Coastal processes and landforms

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Keywords

- https://quizlet.com/cn/782306760/flash-cards/

What cause the waves

- Wind blowing over the surface of the ocean
- Size factors
  - The stronger the wind the larger and stronger the waves
  - The longer the wind has been blowing over the sea the larger and stronger the waves
  - The longer the fetch (the distance over which the wind has blown over the sea) the larger and stronger the waves

Wave breaking

- The wave approaches the coast in the same direction as wind
- The sea floor becomes shallower and steeper
- The wave base slows down because of friction with the sea floor
- The wave becomes higher and eventually the top of the wave breaks
- The water flows up the beach in the same direction as the wind is blowing
  - The water flowing up the beach is called the swash
- Gravity causes the water to flow back down the beach to the sea perpendicular to the coastline
  - This is called the backwash

Types of waves

- Constructive waves
  - Wave is small, low wave height
  - Long wave length (about 100m)
  - Low frequency (6 per minute)
  - More sediment is transported onto the beach than removed
  - Beach is being built up
  - Beach profile is gentle
- Destructive waves
  - Wave is large, high wave height
  - Short wave length (about 20m)
  - High frequency (10-15 per minute)
  - More sediment is removed from the beach than transported in
  - Beach is being eroded
  - Beach profile is steep

Bays and headlands formation

- These are formed at a discordant coastline
  - Discordant coastline: the coast is made of different types of rock positioned perpendicular to the coastline
- Differential erosion
  - The rocks will erode at different speeds
- The weaker rock e.g. clay is eroded faster by corrasion and hydraulic action to create a bay
- The more resistant rock e.g. chalk erodes more slowly and remains to form a headland

Caves, arches, stacks and stumps formation

- Formed at the end of the headland
- A weakness in the headland e.g. a crack is eroded by hydraulic action to form a cave
- The headland is eroded from both sides and eventually the sea erodes a passage through the headland to form an arch

- The arch is continually eroded until the roof collapses to form a stack
- The waves continue to erode the stack making it smaller until it forms a stump
- Headland retreats towards the coastline

Wave-cut notch and wave-cut platform formation

- The wave water erodes the cliff by corrasion and hydraulic action, creating an undercutting called a wave cut notch
- The cliff above then collapses because there is no support underneath
- The fallen rocks are broken up by attrition and removed by waves
- The process will repeat itself causing the cliff face to retreat and leaving a gentle slope of solid rock with is called the wave cut platform

Longshore drift

- Waves are blown in the direction of the wind
- When the prevailing wind direction is at an angle the waves mostly approach the coast at an angle
- The swash moves the sand up the beach at an angle in the direction of the wave and wind
- The backwash moves the sand down the beach perpendicularly due to gravity
- The sand will gradually move along the beach in a zig-zag motion

Transportation

- Traction
  - Rolled along the sea floor
  - Cobbles
- Saltation
  - Bounced along the sea floor
  - Pebbles
- Suspension
  - Carried by the water
  - Sand
- Solution
  - Dissolved in the water
  - Finest material
  - Can't see

Spit formation

- Longshore drift transports sediment along the beach
- When the material reaches the end of the coastline, for example it changes direction, the longshore drift will continue to transport the material and deposit it in the open water
- Overtime the sediments build up to form a spit
- The fast flowing water of the river estuary means that the spit is stopped from growing all the way to the side
- The end of the spit often has a hook
  - This is caused by secondary (short term change) wind directions causing longshore drift to change the direction of sediment movement

Salt marsh formation

- Sometimes the spit may grow across a river mouth
- The river velocity will slow down behind the spit and deposit the river's load
- This will create an area of deposition behind the spit
- The deposited material will be colonised by plant species which can survive in the salt water conditions
- Their roots will trap more sediment and build a salt marsh behind the spit

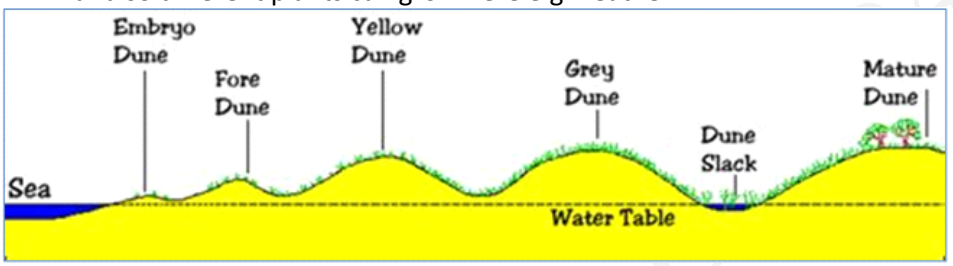
Bar and lagoon formation

- Sometimes longshore drift forms a spit that grows right across a bay
- Joining up two headlands
- The water behind the bar becomes trapped and is called a lagoon

Tombolo formation

- Longshore drift forms a spit that grows from the mainland to join with an offshore island

Sand dune formation (SWOP)

