

Bilingual Marine Data Distribution Using ArcIMS for Coral Reef Conservation

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Abstract

American Samoa is home to some of the most unique coral reefs in the United States. They face several threats, including climate change, pollution, destructive fishing methods, and invasive species. Additionally, the remote location of American Samoa makes distribution of scientific research and data problematic. As part of an ongoing project at Oregon State University, this project will provide for the distribution of research about coral reefs in American Samoa to educators, managers and the public for promotion of reef conservation. Several steps will be necessary to accomplish this goal, including creation of benthic habitat maps for Fagaitua Bay and the National Park of American Samoa, development of a Web-based Geographic Information System in Samoan and English (including a bibliographic database of resources related to reefs in American Samoa), and creation of educational modules about benthic habitat GIS for use by American Samoa Community College.

Introduction

This study addresses the problem of public outreach and accessibility of scientific research and data in American Samoa through a web-based GIS called the American Samoa Benthic Viewer (ASBV). The remote location of the territory makes dissemination of current research that directly concerns American Samoa problematic. While there has been a proliferation of research on the coral reefs around the territory in the past few years, little of this information is available to the public in a form that is readily understandable or useable. This information may potentially be used in the establishment of marine protected areas (MPAs), which, in a society still partially dependent on subsistence fishing, directly affects the general public (Gilman 1997). It is vital that the information used in resource management decisions be made available to those affected by these decisions. In addition to the general public in American Samoa, the target audience of the ASBV will include the American Samoa GIS User

Group (see Wright, 2002b), teachers, students, and local resource managers, as research on coral reefs can be included in any science curriculum.

In the developing world, the lack of local technological infrastructure and capacity exacerbate the problem of GIS and spatial data accessibility. Developing countries offer few opportunities for people to receive GIS training and many who obtain those skills leave for better salaries in developed countries. Along with intellectual flight, data access is an equally challenging problem. The benefits of research may never be made practically available in the areas in which the research was done, preventing local resource managers and the general public from using information generated by such projects, and research results may not be translated into the local language (Britton 2000). A web-based GIS can potentially solve some of the problems of spatial data distribution. It has the practical advantage of allowing the users to work with the data on their own terms and pace.

Study Area

Background Information

The Samoan archipelago is located in the southern Pacific Ocean approximately 2300 miles southeast of Hawaii. American Samoa, a chain of five volcanic islands and two coral atolls on the east end of the archipelago, became a territory of the United States in 1900. The majority of the population and the territorial capital, Pago Pago, are located on the island of Tutuila, the largest island in American Samoa at 53 square miles (CIA 2003). Coral reefs comprise approximately 296 km² of the territorial waters of American Samoa (Richmond et al. 2002). They face threats in the form of bleaching events, hurricanes, sea level rise and from invasive species such as *Acanthaster planci* (crown-of-thorns starfish). Given enough time, coral can recover from most such events; however, the reefs face additional threats from pollution,

over-fishing and destructive fishing methods hampering the corals' ability to recover from natural disasters (Richmond 2002; Craig 2001; Green, Birkeland and Randall 1999). Two federal MPAs have been established in American Samoa to help protect coral reefs. Fagatele Bay National Marine Sanctuary (FBNMS) was established on the southeast end of Tutuila in 1986 with local support (Fiske 1992). National Park of American Samoa (NPSA) was established in 1993.

American Samoa Benthic Viewer

The ASBV allows users to access spatial data from the coral reefs in American Samoa

