F. A. Watford, D. J. Beard, R. J. Hay and K. Ambrose. Innovative Visualisation for Australia's Marine Zone.
Proceedings of SSC 2005 Spatial Intelligence, Innovation and Praxis: The national biennial Conference of the Spatial Sciences Institute, September, 2005. Melbourne: Spatial Sciences Institute. ISBN 0-9581366-2-9

INNOVATIVE VISUALISATION FOR AUSTRALIA'S MARINE ZONE

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KEYWORDS: 3D Visualisation, Marine Zone, Bathymetry, Flythroughs

ABSTRACT

Geoscience Australia collects and manages large amounts of data for Australia's marine zone, including bathymetry data and the legal boundaries of petroleum acreage release areas. Communicating this information to non-specialists can be difficult. To overcome this communication problem Geoscience Australia uses innovative visualisation techniques, including 3D flythroughs and video editing, to integrate raster and vector geospatial data into enhanced multimedia products. Geoscience Australia has used these techniques for a number of years and the resulting products are highly regarded by stakeholders interested in marine zone management and petroleum exploration. This paper examines four case studies where these innovative techniques were used to effectively communicate marine zone information with a wide audience.

BIOGRAPHY

Fiona Watford attained a BSc. (Hons) in Applied Physical Geography from the University of NSW in 1992. She commenced working for NSW Fisheries in 1994 and worked on several projects using aerial photographs to map estuarine fish habitats in a GIS. In 1999 Fiona moved to Canberra to join BAE Systems as a cartographer, producing Geoscience Australia's (then AUSLIG) GEODATA digital data products and maps. After two years with the Defence Imagery and Geospatial Organisation, she joined Geoscience Australia in 2004 working in Geospatial Applications and Visualisation (GAV) to produce GIS and graphics products for internal and external clients. For the past eight months Fiona has been part of GAV's Visualisation team, producing flythroughs and developing 3D VRML (Virtual Reality Modelling Language) models for geological projects in Geoscience Australia.

INTRODUCTION

Australia's marine zone encompasses a vast area of around 14 million square kilometres and includes a diverse range of environments (Figure 1). To the north of Australia, the relatively flat expanse of continental shelf extends hundreds of kilometres from the Gulf of Carpentaria to Papua New Guinea, while in the southeast, deep canyons within the continental slope give way to large ridges, troughs and seamounts. Recent bathymetric surveys have enabled a much more detailed picture of our marine environments to emerge, surprising even scientists with the huge scale of some of the features which are far greater in size than any terrestrial landforms we see on the Australian continent.