- Sand
  - A large supply of sand e.g. wide, sandy beach exposed at low tide
- Wind
  - A strong onshore wind to dry out the sand and transport it inland by saltation
- Obstacles
  - Seaweed or driftwood on the beach to trap the sand to create the first dune called the embryo dune. They can be up to 1m high.
- Plants
  - Halophytes like marram grass can grow in salty and windy conditions
  - These plants grow on the yellow dunes (sand colour) and their roots stabilise the sand
  - They also trap more sand so the dune grows taller
  - When the plants die off, they decompose and start the formation of humus. As the dunes get older, the amount of humus increases and the dune becomes a grey dune
  - The environmental conditions are not so extreme: less salt, less wind, more humus/ fertile soil and so different plants can grow here e.g. heather
- 

Dune slacks

- The valleys between the dunes are called slacks
- These are more sheltered and have more water so there is a greater variety of plant species which can survive here

Plant succession

- The process by which plants improve the environmental conditions so that other plant species to grow there
- e.g. the marram grass stabilises the dunes and creates humus when it dies. This means the marram grass has created a more stable and fertile soil. Now different plants can grow successfully in the area.

Coastal processes and landforms diagrams

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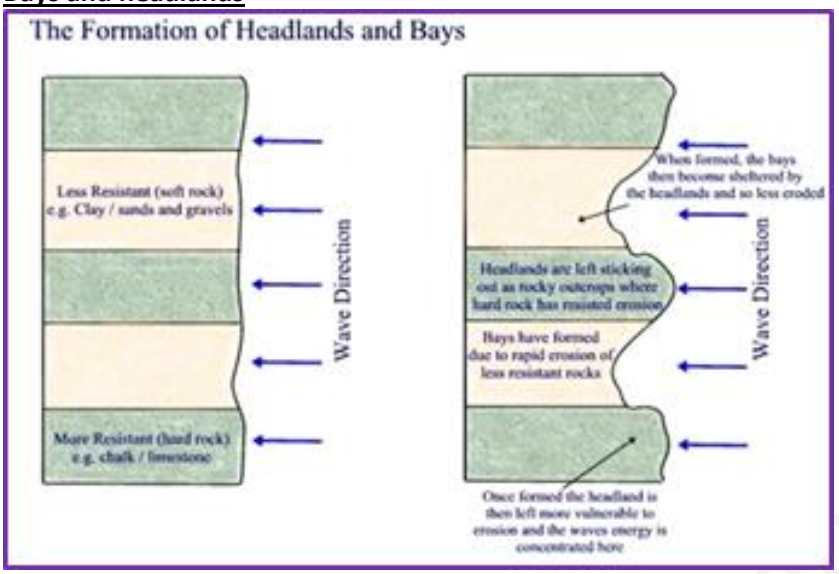
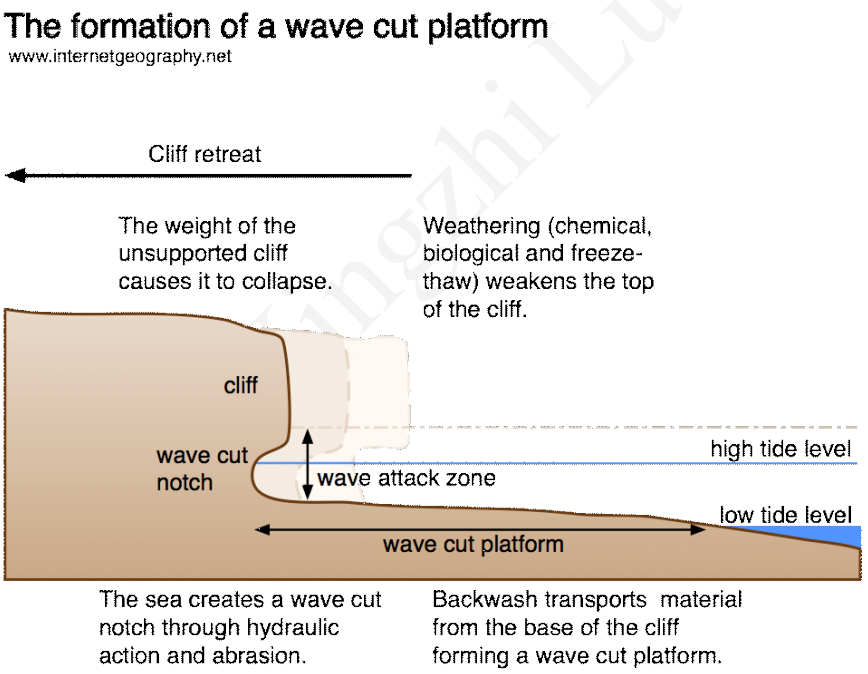
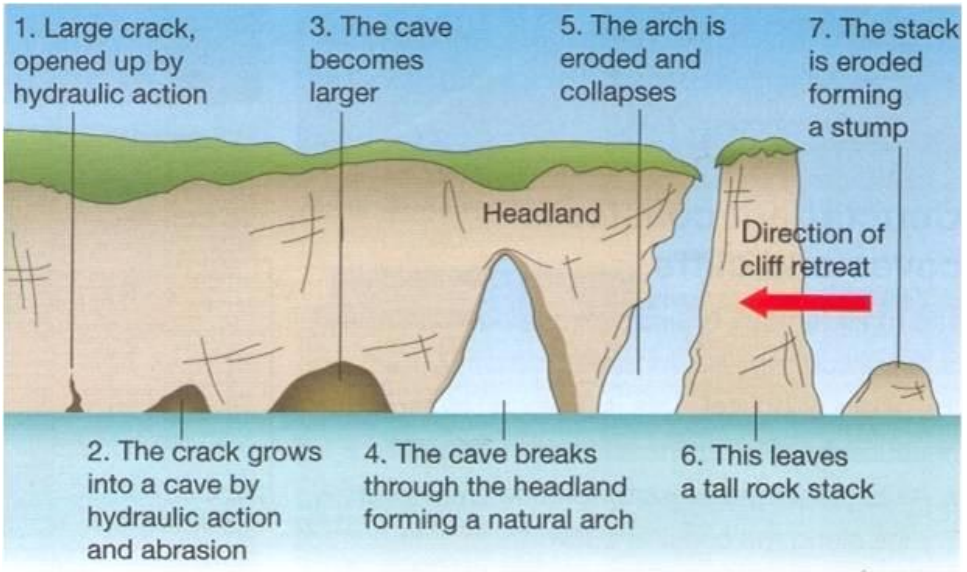
Bays and headlands

