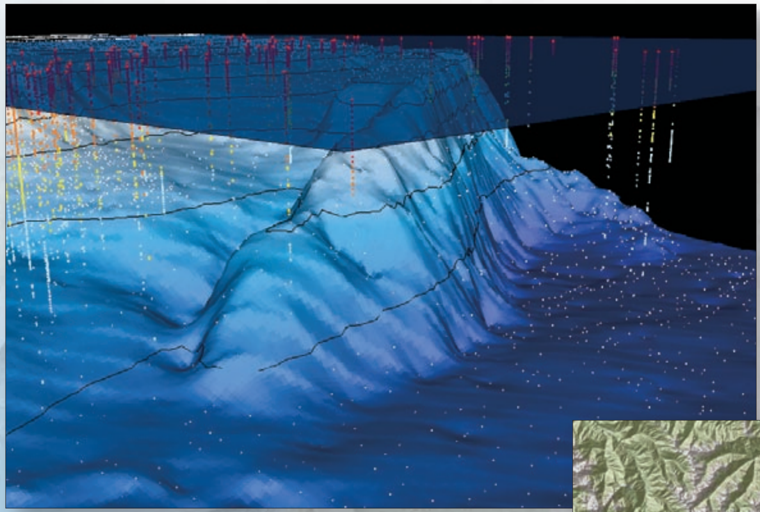
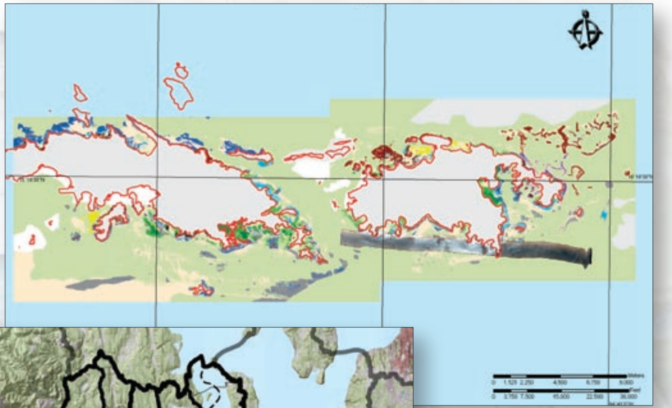
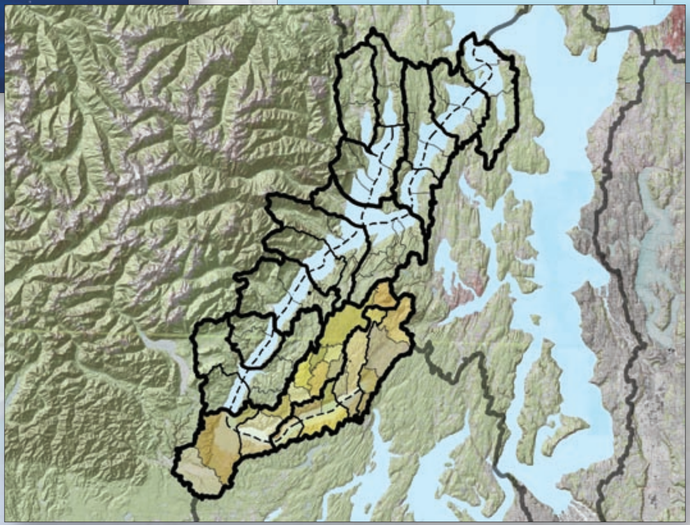
GIS Best Practices

GIS for Ocean Conservation







December 2007

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What Is GIS?

Making decisions based on geography is basic to human thinking. Where shall we go, what will it be like, and what shall we do when we get there are applied to the simple event of going to the store or to the major event of launching a bathysphere into the ocean's depths. By understanding geography and people's relationship to location, we can make informed decisions about the way we live on our planet. A geographic information system (GIS) is a technological tool for comprehending geography and making intelligent decisions.

GIS organizes geographic data so that a person reading a map can select data necessary for a specific project or task. A thematic map has a table of contents that allows the reader to add layers of information to a basemap of real-world locations. For example, a social analyst might use the basemap of Eugene, Oregon, and select datasets from the U.S. Census Bureau to add data layers to a map that shows residents' education levels, ages, and employment status. With an ability to combine a variety of datasets in an infinite number of ways, GIS is a useful tool for nearly every field of knowledge from archaeology to zoology.

