Public Interpretation of Land and Sea Use Using Visualisation Tools

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Summary: Prototype 3D models offer greater flexibility in delivering a comprehensive creative features set with tools for animation, modeling, simulation and rendering in Loch Linnhe. In particular, these tools permit many stakeholders to personally interrogate various datasets at one source. The utilisation of the Linnhe seabed imagery, derived from surveyed sonar data allows the integration of both onshore and offshore topographic and bathymetric data into a single gridded 'landscape'. It is hoped that understanding how sea lice are dispersed in the water within Loch Linnhe will contribute to understanding infestation patterns on farms and wild fish, and will result in information which can be used to help control infestations.

KEYWORDS: Virtual Reality, Land Use, Public Engagement, Loch Linnhe, Sea Floor

1. Introduction

Coastal Scotland is the interface between land and marine environments, generally with discrete management, designations and ownership. Yet, uses of land, lochs and coastal waters can be interdependent for tourism, recreation, economic activity and potential environmental impacts. This area includes:

(i) Forty-five percent of Scotland's population living within 5km of the coast.

(ii) Significant contributions to Scotland's rural economy, including aquaculture and shellfish £600m[2], plus 1,500 jobs; Sailing £101m[3], 2,700 jobs; wildlife tourism £100m, 2,700 jobs; sea angling £141m.

(iii) Sea lochs which are an integral part of its seascape and landscapes, and its cultural heritage (e.g. Machair and crofting landscapes, designated war graves, marine renewable energy).

This paper describes development of a 3D model for use in an interactive manner with the aim of identifying opportunities and limitations to multi-functional land and sea use with different types of stakeholders.

2. Background

The Scottish Land Use Strategy (Scottish Government, 2011) and Marine (Scotland) Act (Scottish Government, 2010) provide policy contexts for engaging communities in planning and decisions relating to managing natural resources. Land use and sea use are often considered separately, but each can be closely interconnected. For example, fishing and farming are both characteristics of many crofting landscapes. However, debates arise of compatibility of uses of land and sea such as forest expansion with water quality, or marine renewable energy with tourism. The identification of multiple benefits for land use is a Principle of the Land Use Strategy, which also encourages means to: "Identify and publicise effective ways for communities to contribute to land use debates and decision-making".

To identify scope for multiple uses of land and sea, and enable community engagement in the discussion, visualisation tools have been employed. As noted by Schroth (2010), they provide means of participation and collaboration with respect to planning, and can be used to combine spatial data and 3D features of significance to understanding the scene or context.

Today, 3D software programs such as Maya, 3D Max, Vega Prime, Octaga or specialized landscape tools Visual Nature Studio provide a high degree of visual realism for land and sea, rendered both as images or animations (Wang C et al., 2012; Ball et al., 2007; Bishop and Miller, 2007; Donaldson-Selby G et al., 2012).

Aiming at the actual demand of the use of visualisation tools to represent marine environments, new visualization technologies and software are applied to underwater exploration (Goralski et al., 2011), submarine habitats characterization (Ray et al., 2011), seabed perception (Wheeler et al., 2011) and scientific data presentation (Rodriguez et al., 2009).

In this study visualisation tools were used to present topographic contexts of land and sea floor, land and sea use, land and marine designations, and the introduction of potentially new features such as forestry, fish farms, and renewable energy. The medium to facilitate representation of alternative futures was the Virtual Landscape Theatre (VLT; Ball et al., 2007). This paper describes the development and use of such a model and virtual environment for the engagement with stakeholders.

3. Methodology

3.1 Study area

The study area was Loch Linnhe, a sea loch on Scotland's west coast, approximately 50 km long, running from Fort William to Oban, at the south end of the Great Glen fault. Land use is dominated by agriculture, particularly crofting on the islands and western shores, forestry, and tourism. Uses of the loch include inshore fishing and fish farming, sailing, and diving, with increasing interest in marine renewable energy.

