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October 2, 2007

To: Liz Fairey
U.S. Department of Commerce
NOAA Coral Reef Conservation Program
National Marine Fisheries Services
1315 East West Highway
Silver Spring, MD 20910

From: Dawn J. Wright, Professor

Re: FINAL REPORT - NOAA Award No. NA05NMF4631048, "Public Education and Outreach Materials for the Fagatele Bay National Marine Sanctuary"

This final report covers the period October 1, 2005 to September 30, 2007 of the above-named project. My departmental accountant and campus research office have made sure that accompanying financial reports are up-to-date. Expenditures on this grant were largely completed by the end of September 2006.

Overview and Final Status of Project

The purpose of this project was to develop a suite of public education and outreach materials for the Fagatele National Marine Sanctuary (FBNMS) in American Samoa. FBNMS has been chosen as focus because it is the smallest and most remote of all sanctuaries in the national system (with the only true tropical coral reef in that national system), and has one of the smallest staffs (only three people as compared to as many as fifteen at the largest sanctuaries), without any reduction in the number or extent of education and outreach activities that it plays a great deal in devising, planning, and coordinating within the sanctuary but also throughout the entire territory of American Samoa. In completing this project, the PI was able to leverage her partnerships and collaboration with the sanctuary and the broader GIS community in American Samoa, in recent years, as well as the data, analyses, results, and educational modules recently developed in her lab at Oregon State University. GIS coordinator Paul Anderson of the American Samoa GIS User Group, and FBNMS Education Coordinator Rosia Tavita and Manda Amituanai provided valuable feedback on the outreach and educator materials as they were being

developed or updated. Paul, Rosia, and Manda also served as the primary disseminators of these project deliverables for village outreach programs, the Le Tausagi environmental outreach program, secondary school programs developed and sponsored by FBNMS for Coast Week and GIS Day, and other educational activities held in cooperation with the American Samoa Coastal Zone Management Program. It is also hoped that these materials will raise the national profile of this small sanctuary, its overworked staff, and its excellent work.

The project was successfully realized via the completion of the following deliverables:

(1) A 36” by 52“ large poster (Figure 1) and (2) an 8”x12” brochure, both explaining and summarizing for a general audience our work with multibeam bathymetric mapping and marine GIS at the Fagatele Bay National Marine Sanctuary (FBNMS) using with graphics, submersible dive photographs, and images of 3-D visualizations