A good GIS program is able to process geographic data from a variety of sources and integrate it into a map project. Many countries have an abundance of geographic data for analysis, and governments often make GIS datasets publicly available. Map file databases often come included with GIS packages; others can be obtained from both commercial vendors and government agencies. Some data is gathered in the field by global positioning units that attach a location coordinate (latitude and longitude) to a feature such as a pump station.

GIS maps are interactive. On the computer screen, map users can scan a GIS map in any direction, zoom in or out, and change the nature of the information contained in the map. They can choose whether to see the roads, how many roads to see, and how roads should be depicted. Then they can select what other items they wish to view alongside these roads such as storm drains, gas lines, rare plants, or hospitals. Some GIS programs are designed to perform sophisticated calculations for tracking storms or predicting erosion patterns. GIS applications can be embedded into common activities such as verifying an address.

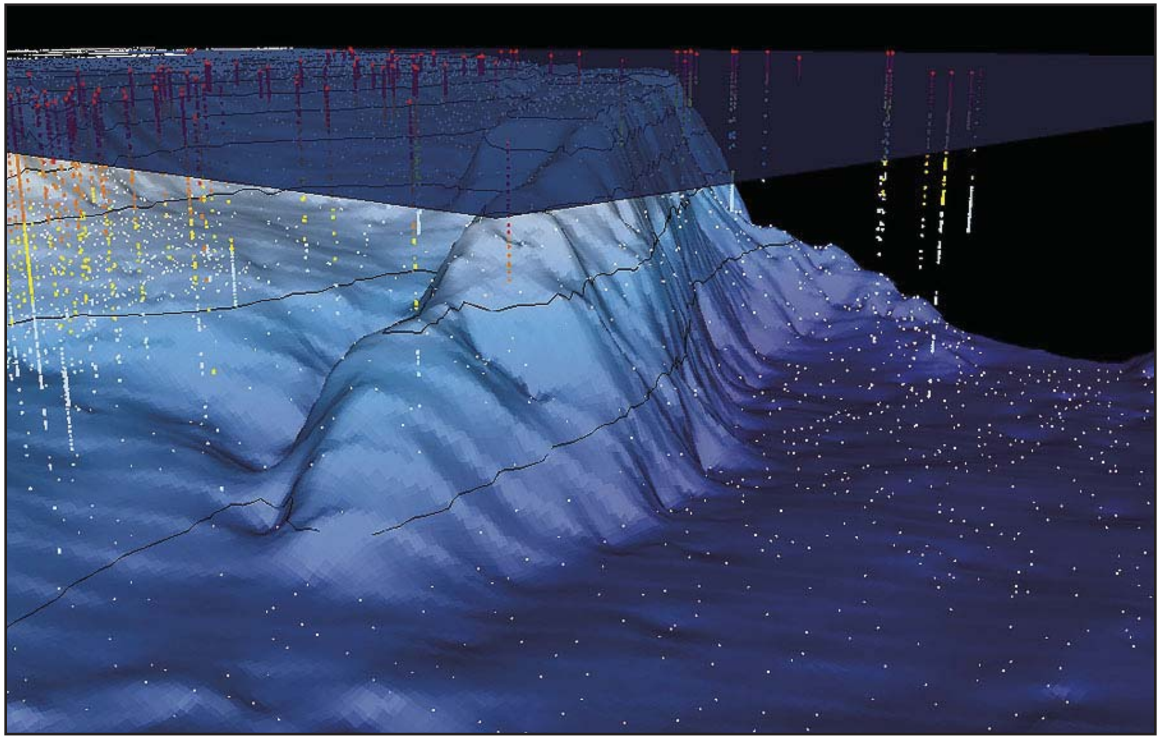
From routinely performing work-related tasks to scientifically exploring the complexities of our world, GIS gives people the geographic advantage to become more productive, more aware, and more responsive citizens of planet Earth.

GIS for Ocean Conservation

Marine habitats and the life they contain are threatened by global warming, extreme weather, natural and man-made pollution, overharvesting, and additional human disturbances. GIS technology is a tool that helps conservationists acquire, manage, analyze, and visualize spatial and thematic oceanic data through map generation. It is used around the world to map marine habitats; water quality; species distribution, population, and behavior; pollution; fishing grounds; and other factors that impact marine life. ESRI's ArcGIS software suite is a tool that can show at-risk areas in danger of biodiversity loss, habitat degradation, and resource depletion. It also acts as an aid in monitoring and examining the effectiveness of conservation practices and protected areas to ensure the preservation of the earth's oceans.

