Landforms caused by changing sea level

Changes in sea level affect the shape of the coastline and the formation of new landforms. A fall in sea level exposes land previously covered by the sea, creating an *emergent coastline*. A rise in sea level floods the coast and creates a *submergent coastline*.

Emergent coastal landforms

As the land rose as a result of isostatic recovery, former wave-cut platforms and their beaches were raised above the present sea level. **Raised beaches** are common on the west coast of Scotland, where the remains of eroded cliff lines (called *relic cliffs*) can often be found behind the raised beach, with wave-cut notches and caves as evidence of past marine erosion. You have already seen a relic stack and a raised beach in Figure **1**. Wave-cut (marine) platforms can also be exposed if sea levels fall sufficiently, although these are often hidden beneath fresh beach deposits.

On the Isle of Arran (see Figure **6**), raised beaches represent separate changes in sea level. Notice the fresh beach deposits at a lower level than the raised beaches. These are probably blanketing ancient wave cut platforms below.

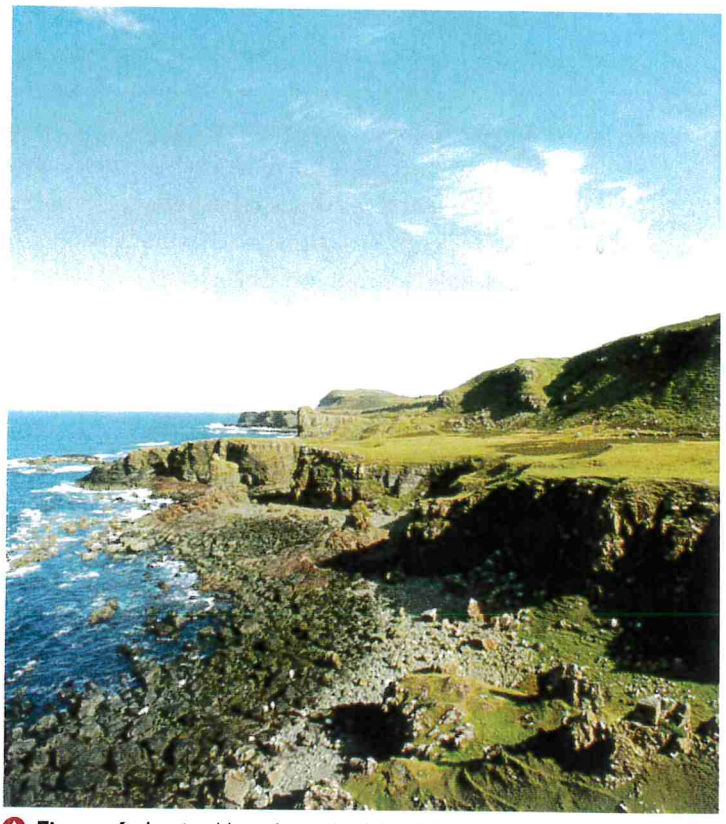

Figure 6 *A raised beach on the Isle of Arran*

Submergent coastal landforms

Essentially, submergence results in the flooding of coastlines. **Rias** (sheltered winding inlets with irregular shorelines) are one of the most distinctive features associated with a rise in sea level. They form when valleys in a dissected upland area are flooded. Rias are common in south-west England, where sea levels rose after the last Ice Age –the lower parts of many rivers and their tributaries were drowned to form rias. The Kingsbridge Estuary in Devon is one of these (Figure **7**). It provides a natural harbour with the deepest water at its mouth.

Fjords are formed when deep glacial troughs (see 4.8) are flooded by a rise in sea level. They are long and steep-sided, with a U-shaped cross-section and hanging valleys. Unlike rias, fjords are much deeper inland than they are at the coast. The shallower entrance marks where the glacier left the valley. Fjords can be found in Norway, Chile and New Zealand (Figure **8**).

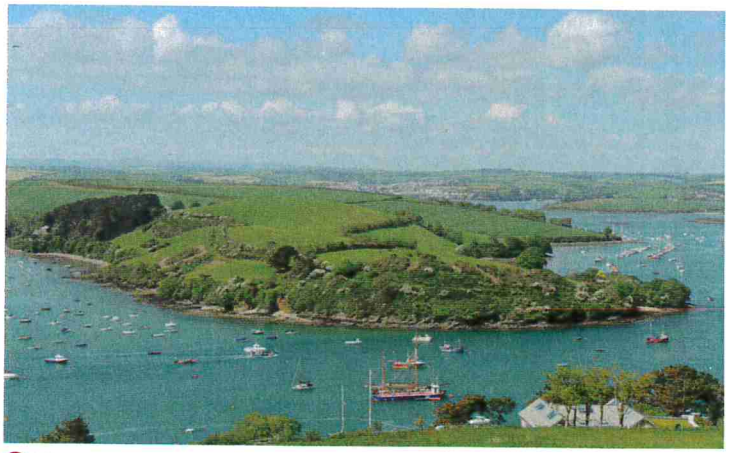

Figure 7 *The Kingsbridge Estuary, Devon*

Figure 8 *Milford Sound (a fjord) on New Zealand's South Island*

Dalmatian coasts are distinctive submergent coastlines that form in a landscape of ridges and valleys running parallel to the coast. When the sea level rises, the valleys flood, although the tops of the ridges remain exposed, forming a series of offshore islands running parallel to the coast. The best example of a Dalmatian coastline is the one that gives this feature its name – the Dalmatian coast in Croatia (Figure **9**). Dalmatian coasts are also known as Pacific coasts, for example, in southern Chile.

Figure 9 *A satellite image of the Dalmatian coa*

Contemporary sea level change

According to the Intergovernmental Panel for Climate Change (IPCC), sea levels stabilised about 3000 years ago and they have changed little since that time until very recently. From the late nineteenth century to the late twentieth century, sea levels rose globally by about 1.7 mm per year, although this has increased to about 3.2 mm per year in the period 1993–2010. The IPCC estimates that by 2100 sea levels could rise by between 30 cm and 1 m from current levels, although there is likely to be considerable variation from place to place.

Sea level rise is the result primarily of thermal expansion of water, due to heating, and the melting of *freshwater* ice, such as the Greenland and Antarctic ice sheets and mountain glaciers. Between 1880 and 2010, global temperatures rose by an average of 0.85 °C.

Notice the link here between coastal systems and the water and carbon cycles (Chapter **1**), and glacial systems (Chapter **4**).

The impact of climate change in Kiribati

The nation of Kiribati consists of 33 islands in the Pacific Ocean, that stretch across an area almost as wide as the USA (Figure **10**). Kiribati's islands are very low-lying sand and mangrove atolls – in most places only a metre or less above sea level. To visitors, Kiribati can seem like paradise, but it has been predicted that many of its islands could disappear under the sea in the next 50 years. In places, the sea level is rising by 1.2 cm a year (four times faster than the global average).

Figure 10 *Tarawa Atoll, Kiribati – a vulnerable speck in the ocean*

What next for Kiribati?

In 2014, President Anote Tong of Kiribati finalised the purchase of 20 km^2 of land on one of the islands of Fiji – 2000 km from Kiribati. Rising sea levels in Kiribati are contaminating its groundwater sources and affecting its ability to grow crops. So the land in Fiji will be used in the immediate future for agriculture and fish-farming projects, to guarantee the nation's food security. In the future, people could move there from Kiribati. The government has launched a 'migration with dignity' policy to allow people to apply for jobs in neighbouring countries such as New Zealand. If the islands are submerged, Kiribati's population will become *environmental refugees* – people forced to migrate as a result of changes to the environment.