The topographic context of Loch Linnhe is of glaciated valleys of an indented fjordic coast, with terrain rising steeply away from the loch, bare rock and scree, and land on the eastern shore which includes a raised beach. During past ice ages, the loch was a major outlet for glaciers from the Rannoch Moor area, where ice built up in the initial stages of development (http://planetearth.nerc.ac.uk/features/story.aspx?id=749).

3.2 Approach

A 3D model was created of the sea floor and surrounding land of Loch Linnhe as follows:

(i) Ordnance Survey (10m resolution) Digital Terrain Model extracted for the land around Loch Linnhe.
(ii) Multibeam sonar data (1m resolution), surveyed by the UK Marine Environmental Mapping programme (MAREMAP) by the Scottish Association for Marine Science (SAMS) and the British Geological Survey, (BGS) and the National Oceanography Centre (NOC), combined with Admiralty seabed data.
(iii) Visual Natural Studio (VNS) used to render a 3D model combining the seafloor and terrestrial areas (221km^2; 2.5m resolution), with true scale above sea level and a 2 times vertical exaggeration below sea level.
(iv) High-resolution aerial imagery used for background landscape textures.
(v) Extruded buildings were derived from Ordnance Survey MasterMap.

Further elements added to the model were:

(i) Features associated with coastal environments, developed in Autodesk Maya, including fishfarm cages, leisure craft and renewable energy structures.
(ii) Data layers representing designations (e.g. National Scenic Areas, shell fishing zones).
(iii) Water, using colour to distinguish between above and below water surface.

Figure 1 shows an extract from the model in development, presented in Maya.

