Getting to the bottom of Scotland's fjords

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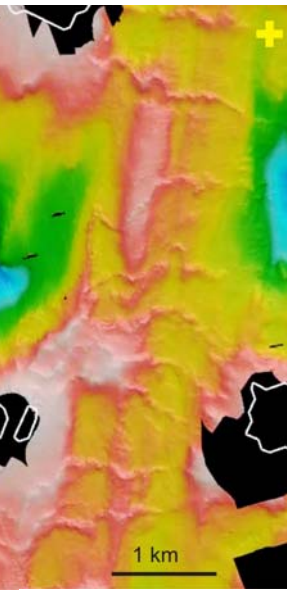
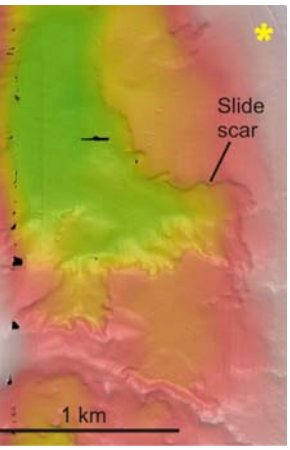


Submarine moraine ridges offshore Achiltibuie (location marked by cross on main image)

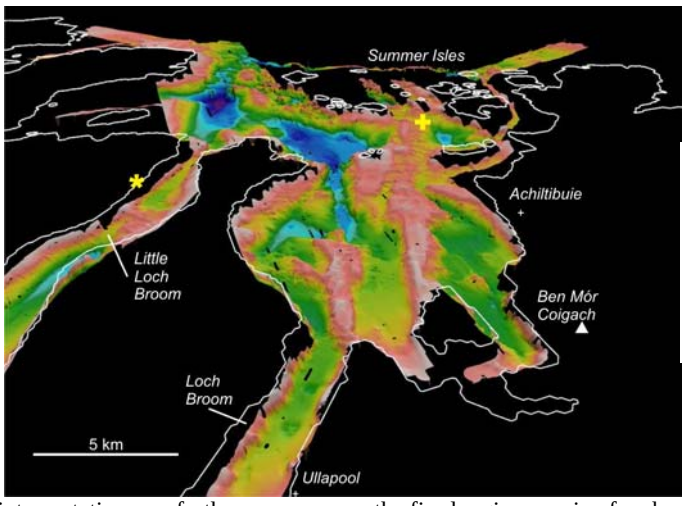


Submarine landslide in Little Loch Broom (location marked by asterisk on main image)

Over the last 500 thousand years, glaciers have carved and shaped the stunning fjord landscape that characterises the west coast of Scotland. The North-West Highlands is one of the best places to view the effects of glacial erosion, from its spectacular mountain peaks and deep ice-sculpted corries to the U-shaped valleys and sea lochs. The special nature of this unique landscape has been acknowledged in its designation as a UNESCO 'European Geopark' (www.northwest-highlands-geopark.org.uk). Less well-known is the dramatic marine landscape that forms an integral component of the region's natural heritage.

Between 2005 and 2009, the British Geological Survey undertook a study of the fjord coastline in the Summer Isles region, west of Ullapool, including Loch Broom and Little Loch Broom; an area of about 200 km^2. Our main scientific objective was to initiate a primary marine geological survey of Scotland's fjords, which, somewhat surprisingly, have received relatively little attention in terms of their glacial history. In addition to the science, we wanted to raise awareness of the unseen marine landscape for socio-economic reasons. All marine activities, be they local aquaculture or fishing industries, or national infrastructure activities, such as cable laying, require information about the marine landscape and the processes that influence sea-bed habitats, in order to maintain a healthy ecosystem alongside human use of the marine environment.

We mapped the seafloor using swath bathymetry and high-resolution seismic-reflection profiling techniques, which transmit acoustic pulses that are reflected off the sea floor and sub-sea-floor layers. By interpreting these reflections, including their calibration with geological cores, a fairly sophisticated picture of the sea floor and its underlying geology was established. This interpretation was further enhanced by the importation of the acoustic data into a 3D-visualization package that produced a digital terrain model of the marine landscape.



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.