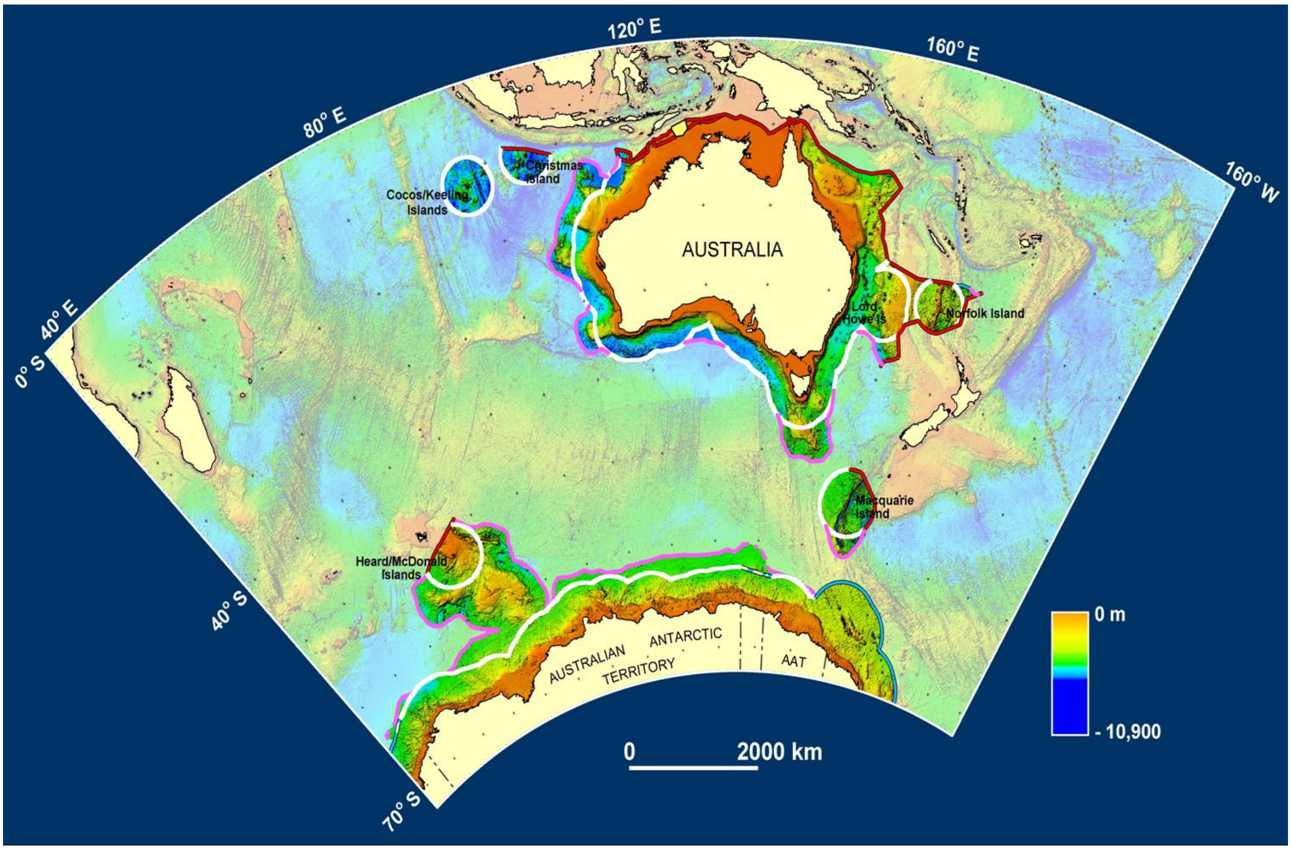

Figure 1. Bathymetry of the Australian region showing the extent of the 200 nautical mile (M) exclusive economic zone (white) and the areas of extended continental shelf (magenta) submitted by Australia in November 2004 under the UN Convention on the Law of the Sea for consideration by the UN Commission on the Limits of the Continental Shelf.

The challenge for Geoscience Australia (GA) is to communicate these discoveries to a wide audience that includes scientists, government, industry representatives and the general public in an informative and interesting way. 3D visualisation products incorporating flythroughs, interactive 3D models and movies have been particularly effective in rapidly communicating large amounts of information to a non-technical audience. These tools provide an access point to the largely unknown but spectacular environment that exists beneath the sea.

As specialists experienced with viewing and utilising spatial data, we sometimes forget that it takes a certain amount of skill to read a 2D representation of the world on a map or to interpret and visualise what a slope looks like from a set of contours. By presenting 3D bathymetry in terms of familiar terrain shapes that more closely resemble our real world experience, the audience rapidly gains a clear understanding of the physical environment being displayed. The ability to move through the data, either via a set flightpath or interactively in the case of a VRML (Virtual Reality Modelling Language) model, engages the audience and provides the opportunity to discover the data from different perspectives.

As well as providing a view of the spatial characteristics of the ocean floor that many may not have seen before, GA's 3D visualisation products rely on the input of more than just geospatial data. They combine elements of cartography, GIS, image processing, graphic design, and computer programming as well as video editing and script writing. Through intelligent amalgamation of these varied skills, GA is able to communicate the results of marine research in a way that is both visually exciting and easily understood.

This paper describes the sources of GA's marine zone data and the 3D visualisation techniques GA has developed over the past five years. Four case studies are presented to demonstrate how these techniques have been applied to communicate scientific discovery, identify resource exploration areas and contribute to defining the outer limits of Australia's continental margins.

These marine zone related examples are only a small sample of the products GA has developed. Similar techniques have also been used to produce visualisation products of catchment management areas, complex geological models and global datasets. Beard *et al.*, [2005] provides more information on some of GA's other 3D visualisation products, focussing in particular on the development of VRML models.

