''YTHANVIEW'' – VISUALIZING AN ESTUARY AND VIRTUAL FIELDWORK AT THE YTHAN ESTUARY, SCOTLAND, UK

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ABSTRACT: This paper describes an ongoing research project, ''YthanView'', to provide online access and visualization tools for geospatial data and information characterizing the Ythan Estuary in northeast Scotland. The project addresses requirements for new and innovative ways to store, catalogue, access, and visualize a wide range of terrestrial and coastal data and information for a small estuarine environment, and to make it more widely available for teaching, research and consultancy activities. Building upon work currently being undertaken at the University of Aberdeen, to facilitate wider access to estuarine data and information resources, the project also considers ways to introduce undergraduate and postgraduate students to coastal and estuarine fieldwork, to reduce staff/student contact hours, and to establish closer links with academic research and consultancy as part of its aims. Several examples illustrate the different ways in which visualization can be used to display, explore, and communicate geospatial information for an estuarine environment.

KEYWORDS: GIS, VISUALISATION, COASTAL MANAGEMENT, YTHAN ESTUARY, YTHANVIEW

INTRODUCTION

The main aim of this paper is to present the role of coastal landscape visualization using different spatial data applied in multimedia cartography and GIS in the context of Integrated Coastal Zone Management (ICZM). The objectives are to demonstrate the creation of a multimedia environment with three-dimensional (3D) visualization of the landscape in the form of VRML environments, fly-throughs and cartographic animations with dynamic elements. Furthermore, to present the use of the Internet as a distributed computing environment for spatial data visualization in cartography and GIS. Finally, to show different methods of creating cartographic animations using different software. A small project was created in ESRI's ArcView 3.3. GIS software to present maps with hyperlinked ground photography. This approach provides a more realistic and up-to-date view of a study site e.g. an estuarine environment, and also a useful aid in visualization studies and for modelling the effects of environmental change.

The visualization work described here is part of an ongoing research project, YthanView, designed to provide online access and visualization tools for geospatial data and information characterizing the Ythan Estuary and surrounds in northeast Scotland, UK. The YthanView project was initially developed to address the need to examine new and innovative ways to store, catalogue, access, and visualize a wide range of terrestrial and coastal data and information for a small estuarine environment, and to make such data and information more widely available for teaching, training, research and consultancy activities. The YthanView project evolved from other work currently being undertaken in the Department of Geography and Environment in the Centre for Marine and Coastal Management (CMCZM), OceanLab and the Aberdeen Institute for Coastal Sciences and Management (AICSM), to facilitate wider access to estuarine data and information resources. YthanView also provided the opportunity to address a growing need to find new and innovative ways to introduce undergraduate and postgraduate students to a new subject area (i.e. coastal and estuarine studies) and fieldwork, whilst seeking to reduce staff/student contact hours, as well as establishing closer links with research and consultancy work being undertaken by staff.

The development of YthanView has taken advantage of the wide range of currently available geospatial and online Internet technologies to provide a framework to collect, store, analyze, visualize and communicate geospatial data and information. Using environmental databases established from a variety of existing sources, a virtual fieldwork experience for a coastal and marine study area, the Ythan Estuary, is also being developed. Provision of an online Internet resource, including virtual fieldwork exercises, laboratory practicals, assignments, both extends and broadens current course delivery opportunities. Innovative ideas such as the use of guest speaker videos, MS Powerpoint presentations, and greater use of remote sensing, GIS and mobile technologies for fieldwork are also explored as ways of enhancing the student experience.

Practically YthanView has provided the means to develop an online resource and project base to assist in the reduction of teaching contact hours for the Marine Resource Management (MRM) degree programme and project work; to enhance project work resources currently available to MRM students for undertaking project work; to develop a virtual fieldwork experience for MRM students with the aim of replacing existing fieldwork as well as complementing half-day and full-day field excursions; and to provide online virtual fieldwork modules for the Ythan Estuary. A number of examples are provided to illustrate the different ways in which visualization tools can be used to display, explore, and communicate geospatial data and information for an estuarine environment.

THE ROLE OF GEOSPATIAL TECHNOLOGIES IN MARINE AND COASTAL MANAGEMENT

In the last ten years the geospatial technologies (e.g. GIS, remote sensing, cartography, digital mapping, GPS and the Internet) have found an increasing role in all aspects of monitoring, mapping, and modelling of the coastal environment: the coastal zone, terrestrial, and marine environments, and in the wider context of integrated coastal zone management. Many different applications of the technologies used on their own or integrated can be cited. (e.g. Green and King, 2004; Green and King, 2003b, c and d; Green and King, 2002; Green et al., 1998; Green, 1995).