- 

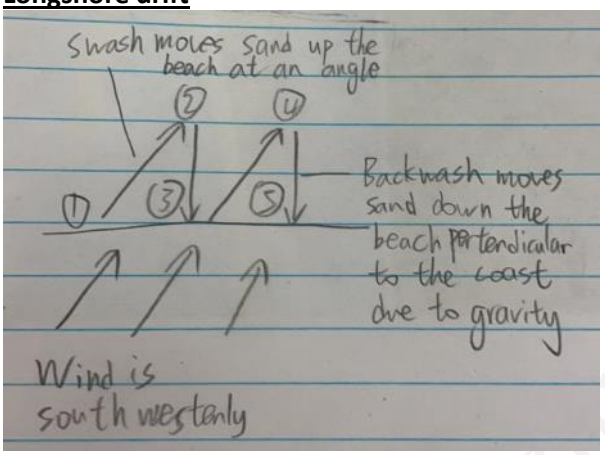
Wave cut platform

- 

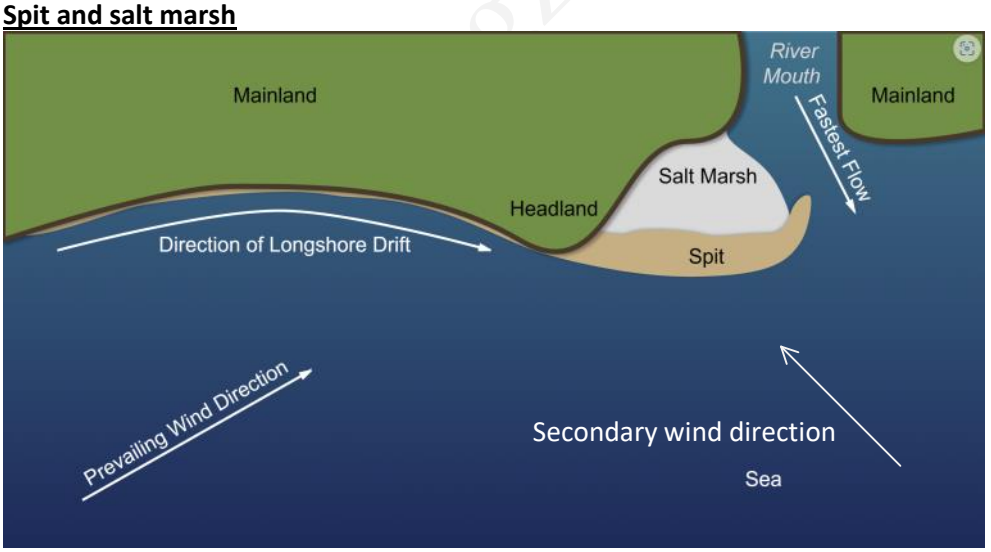
Caves, arches, stacks and stumps

- 

Longshore drift

- 

Spit and salt marsh

- 

Coral reefs and mangrove swamps

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Corals

- They are animals called polyps
  - Individual can be a size of a pinhead to a basketball
- Live in colonies
  - Build limestone skeletons for protection
- Two food sources
  - Zooplankton trapped by tentacles
  - Algae which photosynthesis and provide colour
  - Symbiotic relationship

Coral reefs

- The collection of thousands of corals
  - When one generation of animals die, the next generation builds its protective layer on top so the coral reef grows
- 25% of marine animals live in coral reefs
  - Acts as protection and food source
  - e.g. Crab, lobster, seahorse, shark
  - Creates a biodiverse marine ecosystem