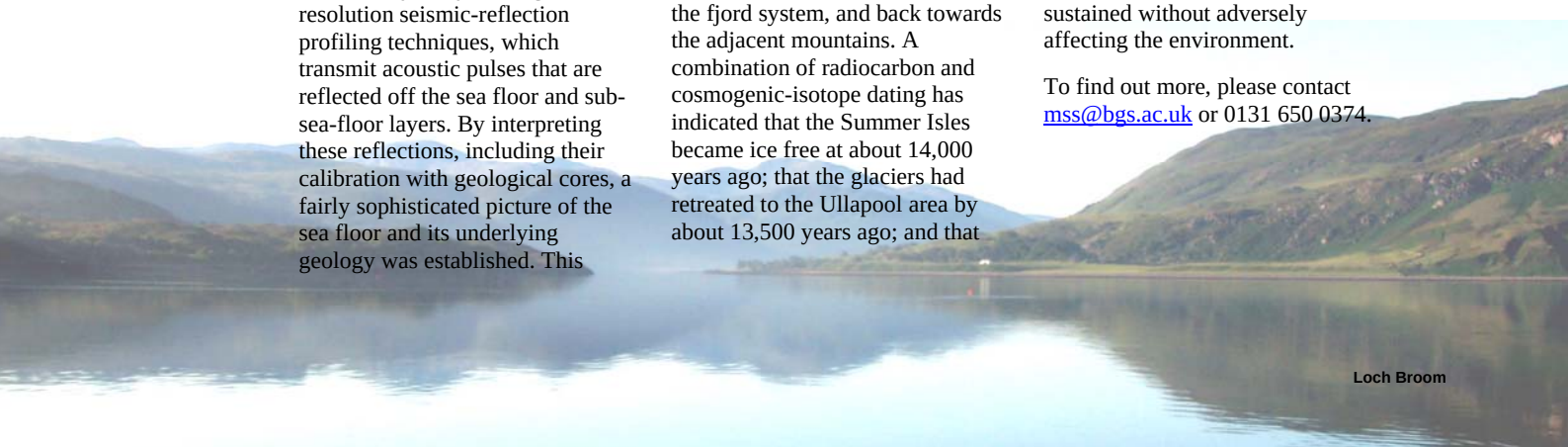
A striking contrast was revealed. Shallow marine banks, less than 15–20 m below present-day sea level are juxtaposed with deeply incised fjord troughs, up to 180 m deep, with steep sides, flat bottoms and undulating axial profiles. The troughs represent the offshore continuation of the modern sea lochs. The views from the mountain tops of Ben Mór Coigach and An Teallach are already impressive, but to appreciate the true size of the fjords in the Summer Isles region you'd have to add an additional 180 m to the mountains' height above present-day sea level.

The shallow banks have a distinct ribbed appearance that reflects the preservation of a spectacular suite of about 40 sea-floor moraines, 5 to 15 m high and 50 to 125 m wide, which can be traced from the Summer Isles to Loch Broom. The preservation of these submarine landforms contrasts markedly with the much more subdued morphology (and common absence) of moraines onshore. These submarine moraines chart the decay of the last British ice sheet as it receded from the adjacent continental shelf, through the fjord system, and back towards the adjacent mountains. A combination of radiocarbon and cosmogenic-isotope dating has indicated that the Summer Isles became ice free at about 14,000 years ago; that the glaciers had retreated to the Ullapool area by about 13,500 years ago; and that the fjord region was ice-free by about 13,000 years ago.

Since the retreat of the glaciers, natural processes of weathering, erosion and slope readjustment have continued to modify the fjords both above and below present-day 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^2 of the sea floor in the outer part of the loch has slid and been displaced. Whereas this event most likely occurred shortly after the retreat of the Little Loch Broom glacier, evidence of more recent slumping and mass failure, within inner Little Loch Broom, suggests that this area may still not have fully adjusted to nonglacial conditions.

There is a growing cultural awareness that we need to monitor excessive pressures on our landscapes. To do this we must recognize that geology provides the Geodiversity that underpins landscapes, habitat and Biodiversity both above and below the waves. Around the Summer Isles, these landscapes are still evolving. Understanding Geodiversity helps us establish whether the use and development of the coastal region can be sustained without adversely affecting the environment.

To find out more, please contact mss@bgs.ac.uk or 0131 650 0374.



Loch Broom