Location
The small town of Criccieth lies on the south coast of the Llŷn Peninsula in North Wales. It overlooks Cardigan Bay, and is just outside the western edge of Snowdonia National Park. The town prides itself for being known as the ‘The Pearl of Wales on the Shores of Snowdonia’.

Physical Geography
Criccieth Bay is an area of soft glacial till (also known as boulder clay), deposited by the Welsh glaciers during the last glacial maximum. On either side of the bay are two headlands composed of hard rocks. The castle headland is volcanic, while Black Rocks (which in Welsh is Craig Ddu) is a combination of volcanic and folded metamorphic rock. Both of these resist erosion with approximately 1mm of retreat every 100 years. The glacial till is a weak, unconsolidated rock. This is easily eroded by storm waves resulting in an average rate of erosion of 1 metre every 10 years.

Human Geography
With its prominent headland Criccieth was an ideal defensive location to build a castle. The original castle was built by Llewelyn Fawr, a local Welsh Prince, in approximately 1239. The castle was strengthened by the English under the rule of Edward I who, after invading Wales, created a network of castles and granted the town a charter in 1284.

In 1867 the Cambrian Railway came to Criccieth allowing an influx of visitors. The town became a Victorian tourist resort and increased in size. Today it is still a popular tourist destination.
The need for coastal management

Due to its location and geology parts of the Criccieth coastline is vulnerable to the threat of rising sea levels and increased storminess. It is exposed to a 7,000 km fetch across the Atlantic which means that the waves reaching the coast here can be carrying a large amount of energy, particularly during storms from the South West. Also much of the town is built atop the soft boulder clay. This unconsolidated material is easily eroded by the sea and sub aerial processes.

In 1927 there was a huge storm which destroyed parts of the promenade. A new hotel and apartments at Merlyn (where the car park behind the promenade now stands) and the houses at Abermarchnedd (next to the lifeboat station) had to be demolished because they were so badly damaged.

Approaches to coastal management

Criccieth lies within the coastal management area that is covered by the West of Wales Shoreline Management Plan (SMP). This document, written by a number of the key players involved in managing the Welsh coastline, is designed to inform 'integrated' coastal management for the next 100 years. This is a ‘second generation’ SMP published in 2011 to replace the first generation SMP’s completed for 11 coastal areas, or management units, in 2001 (see map on right). The West of Wales SMP2 is one of 22 second generation SMPs for the coast of England & Wales. Each starts and finishes at either a prominent headland or a significant estuary. West of Wales SMP covers the coastline from St Anne’s Head in Pembrokeshire to the Great Orme on the North Wales coast. These large sections are then broken down into smaller management units.

In the UK each management unit is surveyed in order to make a management decisions. For each section 4 possible options are considered.

1. **Do nothing.** This is where the coastline is left alone and no management practices are put in place.

2. **Hold the line.** The coastline is held in the location it is at present. Coastal defences are maintained.

3. **Retreat.** A decision is made to allow the sea to take over the land. For example, in Humberside several kilometres of sea wall are being bulldozed, allowing the sea to advance and the coast to retreat landward.

4. **Advance.** Sea defences are built. The new coastline may even advance outward, pushing back the sea.

For each of these options a cost-benefit analysis is carried out. This looks at the cost of each sea defence, and the cost to the area if the scheme was not put in place. A decision is then made.

At the moment a **Hold the line** policy is recommended for the town of Criccieth, whilst a **Do nothing** policy is recommended for the section between the boulder clay cliff and Black Rocks (to the east of the town).

Although total costs of defences used to be recorded, now it is more common for Shoreline Management Plans to state the cost per metre of coastline per defence, for example, a revetment costs around £1,000 per metre, an offshore breakwater around £2,000 per metre and a curved seawall would be around £6,000 per metre.
Examples of coastal management at Criccieth

Timber Crib wall and Rock Armour Revetment

Built in 1997, it protects houses and shops on the old town High Street. Coastal protection here began in 1965 when there were bullhead steel rails and rock armour infill at a cost of £6,300. From 1986 this area was protected by gabions (wire cages approximately 1m in diameter, containing rocks), originally costing £11,600. However, large waves were able to break over the top of these and the cliff was still eroded. In addition the clay was prone to become saturated and so slumped into the sea below. Retreat was at a rate of 2m every 10 years, and in 1996 a large storm significantly damaged the gabions.

The revetment is composed of a grid of wooden planks. Behind this are stones, around 5cm in diameter. This structure holds the cliff in place but allows the saturated clay to drain thus preventing slumping and mass movement. As a result there should be no repeat of the Holbeck Hall type incident on the Yorkshire coast.

A crib wall alone does not offer total protection against the power of the waves. It primarily limits sub-aerial processes from taking place, so it is reinforced by rock armour at the base.

The rock armour revetment consists of large boulders (imported from Norway) engineered securely into place forming a sloping ramp at the base of the crib wall. These highly resistant boulders are generally over 1m in diameter to ensure that they will not be easily moved even under severe storm conditions. The rock armour revetment is designed to break up, or dissipate, the energy of storm waves before they reach the base of the crib wall. This helps protect the otherwise vulnerable base of the wall and dramatically increases the life expectancy of the defence as a whole.

