GIS

The Key to Research Integration at the Australian Institute of Marine Science

Stuart James Kininmonth
The Australian Institute of Marine Science
Townsville, Queensland, Australia

The establishment of an enterprise GIS at the Australian Institute of Marine Science (AIMS) is revolutionizing the acquisition of knowledge in the field. For the last thirty years, AIMS (www.aims.gov.au) has focused on building a knowledge base of the complex marine ecosystems of the tropics with research effort concentrated in the northern waters of Australia. However, the nature of modern research requires considerable specialization, and has the tendency to generate isolated projects. The natural systems being examined are complex, with abiotic and biotic components, and thus highly interactive. Research projects address this problem by dissemination of their results in the final stages, but often this is too late for experimental integration. The data formats describing the research findings are usually custom-made for the particular research field, and direct comparisons are difficult. This represents a considerable waste of opportunity, especially in a multidisciplinary research organization such as AIMS. Efforts to address the interaction between projects utilize the conference and seminar mediums with mixed success. A unifying system based on a fundamental research element is required. That element is location and the system is an Enterprise GIS (or EGIS).

An EGIS utilizes a centralized data management system with all data associated with a spatial feature. The guiding principles of standardization, accessibility, ease of use, and integration are determining the construction of the AIMS EGIS. This involves eventually placing all research data into a central relational database (Oracle 8i) controlled by ESRI's ArcSDE (Spatial Data Engine). Having a common datum with useful metadata is critical to the success of this system. The use of Web-based mapping using HTML and Java generated by ArcIMS (Internet Mapping Service) provide rapid access to the research results in a familiar Internet environment. Traditional ArcInfo workstation and the newer ArcMap 8.1 are available for all staff through a server-based license manager.

Integration of a project's activities occurs at three levels. First, a diverse operating environment at AIMS demands a system that can provide seamless information management. AIMS is unique in the research field with marine operations based on two ships that conduct scientific activities for 74 percent

PHOTO COURTESY OF SALLY INGLETON

Katharina Fabricius checking her location prior to working on her experiment on coral settlement and reef recovery.

of the year. Consequently the widespread use of nautical charts as a base layer to display project areas of interest, experimental sites, and research findings (such as water temperature from remotely sensed data) on board the ships and, importantly, back in the office, provides efficient integration of common data sets. With 351,400 square kilometers of Great Barrier Reef in which to conduct scientific activities, the use of global positioning system (GPS) and electronic charts is essential, and replaces the desperate repetitive searches of past years. On a recent field trip, coral settlement plates were placed close to another experiment to maximize the use of valuable ship and scuba time, despite being dispersed over 1,200 kilometers. Back at the laboratory, the distribution of experimental sites can be displayed with the same data available at sea. Time-consuming data transfer and translation are avoided.

The second level of integration involves researchers comparing and analyzing their own data with the results of others. AIMS has a diverse array of research interests, including oceanographic modeling, marine biodiversity characterization, marine resource management, human impact mitigation, marine biotechnology, and technical engineering development. Using ArcIMS, all research staff have the opportunity to view and integrate data sets through standard, Web-based mapping. For instance, a geneticist investigating the thermal tolerance of coral (photo below) can examine the sea temperature history collected by other project groups with a few mouse clicks. The long-term monitoring group members have been leaders in this area, with results

Mary Wakefield stereo-photographing coral at Young Reef for a monitoring study conducted over 20 years.

PHOTO COURTESY OF TERRY DONE

PHOTO COURTESY OF STUART KININMONTH

Carolyn Smith and Ray Berkelmans comparing the genetic and physiological basis for thermal tolerance of corals.

immediately available on the Web after each voyage. Between dives the survey information is collated to a specified standard in a relational database on board the ships. The age-old problem of motivating staff to prepare and submit data *to a standard* is solved by the open visualization of their data. More sophisticated modeling by specialist staff requires the use of ArcInfo, Idrisi, and custom-made applications. In particular, the use of Bayesian statistical methods to interrogate the multiple data sets highlights the opportunities that integration presents.

A fully functional GIS is a tremendous benefit to an institute, but many data sets are nonspatial yet are still important to the scientific endeavors at AIMS. In a strategic initiative to enhance the entire utility of information at AIMS, the development of a sophisticated data center incorporating the essential activities of operation support, corporate management, and nonspatial science data is in progress. This new data center will utilize the spatial services of the EGIS. The final result will be a system where perhaps the budget information could automatically be an attribute of a coral spawning experiment.