DATA COLLECTION

Different geospatial technologies have been used to gather data at a wide variety of different spatial and temporal scales. For example, GPS and mobile technologies have been used to gather data at the local scale (Green, 2005; and Green and King, 2003a). Airborne and spaceborne remote sensing have been used to gather a wide range of environmental data to study coastal environments ranging from beaches to estuaries, pollution, marina and port management, as well as ship monitoring. Whilst satellite sensors have, until relatively recently, been largely used to gather data providing information about patterns and distributions over large areas (refs) aerial photography and more recently airborne sensors such as the Airborne Thematic Mapper (ATM), CASI (Compact Airborne Spectrographic Imager), and LIDAR (Laser Induced Detection and Ranging) offer much higher spatial resolutions. In combination, remote sensing provides a wide range of sources of environmental data for studying coastal and marine areas at many different spatial and temporal scales (Green and King, 2003).

STORAGE, ACCESS AND PROCESSING

The advent of the digital era in information technology (IT) means that most environmental data now in use are in a digital format convenient for storage, processing and analysis within a computer system. GIS software provides a toolbox in which much geospatial data is now handled and processed. Whilst remotely sensed data is still typically processed within a Digital Image Processing (DIP) system, increasingly there are very few differences between digital image processing and GIS software as more geographic data are being handled in integrated software capable of handling both vector and raster data formats. Software labelled as GIS, however, is more commonly used for handling a wide range of geographical data.

DISPLAY

An important starting point, as well as an endpoint in the processing of data into information is to display or visualise the data, usually in the form of a graphic e.g. a graph, picture or map. Visualisation can be either 2D or 3D. Both GIS and DIP software provide a suite of visualisation tools to allow for the display of data in a variety of different ways e.g. as a graph, a photograph, a remotely sensed image, or a digital terrain model. This enables exploratory data analysis as well as communication of information in both a static and dynamic form, and the creation of virtual field environments that can be useful resources for students and stakeholders involved in coastal management Commercial software is also enhanced with a wide variety of freeware and shareware in the form of utility software and plugins.

INTEGRATION

Access to spatial information using GIS and/or Internet-based information systems facilitates the integration of many different layers of spatial data and information. Providing access to a seamless source of data and information for the coastal environment, for example, provides the basis to bring together coastal, terrestrial, and marine datasets into a single portal or work environment. Already the advantages of bringing together the land and marine environment for coastal areas has been demonstrated by the ICZMAP project (http://www.iczmap.com/) co-ordinated by the Ordnance Survey (OS), the UK Hydrographic Office (UKHO), and the British Geological Survey (BGS). Another related project, Integrated Coastal Hydrography (ICM) (http://www.coastalhydrography.com/), aims to provide metadata for the hydrographic data of UK coastal waters.

SPATIAL DATA INFRASTRUCTURES (DATA QUALITY, STANDARDS, METADATA), AND DATA MODELS

To facilitate the efficient exchange and access to geospatial datasets, consideration must necessarily be given to the use of data and metadata standards, data models and spatial data infrastructures (SDI). Much work has been carried out in recent years and the justification for these considerations is clearly documented in the work of the ISO, the OGC, and the FGDC amongst others. A number of data models have been developed for coastal and marine data. The ESRI Marine Data Model is one such example (http://dusk.geo.orst.edu/djl/arcgis/). Another data model developed for Protected Areas Management, including marine protected areas, is the NATURE-GIS project (http://www.gisig.it/nature-gis). NATURE-GIS is a demonstrator project for INSPIRE (http://inspire.jrc.it/home.html) (**IN**frastructure for **SP**atial **I**nfo**R**mation in **E**urope initiative). An integral component of this project is the development of a set of guidelines for the use of geographic data and information in protected areas management, including consideration of the different potential uses of geographic information, the need for metadata, and the role of data models. The importance of marine and coastal data standards, metadata, and spatial data infrastructures is also being studied by the MOTIIVE project (http://www.motiive.net) which is directly targeted at the coastal and marine stakeholder.

THE ROLE OF VISUALISATION

Scientists visualize data for a wide range of different purposes, from exploring unfamiliar datasets to communicating insights revealed by visual analyses. Visualization is a process for representing large amounts of data as abstract images to better understand the meaning of data or information. Visual images help users to develop and share insights and can help them to be more creative. Today, visualization of spatial data is no longer restricted by technical constraints. Modern computer and multimedia techniques extend cartographic maps using pictures, video clips, animation and sound.

