Coastal environments

With over four billion people living in coastal areas and the numbers growing rapidly each year, the need to understand and manage these areas is critical. Coastal areas are one of the most dynamic environments on the earth and area being constantly re-shaped by both natural processes and human development. They have both economic and environmental value – and it is these conflicting demands that bring about the need for long-term, sustainable management strategies.

The coast is the frontier between land and sea

What processes and factors are responsible for distinctive coastal landscapes?

Coastal environments		
Questions for Investigation	*Key Ideas*	*Content*
What processes and factors are responsible for distinctive coastal landforms?	Weathering, erosion, transportation and deposition give rise to distinctive types of coastal landform. These processes are influenced by a range of factors, which vary from place to place.	The study of an extended stretch of coastline or coastlines, including practical research and out-of-classroom work – fieldwork, to illustrate: • a range of features associated with coastal erosion; • a range of features associated with coastal deposition; • the processes responsible for these features, including wave action and sub-aerial processes; • the factors affecting the development of these features including rock type and structure, aspect and sea-level change.

THE DYNAMIC NATURE OF COASTS

- Coast is constantly being re-shaped by waves, tides, ocean currents and the effects of the weather.
- Where rock structures are more resistant or sheltered from prevailing wind and waves, changes occur slowly. Where rock structures are less resistant and are open to storm conditions and heavy rainfall, sudden and dramatic changes can occur, reshaping the landscape in minutes in the case of coastal landslides or rockfalls.

Waves

- As wind blows over the ocean, friction occurs and energy is transferred, creating waves.
- The stronger the wind, the greater the friction, making the waves higher and more powerful.
- Types of waves:
  - Constructive
  - Destructive

Classifying coastal environments

- **Storm wave** environments characterised by frequent low pressure systems creating strong onshore winds = powerful waves e.g. NW Europe
- **Swell wave** environments characterised by a less extreme pattern of wind/waves but considerable swell built up over a long fetch e.g. W Africa
- **Tropical cyclone** environments characterised by extreme winds = huge waves e.g. SE Asia, Caribbean

Tides

- A tide is the alternate rise and fall of the level of the sea.
- Caused by the gravitational pull of the moon, and to a lesser extent, the sun.
- Moon and sun in alignment = biggest gravitational pull = highest tides

Storm surges

- Storm surge is created when the following factors coincide:
  - High tides
  - Strong onshore winds creating high levels of wave energy
  - Low pressure weather systems allowing the sea to expand

COASTAL PROCESSES

- Coastal landforms are the result of the interaction of a number of processes. These include: marine erosion, weathering, human activity and mass movement/slumping

Marine erosion

- **Hydraulic pressure:** in areas where there is limited beach material to absorb the energy of breaking waves, cliff faces can be attacked. Breaking waves can exert force of up to 40 tonnes per m^2. They force air into joints and cracks in the cliff surface. This compressed air has the power to loosen and break away pieces of rock.
- **Abrasion/corrasian:** during storm conditions, waves have the energy to pick up sand particles and pebbles and hurl them at the cliff face. This 'sand blasting' effect is thought to be the most rapid process of coastal erosion in the UK.
- **Attrition:** rocks and pebbles are constantly colliding with each other as they are moved by waves. This action reduces the size of the beach material and increases its 'roundness' by smoothing away rough edges.

Weathering

- **Corrosion/solution:** in coastal areas the proximity of sea water can speed up the effect of chemical weathering. Saltwater evaporation from sea-spray leads to the growth of salt crystals in the rock. As they develop, salt crystals expand, forcing rocks to disintegrate. Particular types of rock are susceptible to corrosion esp. if they contain limestone, which is dissolved by the carbonic acid in salt water.
- **Wetting/drying:** softer rocks (e.g. clays and shales) are esp. susceptible to this. When these rocks are in the coastal splash zone they are constantly prone to expansion and contraction as they become wet then dry out. This causes weaknesses in the rock which then allows marine proceses to attack and erode the rock easily.