Mapping Benthic Habitats; The Marine GIS Challenge

Mapping the seafloor is getting easier, but finding the data is still sometimes like hunting for an octopus in a coral reef. Hard-bottom and reef regions of the marine ecosystem provide essential habitat for a wide variety of marine species, including sea turtles, lobsters, and an abundant array of fish and invertebrates. The effects of commercial and recreational fishing, as well as other anthropogenic pressures, can threaten and change the long-term viability of fish populations. Study and management of these effects are problematic because of the difficulties involved in assessing fish population size and flux.



Creating a seafloor or bathymetry from a collection of soundings is usually one of the steps toward representing the marine environment. The California Cooperative Oceanic Fisheries Investigations have been collecting data of the water column since 1949, providing one of the longest existing time series data collections of the physics, chemistry, and biology of the dynamic oceanic regime. This has proven to be a useful prototype database to test the capabilities of the Marine Data Model and visual representation with the ArcGIS 3D Analyst extension.

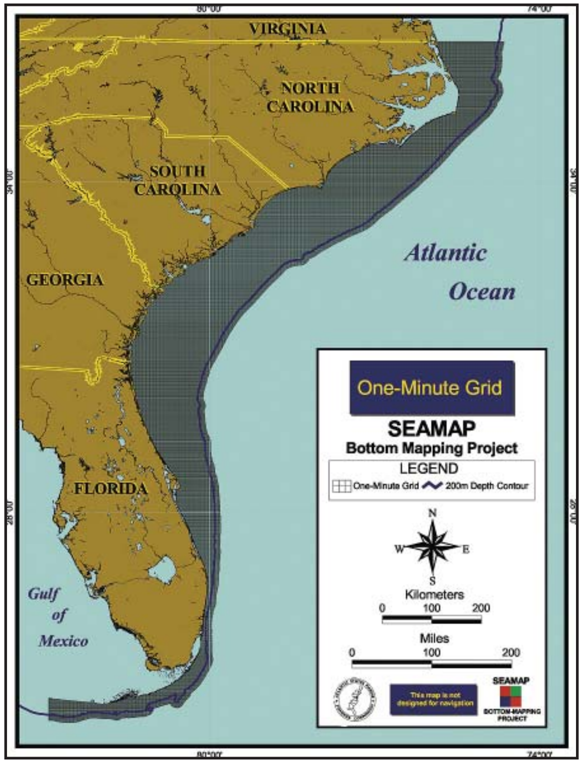
The influence of human activity, including the damaging effect of anchors, trawling, the use of explosives for fishing, and large amounts of runoff and coastal pollution, has measurable negative effects. Knowledge of the location and extent of critical habitat allows researchers and managers to track more accurately the effects of fishing and, thus, more effectively protect essential areas. This knowledge is crucial to the protection of reef-type habitats and the practice of sustainable fish harvesting. But how is critical habitat determined? And once the assessment has been made that a marine habitat supports enough biodiversity to be considered critical, how can the seafloor be mapped using GIS?

Assessing Benthic Complexity

Many studies have tackled the question: What makes a seafloor livable? One of these studies from the work of Jeff Ardron of the Living Oceans Society, Sointula, British Columbia, Canada, shows that the physical complexity of the seafloor is a determining factor. A complex seafloor rich with features that contribute to the terrain is more likely to harbor life-forms of all shapes and sizes. These heterogeneous habitats that support multiple life-forms are often associated with species richness. The slope of the terrain; its relief; and, most important, its complexity are all contributing factors to measuring the likelihood of multiple species habitation. Raster calculation tools in the ArcGIS Spatial Analyst extension in conjunction with ArcInfo are used to perform analysis on ecological distribution, and the resulting layers are new information derived from the data of the original bathymetry.

The bathymetric layer in GIS usually starts as a large set of points. These points are collected most often using multibeam echo soundings or side-scan sonar devices. To the marine GIS user, the resulting data generated by soundings is simply a set of x,y,z coordinates, and rather simple ones at that, because they only have one associated z value for each x,y and usually occur at one instance in time. From the table of x,y,z values, a set of points can be created; with this set of points, the interpolation begins.