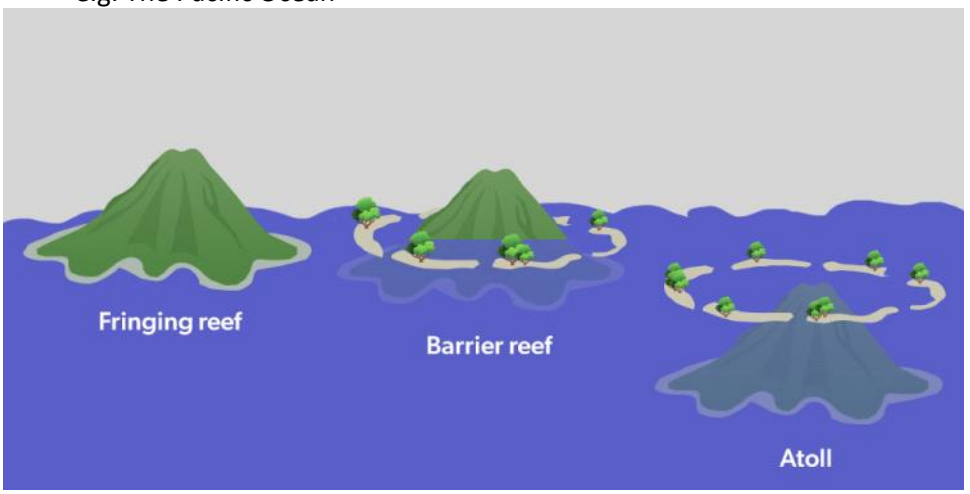
Conditions required for growth

- Warm water/seas
  - Corals need warm water for optimum growth
  - Sea surface temperature (SST) at least 21 ℃
  - Located in eastern side of continents because of the warm ocean current there
- Shallow water
  - Maximum 40 metres deep
  - Polyps need sunlight for photosynthesis to produce energy
- Clear water
  - Water which does not contain a lot of sediment so that there is plenty of sunlight
- Clean oxygenated water
  - Polyps need a plentiful supply of oxygen so the water must not be polluted
- Food supply
  - Plentiful supply of zooplankton
  - The main source of food for corals
- Calm water
  - Lack of strong currents

Types of coral reefs

- Fringing reef
  - Directly attached to the shore or borders it with an intervening shallow channel or lagoon
  - The polyps are adapted to low wave energy conditions
  - e.g. Greater Caribbean region
- Barrier reef
  - Separated from a mainland or island shores by deep channel or lagoon
  - A greater distance away from the coast (several km)
  - Wider, older and larger than fringing reefs
- Atoll reef
  - More or less circular or continuous barrier reefs extends all the way around a lagoon without a central island
  - Form around submerged volcanic islands
  - Sometimes the volcanic island beings to sink because of plate tectonic movement

- The polyps build the coral structure upwards to maintain light conditions
- e.g. The Pacific Ocean



Opportunities of coral reefs

- Fishing industry
  - Coral reefs are biodiverse and contain many fish and seafood
  - Support a subsistence fishing industry as fish is good source of protein
  - Provides income
- Tourism
  - Reefs are a biodiverse and attractive ecosystem
  - Attract tourists for scuba diving and snorkelling
  - This creates job opportunities in hotel resorts and on diving boats
  - Tourists spend money in the local economy
- Protective barrier
  - Absorb wave energy before it reaches the beaches and slow down approaching waves
  - Protect coastlines from tsunamis and storm surges

Threats to coral reefs

- Coral bleaching
  - The polyps within coral die when the sea temperature rises or the water becomes polluted
  - Corals eject algae inside which provides energy by photosynthesis
  - About 10 per cent of the world's reefs are already dead, and a further 60 per cent are endangered.
- Cyanide
  - Used to capture fish for aquariums
- Agricultural run-of
  - e.g. pesticides and fertilisers
- Pollution
  - Urban pollution from land and air
  - Pollution of sea water e.g. oil spills, less sunlight from photosynthesis
- Climate change
  - Rising sea levels, increasing sea temperatures, changing ocean currents
- Disease
  - e.g. viruses which infect and kill polyps
- Habitat destruction from boating
  - Trawling, anchors, fishing nets
- Increasing acidity of sea water
  - From acid rain and pollution
- Tourism
  - Souvenir hunting, reef-walking, diving, boating
- Overfishing
- Greater sedimentation as rivers carry increased loads to the sea
  - Reduces light and oxygen levels

- Coral mining
    - Raw materials for building, industry, tourist souvenirs

Mangroves

- Salt tolerant forests of trees and shrubs which grow in coastal areas in the tropics
- They cover 25% of the tropical coastline

Conditions required for the growth of mangrove swamp

- Need warm temperatures above 24℃ for tropical trees
- High annual rainfall above 1200mm
- Sheltered coastal area with less wave action
- Wide gentle slope with large tidal range (a wide area which is covered in sea water at high tide but not at low tide)

Importance

- Breeding ground and habitat for marine life
    - The muddy water are rich in nutrients from the decaying leaves
    - They are the breeding ground for a variety of fish and crustaceans (crabs, shrimp etc)
    - Many species which live in the coral reefs are born in mangroves
        - The coral reefs depend on the existence of mangroves
    - It is a biodiverse ecosystem and therefore important environmentally
- Coastal protection
    - The forests absorb the wave energy of storm surges and tsunamis
    - Protects coastal communities from flooding
- Fishing
    - Provide sources of fish and seafood for subsistence fishing
- Filters pollution
    - The marine life filter the water
        - Absorb waste from sewage and farming (chemical fertilisers)
        - Clean the sea water naturally
    - The mangroves protect the coral reefs from some sources of human pollution