Multimedia is the combination of basic types of media such as text, graphics, pictures, sound and video. It is intended to expand the channels of information available to the end-user, as well as providing an accessible tool with considerable potential for developing display interfaces to geographical data and information. It offers different ways to view data that has been generated and stored by spatial resources packages. Interactive maps, using hotspots and buttons provide access to underlying data and information, as well as metadata, and allow for the map display to link to other information offering an enhanced spatial information resource. Multimedia technology changes the visualization of spatial data. The map, the traditional presentational form of spatial data, is complemented by other media such as pictures, animation, sound and video. Each of these additional media has particular advantages for communicating information.

Within the context of Coastal Zone Management (CZM), one of the emerging data management tools is GIS. Together with cartography, GIS can easily be used to visualize spatial data used in CZM. A GIS can display the Earth in the form of realistic, three-dimensional perspective views through then use of animations that convey information more effectively, and to wider audiences than traditional, twodimensional static maps. Obtaining, handling, and processing data is often difficult in a 3D environment. The primary data and information required for building and maintaining a 3D GIS includes orthorectified imagery, and digital terrain models (DTMs), 3D features (vectors) and non-spatial attribute information associated with a 3D feature. Digital terrain modelling is a powerful tool in GIS analysis and visualization, and the storage, display and analysis of data about the terrain surface is one of the most widely used areas of GIS functionality (Wise, 2004). Grid-based DTMs are directly compatible with satellite data and can provide a useful basis for terrain analysis (Longley et al., 2002).

Visualization techniques can also be employed to give better information and add interpretive value. Colours and textures can be used to show changing contour heights. Using sun angles and lighting on one side of the image, hill-shading and other illumination models can also be used to highlight topographic relief. Other visualisation techniques can be used to enhance a DTM using composites of imagery and data drapes. Moreover, perspective, integrated oblique views and fly-throughs can also enhance visual interpretation. Viewshed map displays can also be used to determine the visibility of objects from different locations.

The tools to create cartographic animations are now becoming more widely available. Animation of images can be used to create the illusion of movement depicting a trend or change. Animation may also include sound (narration, music, or sound effects) resulting in a multimedia animation, which can be further incorporated into a hypermedia presentation. In the context of the spatial data handling process, animation is a prominent form of dynamic presentation. It is an effective method of visual communication that allows for the representation of very complex processes. The importance of animation is that it creates a link between reality and the abstraction process in the map. It means that animation can easily deal with real data as well as abstract and conceptual data. Animations can be used not only to tell a story, or explain a process, but also have the capability to reveal patterns, relationships, or show trends (Cartwright, 1999). Frame-based animations include special effects between frames such a fades, wipes or swipes and dissolves (e.g. tools within the Erdas Imagine suite of software). Cast-based animation, also called tweening or key-frame animation, is based upon the concept of the cell, an individual layer or frame of animation. Using a computer automatically allows the creation of a specified number of frames between two key frames with objects displayed proportionally in each frame. Tweening also enables a smooth transition in some characteristics of an object or its shape.

The 'look' of an animated map is accounted for not only by the visual variables and typography, but also by the dynamic variables. The dynamic variables can be seen as additional tools to design animation because the pace (fast/slow) and character (smooth/abrupt) of the illusory motion created in an animation depends on how a set of dynamic variables are used. A single static graphic, whose visual characteristics noticeably and regularly change, such as flashing point symbols can be used to depict the phenomenon's distribution. In this instance, a dynamic variable (duration) merely reinforces the visual variables (the value etc.) that comprise the point symbol. Another application of the dynamic variables is to emphasize attributes or relationships among attributes of symbolized cartographic features.

INTERNET

The World Wide Web (WWW) or the Internet provides a powerful basis for an information system by merging the techniques of networked information and hypertext. Moreover it has considerable potential to increase the applications of mapping and GIS. Distributed Geographic Information (DGI) systems based on a combination of network communications and GIS technologies provides access to geospatial data and information in a variety of forms, including maps, images, datasets, analysis operations and reports. More advanced services such as spatial modelling and spatial data analysis are being used by only a few online systems (Bossomaier and Green, 2001).

YTHAN ESTUARY CONTEXT AND STUDY AREA

At the University of Aberdeen, the Ythan Estuary (57^{o}N, 2^{o}W; 14km north of Aberdeen) and the adjoining sand dune system, the Sands of Forvie National Nature Reserve (NNR), has long been an area of academic research and fieldwork. General studies about the geography of the area have been complemented by those on hydrography, sediment, bird habitat, ecology and macro-algal weedmats (e.g. Stove, 1978; Raffaelli, et al., 1989; Raffaelli et al, 1998; Raffaelli, 2000; Chan, 2003; Dunne, 2003; and Orr, 2003). Datasets for the area include topography of the sand dunes as well as vegetation maps and other information such as footpaths, and archaeological features.