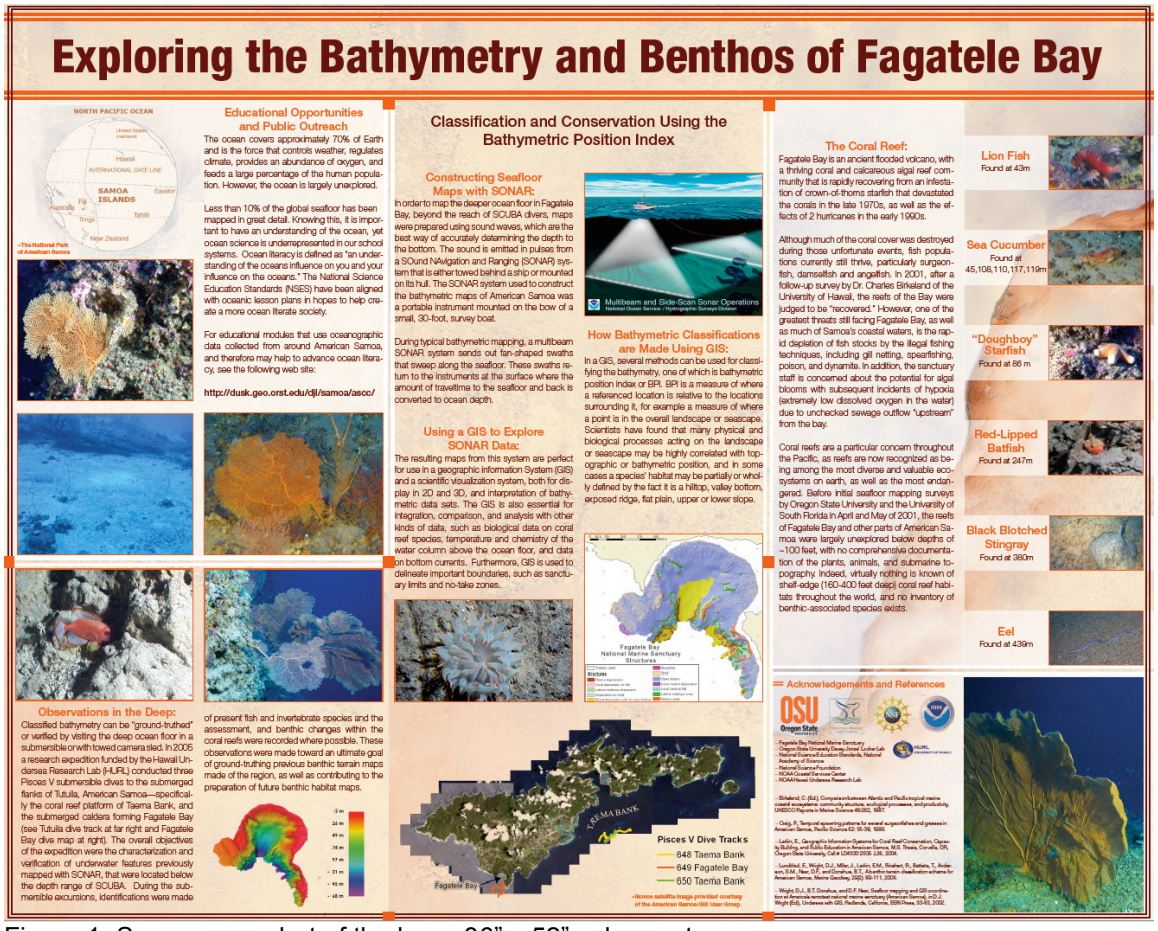
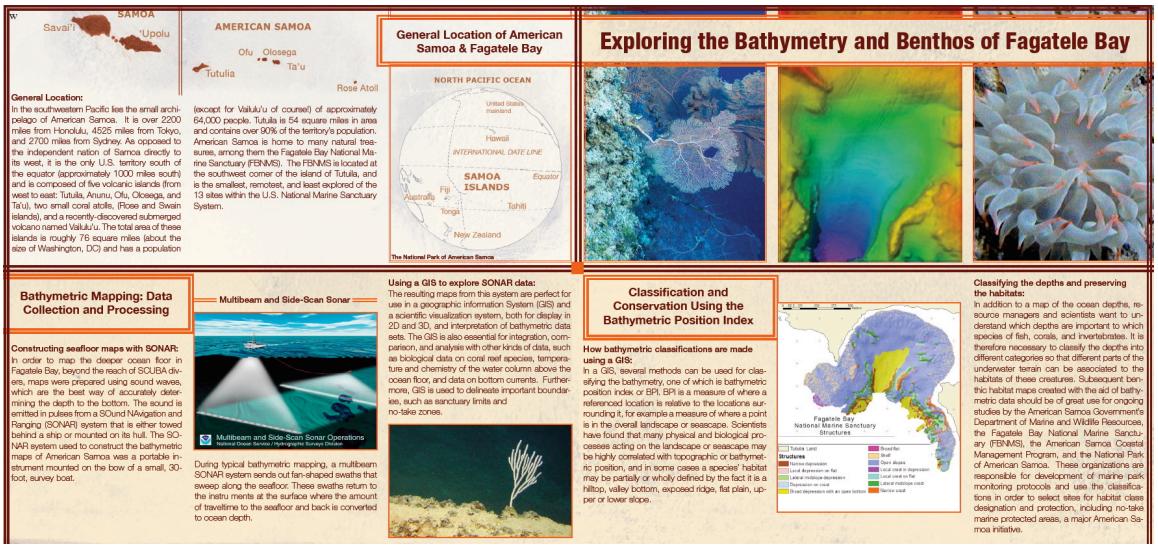
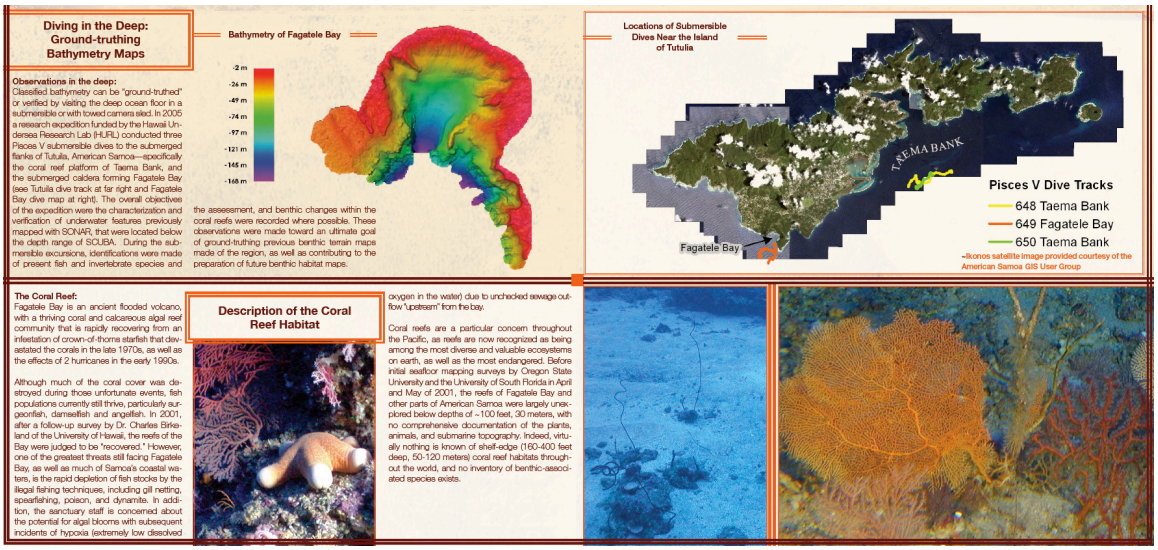