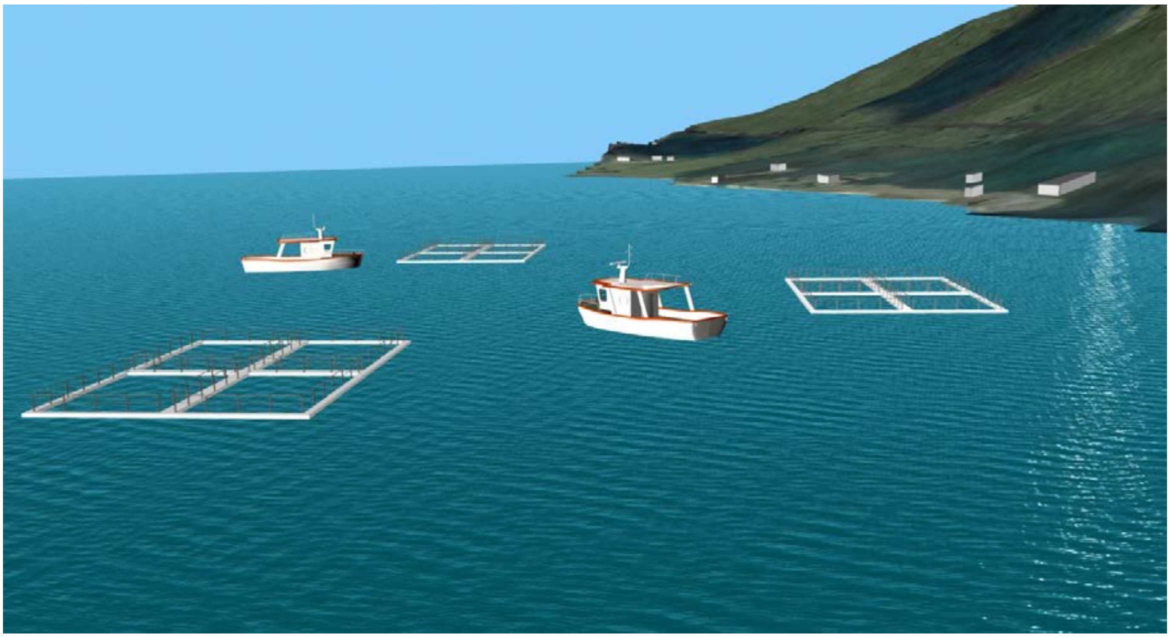

Figure 1. Planning the siting and support of aquaculture in Loch Linnhe

Output data were converted for use in Octaga virtual reality (VR) software in the Virtual Landscape Theatre (VLT; http://www.hutton.ac.uk/learning/exhibits/vlt). Model functionality was tested at the World Marine Biodiversity Congress, Aberdeen, 2011, and feedback used to refine the interactive capabilities of the model, rendering of imagery, and details of the content.

3.3 Eliciting opinions on land and sea use

Different types of stakeholders were invited to participate in events in Oban, May 2012. These included local authority and marine spatial planners, public agencies responsible for natural heritage, forestry and waters, elected representatives, fishfarm and fishing businesses, and members of the public and school children.

Figures 2 and 3 show views to the west from above and below water level of Loch Linnhe, showing fishfarm cages, presented in the VLT. Use of the 3D model followed a set protocol of introduction, presentation, tour above and below sea level, and questions relating to land and sea use. Feedback was captured using electronic handsets and audience comments. The tone of blue for water was set differently when viewed from above compared to below to aid in informing participants of the nature of the viewing location, or navigation through the model.

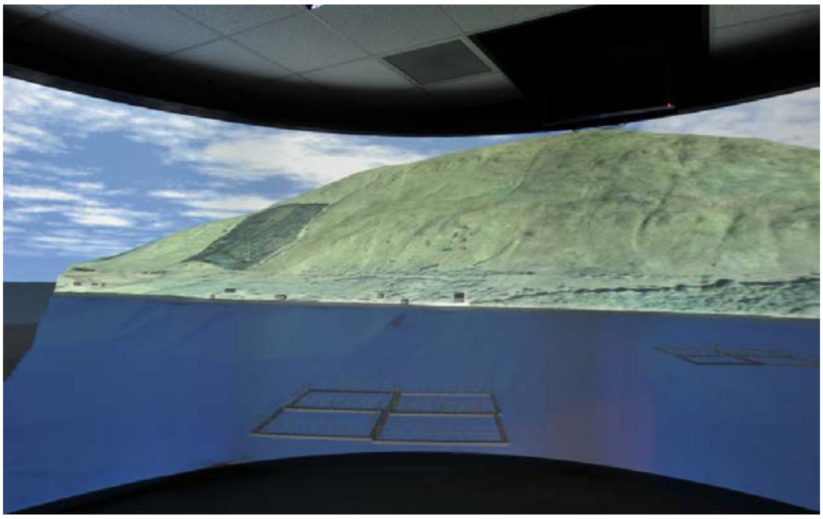

Figure 2. View across Loch Linnhe to the west showing fish farm cages in the foreground, presented in the Virtual Landscape Theatre (VLT).