With databases now storing tens of millions of points from echo sounding surveys, the challenge begins with the need for mass point data storage, a rapid update of newly surveyed points, and the visual display and representation of the surface created from the points. The points are usually a dense set of dispersed known values. The interpolation tools that can be found in the ArcGIS Spatial Analyst extension give the user the ability to predict values that are then assigned to all other locations on a cell-by-cell basis. Input points can be either randomly or regularly spaced or based on some sampling scheme; in the case of echo sounding data, it is most often a track line created by the sounding device, or fish.



The southern U.S. Coast Guard uses fine scale mesh grids to quantify oceanographic phenomenon in ways that enable further GIS application.

Creating the Seafloor

Surface interpolation functions create a continuous, or prediction, surface from sampled point locations, generating a raster data set with values for all the cells whether a measurement has been taken at the location or not. There are many ways to derive a prediction surface using a variety of calculations and different assumptions that are made of the data. Inverse Distance Weighted and Spline are two of the methods used to assign values to locations based on the surrounding measured values, using mathematical formulas that determine the smoothness of the resulting surface. There are also geostatistical methods found in the ArcGIS Geostatistical Analyst extension, such as kriging, which is based on statistical autocorrelation or the statistical relationship between the points. By kriging, users have the capacity to produce not only the prediction surface but also a measure of confidence in the accuracy of the predictions. The resulting bathymetric surface is often only the beginning of the layers that are added to the marine GIS.

Important to the overall process of creating a valid "seascape" is having a well-designed data model. The Bottom-Mapping Workgroup of the Florida Marine Research Institute (FMRI) developed a format for survey data covering the South Atlantic Bight (SAB) database, prior to beginning data collection by the National Marine Fisheries Service and South Atlantic Fisheries Management Council. Historical sources were then identified, analyzed, and considered for inclusion in the SAB database. Protocols for determining positional accuracy and deducing bottom type, based on the type of gear and the method used in collecting each sample, were established. Gear types and methods used in these historical surveys included side-scan sonar, vibra core, aerial photography, dredge, trawl, and trap. The work group also established protocols for tabulating the various data sources and relating them to the primary bottom records.

This process resulted in an effective protocol for determining the locations of hard-bottom habitat: examination of trawl and trap data for the presence of those fish species considered to be indicators of the presence of reef-type habitat. To further complicate the issue, several species are known to use different habitats at different life stages. For example, many species will use grass beds or pelagic habitats as nursery areas but are considered reef species as adults.

Marine data and the resulting ArcGIS 3D Analyst (ArcScene and ArcGlobe) visual representation can range from the standard point, line, and polygon models to a more complex combination of images and seafloor rasters and a corresponding wire frame or "fishnet" mesh. Each transect and the related data collected in a marine survey, in addition to the sonar, and other observation data can be used to assign a bottom type to the grid cell. A reef or hard-bottom assemblage may intersect several raster grid cells while each transect, or area, maintains its identification as a single entity in the database. The result is an expansive grid of one-minute cells covering SAB, with each cell recording the number of data records and bottom type that occurred within the cell and, through the database, tying back to the original data source. Once the modeling of a database for seafloor parameters has been achieved, the architecture and design of a solution to the continual updating of the database with dynamic multidimensional data are the next challenges.

(Reprinted from the Spring 2005 issue of *ArcNews* magazine)

Kenya's Kiunga Marine National Reserve Studies Sustainable Fisheries and Marine Conservation With GIS

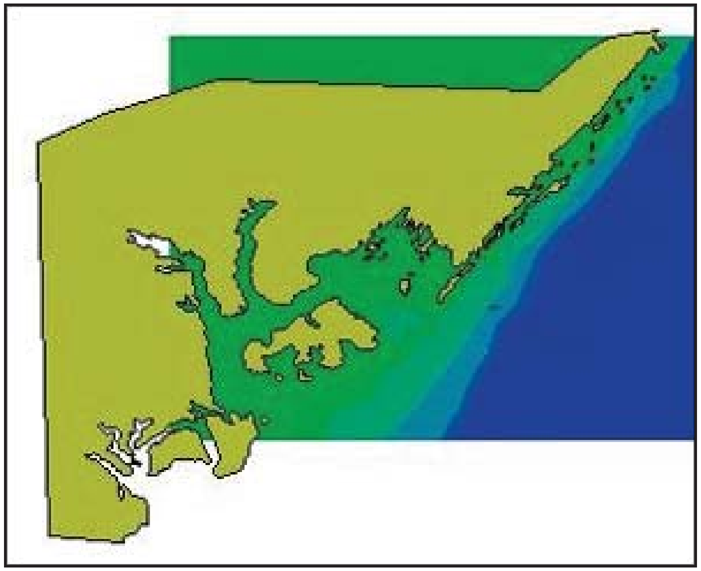
World Wide Fund for Nature Effort Focuses on Coastal Ecosystem