The cost of these 2 measures in 1997 was £271,000 for an 80m stretch of coastline. The benefit was that an estimated £1.6 million pounds worth of properties (including a road, historic housing and cafe) were protected. Each boulder in the rock armour cost between £1,000 to £3,000 depending on its size.

This defence requires regular checks and maintenance, particularly after heavy storms. Should the foundation of the rock armour become unstable this would destabilise the overlying rocks which have been carefully placed into position so that they ‘lock’ together. If rocks where to come loose from this structure they could well become ammunition for the sea to throw against the crib wall leading quickly to significant damage and potential failure. Partial resetting of the rock armour has already had to be undertaken once since its construction in 1997.
Groynes

The West Beach groynes are to be found on the western side of the castle headland. These were originally built in the late 1800’s and rebuilt between 1963 and 1965. Major repair work was carried out in 1999. The cost in 1963-65 was £14,500, and the maintenance work in 1999 cost £20,000.

Their main purpose is to encourage the entrapment of sand. As a coastal resort Criccieth needs a beach to encourage tourists. Beaches also play a vital role in coastal protection as they absorb wave energy and so protect the land behind.

There are also two within Criccieth Bay at the east end of the beach (far end from the castle). One of these is large and very successful at trapping sediment. The cost in 1963-65 was £10,000.

On one side of the large groyne in Criccieth Bay the beach deposits are 1.5m higher than the beach on the other side.

Breakwater

This was built in the early 1900s to protect the launching slipway for the lifeboat station. It creates an area of sheltered water on its north-eastern side, reflecting wave energy away from the shore and turning destructive waves into constructive waves through wave refraction. It was rebuilt in the 1960s. Today this would cost over £500,000 to build.

The breakwater, protecting the RNLI slipway and offering recreation opportunities such as fishing (Photo: FSC)

Victorian Sea Wall

This was originally built in the late 1800’s. It had to be rebuilt in 1963-65 with a concrete toe. In 1975 new facing was added. The Cost to rebuild (1963-65) was £19,500, then in 1975 £46,000 was spent on the defence. The present cost is estimated to be approximately £4,000 per metre.
Recurved sea wall

This is the esplanade area where the buildings were destroyed in the 1927 storm. As a result the land use is very different to other parts of the seafort with open space and carparking. (a similar approach of land-use zoning as in flood management on rivers).

This wall is an addition to the original Victorian Sea wall. The base of the old wall remains, but the top has been replaced by reinforced concrete and a recurved lip rather than a vertical top section. The wall is designed to reflect the energy of storm waves back into the next incoming wave. This helps reduce the energy of the waves reaching the wall. This is a good example of a hard engineering approach to ‘hold the line’ coastal management.

The recurved, or ‘wave return’, lip on the wall is designed to reduce the likelihood of waves overtopping the wall resulting in coastal flooding and deposition of beach material on the road and car park.

The present cost is approximately £6,000 per metre.

‘Do nothing’ – natures coastal management

Although large sections of the Criccieth coastline are heavily managed there are parts that have been left in their ‘natural’ state. As decision makers have decided to allow this it is called a ‘Do Nothing’ coastal management strategy. The most interesting ‘do nothing’ stretch of the Criccieth coastline is the small section of glacial till cliff at the eastern end of the town beach. As the material in front of the cliff becomes insufficient to protect the cliff from large storm waves material is eroded from the cliff. There are some places along the cliff where obvious collapses have occurred. The addition material at the foot of the cliff then acts as a natural defence (it increases the size of the beach) until it is worn away and erosion occurs again. This natural cycle of nature constantly readjusting to find a balance is called dynamic equilibrium.

Between Black Rocks or Craig Ddu and Criccieth a large shingle bank has formed. One theory explaining its formation is that as sea levels rose after the last glacial maximum material was moved inland slowly as the coastline also moved in land (similar to the way that Slapton Sands, in Devon, formed). Behind the bank lies a low-lying marshy hinterland which originally would have been a bay 120,000 years ago before the last major glacial period. You can see the original cliffs around the side of this relic bay. Here ‘do nothing’ is also used.
Physical Features

Beach cusps

*Cusps* are beach formations made of different sized sediment in an arc pattern. The ‘horns’ are made up of coarser materials and the centre contains the finer material. They usually occur in a regular pattern with cusps of equal size and spacing. Usually they are a few metres wide; however they can reach 60 metres across. How cusps are created remains a contentious and unproven area of debate. But once they begin to develop they are self sustaining. As an oncoming wave hits the horn of a beach cusp it is split and forced into two directions. The crashing of the wave into the cusps slows its velocity, therefore causing coarser sediment to fall out of suspension and be deposited on the ‘horns’. The waves then flow into the centre and collide. These waves then flow back out to sea. Once the cusp is established coarser material is constantly being deposited on the ‘horns’ and finer sediment is being eroded from the centre.

Black Rock (Graig Ddu)

This is a headland composed of tough folded rock. The folds and and faults are due to earth movements, and have resulted in many lines of weakness which waves can exploit. This combination of geological process and marine erosion has given rise to impressive caves. At the base of the cliffs a wave-cut notch can be seen clearly in some places, but there is no wave-cut platform. It probably lies buried under the sands which are now being deposited here. There is a stack lying to the east of the headland and a stump at its far eastern end.

*The caves at Black Rock. The jointing pattern is very clear as are the caves and cracks.*