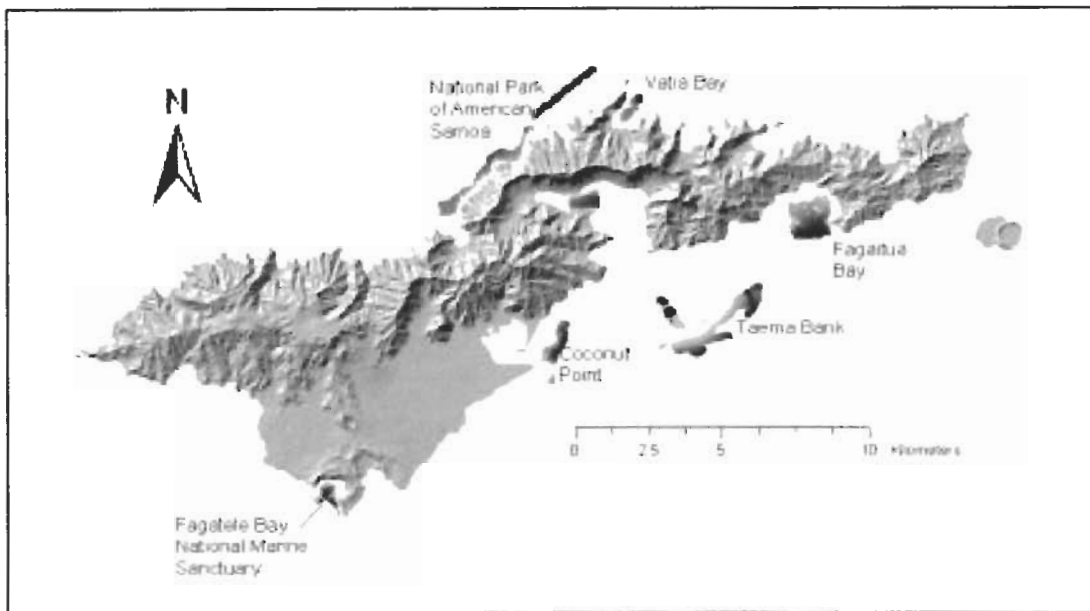


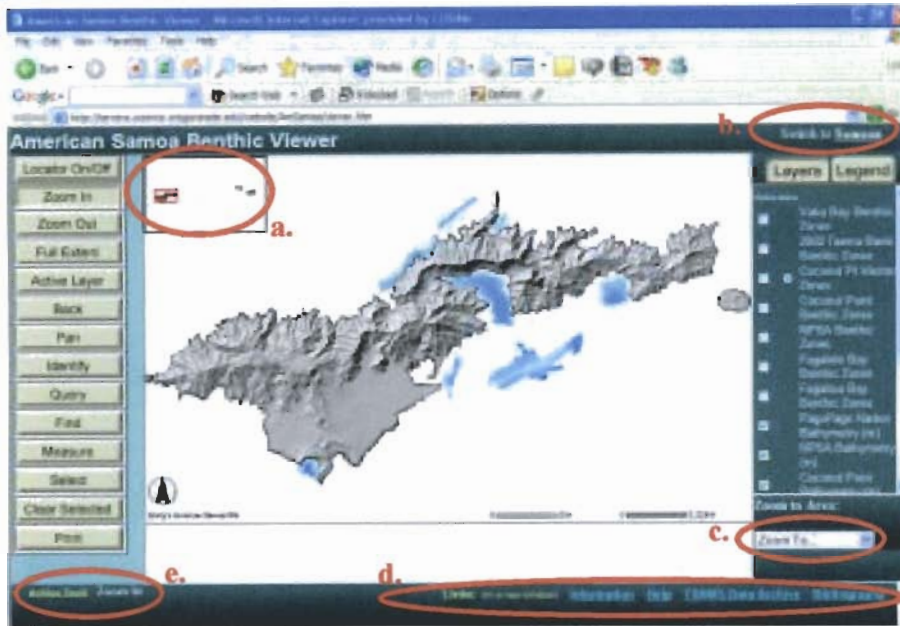
Figure 1. Areas surveyed around Tutuila in 2001 and 2002. General bathymetry for each area is shown as a grayscale with grading from white for shallow areas to black for deep areas.

with either an English-language or a Samoan-language interface. The data on which it is based are multibeam sonar surveys of seven areas around the island of Tutuila (Figure 1): FBNMS, the Tutuila Unit of NPSA, Taema Bank, Pago Pago Harbor, and Fagaitua Bay were surveyed in 2001 (Wright et al. 2002). In 2002, surveys were conducted in FBNMS, Taema Bank, Vatia Bay, and Coconut Point (Wright 2002b). Benthic zone and structure maps have been created for