BATHYMETRIC AND TOPOGRAPHIC DATA SOURCES

The basic digital elevation model (DEM) used in GA's visualisation products of our marine zone is a 1 km gridded bathymetry of Australian waters and surrounding territories developed by Petkovic and Buchanan [2002]. It was generated by combining data from numerous bathymetric surveys, digitised marine charts and predicted depths from satellite altimetry. GA has been actively involved in mapping programs to acquire these data since 1963. Topography was added to the grid from GA's '9 Second DEM of Australia', 2nd edition and United States Geological Survey's 'Gtopo30' for surrounding countries [Geoscience Australia, 2003].

In the mid 1990's, GA pioneered the use of modern acoustic survey methods with multi-beam arrays in Australian waters to quickly and cost effectively generate high resolution maps and images of large areas of the sea floor [Exon and Hill, 1999]. Recent surveys using these swath-mapping methods have been carried out by GA in international cooperative research programs such as the AUSCAN (Australian Canyons) expedition of 2003 [Hill and De Deckker, 2004]. The data collected from these surveys has been fed back into the combined bathymetry-topographic grid, providing increased detail and improving our knowledge of the shape of the seafloor.

VISUALISATION TECHNIQUES

Visualisation in the geoscientific and geospatial fields has undergone a revolution in recent times. Scientists, technicians, and managers can now get a much clearer picture of information, relationships and effects as a result of the spectacular images, models and animations which can be generated using modern graphics systems. Contemporary visualisation permits vast amounts of data and information to be both portrayed, and assimilated, in a very short timeframe. Volumes of data that may have taken specialists days or even weeks to comprehend and assess can now be communicated graphically to a wide audience in a matter of minutes. This enables scientists to more-easily share complex concepts and ideas, and to better explore a range of possible outcomes (models) and solutions to problems.

Visualisation techniques in GA have largely developed over the last five years from creating individual flythroughs and VRML models to composite products involving video editing and HTML scripting to house them in user friendly interfaces. In part the timing of these developments has been driven by the availability of higher end computers with improved graphics capabilities and software systems. The primary motivation, however, remains finding innovative ways to communicate good science to a non- technical audience in ways that are easy to understand.

GA's first simple flythroughs of Australian bathymetry using ERDAS IMAGINE VirtualGIS (VGIS) were created to demonstrate the newly created 1km gridded bathymetry DEM at the Australian Society of Exploration Geophysicists Conference in 2001. An HTML interface was created to house simple flythroughs with little or no video editing, and basic VRMLs of the whole of Australia, Tasmania and SW Western Australia. The product served to showcase a new and exciting view of Australia's marine environment that had never been seen before and enabled the audience to interact with the data through manipulating the zoom and viewpoints of the models.

The value of these bathymetry flythroughs as a communication and publicity tool was further highlighted by the positive response to a product presented at the ministerial launch of the National Oceans Office (NOO) South East Marine Plan in 2002. At the time GA did not realise how successful this product would be. The flythrough of the ocean floor around Tasmania was picked up by the media and generated a large amount of interest in the project. It also highlighted the visualisation capabilities of GA to other organisations [Harris, pers. comm. 2005].

Since that time, GA's flythroughs have become more sophisticated by adding draped vector information, and using video editing to add titles, labels, still images, graphic designs and music to enhance the products. Although it is possible to control the display of vectors within the recording process of the flightpath in VGIS, GA has adopted a process whereby multiple recordings of individual layers are made against a "blue screen" then imported into the video editing software. This process gives much more control and opens up a wide variety of effects that can be used to fade in and out or transition between different layers of information being displayed.

Improved techniques in VRML modelling have been developed through construction of several geological models for GA's Minerals Division, and have been applied to great effect in displaying marine data as well. Building these models requires skills in VRML, Javascript and HTML scripting. The net result is an interactive 3D model that can be viewed from any aspect and level of zoom. Vector layers, draped images and database records can also be displayed in the same 3D space via a simple on/off checkbox menu system. The major advantage of VRML models is that the user is in control of the information they wish to view, unlike a flythrough where the view is restricted to a set flightpath.

The realisation that it is not possible (or necessarily desirable) to produce a visualisation product from any one piece of software or skillset, has lead to GA integrating these techniques to produce high quality visualisation products that successfully communicate often complex ideas and data to a wide audience.