The Ythan Estuary is one of Britain's smallest estuaries, tidal and extends for approximately 8km in the general direction of Ellon. It drains a catchment of about 650km^2 of intense arable agricultural land and has a maximum width of 620m at the Sleek of Tarty (Figure 1) and at its narrowest point is approximately 300m wide. The narrow tidal estuary of the River Ythan is part of the Forvie National Nature Reserve (NNR), which also includes the Forvie Peninsula and Forvie Links. The Sands of Forvie National Nature Reserve (NNR) has also been designated as a RAMSAR site, a Site of Special Scientific Interest (SSSI), an EU Special Protection Area (SPA), and an EU Special Area of Conservation (SAC), where designations were assigned to the estuary because of the birds species it supports.

The average depth at high water is 2.5m with a tidal range of between less than a meter to 3 m or more. Elevations within the catchment range from sea level to 200m and the average annual rainfall varies from 700mm on the east coast to 900mm on the highest parts of the catchment The low water channel is about 71 ha and in the intertidal area there are 115ha of mudflat and 70ha of mussel beds and sand. The salinity of the estuary varies seasonally with water in the lower reaches ranging from 30-34%, the middle reaches from 5-35% and the upper reaches 0-25%.. The Forvie Peninsula and Forvie Links are predominantly made up of sand, largely consisting of deglaciated deposits from the last Ice Age (approximately 10,000 years ago) washed down from the glaciers of the present day Cairngorms to the shelf of the North Sea. The southern part of the estuary is underlain by glacial fluvio-glacial, estuarine and beach terraces, and the northern part of the Forvie peninsula is underlain by a till covered plateau due to the glacial past. The nature of the dune system means that vegetation within the Sands of Forvie exists in a highly dynamic state and is dependent on active physical processes. These processes are wind, wave and tidal.

The Sands of Forvie has active mobile boundaries and older more stable dune systems. This has provided a range of habitats identified from coastal sands, bogs to heath-grasslands. The distribution of vegetation throughout the Sands of Forvie is controlled by the nature of the dunes and their associated processes.

The intertidal area supports a wide variety of wading birds which use the estuary for roosting, feeding and overwintering such as the pink-footed geese, *Anser brachyrhynchus,* which feed on surrounding farmland in winter, and also for the sandwich Tern, *Sterna sandvicensis*, which breed within the dune system. Moreover, the Ythan's mudflats

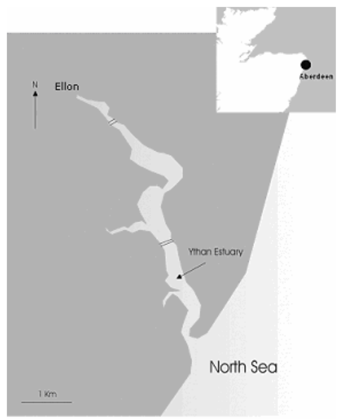

Figure 1 – Ythan Estuary, NE Scotland

support several types of macro-algae namely, *Enteromorpha spp. (E. prolifera, E. intestinalis), Chaetomorpha linum, Ulva lactuca* and *Cladophora spp.* (Gorman and Raffaelli,, 1993; Raffaelli, et al., 1989; Raffaelli et al, 1998; Raffaelli, 2000; Green and King, 2002)

BACKGROUND

The background to the study described in this paper began with a number of studies about the monitoring and mapping of macro-algal weedmats. All of these studies sought to make use of a combination of remote sensing and Geographical Information Systems (GIS) to monitor, map and analyse geographical data for an environmental application. These studies are described in Green (1995), Green et al. (1998), Green and King (2002) and Green and King (2005). Given the significant interest expressed over time by a wide range of stakeholders in studying the Ythan Estuary and the surrounding Sands of Forvie sand dune system, it was considered an important objective to try to bring together the outcome of the past, present and future research studies, including the datasets into a digital archive so as to provide greater educational, training, research and consultancy access to potentially useful datasets. As a result, the YthanView project was developed.