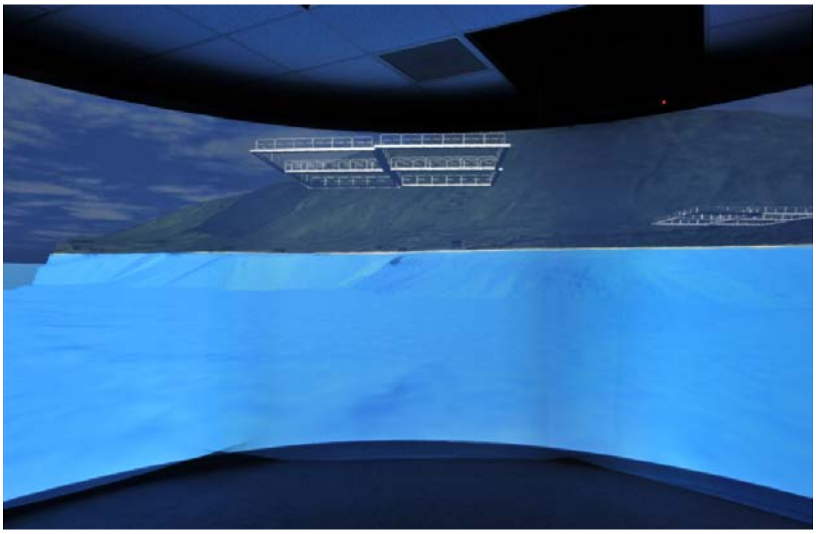

Figure 3. View from below water level in the same direction as that in Figure 1, showing fish farm cages from below.

The use of high resolution data for the seafloor, combined with surface terrain, enabled interpretation and explanation of features such as glacial moraines. Figure 4 shows an overview of the model, looking to the south-west, in which patterns in the surface and subsurface are visible. The visualisation of the seafloor sonar data and the onshore topography permits the tracing of offshore features such as moraine ridges and seafloor faults onshore. This is a very useful tool for palaeoenvironmental reconstruction (McIntyre et al., 2011).

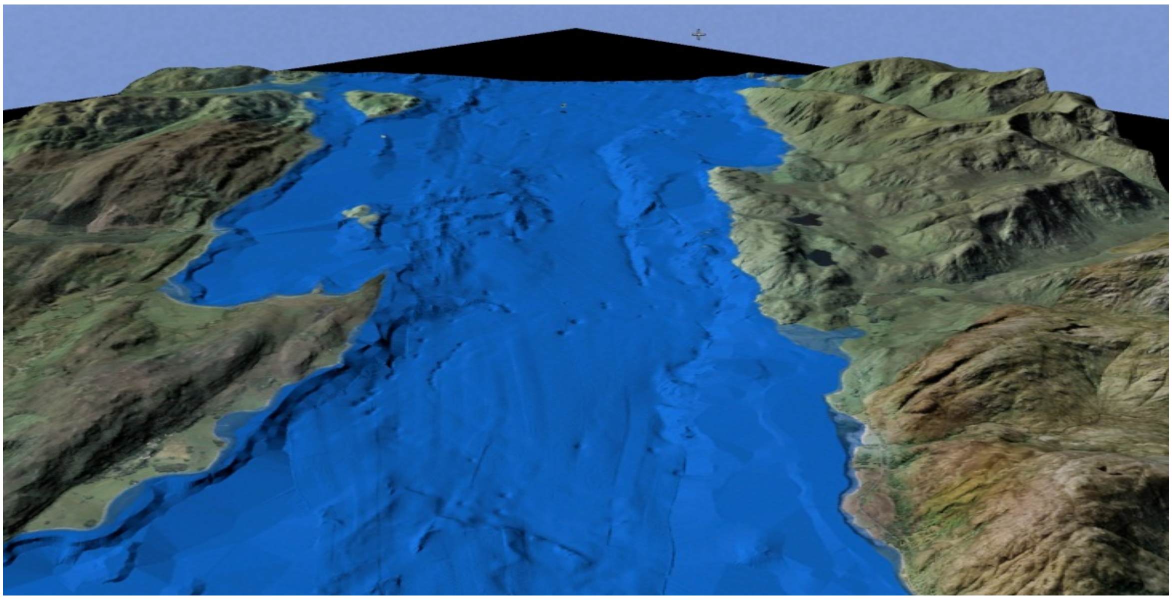

Figure 4. View of surface and subsurface features in Loch Linnhe (view to the south-west)

4. Results

Audiences were invited to identify current and potential future uses of the sea loch and its surrounding area. These included all current significant land and sea uses, plus some of more personal significance, including first trip in a boat, first fish caught, and prospective uses of marine renewable energy, marinas, afforestation and onshore wind turbines.

Amongst questions raised were:

(i) Does woodland expansion increase nutrients in sea water and cause problems for fish farms?
(ii) Are habitats on the sea floor influenced by changes in habitat onshore?
(iii) Does onshore and offshore farming have the same effects on landscape character?