CASE STUDY 1 – BATHYMETRY OF AUSTRALIA

In 2004 GA produced an overview of the bathymetry of Australia for the National Oceans Office. Several multibeam swath-mapping surveys had been completed resulting in new detailed bathymetry across several Regional Marine Planning areas which form the basis of Australia's Oceans Policy. The product was first used at the national media launch announcing the acquisition of Australia's own swath-mapper in August 2004. The aim was to communicate to the general public an overview of the shape of the sea floor around continental Australia and demonstrate how swath-mapping was contributing to the ecosystem-based management at the heart of the Oceans Policy.

A flythrough circumnavigating the continent was produced using the latest available version of the 1km bathymetry-topographic grid draped with a pseudocolour density slice of the terrain. To focus the audience's attention on the marine features, white was chosen to represent land above sea level, with shallow marine environments in orange grading through yellow, green and dark blue for the deepest areas of the abyss (Figure 2).

Figure 2. Snapshots from the National Oceans Office Bathymetry of Australia flythrough.

By including the topography as well as the bathymetry and using a vertical exaggeration of 15, the audience can clearly see how small the largest features on land are compared to the huge canyons and cliffs mapped beneath the sea. Simple labels were added to the flythrough to identify well-known locations along the coast and to assist the audience to orient themselves with what to many would be an unfamiliar view of Australia. Background music, titles and credits were also added using video editing software to enhance the flythrough.

The resulting three minute movie is quite simple in its presentation but very effectively communicates ideas such as: how large Australia's ocean territory is; the wide range of marine environments that exist; and the huge scale of the features on the ocean floor compared to those on land. The background music and basic credits without narration lets the presenter talk to the images, pointing out particular features of interest and allowing the product to be used in a variety of forums.

Since its initial media launch, the bathymetry flythrough has proved to be a valuable educational and publicity tool. It has been distributed to hundreds of people including science and education organisations as a CDROM product. It is also often used in presentations to community groups such as Coastcare and Probus, at festivals and to other interest groups such as the Australian Marine Science Association to introduce the work of NOO. The movie stimulates a high level of public interest, promoting discussion and questions about the undersea features that are shown.

CASE STUDY 2 – OFFSHORE PETROLEUM EXPLORATION AREAS 2005

The annual release of offshore petroleum exploration areas (‘acreage release’) is a key part of the Australian Government’s strategy to encourage investment in petroleum exploration. In 2005 Geoscience Australia compiled information including reports, GIS data, maps, seismic surveys and 3D flythroughs of 29 new offshore release areas. [Geoscience Australia, 2005a]

This information was presented to potential investors at the annual Australian Petroleum Production and Exploration Association (APPEA) Conference, distributed as a CD product and made available on the Department of Industry Tourism and Resources’ web site for potential investors. Local and international companies then use this information to bid for the rights to explore within particular release areas.

Flythroughs have been included in the last three years of acreage release products, providing a different perspective for investors other than the traditional 2D map. The aim of the flythroughs is to provide a quick but rich overview of the new release areas, demonstrating their relationship to current and previously released exploration areas, existing oil and gas fields, infrastructure such as pipelines, towns and the physical environment (bathymetry).

The 2005 acreage flythroughs consisted of a 2 minute overview (Figure 3) that circled the coast from the northernmost release areas on the Darwin Shelf to the Otway Basin off the South Australian coast and nine short 30-40 second close - in views of the acreage within individual geological basins (Figure 4). The 1km bathymetry-topographic grid was again used as the base for the products. In addition, a Landsat mosaic of Australia from imagery acquired in 2002 was stitched into the draped pseudocolour image.

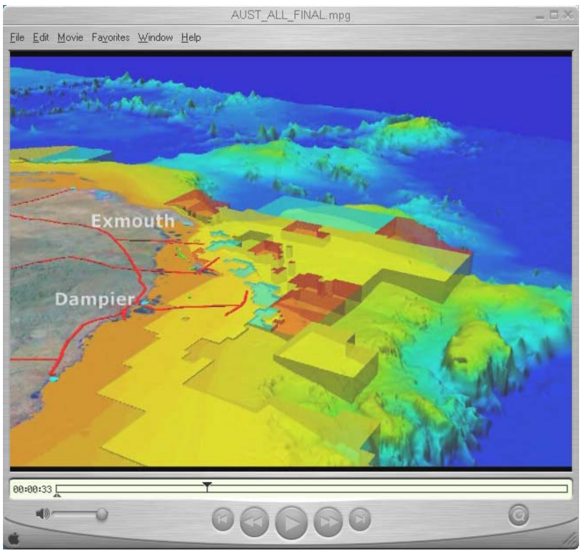

Figure 3. Overview of the 2005 acreage release areas (red) on the Exmouth Plateau. Pipeline, localities, existing (yellow) and current (green) exploration release areas are also shown.

