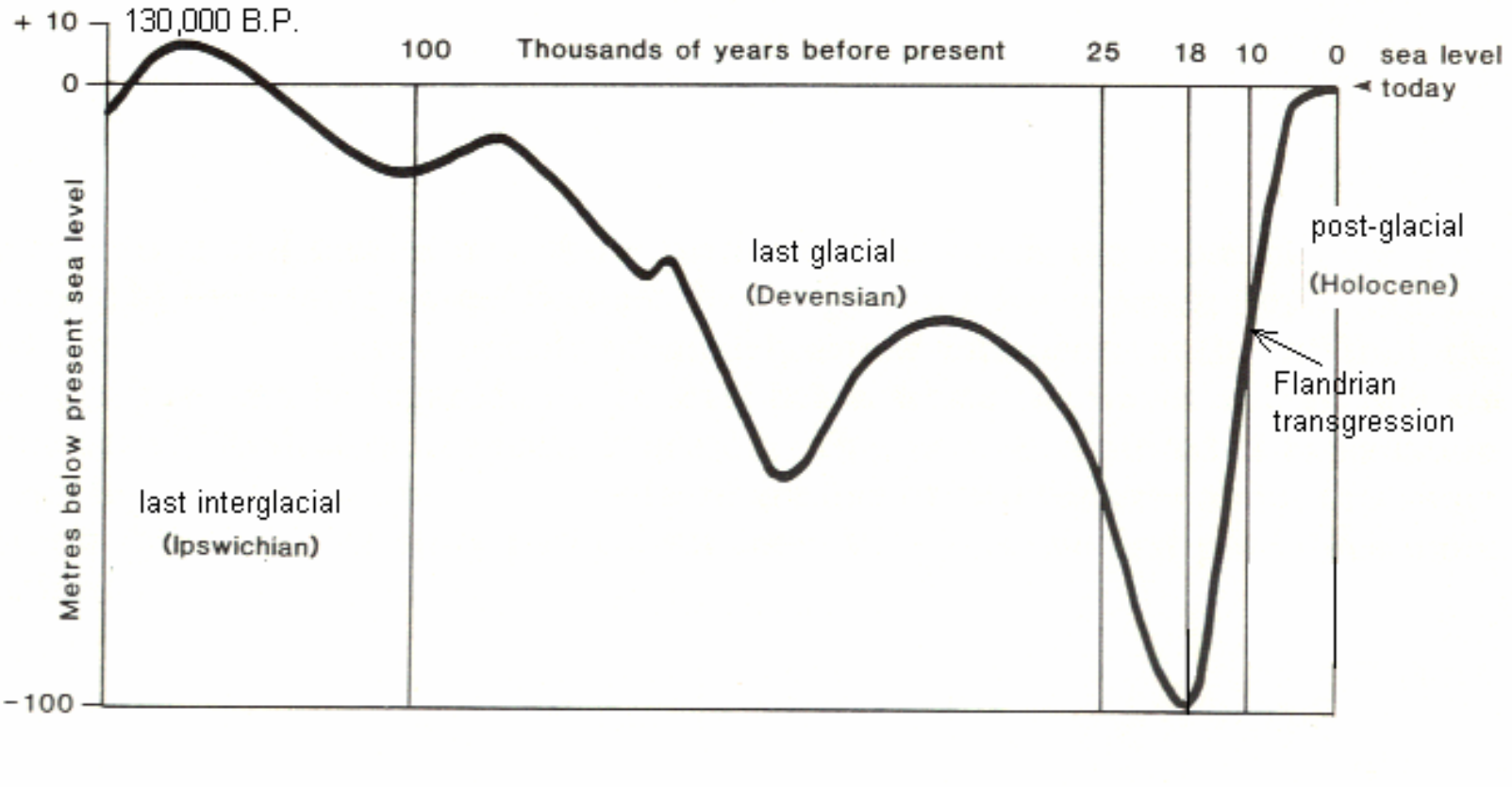
Changes in Sea Level Over Time Influence Coastal landforms

The possible physical and human causes of long-term sea level change, to include both isostatic and eustatic change.

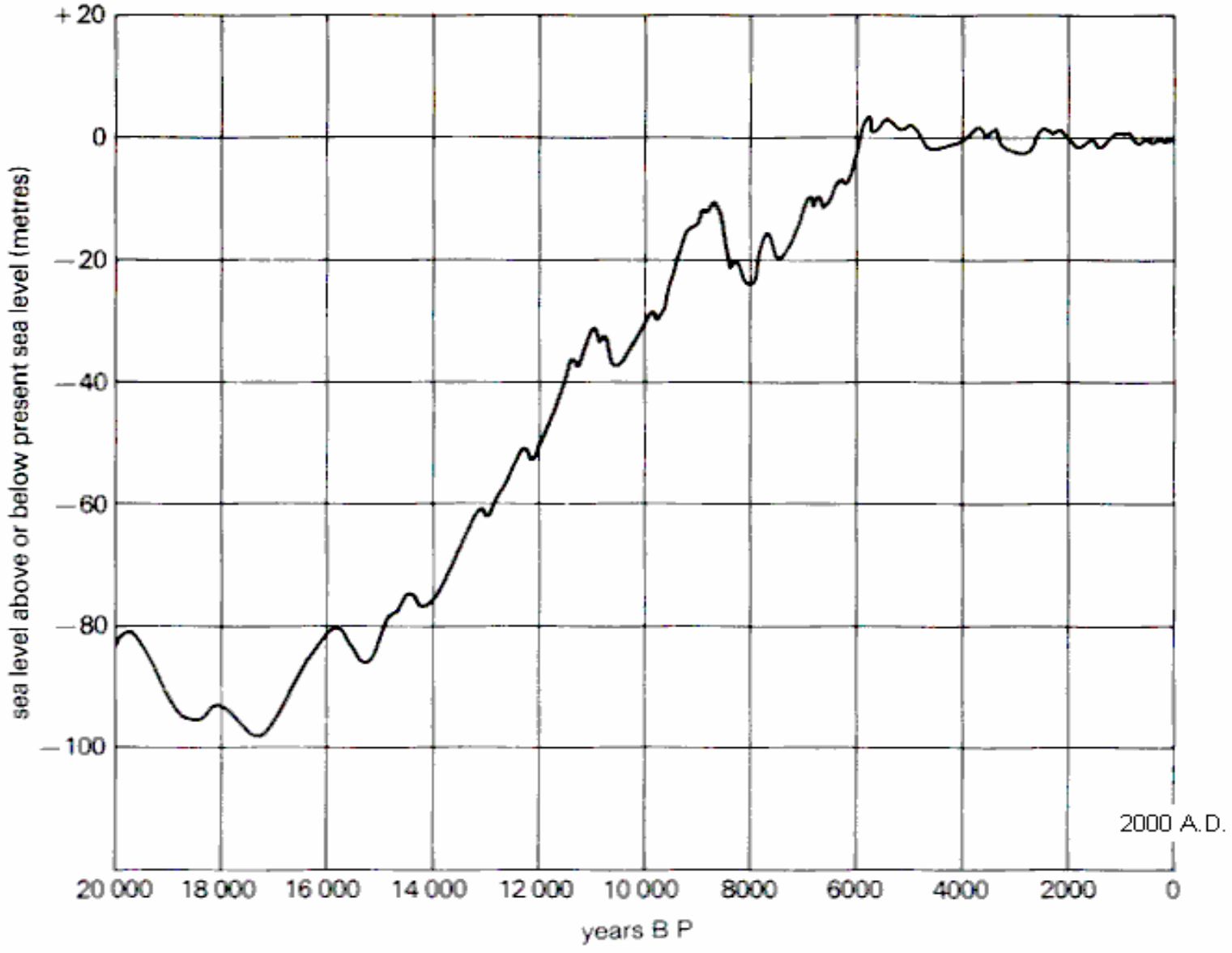
You need to understand long-term changes in sea level and how these changes relate to actual changes in the past and how they may relate to possible future changes.