Of the audience comments above, topic (i) only arose from professional audiences, and reflects awareness of Scottish Government aspirations to increase woodland cover to 25% of land area. The other topics arose from public and professional audiences, triggered by different elements represented in the model. Such triggers were a lack of vegetation on the sea floor, and the viewing of onshore wind turbines from on- and offshore viewpoints. Further analysis of the feedback from audiences is being undertaken.

Figure 5. Audience discussion about fish farming in Loch Linnhe

5. Discussion and Conclusions

Exploring and interpreting the undersea environment was reported by teachers and professionals, as providing a better understanding of Loch Linnhe. Audiences were able to view Loch Linnhe from angles not otherwise possible, with data that revealed features not otherwise visible. From the seabed swim-throughs the glacial features of Loch Linnhe were compared with those of the surrounding land, enabling explanations of the development of land and seascapes due to natural processes. ‘Pockmarks’ were identifiable in the sea floor. These circular depressions, about 100m in diameter and 12m deep, occur across the seabed. There are a number of theories regarding their formation; the most widely accepted is their creation by gas and/or water seepage through the seabed. Whilst benign in character, these features have generated much interest from people local to Loch Linnhe. The pockmarks most likely derive from the slow release of shallow gas from the sub-seabed.

Audience feedback suggests that the virtual environment was very effective in communicating the origins of features by glacier movement, and continuity of surface and subsurface features, and for explaining the links between land-use change and impacts on water quality and sea-floor habitats.

Engaging with stakeholders and the public has enabled discussion, explanations and opinions to be exchanged, and feedback on land and sea use, now and in the future. The results are being used to inform the improved design of tools for eliciting public responses to prospective changes in land use and sea-floor interpretation.

The model is being extended to provide more interactive capability, including the repositioning of features above and below water level, both on the sea-bed and suspended in the water. This will provide greater capability for exploring alternative combinations of sea uses, and prospective issues of incompatibility.

6. Acknowledgements

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Biographies

Chen Wang is a Landscape and Visualisation Scientist at the James Hutton Institute. He received his BEng at Soochow University, and a PhD at University of Bradford. His research interests include 3D modelling of landscapes; urban environment modelling and reconstruction; character and traffic animation; 3D real time flood simulation.

Gillian Donaldson-Selby is a landscape modeller in the Information and Computational Sciences group. She has a background in 3D computer based modelling and visualisation. Her research interests include applications of landscape visualisation in public participation and environmental problem solving, including landscape and river rehabilitation.

David Miller is the leader of the Realising Land's Potential Research Theme, studying natural resources, land use and landscapes. His background is in spatial modelling and remote sensing, with 28 years experience the development and application of tools for monitoring rural and urban land use, and assessing impacts of change.

Paula Horne has a background in handling digital map and satellite data and has extensive experience in the use of Geographic Information Systems (GIS) and image analysis software for studying changes in urban and rural landscapes. She navigates stakeholders through landscape models in the VLT, explaining land use change.

Jane Morrice is a researcher with expertise in spatial analysis and applications in landscapes and Environmental Impact Assessments. She has worked on mapping natural resources using GIS and remote sensing, modelling impacts of renewable energy and developing tools for spatial planning.

John Howe (SAMS) is a marine geologist with over 20 years' experience investigating marine sediment depositional processes and geomorphology. He is currently head of the Biogeochemistry and Earth Sciences department at SAMS and a fellow of the Geological Society of London. He is a leader of the NERC Marine Environmental Mapping program (MAREMAP) and is a partner on the EU-funded INIS Hydro (Ireland, Northern Ireland and Scotland) survey project. He has led or participated in over 30 sampling and survey activities including in the Arctic, Antarctica, Papua New Guinea, and Norway. He has authored 50 peer-reviewed publications and co-edited two books.