Figure 1. Screen snapshot of the large 36” x 52” color poster.


SAMOA
Savai'i
'Upolu
AMERICAN SAMOA
Ofu
Olosega
Ta'u
Tutuila
Rose Atoll
General Location of American Samoa & Fagatele Bay
NORTH PACIFIC OCEAN
Hawaii
INTERNATIONAL DATE LINE
SAMOA ISLANDS
Equator
Fiji
Australia
Tonga
Tahiti
New Zealand
The National Park of American Samoa
Exploring the Bathymetry and Benthos of Fagatele Bay
General Location:
In the southwestern Pacific lies the small archipelago of American Samoa. It is over 2200 miles from Honolulu, 4525 miles from Tokyo, and 2700 miles from Sydney. As opposed to the independent nation of Samoa directly to its west, it is the only U.S. territory south of the equator (approximately 1000 miles south) and is composed of five volcanic islands (from west to east: Tutuila, Aunu'u, Ofu, Olosega, and Ta'u), two small coral atolls, (Rose and Swain islands), and a recently-discovered submerged volcano named Vailulu'u. The total area of these islands is roughly 76 square miles (about the size of Washington, DC) and has a population (except for Vailulu'u of course!) of approximately 64,000 people. Tutuila is 54 square miles in area and contains over 90% of the territory's population. American Samoa is home to many natural treasures, among them the Fagatele Bay National Marine Sanctuary (FBNMS). The FBNMS is located at the southwest corner of the island of Tutuila, and is the smallest, remotest, and least explored of the 13 sites within the U.S. National Marine Sanctuary System.
Bathymetric Mapping: Data Collection and Processing
Constructing seafloor maps with SONAR:
In order to map the deeper ocean floor in Fagatele Bay, beyond the reach of SCUBA divers, maps were prepared using sound waves, which are the best way of accurately determining the depth to the bottom. The sound is emitted in pulses from a SOund NAvigation and Ranging (SONAR) system that is either towed behind a ship or mounted on its hull. The SONAR system used to construct the bathymetric maps of American Samoa was a portable instrument mounted on the bow of a small, 30-foot, survey boat.
Multibeam and Side-Scan Sonar
Multibeam and Side-Scan Sonar Operations
National Ocean Service / Hydrographic Survey Division
During typical bathymetric mapping, a multibeam SONAR system sends out fan-shaped swaths that sweep along the seafloor. These swaths return to the instruments at the surface where the amount of traveltime to the seafloor and back is converted to ocean depth.
Using a GIS to explore SONAR data:
The resulting maps from this system are perfect for use in a geographic information System (GIS) and a scientific visualization system, both for display in 2D and 3D, and interpretation of bathymetric data sets. The GIS is also essential for integration, comparison, and analysis with other kinds of data, such as biological data on coral reef species, temperature and chemistry of the water column above the ocean floor, and data on bottom currents. Furthermore, GIS is used to delineate important boundaries, such as sanctuary limits and no-take zones.
Classification and Conservation Using the Bathymetric Position Index
How bathymetric classifications are made using a GIS:
In a GIS, several methods can be used for classifying the bathymetry, one of which is bathymetric position index or BPI. BPI is a measure of where a referenced location is relative to the locations surrounding it, for example a measure of where a point is in the overall landscape or seascape. Scientists have found that many physical and biological processes acting on the landscape or seascape may be highly correlated with topographic or bathymetric position, and in some cases a species' habitat may be partially or wholly defined by the fact it is a hilltop, valley bottom, exposed ridge, flat plain, upper or lower slope.
Fagatele Bay National Marine Sanctuary Structures
Classifying the depths and preserving the habitats:
In addition to a map of the ocean depths, resource managers and scientists want to understand which depths are important to which species of fish, corals, and invertebrates. It is therefore necessary to classify the depths into different categories so that different parts of the underwater terrain can be associated to the habitats of these creatures. Subsequent benthic habitat maps created with the aid of bathymetric data should be of great use for ongoing studies by the American Samoa Government's Department of Marine and Wildlife Resources, the Fagatele Bay National Marine Sanctuary (FBNMS), the American Samoa Coastal Management Program, and the National Park of American Samoa. These organizations are responsible for development of marine park monitoring protocols and use the classifications in order to select sites for habitat class designation and protection, including no-take marine protected areas, a major American Samoa initiative.