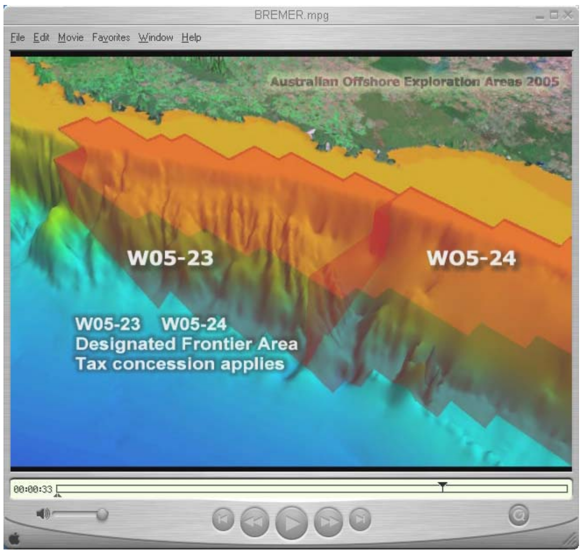

Figure 4. 2005 release areas in the Bremer Basin.

The acreage release areas were added to the VGIS scene as 3D block shapefiles rising from the ocean floor and colour colour coded to represent different dates of release, with the newly released areas shown in red. The opacity of the release areas was reduced to enable the underlying bathymetry to be clearly seen. Other vector data such as pipelines, oil and gas fields and localities were either draped or extruded above the DEM surface within the scene.

The raw flythroughs were taken into a video editing software suite where titles and credits were incorporated, separately recorded vector layers were faded in and out of the scenes, labels added and other editing completed. In the case of the overview flythrough, music was also included to make it more appealing for presentations. The ability to value add to simple bathymetry flythroughs through video editing provides more control over the look and feel of the final product and creates a visually enhanced and ultimately more polished product.

CASE STUDY 3 – MARINE JURISDICTION IN THE MACQUARIE RIDGE REGION

GA's Law of the Sea (LOS) project has been working for many years in conjunction with the Department of Foreign Affairs and Trade and the Attorney-Generals Department to prepare a technical submission to support the definition of the outer limit of Australia's Continental Shelf under article 76 of the UN Convention on the Law of the Sea (UNCLOS). Numerous geospatial products, including a GIS and 3D visualisations of particular regions supporting the submission, were lodged with the UN Commission on the limits of the Continental Shelf in November 2004 [Geoscience Australia, 2005b].

Prior to lodgement, similar products were also used during boundary negotiations with neighbouring countries to explain the science behind Australia's maritime boundaries and its submission in particular, which focussed on the extent of continental shelf beyond the 200 M Exclusive Economic Zone.

With traditional graphic products such as 2D contour maps and black and white images, non-technical audiences often have difficulty visualising the shape of features and some people may interpret a different picture of the terrain than others. It is also difficult to display other information such as sample sites or ship survey tracks over the top of contours as maps can quickly become cluttered and confusing. This leads to a lack of understanding of the data and ultimately suspicion of the message the scientists are trying to convey. The ability to portray the shape of the sea floor, and in particular the areas of extended continental shelf, to non-technical members of the delegations such as lawyers and diplomats, who are largely unfamiliar with interpreting 2D maps and contours, was therefore extremely important during negotiations [Symonds, pers. comm. 2005].

An example of the value of visualising bathymetry in 3D is provided below. Figures 5 and 6 show two different representations of the same undersea canyon between Tasmania and Victoria. The shape and dimension of the canyon are quickly and easily identifiable in the 3D representation at right, whereas the detail of the contour map must be closely examined and interpreted.

