for the African Coelacanth Ecosystem Programme

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THE AFRICAN COELACANTH ECOSYSTEM Programme (ACEP) Geographic Information System (GIS) has been developed to integrate, analyse and map all spatial data generated within the ACEP programme. A GIS is a multidisciplinary tool, and within ACEP the GIS has been used to integrate information from marine biology studies, oceanographic surveys, geophysical exploration as well as the observations made and footage taken from a research submersible. The core data in the GIS are based on deep marine ecosystems and the programme's flagship species, *Latimeria chalumnae* (the coelacanth). Over and above the utility of the GIS as a tool for science through its considerable information storage, analysis and display capabilities, the ACEP GIS has been used for interactive environmental education purposes and to generate public awareness of the programme at various meetings, training events and conferences.

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Introduction

A Geographic Information System (GIS) may be defined as a means for storing, integrating, analysing and displaying spatial information.[1] It has considerable application in the marine environment as it allows the interrogation of complex and diverse spatial data sets with a large geographical scope. A GIS was therefore chosen for the African Coelacanth Ecosystem Programme (ACEP) to provide the most appropriate framework for the efficient storage and retrieval of spatial information generated within the programme.

To date, the ACEP has led seven marine research expeditions, each of which has generated a considerable amount of data and scientific resources, and must be properly managed for them to be safely archived in the long term, as well as to ensure that they are accessible for research purposes.

The primary objective of the GIS initiative was therefore to provide a vehicle for the management of spatial data, but an equally important purpose was to create data products for research, information dissemination, decision support, environmental education, and public awareness.

Methods

Data collection. Numerous types of information have been collected during the ACEP expeditions, from which secondary data sets have been derived in many cases. In addition, spatial information from other sources has been incorporated into the GIS, to provide additional spatial reference, or in some cases to complement the ACEP data with historical records. Information (of a primary or secondary nature) that has been incorporated into the GIS includes the following:

- Bathymetric information [seafloor digital terrain models (DTMs), contour layers, slope layers].[2]

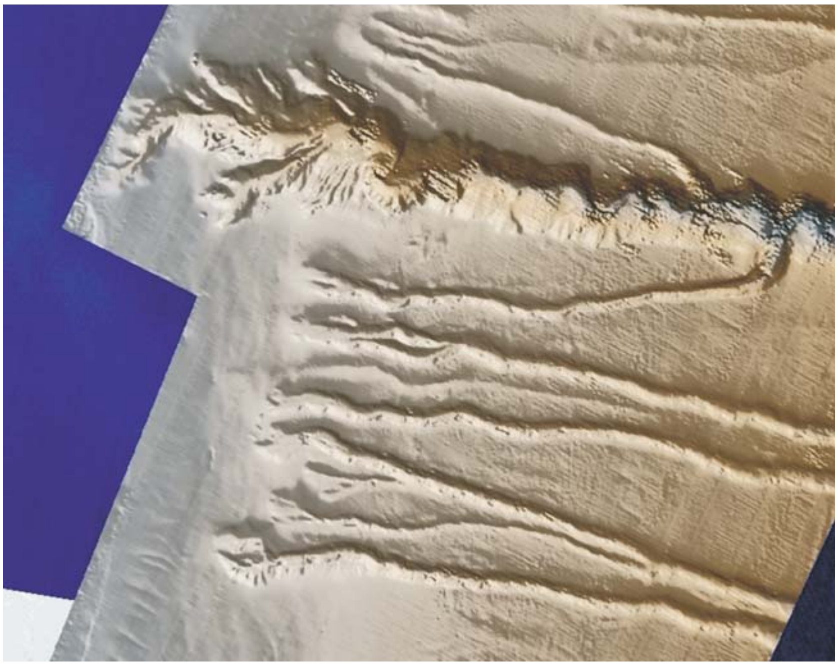

Fig. 1. Shaded, depth-coded digital terrain model (DTM) produced from the swath bathymetry survey of the canyons off Sodwana Bay.

- Coastal topography and DTMs of coastal areas and important catchments.
- Infrastructure (roads, railway lines, airports, ports).
- Human settlement information (cities, towns, villages, urban areas, schools)
- Fish species distribution (ACEP and historical data).
- Benthic community information.
- Conductivity, temperature and depth information at numerous sites.
- Long-term data sets for temperature and benthic community structure at 11 monitoring stations.
- Information from expeditions of the research submersible, the *Jago*.
- Daily and mean time-series data for ocean colour and sea-surface temperature from satellite imagery (1-km and 4-km resolution).
- Coelacanth Conservation Council database of coelacanth catches throughout the Indian Ocean, as published in the council's *Newsletters*.[3]
- Historical fish collection data from the South African Institute for Aquatic Biodiversity in Grahamstown (RUSI collection).