Eustatic Changes in Sea Level

The lowering of temperatures during cold stages of the Pleistocene had the effect of transferring huge volumes of water from the oceans to the land-based glaciers, thus lowering world sea level by as much as 100m (during the Devensian about 18,000 years ago). These cold “glacials” were interrupted by “interglacial” periods, such as the Ispwichian interglacial, in which the climate was moderately warm. This has caused fluctuations in sea level.



The graph below shows the “Flandrian transgression “; the rapid rise in sea level that took place from 18,000 years B.P until about 6,000 B.P, when sea levels reached their current level.



Isostatic changes in Sea Level

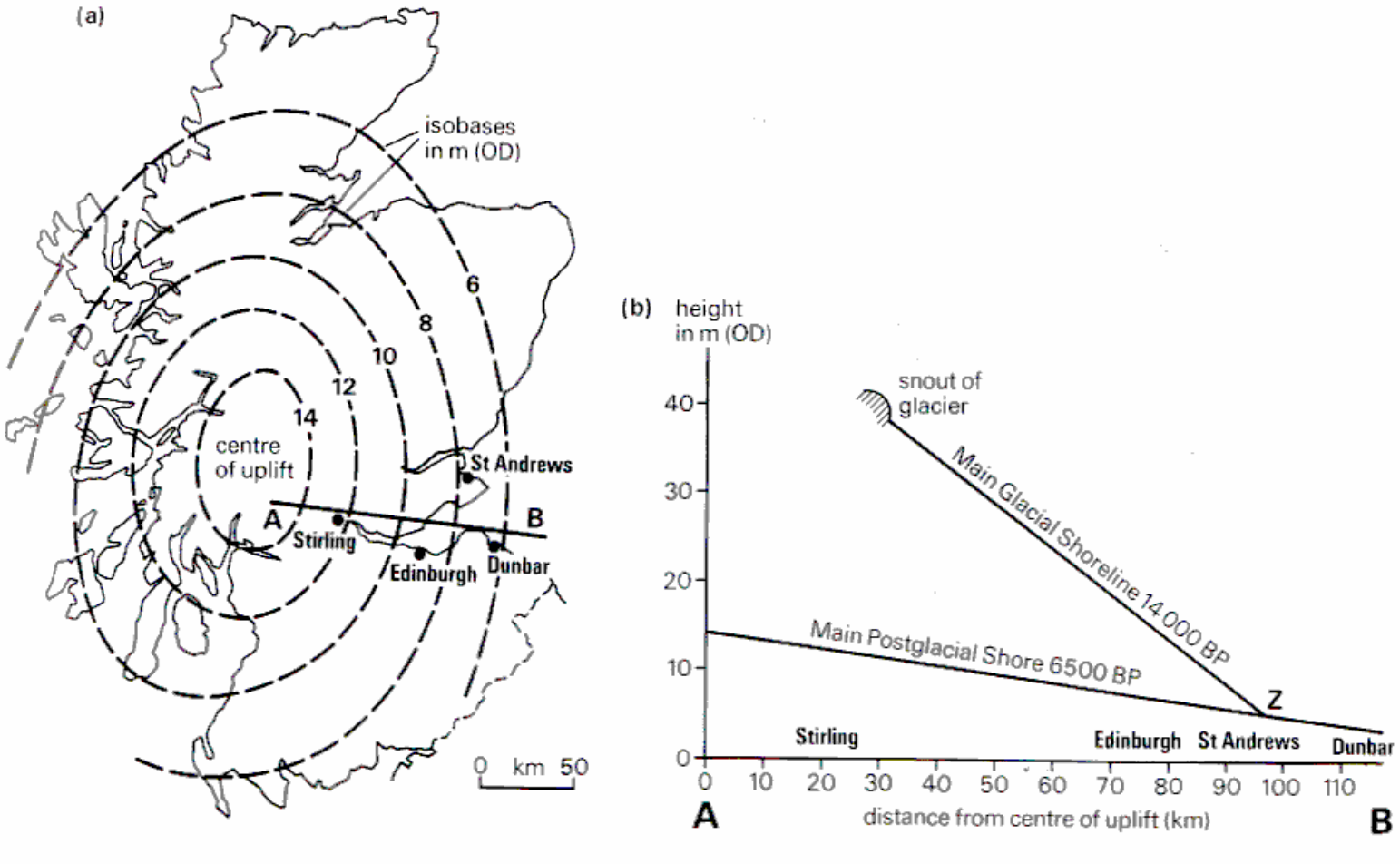
Isostatic changes in sea level are localised (***iso***lated!). The sea level appears to rise and fall due to changes in the level of the land. There are three main causes:

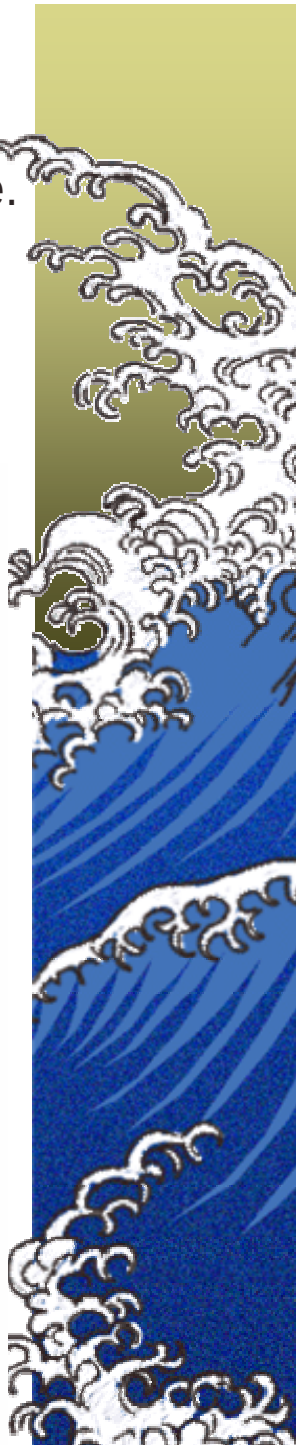
Tectonic causes.

- **Earthquake activity**.
- **Localised subsidence**
- **Localised volcanic activity**

Isostatic Adjustment or Isostacy

The weight of great thicknesses of ice (over 1km in parts of Scotland) depressed the crustal rocks, forcing them down into the more mobile mantle. Removal of the weight has enabled the crust to slowly rise again. This process is called *isostatic adjustment* or *isostacy*. Although ice sheets had disappeared from Britain by 8000 years ago, isostatic adjustment is still taking places.





Human Influences on Sea Level Change

In the past, human activity has had little impact on sea level change. Concern is now growing about the impact of global warming which is causing a global eustatic rise in sea levels (and could lead to isostatic changes in places such as Antarctica). The atmospheric warming causes both glacial ice at the poles to melt, and the expansion of seawater as it warms. Both cause the sea level to rise. Global warming in caused by the release into the atmosphere of carbon dioxide, methane, nitrogen oxides and CFCs.

The Greenhouse Effect

Physics: Earth absorbs incoming solar radiation and then trys to cool by emitting long wavelength infrared radiation. This radiation is absorbed by Greenhouse Gases and hence can't escape → net effect should be to increase mean annual temperature.