YTHANVIEW

YthanView is an ongoing research project designed to provide improved access for educators, researchers and students at the University of Aberdeen to geospatial datasets for the Ythan Estuary and surrounding area (in particular the Sands of Forvie

National Nature Reserve (NNR)) in Northeast Scotland, UK. This project originated, in part, with the educational and research work currently undertaken by the Centre for Marine and Coastal Zone Management (CMCZM – http://www.abdn.ac..uk/cmczm) including an internal University of Aberdeen Learning and Technology Unit (LTU) proposal approved in 2004, and the research work programme currently being undertaken within the Aberdeen Institute for Coastal Science and Management (AICSM – http://www.abdn.ac.uk/aicsm). YthanView was also designed to complement other work currently being undertaken on the Ythan Estuary and surrounds by other researchers within the University e.g. OceanLab (http://ww.abdn.ac.uk/oceanlab), and some of the research interests of the Macaulay Institute (http://ww.mluri.ac.uk), as well as the recently established East Grampian Coastal Forum. The project is co-ordinated by David R. Green (d.r.green@abdn.ac.uk) under the auspices of the Centre for Marine and Coastal Zone Management (CMCZM), the Aberdeen Institute for Coastal Science and Management (AICSM), and OceanLab (http://www.abdn.ac.uk/oceanlab) at the University of Aberdeen. To date the project has gathered together a number of geospatial datasets, information and references for work on the Ythan Estuary that involve the application of the geospatial technologies including: remote sensing (aerial, airborne and satellite platforms), Geographical Information Systems (GIS), Global Positioning Systems (GPS), cartography and digital mapping, as well as databases, decision support systems, and the Internet. These will form the basis of the resources to be made available to staff and students. Current categories of interest are:

- **Map/GIS** datasets (ESRI shapefile format (.shp))
- **Imagery** (usually in the form of scanned colour and panchromatic aerial photographs, airborne imagery, and satellite imagery (SPOT and Landsat) - .jpg and ERDAS Imagine .IMG format)
- **DEMS** (ERDAS Imagine.IMG format)
- **Photographs** (single and panoramic photographs – TIFF, GeoTIFF, and ERDAS Imagine.IMG format)
- **Dissertations** (B.Sc. and M.Sc. dissertations - .DOC (MS-word) or .PDF (Acrobat Reader))

Initially stored on an internally accessible network drive, these will subsequently be provided as a searchable online catalogue and database with online map access using map and image server technology, as well as password protected access to the datasets.

VISUALISATION

As part of the YthanView project, some work was carried out to investigate how a variety of geospatial (image and map) datasets could be brought together using 'off-the-shelf' information technology tools to facilitate visualisation of the Ythan Estuary and surrounding environment.

Many sources of data were available for use in this project. The data sets that were used came in the form of map data, DTMs, remotely sensed imagery, photographs and digitized shape files of algal and sediment cover. A wide range of commercially available off-the shelf software products were used to visualise the datasets available for the Ythan Estuary and Sands of Forvie. These included Erdas Imagine 8.5, ArcView 3.3, Bryce 5, and Microsoft Internet Explorer using a number of different plugins for 3D, video and animation. Only a small selection of examples output is shown here in Figures 2a,b and c. Figure 2a shows an interactive hypermedia animation with several forms of interactivity generated with Erdas Imagine 8.5 using the ParallelGraphics Cortona® VRML Client used to view VRML model. In this example, Ordnance Survey (OS) GRID Digital Elevation Model (DEM) at a scale of 1:50000 (exaggeration 2; level of details 4%) is overlaid with raster Ordnance Survey map data at a scale of 1:50000; an aerial colour photographic mosaic, and a polygon cover (.shp) for 1989 macroalgal weedmat cover. It is saved in VRML in Erdas Imagine 8.5. This application has potential for the analysis of weedmat distribution and land-use/ land-cover analysis dependent upon surface relief. The second example, Figure 2b, is an ArcView 3.3. project using raster Ordnance Survey (OS) map data at a scale of 1:50,000 with hotlinks to 21 ground truth colour photographs at 1280 x 960 pixels resolution saved in TIFF format and hot linked into a series of photographic arrays showing the direction in which the photograph was taken. Potential applications include a visual presentation of tourist attractions in the context of sustainable coastal tourism. Figure 2c, the third example, is a video clip (11.4Mb filesize, with a duration of 25 seconds, comprising 375 frames, at 15 frames per second, using the DivX High Definition Profile, at a resolution of 768 x 512) generated by the Bryce 5 software. The imagery contained in the video was created using a combination of Erdas Imagine 8.5 and Virtual GIS, VRML 1.0, and Corel Photo Paint 9. This is an example of cast-based, process animation, using motion and trajectory with some elements of thematic animations (comparing distribution) and aerial animations (fly-through) (Lobben, 2000), and a non-temporal animation with elements from animation with successive build-up (displaying themes in sequences) and the animation with changing representation (a simulated fly-through).