Diving in the Deep: Ground-truthing Bathymetry Maps
Bathymetry of Fagatele Bay
-2 m
-24 m
-49 m
-74 m
-97 m
-121 m
-145 m
-168 m
Observations in the deep:
Classified bathymetry can be "ground-truthed" or verified by visiting the deep ocean floor in a submersible or with towed camera sled. In 2005 a research expedition funded by the Hawaii Undersea Research Lab (HURL) conducted three Pisces V submersible dives to the submerged flanks of Tutuila, American Samoa—specifically the coral reef platform of Taema Bank, and the submerged caldera forming Fagatele Bay (see Tutuila dive track at far right and Fagatele Bay dive map at right). The overall objectives of the expedition were the characterization and verification of underwater features previously mapped with SONAR, that were located below the depth range of SCUBA. During the submersible excursions, identifications were made of present fish and invertebrate species and the assessment, and benthic changes within the coral reefs were recorded where possible. These observations were made toward an ultimate goal of ground-truthing previous benthic terrain maps made of the region, as well as contributing to the preparation of future benthic habitat maps.
Locations of Submersible Dives Near the Island of Tutuila
TAEMA BANK
Fagatele Bay
Pisces V Dive Tracks
648 Taema Bank
649 Fagatele Bay
650 Taema Bank
~Ikonos satellite image provided courtesy of the American Samoa GIS User Group
The Coral Reef:
Fagatele Bay is an ancient flooded volcano, with a thriving coral and calcareous algal reef community that is rapidly recovering from an infestation of crown-of-thorns starfish that devastated the corals in the late 1970s, as well as the effects of 2 hurricanes in the early 1990s.
Although much of the coral cover was destroyed during those unfortunate events, fish populations currently still thrive, particularly surgeonfish, damselfish and angelfish. In 2001, after a follow-up survey by Dr. Charles Birkeland of the University of Hawaii, the reefs of the Bay were judged to be "recovered." However, one of the greatest threats still facing Fagatele Bay, as well as much of Samoa's coastal waters, is the rapid depletion of fish stocks by the illegal fishing techniques, including gill netting, spearfishing, poison, and dynamite. In addition, the sanctuary staff is concerned about the potential for algal blooms with subsequent incidents of hypoxia (extremely low dissolved oxygen in the water) due to unchecked sewage outflow "upstream" from the bay.
Description of the Coral Reef Habitat
Coral reefs are a particular concern throughout the Pacific, as reefs are now recognized as being among the most diverse and valuable ecosystems on earth, as well as the most endangered. Before initial seafloor mapping surveys by Oregon State University and the University of South Florida in April and May of 2001, the reefs of Fagatele Bay and other parts of American Samoa were largely unexplored below depths of ~100 feet, 30 meters, with no comprehensive documentation of the plants, animals, and submarine topography. Indeed, virtually nothing is known of shelf-edge (160-400 feet deep, 50-120 meters) coral reef habitats throughout the world, and no inventory of benthic-associated species exists.