Greenhouse Gases:

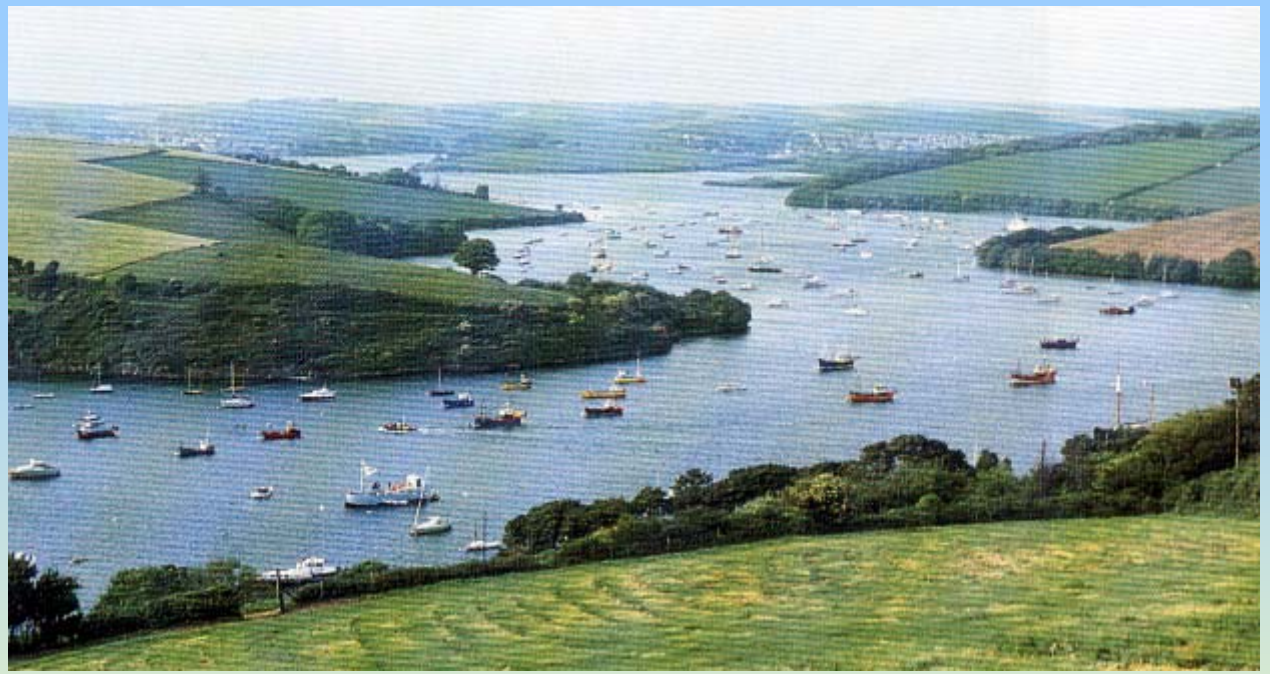
- **CO_2 → burning of carbon based fuels**
- **CH_4 → anerobic bacteria in rice fields, cows, sewage**
- **N_20 → fossil fuels and fertilizer**
- **CFCs → refrigeration and spray cans**

Importance:

- **CO_2 → 65% ; 0.4 % (150 years) ; 1**
- **CH_4 → 25% ; 1 % (70 years) ; 25**
- **CFCs → 10% ; 5 % (14 years) ; 10,000 !**

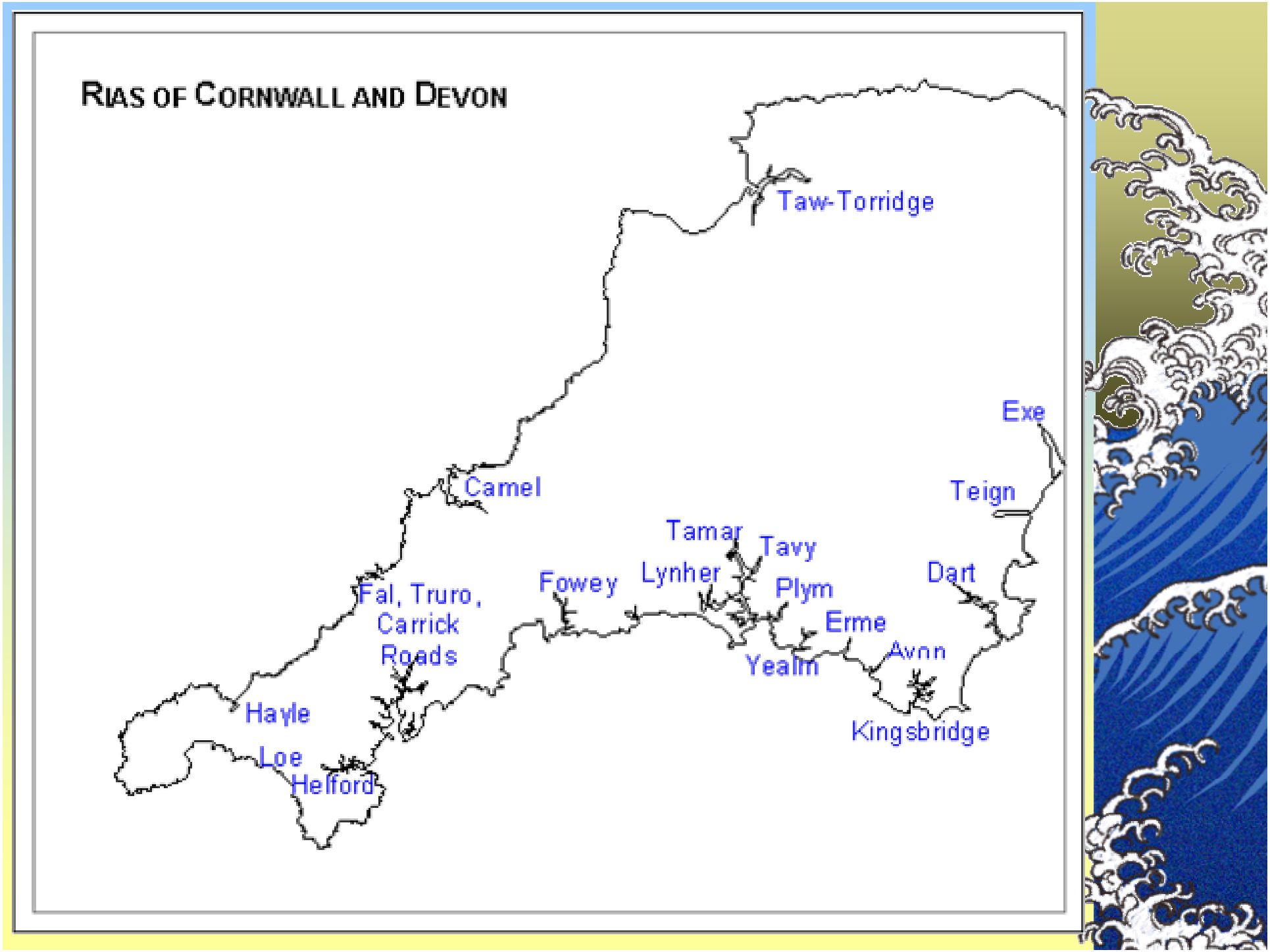
Landforms of submergence and emergence, to include rias and fjords, raised beaches and abandoned cliffs.

You should be able to describe and explain the formation of each landform listed. You must be able to use annotated diagrams and sketches in your descriptions and explanations. You need to know located examples, primarily, but not exclusively, from two contrasting stretches of coastline (North Devon and Dorset Coast).