DISCUSSION

Multimedia cartography and GIS can play a very important role in the process of visualisation of spatial data. Recent technical advances in digital cartography and its convergence with the Internet have fostered the development of interactive visualization of geospatial information on-line. Multimedia as an interaction with multiple forms of media is supported by the computer that is both the tool of multimedia and its medium. Without means of creation or distribution, the current interactive form of multimedia would not be able to exist.

In this study, the use of multimedia cartography and GIS is presented in the context of coastal landscape visualization. Image draping, photorealistic rendering, virtual worlds and static images viewed in the Internet browser were the main methods used in the process of visualization of geospatial data in monitoring and mapping coastal areas. Multimedia presentations can play an important role in ICZM only if they provide appropriate information about the issues of concern with a better understanding of geospatial matters; and also allow one to perform analyses and to forecast future demand on coastal resources.

Although data and information are essential components of ICZM, they may be limited by availability. However, good multimedia presentations should allow one to identify some of main resources/components such as: land area, agricultural land, build-up area, forests, water resources, marine resources or wild life resources and also infrastructure represented by roads, railways, water supply amongst others. In this case, 3D visualization is a useful tool for annotating 2D images by providing a simulation of, and the potential to, explore the landscape. On this basis the identification of key indicators of existing conditions to the past and present state of the coastal environment is possible.

3D modelling where data is draped over a DEM together with the creation of different types of animation for data sourced from different years not only provides better understanding of spatial phenomenon but also enables comparisons, analyses and the potential to discover and isolate reasons for landscape change. Multimedia presentations, especially those with navigational tools, allow one to identify the impacts of the main land and marine uses, after analyses of appropriate components. Coastal and marine ecological or landscape value can be influenced by urbanization and settlement, tourism and recreation, industry, fisheries and aquaculture, transportation, agriculture and forestry.

Virtual environments created with databases should allow identification of coastal resources under stress or at risk, and their level of vulnerability or risk of degradation. Although natural risks such as seismic activity, flooding, tsunami, landslides and volcanic eruptions are not necessarily easy to predict, areas most exposed to risk can be identified. Forecasting future demands on coastal resources can also be generated with animation showing changes of the phenomenon over the time. GIS can also be used to show, for example, where marine features are in relation to terrestrial features and the geographical position of a coastline can be mapped over a period of time. Using animation techniques it is possible to model sea-level rise scenarios and potential impacts on the coast. However, forecasts should be based both on projections of existing trends and on forecasts of the activities expected to affect the natural systems in the future.

Virtual worlds generated in this study allow one to perform land-use analysis depending on the surface relief. Analysis of the research area using sunlight illumination tools can provide additional information about erosion and the distribution of vegetation. Moreover, the relationship of estuarine channels and sandbanks can also be more readily visualized and analysed.

Using animations created in the Bryce software, the distribution of weedmats and their changes can be better understood and additional analyses using sediment coverage can be made. All these changes can also be easily compared. Furthermore, analysis of the coastal line can give the view of erosion impacts and changes in vegetation can be analysed.

Multimedia cartography and GIS can be very effective visual information tools for costal monitoring, including detailed monitoring of coastal landscapes, habitats, sediment processes, such as erosion, deposition with the consequence effects on the position of the shoreline and mapping vegetation changes, especially dune and marsh systems.

Due to the main ideas of this research, multimedia information system was created corresponding to the needs of expert and non-expert audience. These multimedia presentations could be presented on online and offline systems in an attractive and user friendly way using utilized an online mapserver. It also means that in the future the access to this kind of geospatial information about the Ythan Estuary derived from multimedia virtual database can be used by the public users as a regional tourist information system and also be used in scientific research and analyses.

Future multi-temporal monitoring and mapping of environmental changes in the Ythan could be also integrated with archival and new datasets to generate GIS based Internet environment. Implementation of other available data from different years into the project such as: satellite images, aerial photography covering other parts of the study area, panoramic photographs and possibly videography could result in creating new virtual worlds with VRML models, fly-throughs and other animations. Moreover, datasets concerning geology and bathymetry together with DEM for bathymetry of the sea and the estuary could enhance multimedia visualization and enable more complex analyses. Besides, viewsheds layers overlaid over DTMs could allow additional GIS analyses.

New capabilities and visualization methods could also be explored within visualization software packages used in this study. Also due to both software and processing limitations other professional landscape programs, depending on their availability, could be applied to produce different multimedia presentations and enhance a higher degree of realism in the final output.