Threats to the mangroves

- 35% of mangroves deforested in last 50 years (faster rate than rainforest deforestation)
- Cut down for wood
- Cleared for other uses
    - Rice cultivation
    - Shrimp farming
    - Tourist resorts
    - Coastal settlements
- Pollution from oil

Examples

- Grand Cayman in Caribbean Sea
- Originally 1/3 of island was covered in mangrove swamps and protected island from hurricanes
- At beginning of 21st century there was a lot of hotel development on the island and much of the mangroves have been cut down
- 60% of west coast mangroves have been cut down
- Tourism provides 75% of the islands GDP so it is important to create land to build the new resorts
- However, now the island is more vulnerable to the high winds and storm surges from hurricanes

Opportunities and hazards of coasts

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Opportunities

- Flat land
  - Coastal land is often flat or gentle slopes
  - Good for building settlements, transport links e.g. roads/ railways, farming, and factories
- Deep water ports
  - Some coastal areas have deep water in areas which are sheltered from storms
  - This is good for building a port for importing and exporting goods
- Manufacturing industry
  - Often built near the port
  - Benefit from access to imported raw materials and for exporting finished products
- Extracting raw materials
  - Primary industries which extract raw materials from the sea can develop along coastline
  - E.g. fishing industry or oil and natural gas extraction
- Tourism industry
  - Can develop if the coast is attractive with beaches and has a suitable climate for outdoor activities e.g. sunbathing and swimming
  - Creates job opportunities for locals in tourism industry

Hazards and challenges

- Coastal erosion
  - Cause the cliff to collapse
  - Buildings destroyed e.g. home, farms and communication
- Coastal storms
  - Cause flooding from high energy waves and heavy rainfall
- Tsunamis
  - Earthquakes under sea floor causing a series of waves → flooding
- Tropical storms
  - Large scale ocean storms which form in the tropics where sea temperatures are above 28℃
  - They form in late summer when the sea has had sufficient time to warm up
  - Extremely high wind speeds (over 120km per hour)
  - Cause coastal flooding due to storm surges and heavy rainfall
  - E.g. cyclones, hurricanes, and typhoon

Managing coastal erosion

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Hard engineering methods

- Sea wall
- Gabions
- Revetments
- Rock armour / Rip rap
- Groynes

Sea wall

- Description
  - Concrete walls / rock barriers built along the base of cliffs to prevent erosion
  - Some are built between the settlement and the sea to prevent flooding
  - Often curved to deflect the wave energy back into the sea
- Advantages
  - Very effective method to stop erosion and flooding
  - Increase access to the coast by creating a concrete pathway for walking
- Disadvantages
  - Expensive to build and maintain
  - Unattractive (block views)
- 

Gabions

- Description
  - Metal cages which contain small rocks or pebbles
  - Used to create a wall at the base of the cliff to prevent cliff collapse + prevent erosion
- Advantages
  - Cheaper than sea walls
  - Effective at preventing erosion
- Disadvantages
  - Shorter life span than sea wall
  - Visually unattractive
- 

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Revetments

- Description
  - Wooden slatted barriers which are built mid-way up the beach and parallel to the sea
  - Encourages the waves to break before the base of the cliff and prevents erosion
- Advantages
  - The cheapest hard engineering method
  - Effective at breaking the force of the waves and reducing erosion
  - Sediment is trapped in front of the revetment → creating a bigger beach → attract more tourists
- Disadvantages
  - Not as strong as gabions + sea walls so not useful where waves are high energy
  - Do not give a total protection to the base of the cliff
  - Short life span because made of wood
  - Can restrict access to the beach + visually unattractive

- 

Rock armour / rip rap

- Description
  - Large boulders of hard rock e.g. granite placed along the base of the cliff
  - Absorb wave energy and prevent erosion
- Advantages
  - Strong material so effective protection of the cliff
  - It looks natural
- Disadvantages
  - They are expensive to buy because they are large and heavy so very costly to transport (when bought abroad)
  - Rocks do not fit with local geology

- 

Groynes

- Description
  - Barriers usually made of wood, built at right angles to the beach
  - Trap sediment and prevent longshore drift
  - This is to maintain the beach which can absorb wave energy
- Advantages
  - This uses the beach as a natural defence
  - Bigger beach can attract more tourists
- Disadvantages
  - Stop other beaches down the coast from getting sediment and often lead to more erosion down the coast
    - Not completely solving the problem
  - They are expensive to build and maintain
  - They are unattractive and can restrict beach access

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Soft engineering methods

- Beach replenishment
- Planting vegetation

Beach replenishment

- Description
  - Replacing beach sediment e.g. sand/shingle which has been removed by erosion or longshore drift
  - The beach material is often dredged from offshore and transported to the beach
  - The beach absorbs wave energy and prevents erosion
- Advantages
  - A cheap method
  - Protects the natural look of the beach → this can encourage tourism
- Disadvantages
  - It has to be repeated every year
  - Offshore dredging can cause environmental problems

- 

Planting vegetation (sand dune regenration)