Rias in South and North Devon

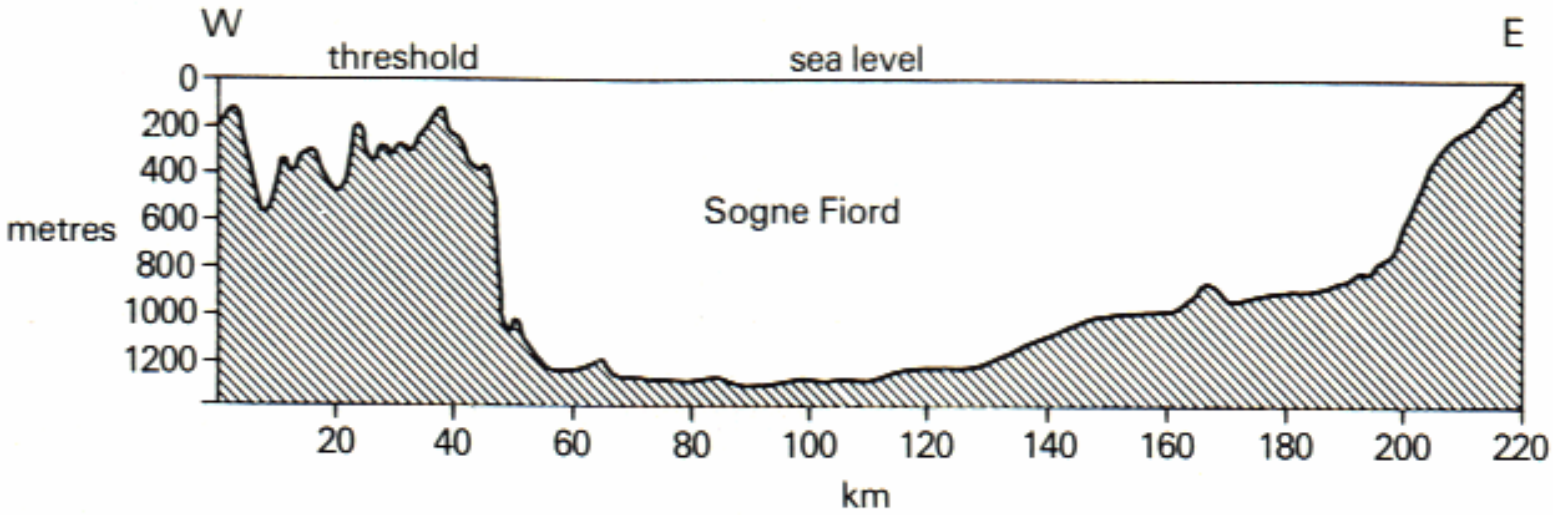
Rias are river valleys that were formed when sea level was lower. The rivers cut down to a base level (sea level) as much as 100m below the present sea level. These valleys were then flooded as the sea level rose in the Flandrian transgression. Many rias have a dendritic (tree like) pattern, reflecting the pattern of the drowned valley and its tributaries. Rias are common throughout southwest Britain and include Milford Haven in southwest Wales and the Fal estuary in Cornwall, which extents some 18km from the open sea. In North Devon, the shared estuary of the Taw and Torridge Rivers is effectively a ria.


RIAS OF CORNWALL AND DEVON
Taw-Torridge
Exe
Teign
Camel
Tamar
Tavy
Lynher
Plym
Dart
Fowey
Fal, Truro,
Carrick
Roads
Erme
Yealm
Avnn
Hayle
Loe
Helford
Kingsbridge

Fjords in Norway, Chile, South Island New Zealand, Alaska and British Columbia

Fjords (or Fiords), such as the Songne Fiord in Norway, were formed by glaciers that eroded deep glacial troughs below the present sea level. The eustatic post-glacial sea level rise has flooded these troughs to create long, narrow, steep sided inlets with hanging valleys (often marked by waterfalls). The glaciers probably formed in pre-glacial river valleys. Unlike rias, the fjords are deeper inland and shallow towards the seaward end. A rock bar marks the shallow “threshold”. There may have been less glacial erosion at the threshold as the glacier may have started to melt and thin, or to float on the sea, therefore reducing its erosive powers. Some thresholds may be terminal moraines where the glacier deposited rock debris. The Songne Fjord extends 195km from the open sea and reaches a depth of 1308m

Long profile of Sogne Fiord, Norway

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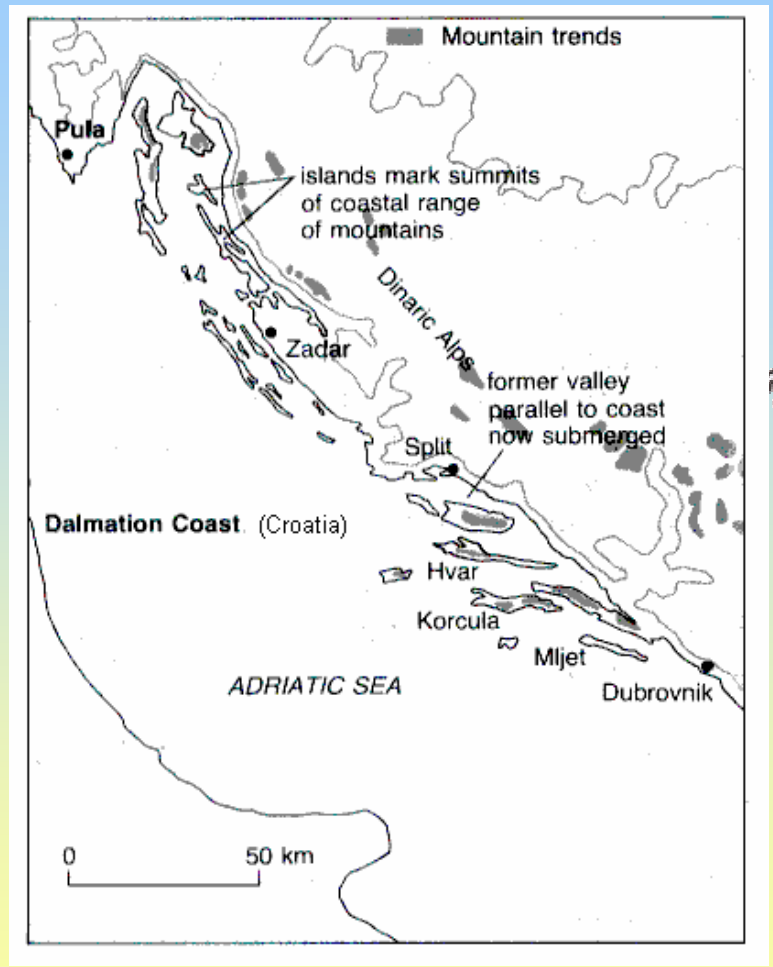
Dalmatian Coasts in Croatia

Dalmatian coasts are similar to rias, except their rivers run parallel to the coast. On Croatia's Adriatic coast, parts of the Dinaric Alps have been drowned creating a series of parallel islands, which represent the summits of the former coastal mountain range.

The sea level rise here was partly eustatic, but also isostatic. Like many parts of the Mediterranean Basin, there is gradual subsidence taking place in this part of the Adriatic, caused by the reduction in compressive forces between the African and Eurasian tectonic plates.