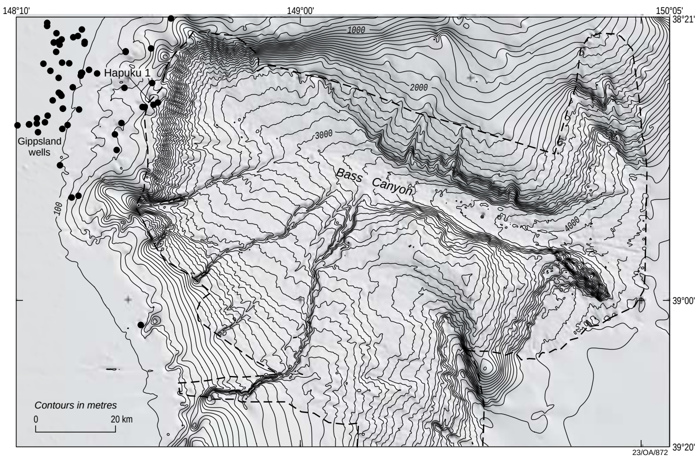

Figure 5. Contour map of Bass Canyon between Tasmania and Victoria (after Exon and Hill 1999).

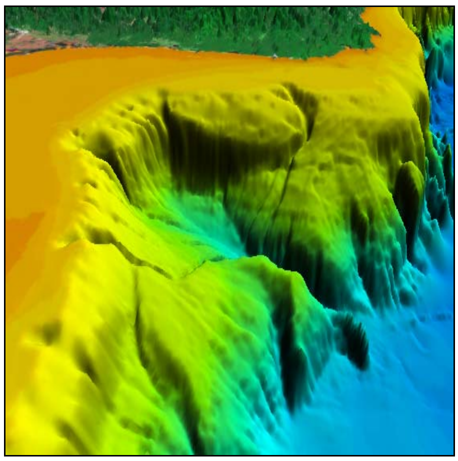

Figure 6. Bass Canyon in 3D with 15 x vertical exaggeration.

The Macquarie Ridge Region combined flythrough and 3D VRML model is just one example of the types of products used in Australia's continental shelf submission and during maritime boundary negotiations (Figure 7). Visualising the seafloor as familiar shapes - ridges, troughs, plateaus and basins -improved the level of understanding over 2D contour maps that had been used in the past. It enabled a large volume of information to be presented and rapidly understood.

In the Macquarie Ridge Region product, the flythrough gives easy access to information on a predefined path. This was a useful method of providing a broad overview of the region. The VRML model then allowed the negotiating delegations to view the region from any angle and focus on particular features for discussion. Vector layers representing boundaries and points depicting foot of slope, could also be turned on and off. The model was very useful for quickly illustrating answers to questions, improving discussions and reducing potential disagreements. Negotiations were then able to move from describing the seafloor to discussing the importance of various features that were critical to the outcome. The scientists were also able to use the model to visually demonstrate the connectivity and continuation of various features which aided the credibility of the arguments [Symonds, pers. comm. 2005].