The Kiunga Marine National Reserve, on Kenya's northern coast, protects outstanding mangrove forests, sea grass beds, and coral reefs. Its beaches provide nesting sites for marine turtles, and its sea grass beds provide feeding grounds for the enigmatic dugong. Its offshore rock formations shelter bat roosts and support the world's largest nesting colony of roseate terns, and sharks, rays, whales, and dolphins are found further out to sea. Tidal creeks, limpid lagoons, and towering dunes enrich the landscape.

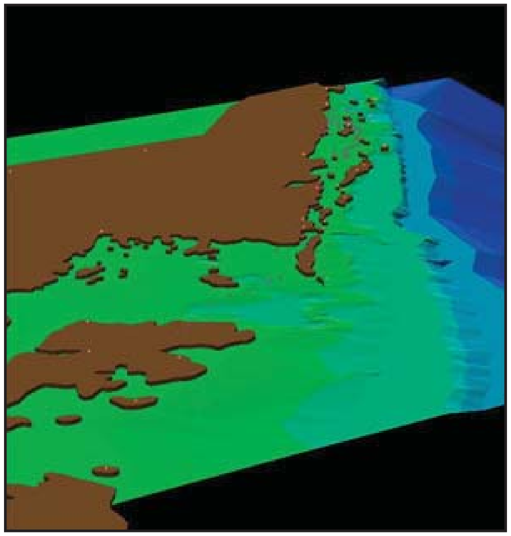
Much of Kenya's coast has experienced rapid human population growth, spiraling demand for marine resources and unplanned development. Unregulated harvesting of fisheries and forests have outstripped rates of natural renewal, while discharges of domestic and industrial waste have overwhelmed the capacities of intertidal wetlands to absorb, dilute, and detoxify effluents.

The Kiunga Reserve has survived intact mainly because of its remoteness. Most of the Bajuni people living around the reserve earn their living from fishing. Traditionally they used woven traps to catch reef fish in shallow waters. Mzee Abbas is one of the few remaining practitioners of this technique. "I've always used the uzio and malema traps and can't see the need to change," he says.

But most fishermen today use highly effective-and destructive-seine nets, which catch all fish size classes indiscriminately and damage corals and sea grass beds. Larger meshed gill nets are also used-though less damaging to the substrate, they entangle and drown turtles and dugongs.



Using topographic maps and bathymetric information from nautical charts, ArcView's 3D Analyst was used to produce 3D representations. 3D visualization of the reserve helps in understanding the dynamics of the fishery.



Kiunga's lobster divers use the kimia technique, in which the fisher spears an octopus and ties it to his spear. Lobsters shelter in the reefs in holes with an exit route, so the diver places his hand net over the back door and waves the octopus at the front-the lobster heads for the emergency exit and ends up in the net. Increasingly smaller lobsters are being taken on the reefs.

Kiunga's lobster fishery supplies much of Kenya's demand. Large lobsters may attain weights of 6 kg, but concerns are emerging about sustainability.

External pressure is intensifying in Kiunga. Sixty percent of users come from outside the reserve, and there is growing demand from commercial outfits interested in "mining" the fishery. Habitat damage and declining catches already are apparent. Left unchecked, they will diminish the biological value of the reserve and impoverish the people most dependent on it.

Fisheries Management Strategy in Kiunga

A fear expressed by Kiunga fishers is that "effective management of the fishery" means "reduced income for fishermen." To address these concerns, World Wide Fund for Nature (WWF) is facilitating a joint effort with all stakeholders toward

- Objective appraisals of the fishery in biological and socioeconomic terms
- Clear identification of threats to fishery sustainability
- Agreements on management interventions needed for sustainability

- Pilot testing of interventions
- Monitoring to track the performance of the interventions
- Mechanisms to disseminate information to all the stakeholders

Development of the WWF Kiunga GIS

WWF-trained community monitors have been collecting data on fish and lobster harvests since 1998, but financial constraints hampered the project's ability to use the accumulated data. Now a Microsoft Access database is being developed to manage the data. This provides the flexible automated analyses to explore the key issues of concern.