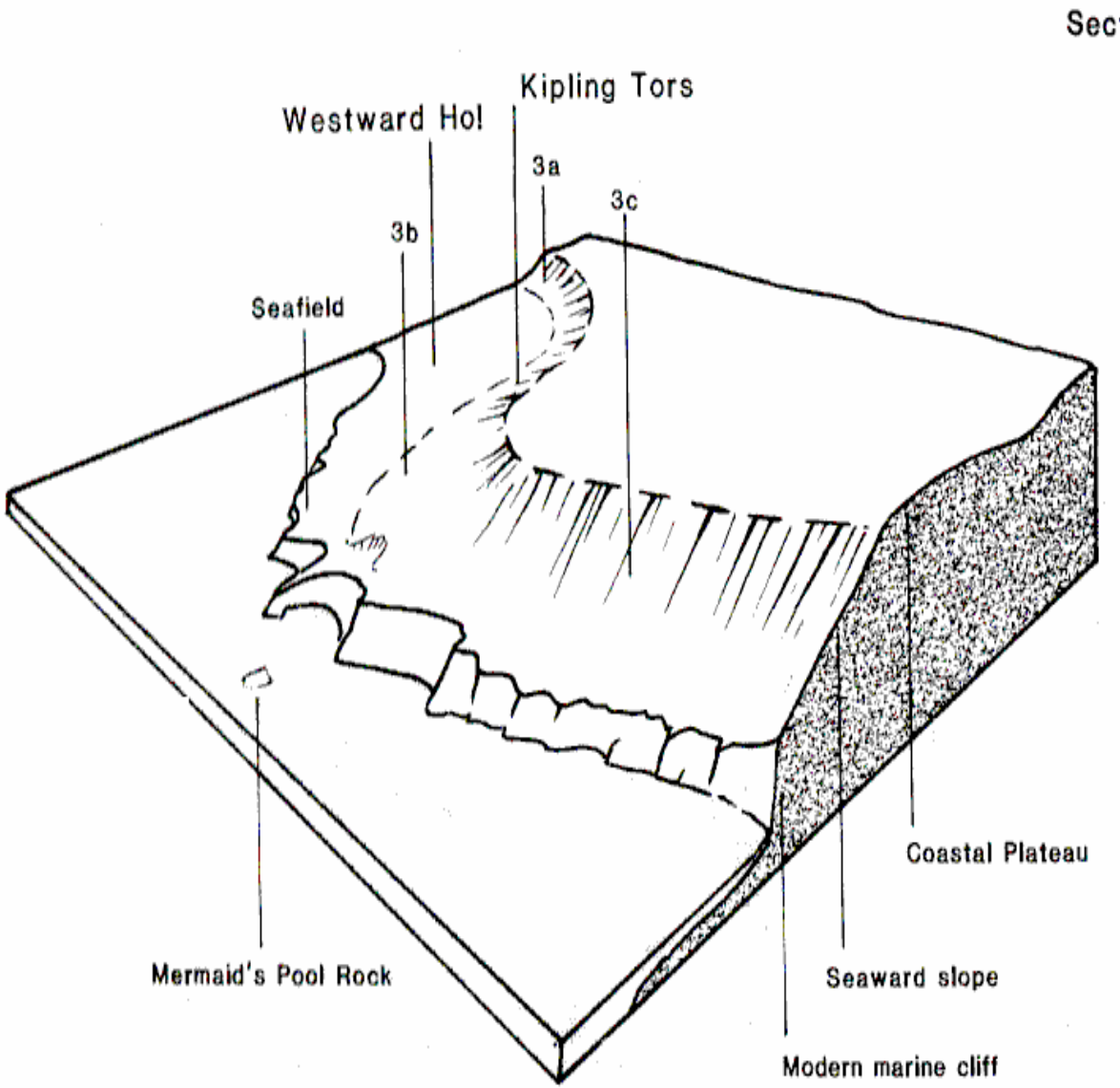
Raised Beaches

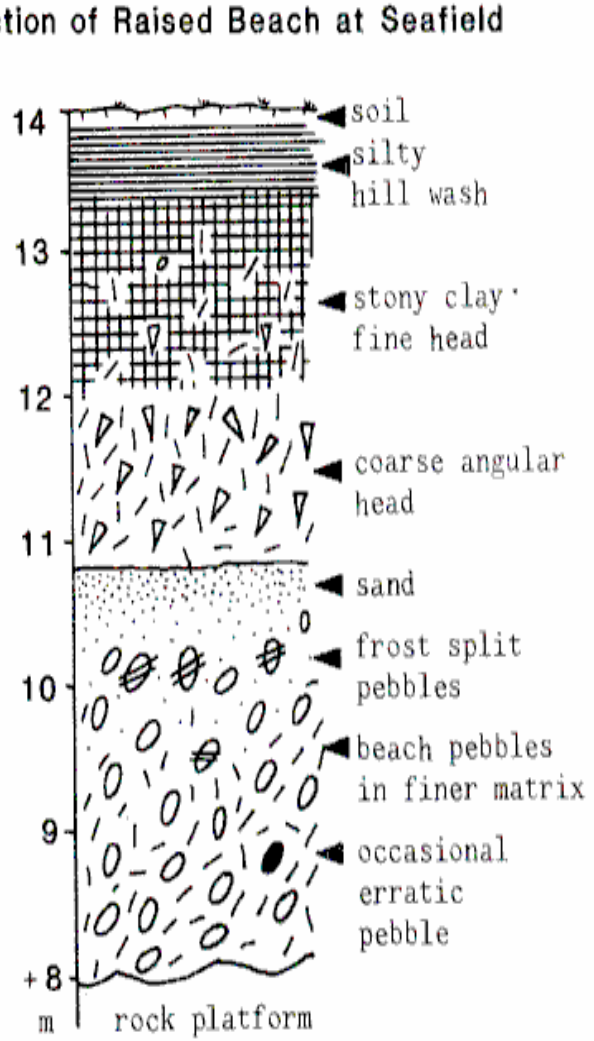
As sea level falls, wave-cut platforms and their beaches are “raised” above the reach of wave activity. Many raised beaches are recognised by a line of a degraded cliffs, fronted by what was once a wave-cut platform, often with beach deposits resting on it. On the Isle of Arran in Scotland, there are many other relict landforms including wave-cut notches, caves, arches and stacks.

Most raised beaches in Britain are either a result of post-glacial isostacy, particularly in Scotland, or a result of former higher global sea levels in the Ipswichian interglacial or earlier. Those in southern Britain fall into the latter group.


Raised Beach at Rhossili
on the Gower Peninsula

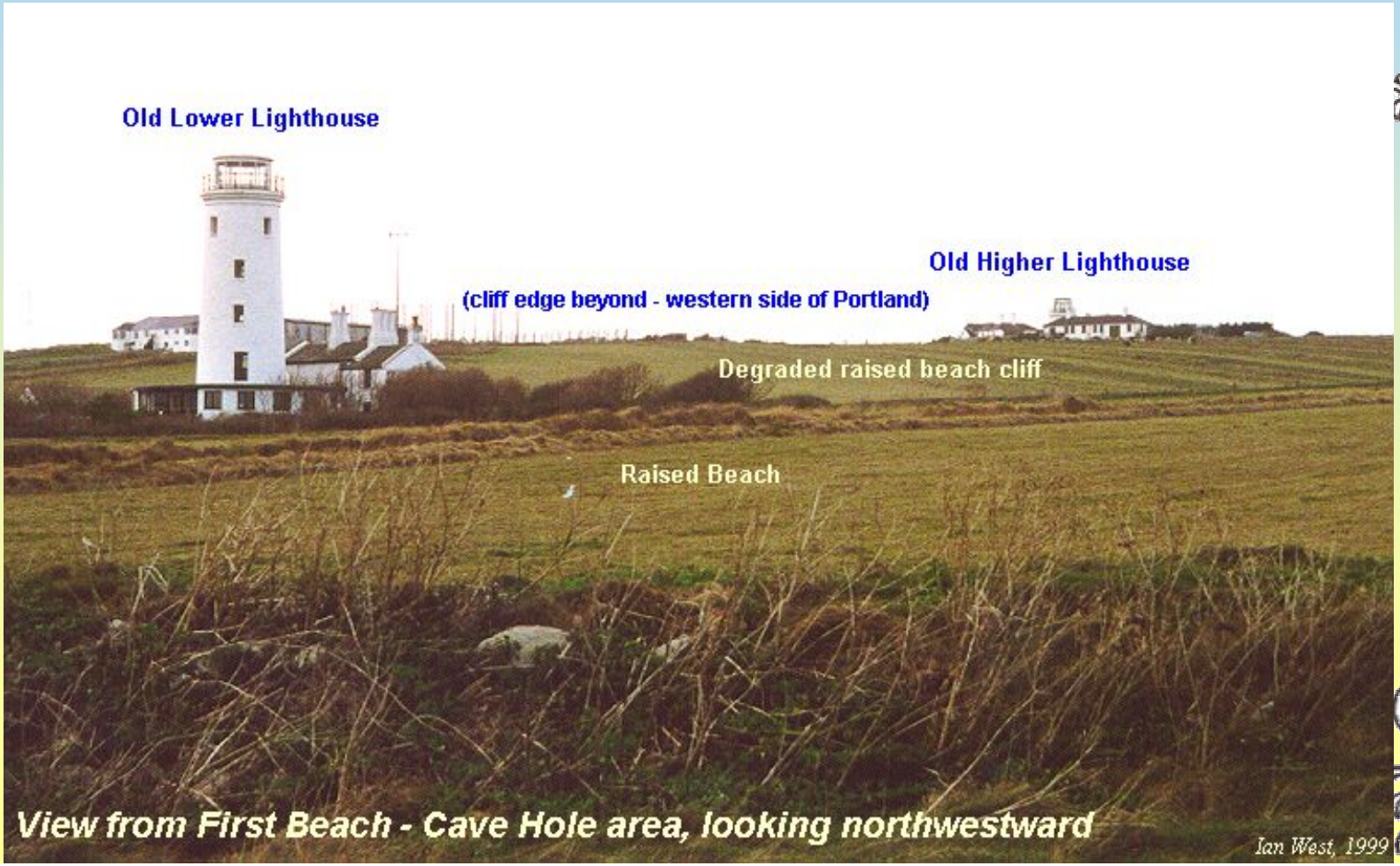
Raised Beaches at Westward Ho!