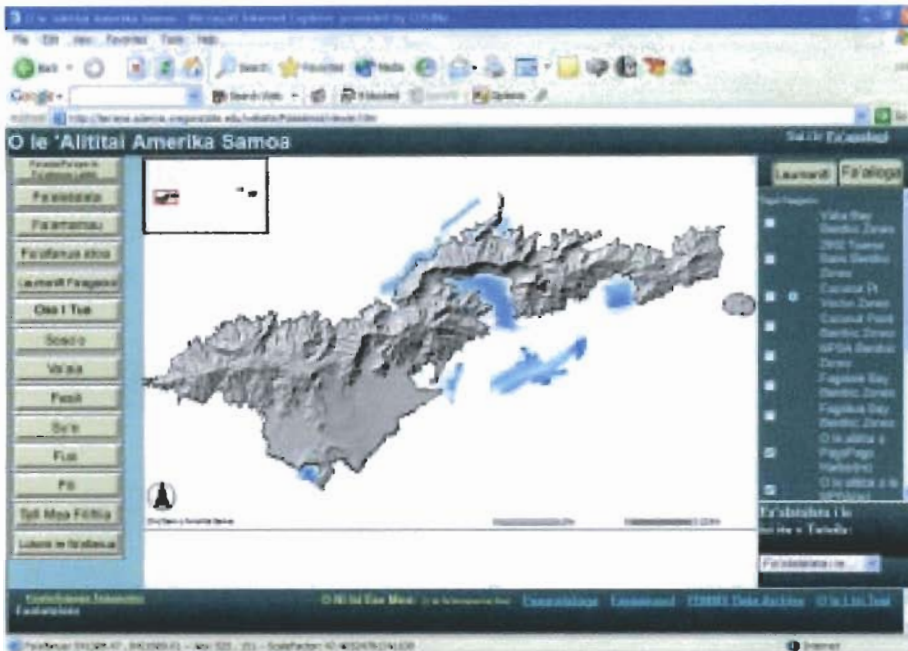
the seven study areas from the bathymetry data produced by the multibeam mapping surveys. Benthic zones are defined as general categories of underwater landforms defined using derivatives of bathymetry including slope and bathymetric position index (BPI). Benthic structures are more specific, finer classifications of bathymetry based on slope and BPI (Lundblad et al. in prep., *Mapping Sciences & Remote Sensing*). The ASBV allows users to access bathymetry data produced from the surveys along with the benthic zone and structure classifications. These data may be used in future resource management decisions as part of a larger project involving mapping potential areas of high biodiversity or particularly sensitive areas.

Since this project attempts to solve problems of data distribution and access by publishing research and data on the Internet, it is important to have an idea of what Internet infrastructure exists in American Samoa. There are approximately 13,000 phone lines in American Samoa (CIA 2003). There is one Internet service provider in American Samoa, Samoatelco.com, and free Internet access is available at the Feleti Barstow Public Library in Pago Pago. The public schools in American Samoa received a grant in 2002 to upgrade Internet access to T-1 connections (Bannan 2002). The ASBV works when viewed over a 50 kbps dial-up Internet connection (although higher speeds are recommended). Although there are no data available on the level of computer ownership or home Internet access, sufficient Internet users exist in American Samoa that Google, the popular search engine, has established a mirror site in American Samoa.

General Site Architecture



i.



ii.

Figure 2 i). Screenshot of the American Samoa Benthic Habitat Viewer using Microsoft's Internet Explorer v. 6.0. Features of the ASBV include: a) the overview map, b) a link to the Samoan-language version of the ASBV, c) a menu allowing users to zoom in to an area of interest, d) links to more coral reef resources, and e) the active tool box. ii). Screenshot of *O le 'Alititai o Amerika Samoa* (The Seafloor of American Samoa) using Microsoft's Internet Explorer.

The ASBV and the Samoan version, *O le 'Alititai o Amerika Samoa* (The Seafloor of American Samoa), were created using Arc Internet Map Server (ArcIMS) version 4.01.

The ASBV was designed as an image server rather than as a feature server because of the need to display raster data and to avoid the need for users to download an additional plug-in.

The initial display on the ASBV is a hillshaded digital elevation model of the island of Tutuila along with the bathymetry for seven areas around Tutuila: FBNMS, NPSA, Taema Bank, Fagaitua Bay, Coconut Point, Pago Pago Harbor and Vatia Bay (Figure 2). The user is then able to add or remove layers as he or she wishes. The featured layers are the benthic zone classifications developed as part of a larger project in the territory (Lundblad et al. in prep.).

Terrestrial layers such as villages and roads are included to help users orient themselves on the map (Table 1). A dropdown menu allows users to zoom directly to one of the areas of focus.