However, the whole process of generation virtual environments requires appropriate computer requirements such as: hardware, high speed processor, very good graphic card, and huge amount of storage space. The final result will also depend on available datasets, their resolutions, compatible file formats and visualization software packages.

This multimedia presentation of Ythan Estuary enhanced with other new 3D visualizations placed over the Internet or stored in the form of multimedia CD could be used to introduce new users to the characteristics of the region, particularly to its nature, environmental changes and risks, tourist attractions and even the local economic infrastructure including ecotourism aspects.

SUMMARY AND CONCLUSIONS

This paper has briefly outlined an innovative and ongoing project, YthanView, at the University of Aberdeen. Initially developed to examine new ways to store, catalogue, access, and visualize a wide range of terrestrial and coastal data and information for a small estuarine environment, and to make such data and information more widely available for teaching, research and consultancy activities, YthanView has also provided a number of other educational opportunities. One of these is new ways to introduce undergraduate and postgraduate students to a new subject area (i.e. coastal and estuarine studies) and fieldwork, and to establish closer links between education and research and consultancy work being undertaken whilst at the same time seeking to reduce student contact hours.

The development of YthanView has sought to take advantage of the wide range of current geospatial and online Internet technologies available to provide a framework to collect, store, analyze, visualize and communicate geospatial data and information. Using the environmental databases established via existing sources, a virtual fieldwork experience for a coastal and marine study area, the Ythan Estuary, is now being developed. Provision of an online Internet resource, including virtual fieldwork

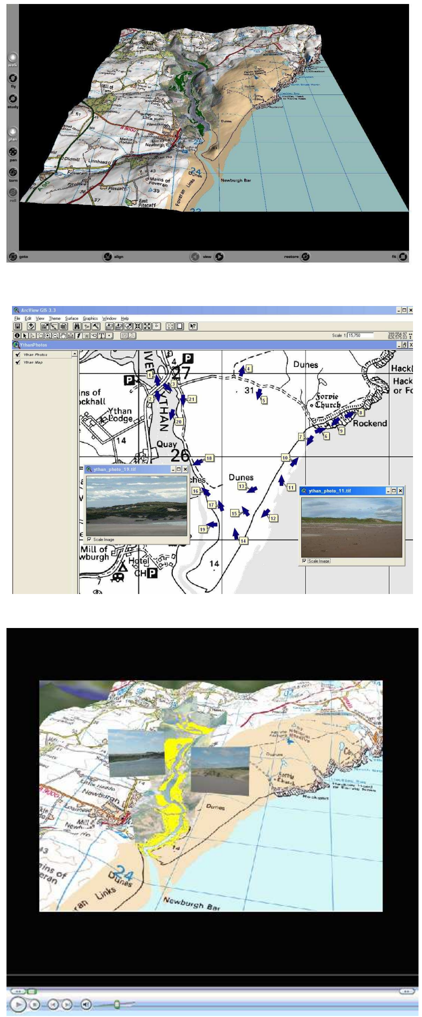

Figure 2a (interactive hypermedia animation), 2b (ArcView 3.3. project), and 2c (example of cast-based, process and non-temporal animation) (Ordnance Survey datasets courtesy of the Edina Digimap website - http://www.edina.ac.uk)

exercises, laboratory practicals, and assignments, will both extend and broaden current course delivery offerings. The use of guest speaker videos and greater use of remote sensing, GIS and mobile technologies for estuarine fieldwork are also being explored as ways to enhance the student experience. Practically, YthanView has provided the means to develop an online resource and project base to assist in reduction of teaching contact hours for the University of Aberdeen's Marine Resource Management (MRM) degree programme and project work; to enhance project work resources currently available to MRM students for undertaking project work; to develop a virtual fieldwork experience for MRM students with the aim of replacing existing fieldwork, as well as complementing half-day and full-day field excursions; and to provide online virtual fieldwork modules for the Ythan Estuary, NE Scotland.

This is an ongoing project, and is currently being expanded and enhanced to develop an online map and image-based information system and resource for the Ythan

Estuary, one that can provide access to data and information for a wide range of coastal and marine stakeholders.

REFERENCES

Bossomaier, T. R. J., and Green, D.G., 2001. *Online GIS and Spatial Metadata*. Taylor & Francis, London.

Cartwright, W., 1999. Extending the map metaphor using web delivered multimedia. *International Journal of Geographical Information Science*, Vol. 13, No. 4, pp. 335-353.

Chan, K., 2003. Sediment and Macro-Algae Relationship of the Ythan Estuary: A Remote Sensing and GIS Approach. *Unpublished M.Sc. Dissertation*, Department of Geography, University of Aberdeen, Scotland, UK. 60p.