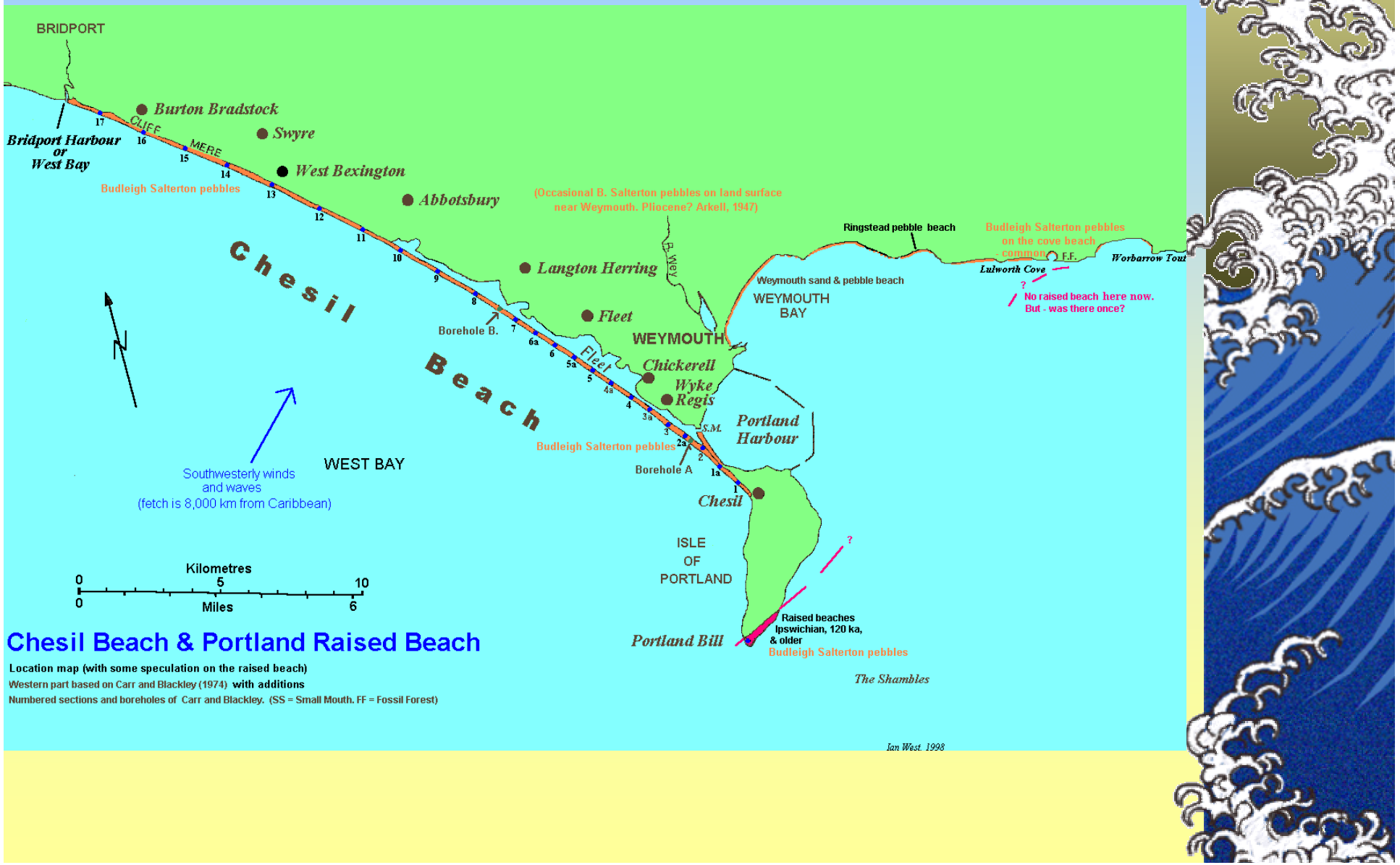
Raised storm beach above the rocky foreshore, Westward Ho!

In Dorset, raised beaches can be found at the southern end of the Isle of Portland, one at 16m and one at about 8m OD. The first was probably formed in an earlier interglacial (the Hoxnian) about 210,000 years ago. The 8m beach is probably Ipswichian and about the same age as the raised beach at Westward Ho! (125,000-130,000 years old).



Raised Beach, Isle of Portland

Chesil Beach and Portland Raised Beaches

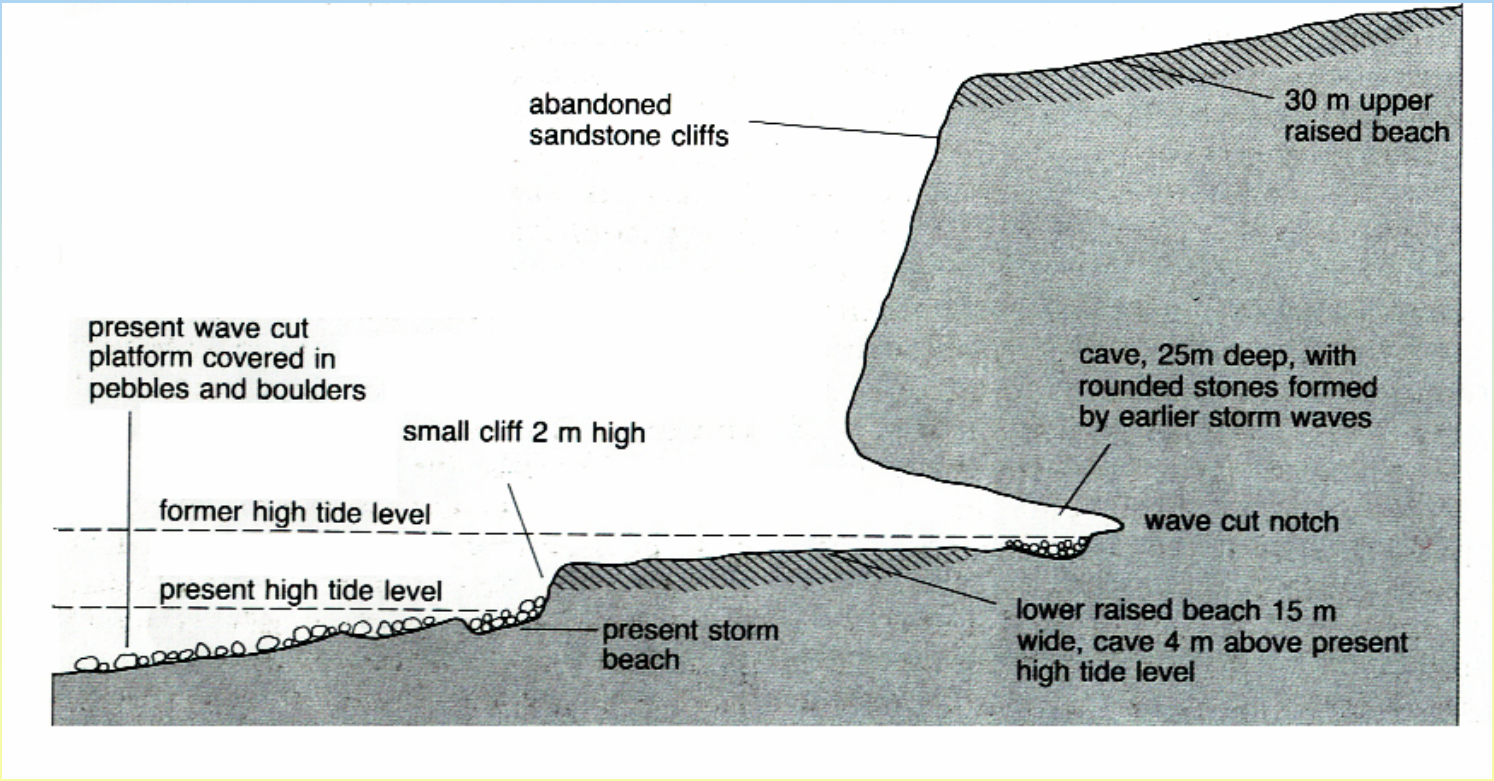


Abandoned Cliffs on the Isle of Arran

On the Isle of Arran, there are at least three raised beach levels at 8m, 15m and 30m but because of isostacy, the levels vary considerable across the Island. For example, the so-called 8m beach is often only 4m OD. More recent raised beaches are rich in shell fragments that can be carbon-dated.