American Samoa Benthic Habitat Viewer Layers	
Marine—	Terrestrial--
FBNMS Bathymetry	Roads
Fagaitua Bay Bathymetry	Villages
NPSA Bathymetry	DEM of Tutuila
Coconut Point Bathymetry	DEM of Manu'a Islands
Vatia Bay Bathymetry	
Taema Bank Bathymetry	
FBNMS Benthic Zones	
Fagaitua Bay Benthic Zones	
NPSA Benthic Zones	
Coconut Point Benthic Zones	
Vatia Bay Benthic Zones	
Taema Bank Benthic Zones	

Table 1—Layers included on the ASBV.

To help users unfamiliar with typical GIS tool images, the default toolbar images in ArcIMS were replaced with images containing words (Figure 3). The site has links to other important resources such as the American Samoa Online Bibliographic Database and the Fagatele Bay National Marine Sanctuary GIS Data Archive, where users can download the actual data used to build the site if they have the capability to work with the data (Wright 2001). An extensive help screen has been written to help users unfamiliar with GIS use the site more effectively (Figure

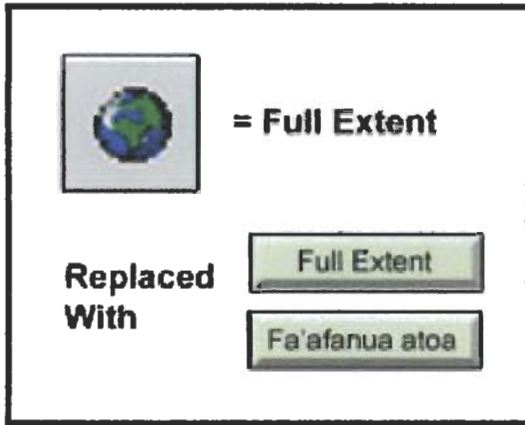


Figure 3 Toolbar images were replaced with word buttons to enhance usability.

4). To further the aim of public education and outreach, an additional screen has been created with information about the coral reefs in American Samoa and how they were mapped. The coral reef page contains links to sites with more detailed information about coral reefs, should the user be interested in learning more than the ASBV offers.

The ASBV and the Samoan version of the site, along with all data, are currently being hosted at Oregon State University using an Apache 2.0 and Apache Tomcat 4.0 Web Server. There are plans to serve and support the sites locally on Tutuila; however, as of 2004, the technological infrastructure is not at a level where this is possible. The ASBV and its Samoan



Figure 4 A portion of the help screen for the American Samoa Benthic Habitat Viewer using Netscape Navigator 7.1. Each tool is explained in detail next to a picture of the tool. The use of words rather than symbols, such as a magnifying glass to indicate the zoom function, will aid users unfamiliar with common GIS tool symbology.

counterpart are two separate map services with separate .axl files and separate sets of HTML and Java files that reference the same data directories and data. This allows for simpler updates and ensures both sites contain the same content. Changing the display language of an ArcIMS map service is accomplished by changing each display parameter in the Java script file, aimsResource.js.

Discussion

The communications infrastructure in American Samoa is at a level to allow use of the Internet as a public education tool. Although the ASBV does require a minimum level of computer literacy and an Internet connection for use, there appear to be few feasible alternatives for real data distribution to the general public. The problems ArcIMS has with raster data will be addressed in the next few months. The site will be upgraded to allow better use of the raster data, such as bathymetry, with the installation of ArcSDE and the conversion of raster data to geodatabases. It will be “field tested” during a series of workshops at American Samoa Community College in September 2004.

Although English is the official language in American Samoa, Samoan is still widely spoken. In addition to making the ASBV accessible to as many people as possible, translating the ASBV into Samoan adds to the limited Samoan-language resources available on the Internet. The ASBV is the only Samoan-language web-based GIS in existence and it is one of only a handful of Samoan-language sites dealing with scientific information. Britton (2002) and Crosby et al. (2001) recognized that scientific information translated into the local language greatly improves accessibility and can generate more interest in the subject area by people who would normally be left out of the information distribution process. Currently, few official government web pages are translated into Samoan in either American or the independent nation of Samoa. There are even fewer Internet resources concerned with scientific research in American or independent Samoa and most of these contain little if any Samoan language content. A notable exception is the National Park of American Samoa preliminary online fish inventory, which includes Samoan, English and scientific names for most fish found in American Samoa (National Park Service 2003).

