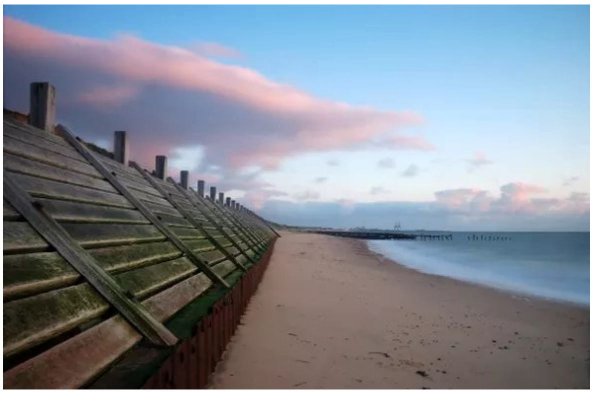
Rip Rap (Rock Armour)

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 Stablisation

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

Cost-Benefit Analysis (CBA)

This is an analysis that is **carried out before any form of coastal management takes place**. The **expected cost** of the construction, demolition, maintenance etc. of a coastal management plan is then compared to the **expected benefits** of a scheme which may include the value of land, homes and businesses that will be protected. Cost and benefits may be **tangible** (monetary value) or **intangible** (other effects such as visual impact). According to **DEFRA's** 1:1 analysis, the **expected benefits have to out way the costs** for a project to go ahead.

Sustainable Coastal Management

As the negative impacts of many coastal management schemes have become clear, **sustainable integrated approaches** are becoming more widely used. It is key that you have a good understanding of these methods as they are a topic that you may include in 20 mark question answers. They are **holistic strategies**, meaning that it is recognised that all of the different sections of the coastline are interlinked and function together as a whole. Smaller sections are not considered separately, unlike with traditional methods. Aspects of managing coast in a sustainable way include:

- **Managing natural resources** like fish, water, farmland to ensure **long term productivity**
- Ensuring that there are **new jobs** for people who may face unemployment as a result of protection measures. E.g. if a decision is taken that fishing needs to decrease as currently it is above sustainable levels
- **Educating communities** about the need to adapt and how to protect the coastline for future generations
- **Monitoring coastal changes** and then using **adaptation or mitigation** as a response to the observed changes
- Ensure that **everybody is considered** when changes are proposed and then adopted

Integrated Coastal Zone Management (ICZM)

ICZM is one method of sustainable coastline management. Large sections of coastline (often **sediment cells**) are managed with **one integrated strategy**. Management occurs **between different political boundaries**, which is both beneficial and problematic as decision making is likely to be a longer process. 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 is **not prioritised over protection of the coastal environment**
- The ICZM **must involve all stakeholders**, plan for the long term and try to work with natural process and not against them
- It recognises that **sediment eroded in one location may form a protective beach elsewhere** and therefore a decision to protect one coastal community may not outweigh the disadvantages of exposing another community to increased erosion
- In 2013 the EU adopted a new initiative which promotes the use of ICZM's across all of Europe's coastlines, which recognised the benefits of the ICZM strategy

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 majority of environmental protection in the UK). Four options are considered for each stretch of the coastline:

- **Hold the Line**: Defences are used to maintain the current position of the shoreline
- **Managed Realignment/Retreat**: Defences and engineering techniques are used to allow the coastline to advance inland and create its own natural defences such as salt marshes
- **Advance the Line**: Defence are built to try and move the shoreline seawards, potentially to protect an important population centre or tourist amenity
- **No Active Intervention**: The coastline is exposed to natural processes

Different factors are considered when choosing a management option:

- **Economic value of assets** that could be protected. A known area of gas reserves may be protected, though a caravan park may not be
- The technical feasibility of **engineering solutions**. 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 areas and **Sites of Special Scientific Interest (SSSI)**

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.

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.