Human activity

- Increasing use of coastal areas for leisure and recreation can put pressure on coastal environments.
  - Human erosion of cliff top footpaths can cause weaknesses in rock structure
  - Removal of vegetation can leave rock surfaces more prone to weathering and erosion

Mass movement/slumping

- Rockfalls and landslips are common features of cliff coastlines, often occurring as a result of the combination of wave action weakening the base of the cliff and sub-aerial processes attacking the upper part of the cliff face.
  - Sub-aerial processes can include weathering processes and the effects of rainfall eroding cliff surfaces or weakening rocks by percolation.
- **Rockfalls** are often found with more resistant rock (e.g. chalk) being the result of undercutting by the sea and weakening of the rock by corrosion and ongoing wetting and drying.
- **Landslides and slumping** are more associated with weaker rocks such as clays and sands. Can often be triggered by prolonged periods of heavy rainfall. When the ground becomes saturated, the combination of extra weight, slope and increased lubrication can lead to slope failure and cause small-scale mudslides or landslides. Slumping is a result of a combination of marine processes undercutting the base of a cliff, heavy rainfall, and curved slipping planes where different rock types meet.

Impact of geology on coastal landforms

- Both rock type and structure can have a significant impact on coastal landforms.
- Rock type
  - More resistant rocks (e.g. chalk, limestone) erode more slowly.
  - Weaker rocks (e.g. clays and sands) have less structural, strength and are eroded easily, producing a lower cliff profile with mudslides and slumping.
- Structure
  - Concordant (rock type runs parallel to the sea). Often produce straighter coastlines.
  - Discordant (rock type runs perpendicular to the sea). Often produce headlands and bays.

FEATURES OF COASTAL EROSION

- Clear link between high energy coastlines and rates of erosion. However, wave power is only one factor that explains both the rate of erosion and the resulting landform.
- Characteristics of the rock (lithology) can also play a significant part.
  - Some rock types are more coherent (i.e. well connected particles and few lines of weakness) = more solid coastline with a steep cliff profile and slow rates of erosional retreat e.g. chalk and sandstone
  - Some are more incoherent (poorly connected or lots of cracks and joints) = high level of weakness e.g. clay

Landforms associated with resistant rock

- **Headlands**

Landforms associated with weaker rock

- **Landslides**
  - the general term for gravity controlled processes (mass movement). The three main types of landslide processes are: falling, sliding and flowing.
- Clay coastlines are esp. susceptible to landslides as the clay is poorly consolidated and becomes very unstable when wet.

FEATURES OF COASTAL DEPOSITION

- Beaches
  - Swash aligned beaches: form when waves approach the coastline parallel to the beach. Swash and backwash move sediments up and down the beach often creating a stable, straight beach. During storm conditions severe backwash can move sediment out to sea, creating sand or shingle bars on the sea bed.
  - Drift aligned beaches: form when waves approach beach at an angle and sediment is moved along the coast by longshore drift.
- Spits, bars and tombolos.

COASTAL SYSTEM

- A coastal area can be seen as a system which produces, transfers and deposits sediment. It is an open system with inputs, stores, transfers and outputs.
  - Equilibrium = balance between inputs and outputs
  - Positive sediment budget = beaches are developing and are relatively stable
  - Negative sediment budget = loss of beach material and possibility of increasing wave action on cliffs (e.g. Holderness)

Changing sea levels

- Sea level is the relative position of the sea as it meets the land. Change can be due to eustatic and isostatic adjustment.
  - Submergent coastlines due to rising sea levels: rias (drowned river estuaries), fjords (drowned glacial valleys)
  - Emergent coastlines due to falling sea levels: raised beach (e.g. Arran, NW Scotland)

Preparing for rising sea levels

- 80 million people living in coastal areas in Europe = significant threat to both life and property.
- Potential effects:

- Climate change is likely to result in changes to three key influential factors: rising sea levels, changes in wave patterns, increases in rainfall in winter.
- There may be an increase in the number of storm events.
- Flooding of developments built on lowlands is likely to intensify.
- Existing trends for erosion of salt marshes is likely to accelerate.
- Soft rock coastal cliffs are likely to retreat more rapidly because of increasing rainfall and rates of cliff top erosion. However, this may increase the supply of valuable sediments to nearby beaches.
- Protecting vulnerable coastlines will become increasingly difficult and more expensive.