

# Out of sight, not out of mind

Some of the Scottish coast's most dramatic landscapes are hidden beneath the waves. Martyn Stoker and Alan Stevenson have been exploring.

Say 'fjord' and, not surprisingly, most people picture the stunning west coast of Norway. Fjord is a general Nordic name for a marine inlet, mostly used for inlets made by glaciers. Anyone familiar with the intricate geography and spectacular scenery of the west coast of Scotland will easily recognise that the very same glacial processes have been at work here too. Less obvious, though, is the dramatic underwater landscape that forms an integral part of western Scottish fjords.

In July 2005, the British Geological Survey mapped the seafloor of the Summer Isles region, west of Ullapool in the North-west Highlands. The area we studied lies on the southern edge of the North-west Highlands Geopark. This is Scotland's first such site, designated in September 2005. Geoparks are European designations that UNESCO (the United Nations Educational, Scientific and Cultural Organisation) recognises as having special geology and landscapes. Scotland's fjords are an

important component of the region's natural heritage.

As well as doing some science, we wanted to raise awareness of the unseen marine landscape for socio-economic reasons. The aquaculture and commercial fishing industries are important employers in this rural area, however, some activities, such as trawling, can sometimes damage seabed habitats. A good way to help local communities weigh up the pros and cons

## This is Scotland's first Geopark.

is to give them more information about the marine environment and the processes that influence seabed habitats, for example mapping easily damaged soft sediments and more robust rocky habitats.

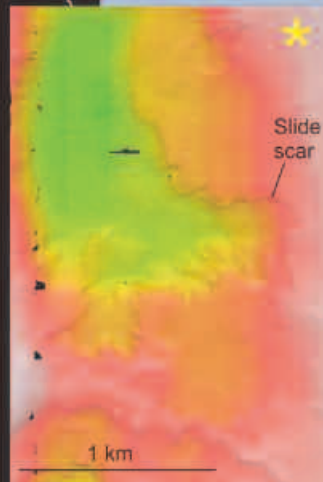
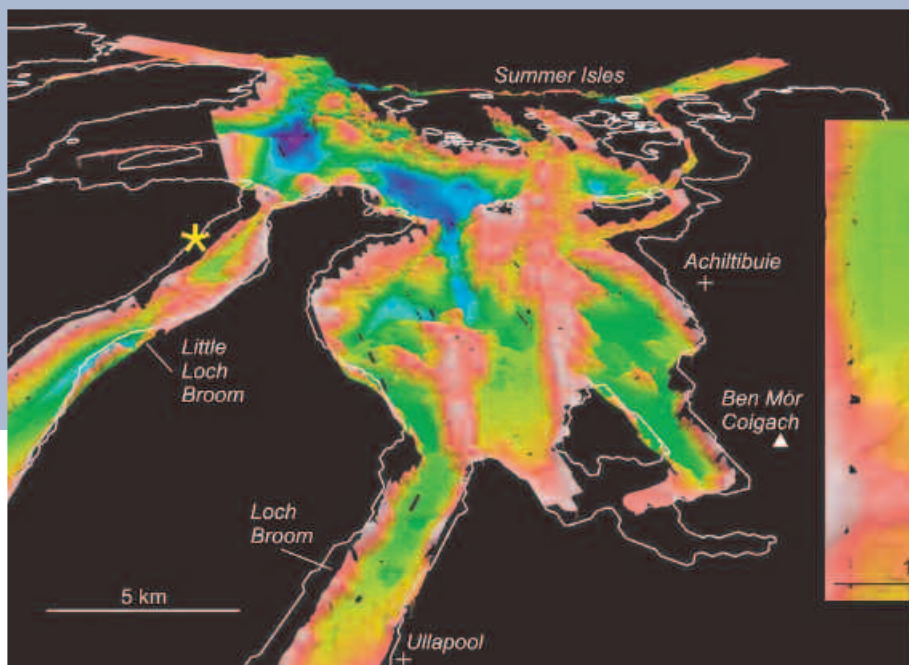
We mapped the seafloor using swath bathymetry and high-resolution seismic-reflection profiling. Basically, we transmit acoustic pulses that are reflected off the seafloor and sub-seafloor layers\*. By

interpreting these reflections, we can get a fairly sophisticated picture of the seafloor and its underlying geology. We wanted as complete a picture as possible, so surveyed along lines just 200m apart. A computer aboard the vessel merged the data into a mosaic. At the end of each survey day, we could actually turn the information into a three-dimensional image that let us start to understand the submarine landscape.

After three weeks, we had covered about 200 km<sup>2</sup> of sea floor, including Loch Broom and Little Loch Broom.

A striking contrast emerged. We saw shallow marine banks, less than 15–20m below present-day sea level, the surface of which often looked ribbed where retreating glaciers had repeatedly dumped their load of stones and debris in glacial moraines. Close to the banks are undulating troughs, up to 180m deep, with steep sides and flat bottoms. These are the modern lochs, continued offshore. The views from the mountaintops of Ben Mór Coigach and An Teallach are already impressive, but to appreciate the true size





Perspective, colour-shaded, view of seafloor looking west from Ullapool towards the Summer Isles. Shallow banks are white/pink; deep troughs are blue/dark blue. Inset shows submarine landslide in Little Loch Broom.

of the fjords in the Summer Isles you'd have to add an additional 180m to the mountains' height above present-day sea level.

Glaciers scoured out these troughs when sea levels were much lower. They are deeper than the present-day lochs because they accumulated less sediment when the glaciers retreated. This could have been because the ice retreated faster here. In the narrower part of the valleys, ice became pinned to the sides and floor, slowing the glacier's retreat and letting large amounts of sediment build up. Large blocks of ice might also have separated from the retreating glaciers, plugging the mouth of the fjord, forming a temporary lake that filled with sediment. When these detached blocks of ice eventually melted, they would have left behind holes akin to kettle holes. These hollows, left by melting blocks of isolated ice, are common in onshore glaciated landscapes. If this is what

happened, the step-down from the relatively shallow floor of the modern sea loch to the deeper trough farther offshore may mark where the block of ice once sat. Since glaciers retreated from this coastal region, some 15,000 years ago, the sea level has risen and drowned the marine landscape. But natural processes of weathering, erosion and slope readjustment continue to modify the fjords both above and below sea level. On the mountainsides, scree and rockfalls provide recent evidence. Below water, similar features show up in our swath bathymetry data. Extensive slumping has scarred the submerged sides of the fjords. In Little Loch Broom, about 1.5 km<sup>2</sup> of the sea floor in the outer part of the loch has slid and been displaced. At the moment we're not sure exactly when the landslide occurred, but it seems fresh, suggesting it happened within the last few thousand years.

There's a growing cultural awareness

that we need to monitor excessive pressures on our landscapes. To do this we must recognise that geology provides the foundations for landscapes, both above and below the waves. Around the Summer Isles, these landscapes are still evolving. Knowing their geology helps us understand whether aquaculture and fishing can be sustained without adversely affecting the environment.

*\*Before seismic work, we assessed how the sound might affect marine communities, including dolphins and whales, and confirmed it would not be damaging. Our July survey avoided seasons when spawning fish might be affected, and our seismic signal is comparable to frequencies from standard echosounders used on most ships.*

Martyn Stoker and Alan Stevenson are geologists within the Marine, Coastal and Hydrocarbons Programme at the British Geological Survey, Murchison House, West Mains Road, Edinburgh EH9 3LA, tel: 0131 667 1000, email: mss@bgs.ac.uk; agst@bgs.ac.uk respectively.

View towards the head of Loch Broom.