Data processing and integration. The GIS was designed with TNTmips© software (MicroImages), which has powerful processing tools for raster, vector and remotely-sensed data, and is also well-suited to the import and export of spatial data in many different formats. The ACEP GIS was designed to incorporate many different types of spatial data, each of which requires a different method of importing, processing, and integration. An example from each of three different types of data is provided below:

a) Bathymetry data: five areas off the Sodwana Bay coast, northern KwaZulu-Natal, South Africa, were surveyed by Marine GeoSolutions using swath bathymetry, generating a data set containing a series of *XYZ* points. These points were converted to a raster theme with the TNTmips© Surface Modelling function that generated a 10 m × 10 m raster for each of the survey blocks. A sun-shaded digital terrain model was produced from each of the raster themes, with an elevation of 45° and an azimuth of 45°. An 8-bit version of each DTM was also produced, and the sun-shaded model was fused with the 8-bit version to produce a shaded, depth-coded DTM. All the rasters were resampled to produce 5 m × 5 m map layers (Fig. 1). Contour lines at 10-m intervals were also generated from each of the DTMs, and map layer styles were set to display the information in the most effective way.

b) Point data with attached attribute information: The information recorded by the research submersible *Jago* was linked to waypoints with *X* and *Y* coordinates. This information was formatted in Excel© (Microsoft) and converted into a database table before being imported into the GIS as a vector. The projection settings were set and styles were chosen to display best the information attached to each record, and data-tips (boxes that pop-up under the cursor) were devised to show attribute information for each of the points (Fig. 2).

c) Access databases: The Marine Ecology database contains georeferenced information about all the activities and data collected on the Marine Ecology subdiscipline of the ACEP programme in a series of related database tables. This database was linked to the GIS using an ODBC (open database connectivity) connection, and relationships were manually re-established in the GIS to match the Access© (Microsoft) links.

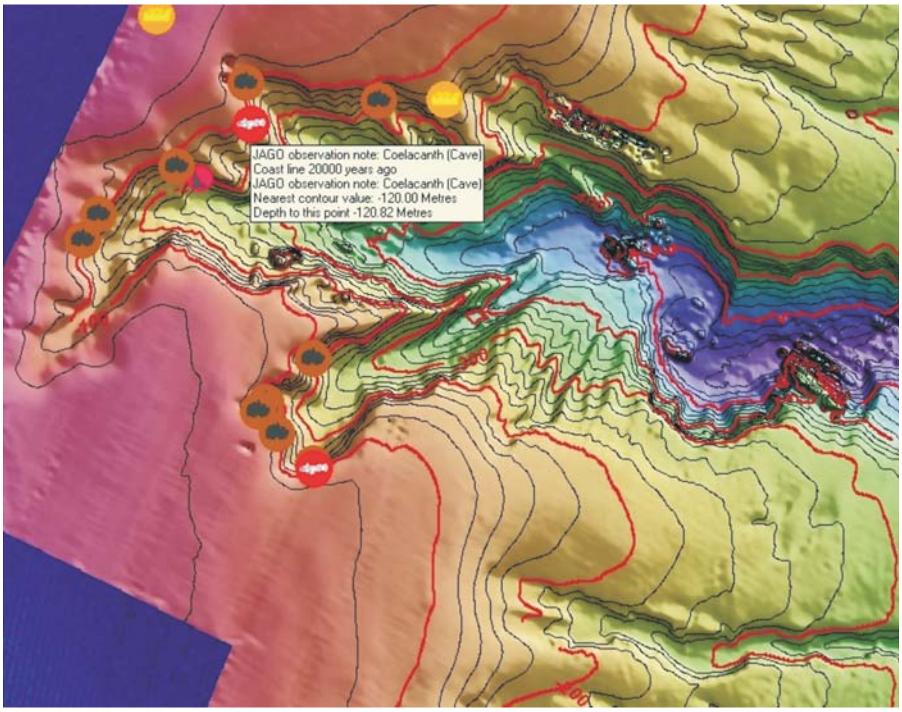

Fig. 2. Point data displayed over a colour-coded bathymetry model of Wright Canyon, off Sodwana Bay. The symbols representing observations from the *Jago* research submersible are linked to an attribute table, from which data-tips show information recorded at each point.

Sub-categories of data were selected for mapping, and styles and data tips were assigned.

Metadata and data archiving. Comprehensive metadata for each spatial coverage were entered into a metadatabase to allow the monitoring of additions to the GIS, and to keep track of file and archive locations. Each data set unique to the GIS is copied to an off-site archive for security.