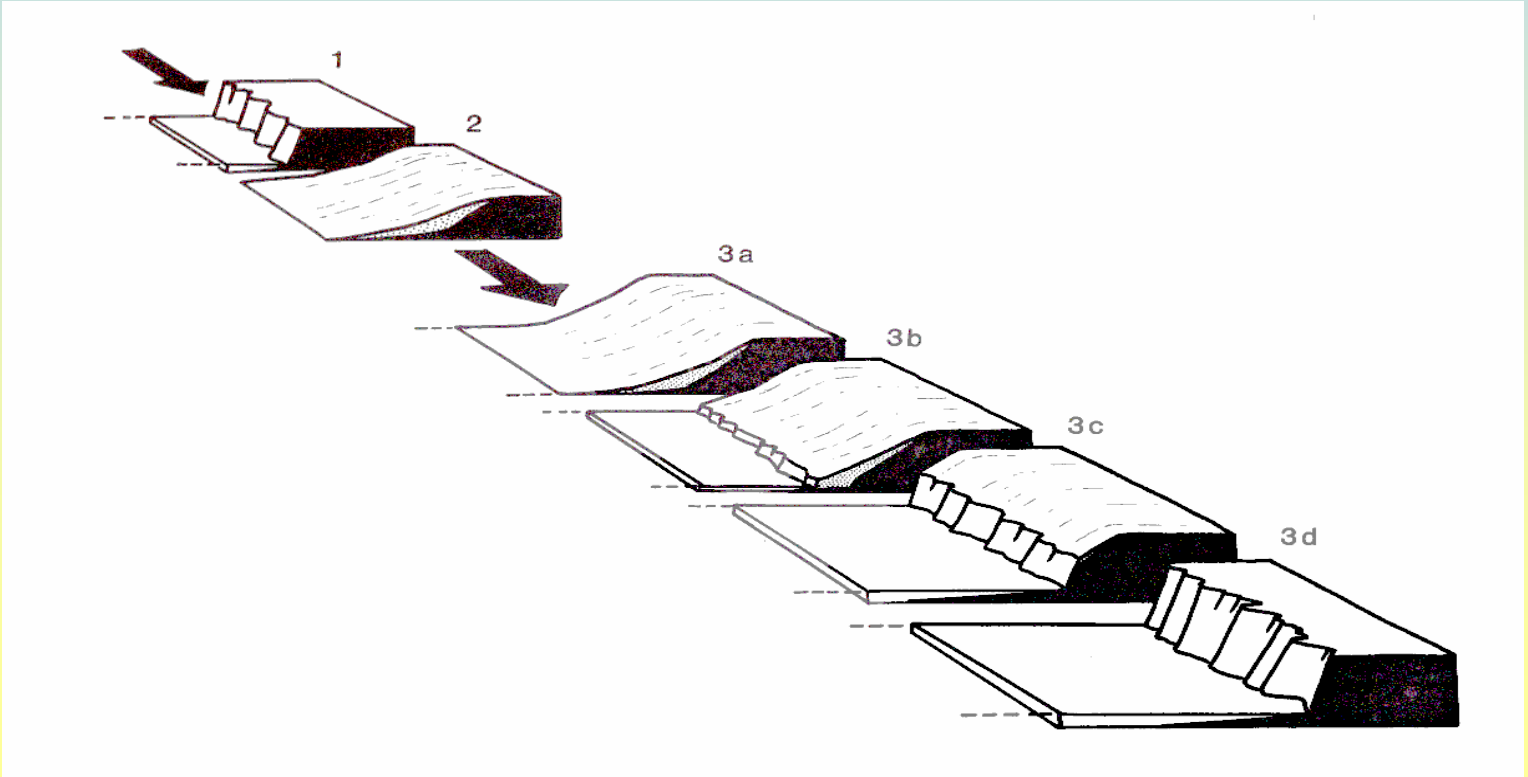
The photograph shows the abandoned cliff line at King's Cave with its 8m raised beach.

The Relationship of Arran raised beaches with present sea level



Slope-over-Cliff Profiles in North Devon

Many cliffs in southwest Britain, including north Devon show two distinct slopes in their profiles called slope-over-wall cliffs. The lower steep face is a result of present-day wave cliff erosion. The gentler upper gradient was formed when the climate was colder and the sea level much lower. Periglacial processes, such as solifluction, degraded the cliff. In some cases, modern marine processes have removed the resulting head deposits. The diagrams below show the sequence of events:



The impact of rising sea levels on the human use of the coastline.

You need to be aware of both actual and potential impact, illustrated by a range of examples, emphasising development issues.

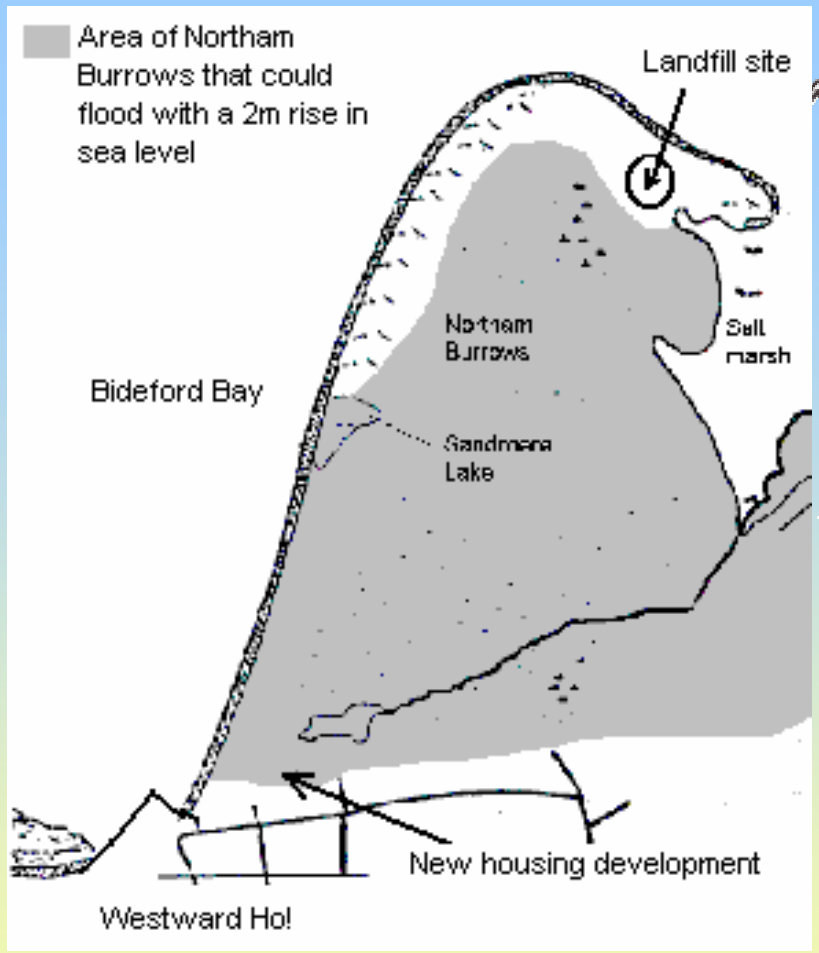
The future of the Dorset Coast

In places, the Dorset coast is also vulnerable to sea level rise. The cliffs at West Bay and Lyme Regis will be much more vulnerable to wave attack and Chesil Beach will be more prone to breaching. Widespread flooding could occur in Chichester Harbour and valuable shallow water and salt marsh wildlife habitats could be lost in Poole harbour, particularly on the northern side of Brownsea Island. However the local authority is more concerned about the effect of predicted increases in storm activity and there is already evidence of an increase in mean wave height.

The future of The North Devon Coast

Several parts of the North Devon coast are low lying and relatively unprotected from rising sea levels. This includes the extensive sand dune system at Braunton Burrows and Northam Burrows in the lee of the Pebble Ridge Spit.