- Description
  - Plant salt tolerant vegetation e.g. marram grass to secure the sand
    - Sand dunes can develop
  - Area can be fenced off to keep people off newly planted dunes
  - Act as a barrier to wind erosion and flooding
- Advantages
  - Cheap
  - Develops the natural environment → popular with wildlife and people
- Disadvantages
  - Not effective against high energy waves
  - Takes time to plant marram grass + fence off the area
  - Restrict access to beach
  - Can be damaged by storms
- 

Coastal management strategies

- Hold the line
  - Use many hard engineering techniques to make sure that the coastline is not eroded at all
  - Usually used where there is a high economic value land use on the coast e.g. a tourism resort
- Managed retreat
  - Some coastal management is in place, usually soft engineering
  - Some erosion and flooding is encouraged
    - Aim = to create beaches and salt marshes to protect the area further inland
  - Usually used where there is farmland which can be destroyed because it has low economic value
- Do nothing
  - No coastal management is used and the sea is allowed to erode and flood the land
  - Used where the land has no economic value or the wave energy is so high that it is not possible to control the erosion

Importance of coastal management

- Many people live on the coast
  - It is important to protect them from the hazards
- Many businesses and transport communications are located on the coast
  - The area is economically valuable
- The coastline often has fragile ecosystems
  - e.g. coral reefs and salt marshes
  - Take a long time to recover if they are destroyed so the area is environmentally important

Criccieth

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Opportunities of Criccieth coastal location

- Attractive residential location
  - Coastal location + attractive coastal scenery of Cardigan Bay
- Attractive for tourists
  - Historical attractions e.g. Criccieth Castle
  - Attractive natural landscape with scenic Snowdonia National Park nearby
  - Large sandy beach and opportunity for sport fishing
- Tourism activity creating job opportunities
  - e.g. Dylan's restaurant, ice cream shops, hotels, camping / caravan site just outside of town
- Flat land along coast
  - Allow good communication links to be built
    - Railway station with trains to Birmingham
    - Main road A497 links town with other coastal resorts
- Lifeboat station
  - Calm water created by breakwater allows launch of life-saving boat

Hazards of Criccieth coastal location

- Rapid erosion of the bay area
  - Retreats 1m every 10 years
  - Threatening some of the houses + businesses located behind the beach
- Strong destructive wave created during winter storms
  - Causes coastal flooding of the area behind the beach + increases the rate of erosion
- Climate change effects
  - Storm frequency and intensity are increasing
  - Sea levels are rising by 3.2 mm per year due to climate change causing ice caps to melt
  - Threatening to flood the beach area and properties behind the beach

Coastal management strategies used

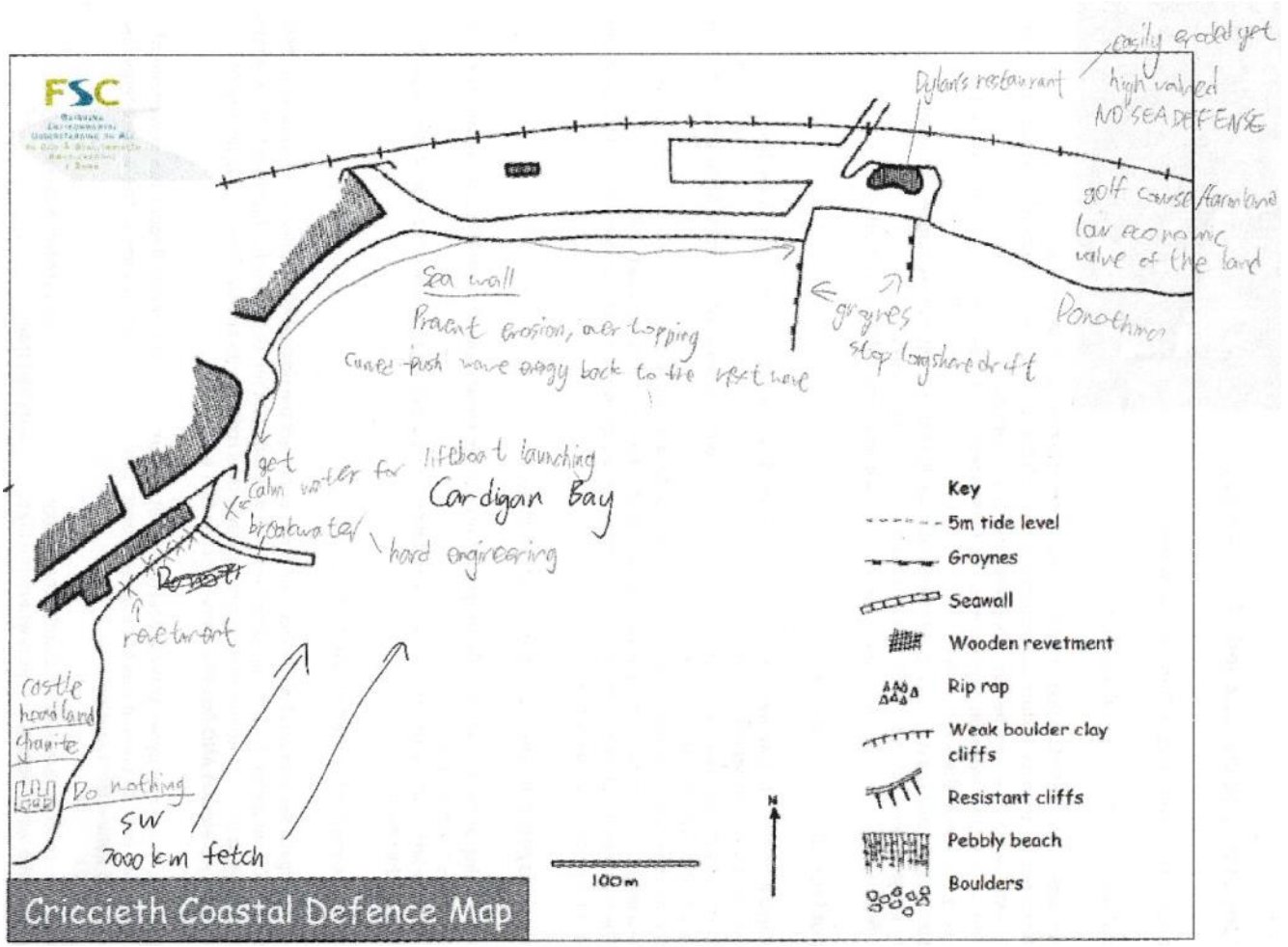
- Do nothing
  - At Castle Rock
    - The granite is resistant to erosion
  - At golf course
    - The land has low economic value
- Hold the line
  - From Castle Rock to Dylan's Restaurant
  - High economic value of the properties behind the beach