Results

The GIS has been brought together successfully from a number of different sources, and currently contains 153 layers, an example of which is illustrated in Fig. 3. As a result of the integration of different types of data into one system, several discrepancies became evident among data sets. These are due to different people collecting data using various methods in different formats over a long time. As problems or errors are noted, the corresponding records in the metadatabase are flagged and annotated.

GIS tools and products

The GIS component of the ACEP forms the structural hub for the efficient storage and retrieval of spatial information generated within the programme. The GIS has been used to generate maps for posters, scientific reports and to integrate different kinds of information to address scientific questions. It has been used for project and expedition planning, as well as to share information about research in the Western Indian Ocean (WIO) region. Although the ACEP GIS is a product in itself, several secondary user-specific products have been generated from the GIS, as detailed below.

Sodwana Bay GIS atlas. This atlas was produced for the Sodwana Bay area, to include spatial data in several formats, which is fully interactive and available on CD with a built-in GIS browser to allow it to be viewed on any computer (Fig. 4). The DTM generated for the GIS was used to create a 3D simulation of Wright Canyon in the Sodwana Bay area, which may be interactively explored using keyboard controls or a joystick. This simulation was demonstrated, along with the GIS atlas, at the World Summit on Sustainable Development (WSSD) in Johannesburg in 2002.

Western Indian Ocean GIS atlas (in progress). A GIS atlas for the WIO is being developed to include ACEP spatial information generated on the several research cruises, together with selected additional GIS information. The purpose of this atlas is to share spatial information in the region and to provide the basis for project planning for country-specific GIS atlases and user-defined atlases for management and conservation decision-support.

A tool for environmental education. Geographic information systems can be a particularly useful learning tool to engage students in ocean-related activities.[4] The ACEP GIS has been used as an educational tool and point of interest for young pupils through its interactive and user-friendly interface. At the 2003 science festival in Grahamstown, an interactive station was set up to allow young learners to browse information collected by the programme, and generate interest and enthusiasm for GIS technology. The GIS has also been used to produce maps and images for educational brochures.

A tool for public awareness. At the WSSD,

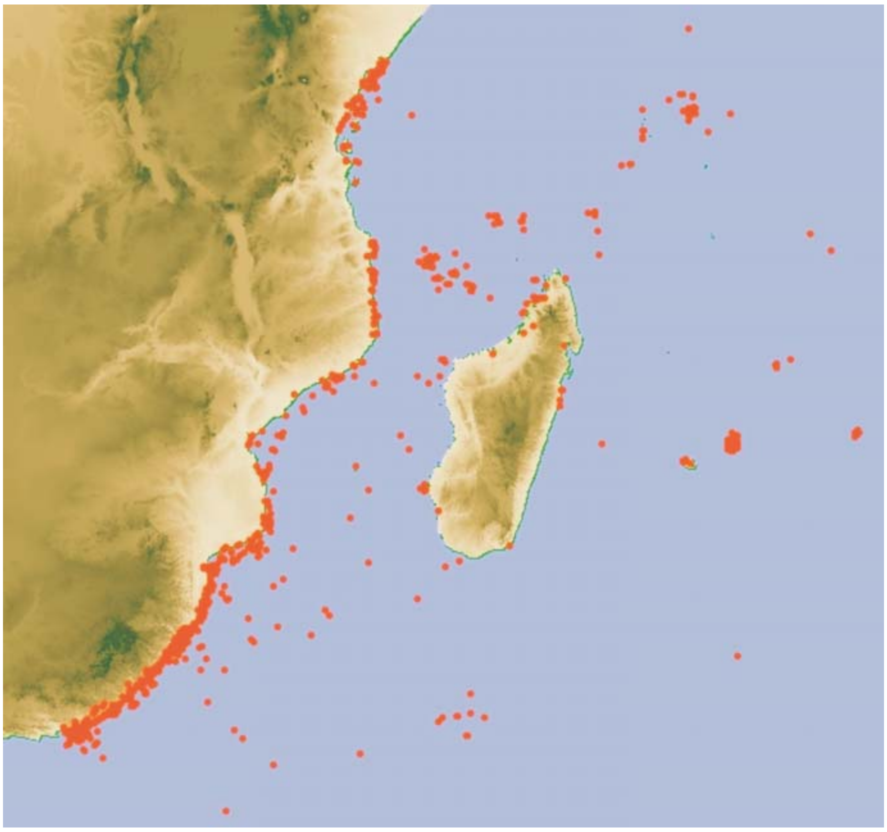

Fig. 3. Historical fish collection data from the South African Institute for Aquatic Biodiversity in Grahamstown, South Africa. Each point is linked to attribute information about the specimen that is housed in the collection.