Having had previous experience with the applicability of ArcView and its extensions to natural resources management and protected area planning, the Kiunga Reserve and the WWF selected ArcView to augment the fisheries database. The GIS role is to communicate outputs from the fisheries database. Connectivity between ArcView and Access is therefore an important asset, simplifying the process of linking spatial features and related attribute data. The level of use is very simple-with everything on one PC, the WWF Kiunga relies on ArcView SQL Connect and database table linking/joining to access fisheries data in the database.

Today most fishermen in Kiunga operate using unmotorized sailboats or dhows.

WWF Kiunga has used ArcView Image Analysis to manipulate and georectify graphical background themes and employed ArcView 3D Analyst to create and view TINs that provide a conceptual three-dimensional representation of the fishery. Themes include the basic outlines of coastal and island landforms, key locations and fishing grounds, and tracks and seafloor contours. Data was sourced from topographical maps, nautical charts, scanned graphics, and GPS. In addition, the ArcView Spatial Analyst extension includes the necessary tools to help investigate the relationship between physical features and aspects of species ecology and fishery production. Together, these extensions ease the process of incorporating and manipulating remotely sensed raster data such as aerial and satellite imagery.

Any fisheries data analyses with a spatial element (e.g., catch per fishing ground, relations between habitat health and gear use) can be linked to the GIS. This is helpful for presentations at fisheries management meetings-displaying such relationships on maps makes them more explicit. For all audiences, it helps if the results can be fit to a mental map-the "yes, but where is it?!" factor-that satisfactorily clarifies the issues. The process of development of resource maps is an excellent way of involving local fishers in planning resource use.

GPS work provides ground control points with which WWF Kiunga can refine and classify landscape themes and complete data on fishing grounds, or imbos. From May through September the southeast monsoon makes offshore conditions too rough for small craft, so WWF Kiunga concentrated on mapping imbos lying within the reefs. These were sheltered from the open sea but still experienced tumultuous surf-quite a distraction to survey work for those more used to dry land! Back on terra firma, GPS data is downloaded via Garmin's MapSource program and then converted to point shapefiles with ArcView software's AddEventTheme protocol.

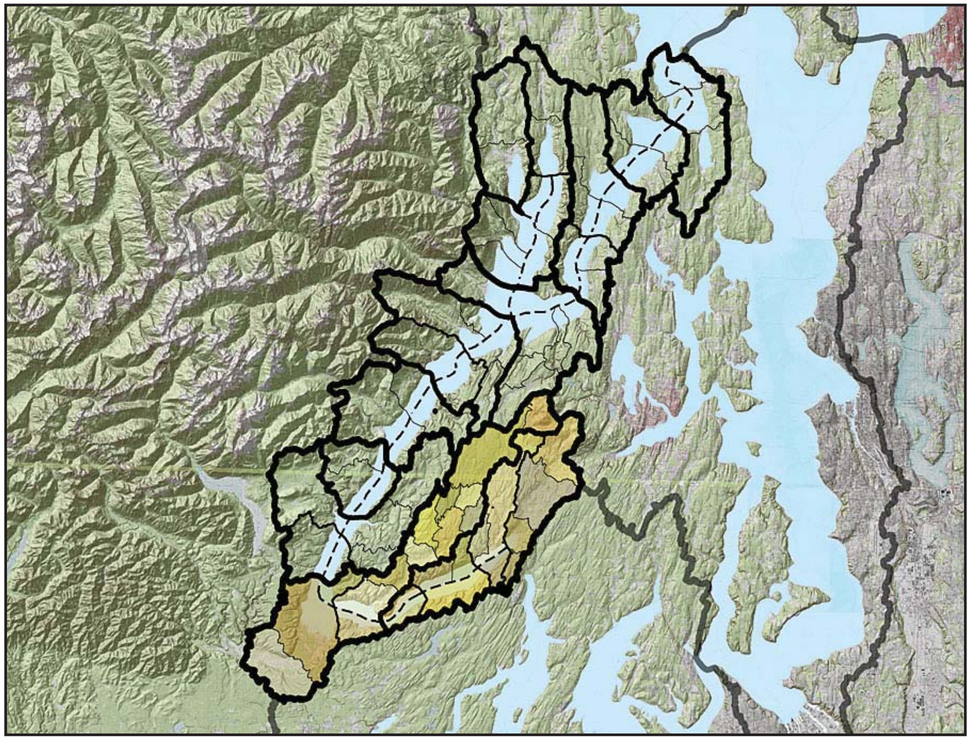
The GIS will permit increasingly revealing spatial analyses of the ecology of the reserve. Obvious options are habitat associations, occurrence maps, and ranging models for species of concern (using ArcView Spatial Analyst), detailed maps of sensitive sites, sampling sites, and habitats under restoration. The GIS could also be used to undertake change assessments of the productivity of fishing grounds, coral reefs, recovering habitats, and nesting beaches.