Conclusion

The ASBV provides public access to marine spatial data for American Samoa without the need for expensive stand-alone GIS software. The ASBV is one of the few web-based GIS sites developed specifically for distribution of current scientific information in the South Pacific and it is the only Samoan-language web-based GIS in existence. By using words instead of images for tools and automatically refreshing the map, the ASBV has been designed in a way to minimize the GIS and computer skills necessary to make use of the site. The supporting help and explanatory web pages will increase the amount of information the average user can obtain from the site. While providing access to scientific information for the public, the ASBV will also provide more advanced users such as the American Samoa GIS User Group a tool for public outreach and data access. The ASBV may lead to greater public participation in the resource planning process by giving the public greater access to information about the coral reefs in American Samoa.

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References:

Apache Foundation. Apache Tomcat 4.1. Forest Hill, MD.

Apache Foundation. Apache Server 2.0. Forest Hill, MD.

Bannan, J. 2002. Pacific resources for education and learning: PREL Provides Distance Learning Programming for the Pacific. *Pacific Magazine*. January. <http://www.pacificislands.cc/pml2002/pmdefault.php?urlarticleid=0026> (last accessed 10 February 2004).

Central Intelligence Agency (CIA). 2003. *The World Fact Book: American Samoa*. <http://www.cia.gov/cia/publications/factbook/geos/aq.html> (last accessed on 13 February 2004).

- Craig, P., Birkeland, C. and Belliveau, S. 2001. High temperatures tolerated by a diverse assemblage of shallow-water corals in American Samoa. *Coral Reefs*. 20:185-189.
- Crosby, M. P., Brighthouse, G. and Pichon, M. 2002. Priorities and strategies for addressing natural and anthropogenic threats to coral reefs in Pacific Island Nations. *Ocean & Coastal Management*. 45:121-137.
- ESRI. 2002. *Customizing ArcIMS: HTML Viewer*. Redlands, CA. Environmental Systems Research Institute.
- ESRI. ArcIMS v. 4.0. Redlands, CA.
- ESRI. ArcSDE v. 8.2. Redlands, CA.
- Fiske, S. J. 1992. Sociocultural aspects of establishing marine protected areas. *Ocean & Coastal Management*. 17 (1): 25-46.
- Gilman, E. L. 1997. Community based and multiple purpose protected areas: A model to select and manage protected areas with lessons from the Pacific Islands. *Coastal Management*. 25:59-91.
- Google American Samoa. <http://www.google.as> (last accessed on 11 February 2004).
- Green, A. L., Birkeland, C. E. and Randall, R. H. 1999. Twenty years of disturbance and change in Fagatele Bay National Marine Sanctuary, American Samoa. *Pacific Science*. 53 (4): 376-400.
- Harris, T. and Weiner, D. 1998. Empowerment, Marginalization, and "Community-integrated" GIS. *Cartography and Geographic Information Systems*. 25 (2): 67-76.
- Lundblad, E., Wright, D., Naar, D., Donahue, B. Miller, J. and Rinehart, R. in Prep. The classification of deep water benthic habitats around Tutuila, American Samoa.
- National Park Service. Fishes of National Park of American Samoa. <http://www.nps.gov/npsa/NPSAfish/> (last accessed on 10 February 2004).
- Richmond, R., Kelty, R., Craig, P., Emaurois, C., Green, A., Birkeland, C., Davis, G., Edward, A., Golbuu, Y., Gutierrez, J., Houk, P., Idechong, N., Margos, J., Paulay, G., Starmer, J., Tafleichig, A., Trianni, M., and Vander Velde, N. 2002. Status of the coral reefs in Micronesia and American Samoa: US affiliated and freely associated islands in the Pacific. in *Status of Coral Reefs of the World 2002*. C. Wilkinson, ed. Cape Ferguson, Queensland: Australian Institute of Marine Science. 378p.
- Wright, D. J. 2001. Fagatele Bay National Marine Sanctuary (FBNMS) GIS Data Archive. <http://dusk.geo.orst.edu/djl/samoa> (last accessed 22 February 2004).

Wright, D. J. 2002a. Mapping and GIS Capacity Building in American Samoa. *Proceedings of the 22nd Annual ESRI User Conference*, Paper 101, <http://dusk.geo.orst.edu/esri02> (last accessed 21 June 2004).

Wright, D. J. 2002b. Mapping the seafloor in American Samoa. *Geospatial Solutions*. 12 (7): 24-25.

Wright, D. J., Donahue, B. T. and Naar, D. F. 2002. Seafloor mapping and GIS coordination at America's remotest National Marine Sanctuary (American Samoa). in *Undersea with GIS*. D. J. Wright, ed. Redlands, CA, ESRI Press: 33-63.

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