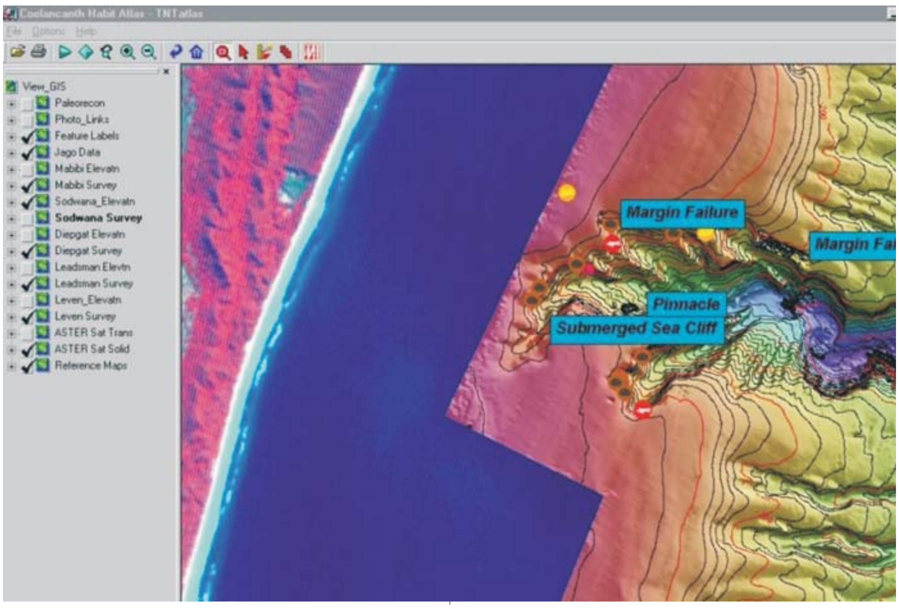

Fig. 4. The interface of the Sodwana Bay GIS atlas that was produced for the World Summit on Sustainable Development in 2002.

the Sodwana Bay GIS atlas and canyon simulations were used to raise public awareness of ACEP and the multidisciplinary benefits the programme will have. The atlas was made available for visitors to explore the coelacanth habitat and retrieve information about sites at which coelacanths were sighted.

GIS networks. Data providers and users are an integral part of any GIS as they inform the design and content of the system. ACEP, being a regional programme, has a regional network for GIS coordination, with a representative on each of the national management committees in each country[5] to: promote information sharing in the region; identify priorities for data collection; collect existing information together; network with other organisations and institutions; and identify, lead and promote capacity building and training.

Plans for the future

Although the core data in the GIS are at present based on coelacanths and their habitat, the GIS is a dynamic tool and it will grow with the incorporation of more information to be a truly representative aquatic information resource for the biology, oceanography and ecology off our shores. The Coelacanth GIS is not only a valuable tool for the programme but links with existing GIS and spatial database projects in southern and eastern Africa, and to the new South-West Indian Ocean Fisheries Programme (SWIOFP) and Agulhas Somali Current Large Marine Ecosystem (ASCLME) programmes.

Although there are significant challenges to the understanding of marine processes and ecosystems, scientific knowledge of our marine systems is increasing rapidly.[6] The appropriate integration, archiving, application and dissemination of this information will be the basis for systematic conservation and management plans, and the ACEP GIS will provide a vehicle for this process.

Products from the GIS will be designed to make the information in the system easily available to a range of participants. This is essential if it is to be used for the informed management and conservation of natural resources, as well as to guide policy making.

For the GIS to continue to provide a service to ACEP and the wider marine community, it requires sustained funding and a secure institutional home.

Technology transfer and the development of institutional capacity

An output of the programme will be to strengthen research and higher education institutions in the Western Indian Ocean, in association with existing capacity-building initiatives. With GIS resources established at the South African Institute for Aquatic Biodiversity, facilities are available to support students in a variety of scientific disciplines. The ultimate aims of generating interest and enthusiasm for marine biology and our marine environment will also be furthered by this initiative. The GIS programme currently has three students from educationally impoverished backgrounds now at Fort Hare University in the Eastern Cape doing projects using ACEP GIS data, and they will be encouraged to continue their studies to master's level.

Conclusion

The value of the GIS component of the ACEP programme is considerable and will continue to contribute to the growing body of knowledge about our marine environment. A GIS is an efficient and consistent way of storing spatial information, which will allow the integration of the research data from this programme with other spatial information, and have a continuing and increasing use as an aquatic information resource for the countries adjacent to the Western Indian Ocean.

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