Dunne, B., 2003. The Relationship Between Algal Mats and Wading Bird Populations in the Ythan Estuary, North East Scotland. *Unpublished M.Sc. Dissertation* in Ecology, University of Aberdeen.

Gorman, M. and Raffaelli, D., 1993. The Ythan Estuary. *Biologist (1993)*. Vol. 40/1:10-13.

Green, D.R., 2005. *Going Mobile: Mobile Technologies and GIS:* URISA Quick Study Guide. URISA. 60p.

Green, D. R. 1995. Preserving a Fragile Environment: Integrating Technology to Study the Ythan Estuary. *Mapping Awareness* 9(3, April 1995):28-30.

Green, D.R., and King, S.D., 2005. Applying Geospatial Technologies to Weed Mat Monitoring and Mapping: The Ythan Estuary, NE Scotland. *Zeitschrift fur Geomorphologie*. (Special Issue forthcoming)

Green, D.R., and King, S.D., 2005. GIS-based Estuarine Management Systems. Chapter 18 in *GIS for Coastal Zone Management*. (Bartlett, D, and Smith, J., Eds). CRC Press. pp. 239-255.

Green, D.R., and King, S.D., 2003a. Pencil Out, Stylus In: Geospatial Technologies Give Fieldwork a New Dimension. *Geography*. Vol. 89(1):58-70.

Green, D.R. and King, S.D., 2003b. (Eds.) *Coastal and Marine Geo-Information Systems: Applying the Technology to the Environment*. Coastal Systems and Continental Margins. Vol. 4. Kluwer, The Netherlands. 580p.

Green, D. R., and King, S.D., 2003c. Application of New Technologies to Coastal Management. In: Taveiro-Pinto, F. (Ed.) Good Practices in Coastal Zone Management and Coastal Defence. Chapter 6. pp. 65-83. ISBN: 972-752-057-X. Hydraulics and Water Resources Institute, Porto, Portugal.

Green, D.R., and King, S.D., 2003d. Advances in Coastal GIS Modeling. Chapter 21:553-580, in *Advances in Coastal Modeling*. Ed. Lakhan, V.C. Elsevier. 2003.

Green, D.R, and King, S.D., 2002a. *Coastal Remote Sensing Guidelines*: URISA Quick Study Guide. URISA. 2002. 36p.

Green, D. R.; King, S.D., 2002b. Ythan Estuary – The Distribution of Weedmats in the Intertidal Zone. *Report to Formartine Partnership*, University of Aberdeen, Aberdeen.

Green, D. R., King, S. D., & Morton, D. C. 1998. Small-scale airborne data acquisition systems to monitor and map the coastal environment. *Proceedings of the 5th International Conference: Remote Sensing for Marine and Coastal Environments*, San Diego, California, 5-7 October 1998, 1479-1486.

Lobben, A., 2000. Classification and Application of Cartographic Animation. *The Professional Geographer*. Vol. 55(3): 318 – 328.

Longley, P., 2001. *Geographic Information Systems and Science*. Wiley, New York,.

MOTIIVE. Marine Overlays on Topography for Annex II Valuation and Exploitation. Data Harmonisation and Integration for Coastal and Marine Stakeholders. http://www.motiive.net.

Orr, G., 2003. The Distribution of Enteromorpha Alga Mats in Relation to the Sediment Facies of the Intertidal Zone of the Lower Reaches of the Ythan Estuary. *Unpublished Undergraduate Dissertation*. Department of Geography. University of Dundee, Scotland, UK. 75p.

Raffaelli, D., 2000. Interactions Between Macro-Algal Weedmats and Invertebrates in the Ythan estuary, Aberdeenshire Scotland. *Marine Research (2000).* Vol. 54:71-79.

Raffaelli, D.G., Raven, J.A., and Poole, L.J., 1998. Ecological Impact of Green Macro-algal Blooms. *Oceanography and Marine Biology: an Annual Review 1998*. Vol. 36: 97-125.

Raffaelli, D., Hull, S., and Milne, H., 1989. Long-Term Changes in Nutrients, Weedmats and Shorebirds in an Estuarine System. *Cah. Biol. Mar* (1989). Vol. 30:259-270.

Stove, G.C., 1978. The Hydrography, Circulation and Sediment Movements of the Ythan Estuary. *Unpublished PhD Thesis*. University of Aberdeen.

Wise, S.M., 1998. Digital Terrain Models - Traps for the Unwary. http://www.ccg.leeds.ac.uk/geocomp/1998/80/gc_80.htm. Accessed 2004.