Profile view of sea floor
Lion Fish
Found at 43m
The Lion-Fish Pterois volitans, belongs to the Scorpaenidae family. The species is often found in shallow waters hovering in caves or near crevices. The Lion Fish have enlarged pectoral fins and elongated dorsal fin spines. This species uses its large fins to corner its prey before swallowing it whole. In addition, their spines contain venom that produces an immediate adverse reaction in the Lion-Fish's predators when punctured. In humans the side effects include rapid swelling of the punctured area, nausea, breathing difficulties, paralysis, convulsions, and even death in exceptional circumstances.
Sea Cucumber
Found at 45,108,110,117,119m
The sea cumber is an echinoderm, belonging to the class Holothuroidea. They are oblong in shape and many look like brightly-colored garden cucumbers. They have five rows of tube feet running lengthwise. At the oral end of the sea cucumber, there are specialized tube feet used as tentacles to capture food. Unlike other echinoderms, it has its own body fluid; therefore there is no direct interface between the sea water and the internal organs of the animal. Sea cucumbers are found at a variety of ocean depths. In American Samoa they are often found lying on their side, usually in the sandy shoals. The sea cucumber is a benthic scavenger that protects itself when threatened by expelling poison, parts of its intestine, or a non-toxic sticky substance.
"Doughboy" Starfish
Found at 86m
This sea star, Choriaster granulatus, more commonly referred to as Doughboy, is in the class Asteridea. Doughboy moves by suctioning seawater into the system of canals at the center of its body; it then changes the pressure by circulating the water through its vascular system. This allows its feet to move in a wave-like manner. This class of sea stars is carnivorous, feeding on a wide variety of invertebrates by injecting its prey with digestive juices before engulfing the digested prey directly into its stomach. Its choice of prey includes sessile mollusks, and all forms of soft and stony corals. Due to their predatory nature, these sea stars can cause significant damage to the coral reef.

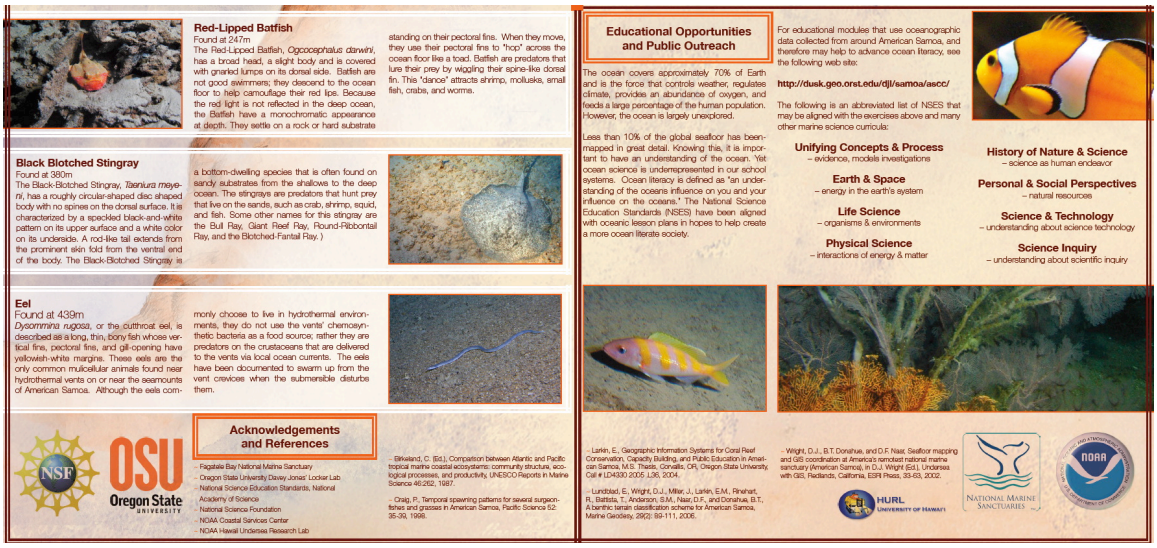


Figure 2. Screen snapshots of parts 1-4 of the 8" x 12" brochure.

Five copies of the poster and 150 copies of the brochure were sent to FBNMS for their use and for distribution to the American Samoa GIS User Group, the American Samoa Community College and local high schools.