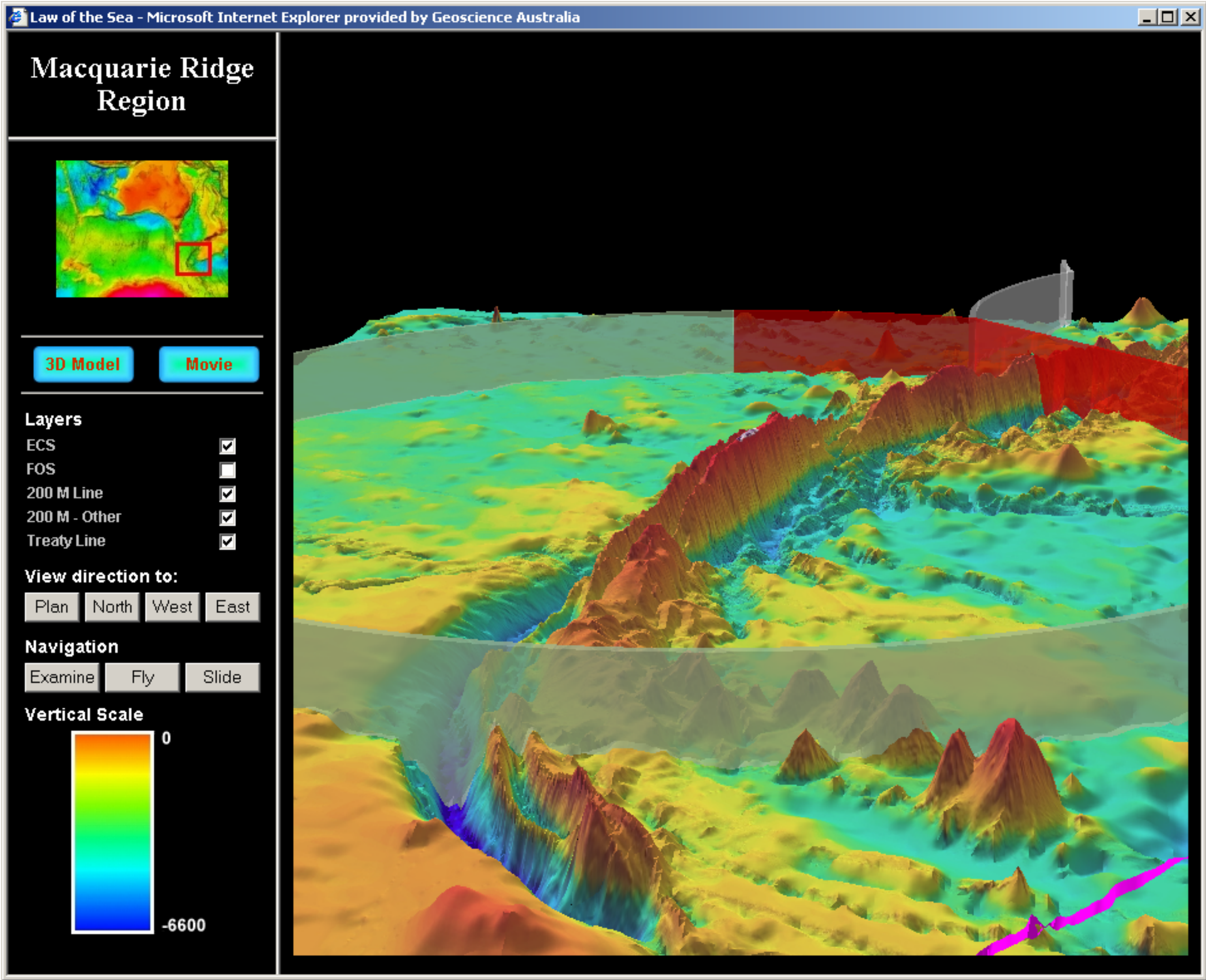

Figure 7. Snapshot of combined Macquarie Ridge Region movie and 3D VRML model product.

CASE STUDY 4 - MURRAY CANYONS

In 2003 the AUSCAN (Australian Canyon) international collaborative research expedition conducted multibeam swath-mapping off Australia's southern margin. The expedition provided new high resolution bathymetry of marine areas that had at best been poorly mapped in the past [Hill and De Deckker, 2004]. The expedition was primarily an initiative of NOO to collect data to support their regional marine planning work.

One of the major outcomes of this survey was the creation of a high resolution (150m) grid of the Murray Canyons, a spectacular system of deep sea canyons on the edge of the continental shelf located south of Kangaroo Island, South Australia. Although these features were known to exist, no one really knew just how big they were until the swath-mapping was undertaken, with the deepest canyon dropping from 200m to 5000m in depth over a distance of 40 kilometres [Hill, 2003].

To communicate the immense size of these undersea features, GA produced a combined flythrough and movie (Figure 8) on behalf of NOO. This product was innovative in that it combined flythrough footage with other more detailed information. It not only displays the spectacular terrain of the canyons but also explains how the data was acquired, putting the information in a context of scientific discovery. In addition to the input of specialist geospatial skills to create the flythrough, graphic design and video editing skills were equally as important in successfully communicating the overall message.

The Murray Canyons movie was distributed on CDROM and was the first product of its kind used widely by NOO. It was used by scientists to explain the recent advances in seafloor mapping in Australian waters and stimulated a high degree of general interest at the time of its release.