Coastal defence methods used to hold the line

- Seawalls
  - The original sea wall was built in Victorian times to protect the original railway line
  - It was rebuilt in 1960s at a cost of £4,000 per meter
  - A concrete curved sea wall was built further along beach
    - Rreflects the energy of a wave that has just broken into the next oncoming wave, thus reducing its energy
    - Costs £6000 per meter
  - Reduce erosion and flooding
  - Very effective but expensive
- Groynes
  - Several wooden groynes at West Beach and 2 at eastern end of the beach
  - Reduce the movement of sand by longshore drift to prevent loss of beach sediment
  - The beach will absorb some of the wave energy and protect the land behind from erosion

- Breakwater
    - The concrete breakwater absorbs the energy of breaking waves and creates an area of low energy environment / calm water behind it
    - This is where the lifeboat is launched from
- Rip rap / rock armour
    - Large boulders of granite are placed around the breakwater to absorb the wave energy and protect it from erosion
- Wooden revetment built on cliff face
    - To prevent cliff collapse because there are expensive houses on the cliff top
    - The stone behind the wooden barrier allow for water to drain easily from the cliff
    - The rip rap boulders at the foot of the cliff prevent the wave energy eroding the base of the cliff

Map



Case study sheet

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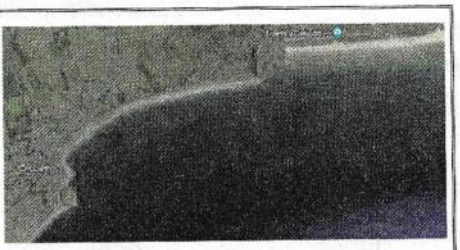
Criccieth case stud...

Case study of a coastline: Criccieth, Cardigan Bay, Wales



Location: Coastal resort town on Cardigan Bay, Wales

Opportunities of Criccieth coastal location

- **Attractive residential location**: coastal location, attractive coastal scenery on Cardigan Bay
- **Attractive for tourists**: Historic attractions e.g. Criccieth Castle, the attractive natural landscape with scenic Snowdonia National Park nearby, large sandy beach and opportunity for sport fishing
- Tourism activity **creates job opportunities** e.g. Dylan's restaurant, ice cream shops, hotels and at the camping/caravan site just outside of town
- Flatter land along coast allowed **good communication links** to be built: railway station with trains to Birmingham and main road A497 links town with other coastal resorts
- **Lifeboat Station**: calm water created by breakwater allows launch of life-saving boat

Hazards of Criccieth coastal location

- Rapid erosion of the bay area which retreats 1m every 10 years is threatening some of the houses, businesses located behind the beach
- Strong destructive wave energy created during winter storms causes coastal flooding of the area behind the beach and increases rate of erosion
- Storm frequency and intensity are increasing due to climate change
- Sea levels are rising by 3.2mm per year due to climate change causing ice caps to melt.
- The rise in sea levels and more frequent strong waves caused by storms are threaten to flood the beach area and properties behind the beach

Coastal management: Two management strategies used:

1. **Do nothing:** at Castle Rock because the granite resistant to erosion and at the golf course because the land has low economic value
2. **Hold the line:** from Castle Rock to Dylan's Restaurant because of the high economic value of the properties behind the beach

Coastal defense methods used to hold the line:

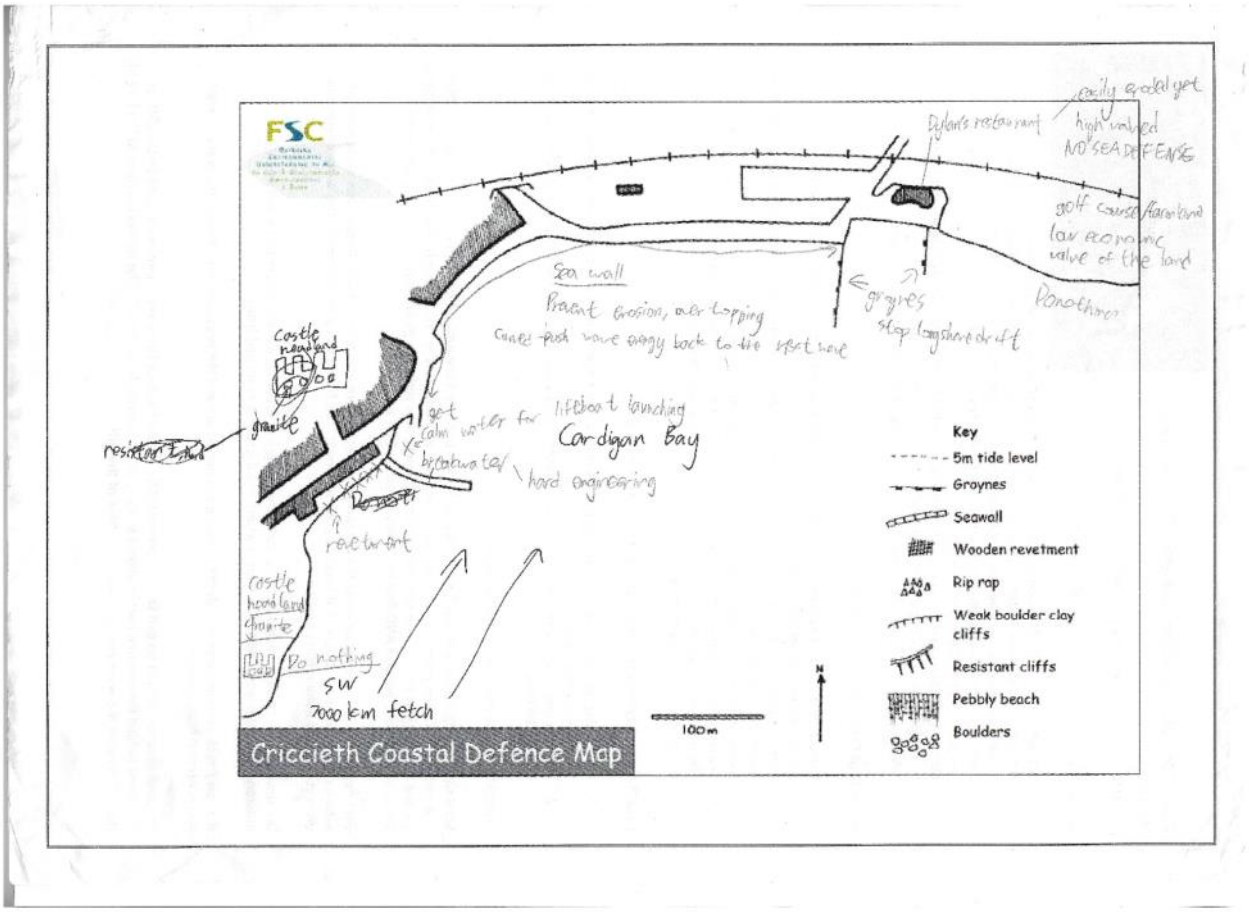
Seawalls: the original sea wall was built in Victorian times to protect the original railway line. It was rebuilt in 1960s at a cost of £4,000 per meter. A concrete curved sea wall was built further along beach. This reflects the energy of a wave that has just broken into the next oncoming wave, thus reducing its energy. Costs £6000 per meter. These walls reduce erosion AND flooding. Very effective BUT expensive.

Groynes: several wooden groynes at West Beach and 2 at eastern end of the beach. Reduce the movement of sand by longshore drift, to prevent loss of beach sediment. The beach will absorb some of the wave energy and protect the land behind from erosion.

Breakwater: the concrete breakwater absorbs the energy of breaking waves and creates a low energy environment/calm water behind it. This is where the lifeboat is launched from.

Rip rap / rock armour: large boulders of granite are placed around the breakwater to absorb the wave energy and protect it from erosion.

Wooden revetment built on cliff face: to prevent cliff collapse because there are expensive houses on the cliff top. The stone behind the wooden barrier allow for water to drain easily from the cliff. The rip rap boulders at the foot of the cliff prevent the wave energy eroding the base of the cliff.


FSC
easily eroded yet high valued NO SEA DEFENCE
Dylan's restaurant
golf course/farmland low economic value of the land
Sea wall
Present erosion, over topping
Cause high wave energy back to the next one
groynes
stop longshore drift
Ponathmor
castle hotel
granite
resistant headland
get calm water for lifeboat launching
Cardigan Bay
hard engineering
reactivate
castle hotel headland
granite
Do nothing
SW
7000 km fetch
100m
N
Criccieth Coastal Defence Map
Key
5m tide level
Groynes
Seawall
Wooden revetment
Rip rap
Weak boulder clay cliffs
Resistant cliffs
Pebbly beach
Boulders