(3) Glossy, finalized copies of education modules that had been initially developed in the summer of 2004 but now included updated instructions using the new Benthic Terrain Modeler ArcGIS extension, jointly developed by OSU and the NOAA Coastal Services Center. Seven copies of the educational modules were sent to FBNMS for delivery to the American Samoa Community College (as the intended audience for those modules is the community college student or resource management professional).

And by "professional" we mean the researchers, managers, and instructors, who attended our summer 2004 workshop, from the American Samoa government's Department of Marine & Wildlife Resources, the American Samoa government's Department of Commerce, Coastal Zone Management Program, the American Samoa Community College, and the FBNMS education coordinators. These agencies are also part of the broader American Samoa GIS User Group. The modules are focused on the benthic habitat characterization methods that we have used with recently collected multibeam bathymetry, and can also be used for marine protected area designation. This will enhance the capacity to manage these ecosystems because these are actual maps of the physical habitat of the ecosystem. The bathymetry that we have collected is all from the coral, not the rocky substrate that the coral sits upon (we know this from prior snorkeling and SCUBA that we have done ourselves). In other words, our data and maps show the depths determined from reflections of acoustic pulses from the coral reefs themselves, and therefore represent the roughness and complexity of the different species of coral. The modules guide the user in how to understand the bathymetric data, but also how to move to the next step of actually classifying the coral into different categories of benthic habitat (fish, invertebrates, algae),

habitat that needs to be monitored and protected further into no-take or no-visitation. So the primary management activity is marine protected area designation (in addition to FBNMS and the National Park of American Samoa, or different types of protection within these existing reserves). This is especially critical in the wake of the aftermath of Cyclone Olaf.

Additional copies of brochure, poster or education modules were not produced because the color copy charges would have exceeded the amount of funds available in the grant. But **additional copies can always be downloaded from my web site at http://dusk.geo.orst.edu/djl/samoa/ascc.**

(4) One solid plaster-of-paris terrain model of FBNMS bathymetry as produced by project partner Dr. Mike Bailey of OSU Computer Science (http://web.engr.oregonstate.edu/~mjb/WebMjb/ mjb.html) using stereolithography and laminate object-modeling techniques. We had repeatedly requested 4 additional copies for use in local high schools and by the American Samoa GIS User Group and Coral Reef Task Force. Dr. Bailey agreed to produce the four copies but never responded to repeated queries as to when we might ever receive them. His machine repeatedly broke down in 2006 and early 2007, but in mid-to-late 2007 he just stopped responding to emails, phone calls, and reminder notes, which was extremely disappointing. In the end, the one draft solid terrain model that we sent to FBNMS in the summer of 2006 ended up being the only model that we could provide to the American Samoa community.

On July 20, 2007 I received an email from new FBNMS Education Coordinator Manda Amituanai (Manda.Amituanai@noaa.gov), requesting permission to include materials from our project in packets for high-ranking officials attending the U.S. Coral Reef Task Force Meeting in American Samoa, August 20-23, 2007, and was pleased to assist.

Resulting Impact of Project

The project has enjoyed broad support by the American Samoa coastal management community via the FBNMS and the American Samoa GIS User Group. I hope that the materials produced by the project will continue to be useful. OSU still has a formal memorandum of understanding in place with the American Samoa GIS User Group to pursue projects such as this one, which will continue to aid the FBNMS and the user group in village outreach programs (Coast Week, Arbor Week, Earth Day, GIS Day, etc.), in professional development for government agencies, and in their work with U.S. Coral Reef Task Force. In addition we greatly anticipate the deliverables being used effectively at Tafuna High School (oceanography class of Ms. Telesia Mauigoa)

and Leone High School (marine science class of Mr. Wayne Salavea, djsala2@yahoo.com).

NOAA has stated that increasing participation by under-represented minorities, as well as women, in the fields of GIS and remote sensing of coastal environments is a top priority. This project has contributed to that objective, with the participation of a woman graduate student, a woman-of-color PI, and with our focus on the Polynesian communities in American Samoa. A diverse workforce is absolutely vital to ensure the future economic and cultural sustainability of marine resources and communities. The continuing low level of matriculation of minority students (i.e., African-American, Native American, Latino/Hispanic and even Pacific Islanders) into the marine sciences (including coastal resource management), as well as geographic information science has significant implications for these professions, not least of which is the intellectual health and vitality of the disciplines.