In both cases, endangered plants, such as the water germander could be lost. In the case of Northam Burrows, the flooding would threaten recreational land (golf, walking, horse-riding) and a new housing developments (the planning permission was given before the flood risk was clearly understood). An additional problem is a disused landfill site at the distal end of the spit, which could erode into the sea if coastal protection (mainly rip-rap) is not maintained.

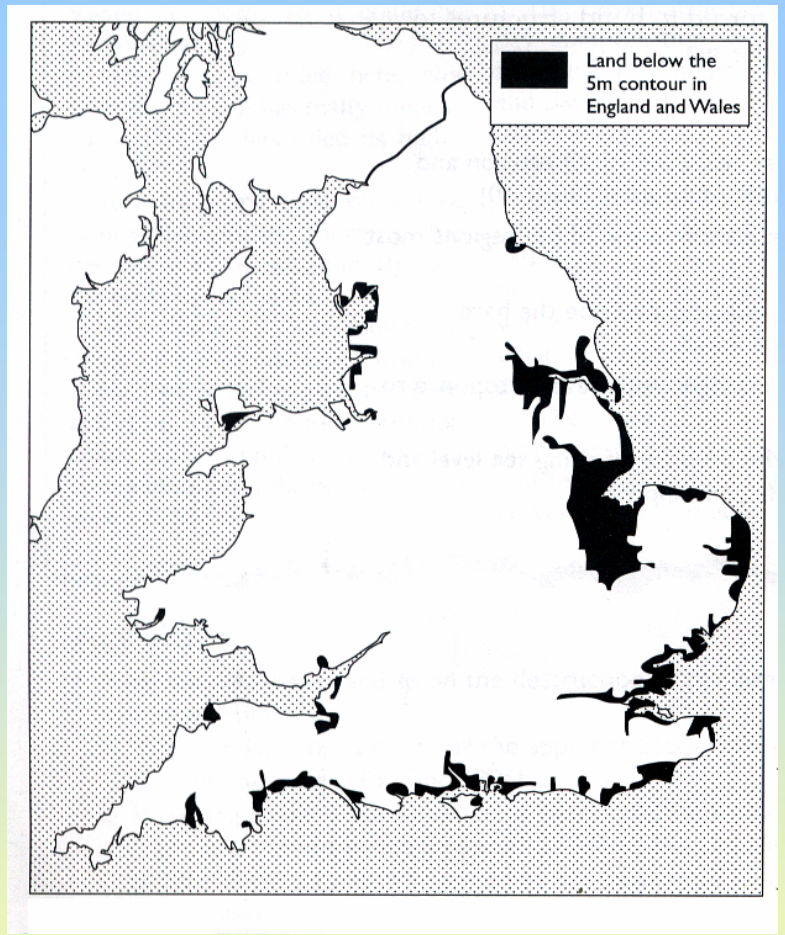


The council is considering a policy of managed retreat in which the tip will be excavated and removed to an inland site. This will be costly, but less so than continued coastal protection.

The Impact on Coastal Lowlands Across the UK

The map shows coastal lowland areas in Britain that will need additional flood protection as sea levels rise.

In the ecologically important Essex marshes, salt marshes have already been lost (23% between 1973 and 1990) and are concerns that marsh will be replaced by sand and gravel. Inland fresh water marshes may become more brackish as saltwater penetrates inland.



At Nothey Island, near Maldon, in the Blackwater estuary, an experiment in managed retreat is being tried in which the sea wall has been removed, allowing the sea to reclaim former marshland (once drained for farmland), creating a new natural protection. The general retreat of all flood embankments is under consideration, rather than attempting to maintain and raise **sea walls at great expense.**

It is also likely that coastal erosion around Britain will increase as the protective wave-cut platforms sink below the rising water at high and low tides. Wave activity will have greater access to the base cliffs. This will be made worse by the predicted increases in storm activity. The rapidly eroding Holderness coast of Yorkshire is showing an accelerated rate of erosion form 1-2 m per year in e 1970's to up to 5m per year in the 1990's. The greater frequency of major coastal landslides, such as that at Beachy Head in January 1999 is also blamed on global warming. In this one event, a slab of cliff 15m wide, 200m long and 150m high, fell into the sea. This was aided to the increased weight of the cliff blamed on heavy winter rain: another symptom of global warming.

The Impact of Future Sea Level Rise on Bangladesh

The problems associated with global warming in a low lying country like Bangladesh are complex and potentially widespread as much of the country is only 8m above sea level.

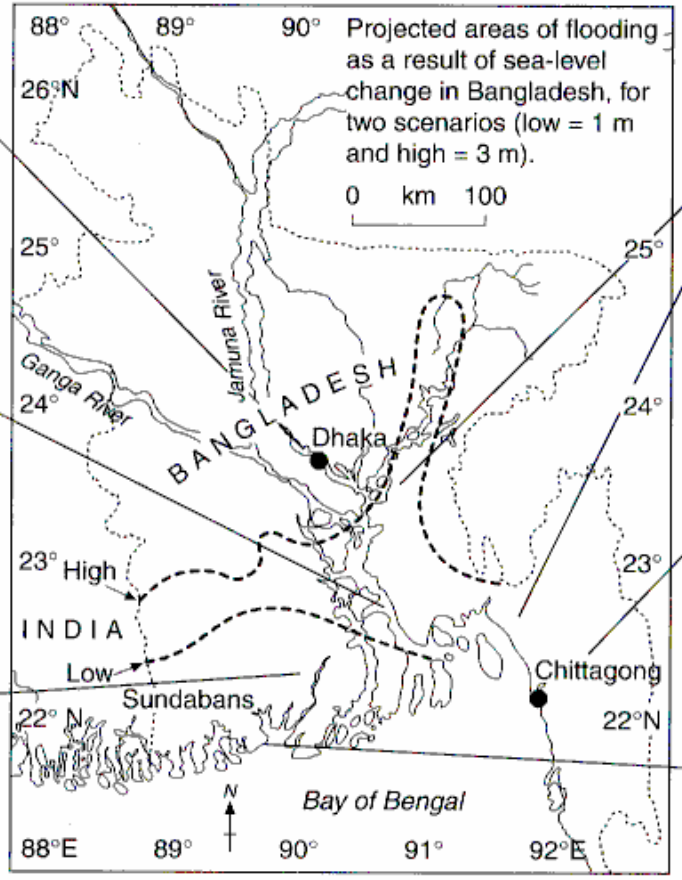
SEA-LEVEL RISE IN BANGLADESH

Probably the most important geomorphologic consequence of global warming would be a worldwide rise in sea-level due to the thermal expansion of the upper layers of the oceans and the melting of land ice.

Flood protection
- increased costs of protection for cities

Inlets and estuaries
- will be enlarged and deepened
- salinity will increase, affecting agriculture and coastal ecosystems

Low-lying areas
- permanently flooded to form lagoons or a new coastline
- loss of fertile agricultural land



Hazard events
- structural damage and marine flooding caused by storm surges would increase and intensify
- greater heights of waves arriving through deepening coastal waters

Population
- a 1 m rise would inundate 11.5% of the total land area and affect 9% of the population directly
- a 3 m rise would inundate 29% of the land and affect 21% of the population

Coastal erosion
- the Brown rule states that a rise in sea-level gives an increase in beach erosion

The Impact of Sea Level Rise on the Maldives

The Maldives is a group of about 1200 island formed into an archipelago in the Indian Ocean. 200 islands are inhabited. The population is about 270,000 and the main sources of employment are tourism and fishing. Most land is within 2m of sea level. Even a 0.5m rise in sea level, predicted this century will cause major problems for the inhabitants, particularly in tropical cyclones, which create huge storm waves accompanied by 4-5m storm surges. Not only would the delicate ecological balance of the island be threatened but also the islands could be “wiped-out”, according to their president Maumoon Addul Gayoom. The 270,000 inhabitants could become “global warming refugees”.

It is worth noting that the traditional lifestyle of the people of the Maldives makes a negligible contribution to global warming.