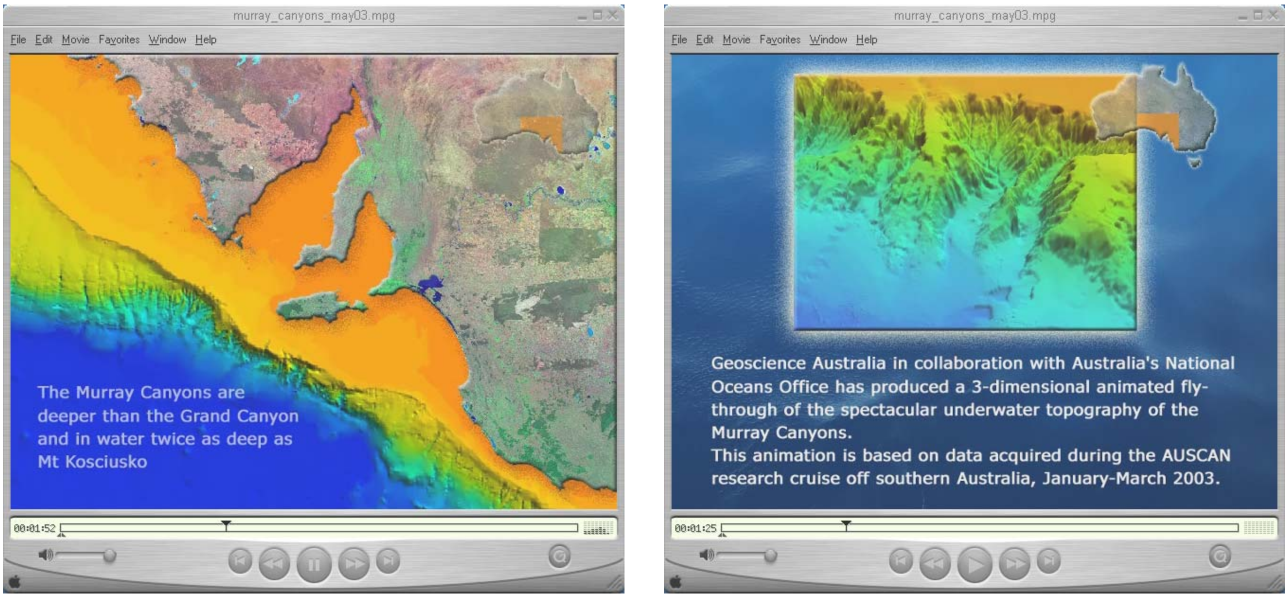

Figure 8. Scenes from the Murray Canyons movie combining flythroughs with additional information.

How big are those canyons really?

The choice of a particular vertical exaggeration, colour and shading of the terrain can be used to highlight certain aspects of the data and may present a skewed version of reality. Because the Australian continent is so flat compared to the features on the ocean floor, a relatively large vertical exaggeration is required to show any shape to the land surface at all on a continental scale. As a result the already steep bathymetry appears even more so.

It is important to note that these visualisations are not necessarily intended to provide a high level of detailed information but rather to be used as an overview and synthesis of spatial data and provide an access point to the concepts being communicated. As such they do not replace the need for 2D maps and other scientific material. The LOS and acreage release case studies described above demonstrate the way visualisation products are used together with detailed reports, cross-sections, seismic surveys, GIS data and other scientific material to benefit a project.

What these 3D visualisation products do achieve is to provide an easily understood and visually effective introduction to the data.

CONCLUSIONS

GA has successfully developed techniques for producing high quality innovative 3D visualisations of Australia’s marine zone. The visualisations have been used to highlight new petroleum exploration areas and assist international boundary negotiations and definition of maritime jurisdiction. The products particularly assist non-technical audiences to better understand the physical features of the ocean floor and provide an interesting and engaging entry point to marine research projects.

3D visualisations have been important communication and promotional tools for individual projects, generating large amounts of interest within the media, general public and scientific community. The products have also helped to promote the innovative capabilities of GA. They are produced through a combination of visualisation techniques, as no single application generates the required outputs. A wide range of skills and techniques including GIS, image processing, scripting, graphic design and video editing have been used to produce stimulating and effective multimedia displays. These types of visualisation products continue to be requested because they have proven to be a very effective tool for sharing marine zone science with a wide audience.

ACKNOWLEDGEMENTS

The authors would like to thank: Dr Peter Harris, Group Leader, Marine and Coastal Environment, Petroleum and Marine Division, Geoscience Australia; Jenny Maher, Project Leader - Acreage Release & Petroleum Promotion Petroleum & Marine Division, Geoscience Australia; Dr Vicki Nelson, Project Manager, Science, National Oceans Office; and Phil Symonds, Senior Adviser, Law of the Sea Project, Geoscience Australia for their assistance in preparing this paper.

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