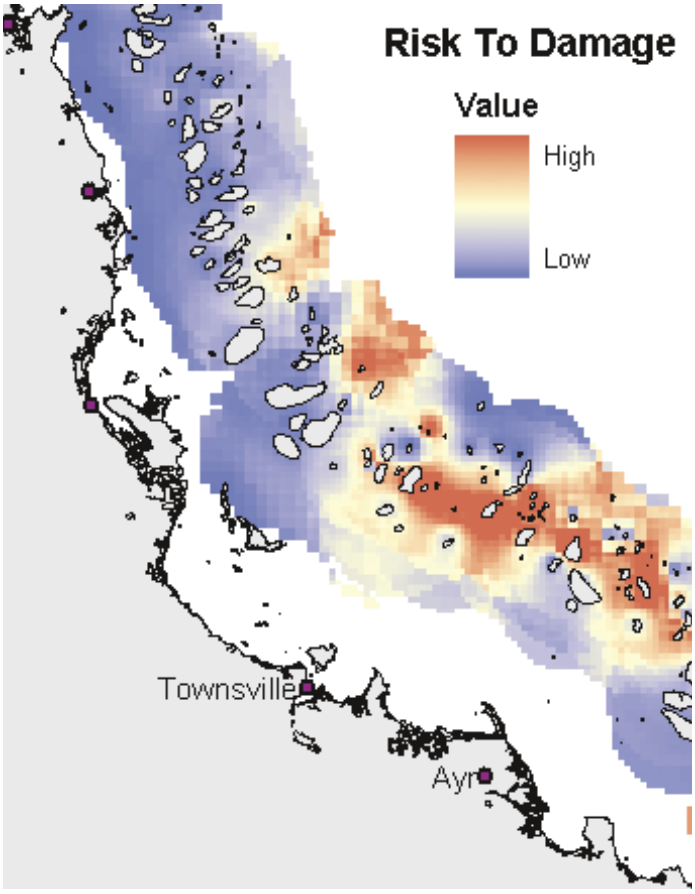

Figure 1: Map generated by the Bayesian "weight of evidence" model of the predicted damage of crown-of-thorns starfish by Scott Wooldridge.

The third level of integration is the complex sharing of research knowledge between organizations. Recognizing the benefit of synergetic organizational structures, the Australian federal government established cooperative research centers (CRC). The CRC Reef is a "knowledge-based partnership that provides research solutions to protect, conserve and restore the world's coral reefs..." (CRC Reef mission statement, *www.reef.crc.org.au*). Using the growing utility of the Web for data sharing, the CRC Reef is supporting the development of Internet mapping and hyperlink information networks. These easy-to-use mass media tools facilitate the exploration of complex issues through informative displays generated by the relevant organization. Maps that permit exploration and simple analysis are essential to this process, where the complexity of the issue is not masked by a one-page summary (figure 1).

With the recent installation of spatial Web servers in other marine organizations, the ability to combine up-to-date spatial information in a customized format is a powerful addition to the effectiveness of knowledge dissemination. The display of research results is rarely hassle-free, and the protection of intellectual property rights remains a difficult issue. The livelihood and future

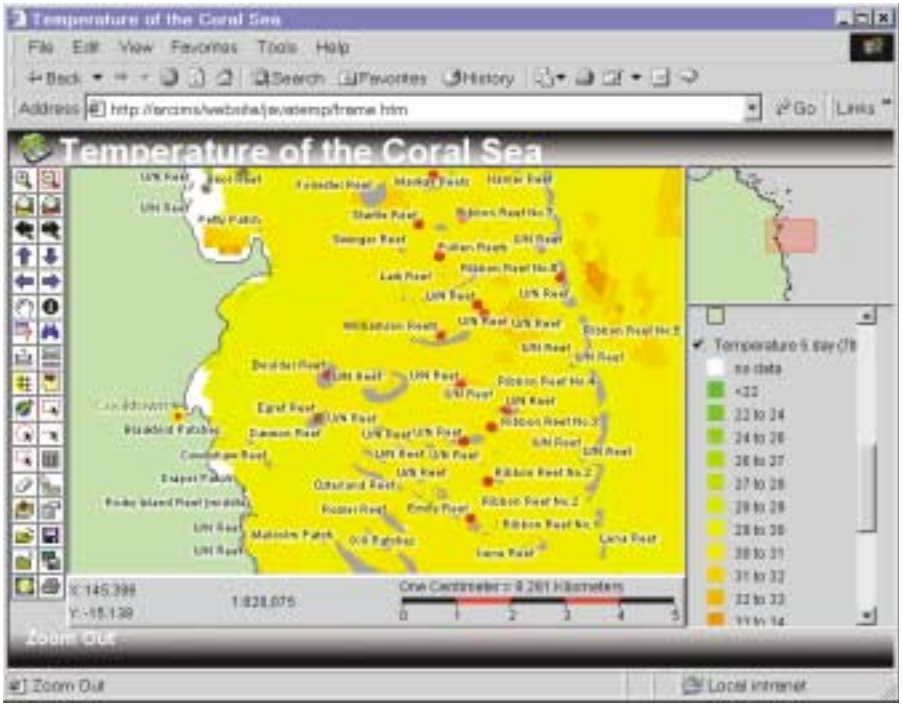

Figure 2: Screen capture of a Web map showing coral bleaching survey data with reefs and remotely sensed temperature data.

prospects for a researcher rely on the exclusive rights to scientific data until published. This process often takes several years, by which time the use of the raw data by another researcher may be temporally too disjointed. To address this issue in the short term, researchers can supply summary results that will facilitate integration. In the long term, a negotiated period is established after which the data becomes available for open institutional use. Experience with global coral species data shows that the popularity of a data set can be influenced by the open promotion of summary data such as a visual portrayal of extrapolated point samples (see also Shapiro and Varian 1998).

The hunger for visual displays highlighting the integration of past events is considerable, but the thirst for visual representations of the future is insatiable. The CRC Reef-funded group at AIMS, called "Reef Future," seeks to use modern statistical methods to explore future scenarios based on present actions. Utilizing a vast array of spatial data and model outputs, Reef Future researchers such as Terry Done, Glenn De'ath, Scott Wooldridge, and the author are value-adding thirty years of research results. Using Bayesian "weight of evidence" models combined with predictive statistical procedures, the future status of selected tropical ecosystems can be described (figure 2). This form of modeling can be achieved only with data sets that are professionally managed in an EGIS.

EGIS is still in its early stages of development and many valuable data sets remain to be converted, but the momentum to adopt modern spatial tools in support of the exploration of the marine environment continues to increase.

Acknowledgments

Special thanks to the information technology team (Scott Bainbridge, Peter Hewitt, James Smith, Carsten Malan, and Cathryn Anderton) for supplying the wonderful system that supports the institute's EGIS.

Reference

Shapiro, C. and H. R. Varian. 1998. *Information Rules: A Strategic Guide to the Network Economy.* Harvard Business School, Cambridge, MA, 352 pp.