(Reprinted from the Winter 2002/2003 issue of *ArcNews* magazine)

For Puget Sound, Washington, GIS and Modeling Are Protecting and Restoring Shorelines and Open Spaces

Listening to the Land—The Role of GIS in Protecting the Intrinsic Landscape

The landscape has a "voice," and it needs to be heard. Its intrinsic assets stand there, such as Garfield Mountain on the Middle Fork of the Snoqualmie River in western Washington state, but they are not usually given standing. Every region of the country has its own intrinsic landscape forms that define its scenic character and contain its cultural heritage (in other words, the spirit of the place). Many conservation organizations are realizing that by cataloging the voice of the landscape, they can make an enormous difference in their efforts to protect Puget Sound.



The watersheds of the Hood Canal region of Puget Sound.

Seattle is just one river delta city on the shores of an immense estuary called Puget Sound, the second largest estuary in the United States, two-thirds the size of the Susquehana's Chesapeake Bay. Puget Sound extends from Olympia through Tacoma past Seattle to Everett, to Bellingham, and on to Vancouver, B.C. It is fed by hundreds of rivers and has thousands of coves and bays of islands forming its many saltwater basins. It has more than 1,000 miles of shoreline reaches that are distinctly different from each other. Each subregion has its own extraordinary scenic resources, and, together, it's a huge watershed.

Groups, such as the Trust for Public Land (TPL), are recognizing the value of listening to Puget Sound to identify the landscape resources that define the identity of each region of the sound and how people value each one. During a meeting with the conservation planning team, Roger Hoesterey, Northwest regional director for TPL, states, "You can do all the science you want, but the only proposal approved is the one whose local delegation is telling its representatives what's important to them. So if you don't ask the local people what's important to them, what they care about, and why they go to a particular region—whether it's to see the view, the beaches, the clams, or the mountain cliffs—you won't get anywhere. Ask them: 'Did you know this is the last sandpit, the biggest lagoon, and the highest mountain face in your subregion and it's got access, but it's not publicly owned?' Turn it into a compelling story with GIS."

In 2003, TPL engaged Jones & Jones, a landscape architecture, environmental planning, and architecture firm in Seattle, to help it strategize on how to better protect Puget Sound and identify acquisition priorities. Called the Greenprint for Puget Sound, the project is a vision for the Puget Sound watershed with the goal of protecting and restoring the shorelines and open spaces of the sound's eight distinct regions. In the past, the two organizations had worked together on other projects in Puget Sound, such as the San Juan County Open Space Plan and the Mountains to Sound Greenway because of a mutual love of nature and an appreciation for the intrinsic landscape.

TPL and Jones & Jones understood that the Puget Sound landscape has its own signature landforms—characteristic vegetation forms, highly visible wildlife forms, and landmark built forms—that, together, make up a cultural landscape of scenic or aesthetic quality. These landforms are the signature physiographic and landscape features that represent exceptional aesthetic resources and can be better protected. Both organizations realized that better decisions for protecting Puget Sound could be made by using GIS to "listen to the land."

Jones & Jones found that ArcGIS 9 Desktop and its included ModelBuilder application are the ideal tools for rapidly cataloging intrinsic landscape resources and determining signature landscapes, which they built into a model called the Intrinsic Landscape Aesthetic Resource Information System (ILARIS). The ILARIS model consists of 40 ModelBuilder submodels and three Python scripts organized into seven ArcGIS Desktop toolsets. Together, all the ModelBuilder models inform a decision-support framework to allow the presence, quantity, and visual properties of different intrinsic landscape forms to be captured and the significance of these forms to be identified, as well as the cumulative effect of the viewshed and the relative uniqueness of Puget Sound's landscapes. ILARIS included peer review and technical guidance from ESRI; California State Polytechnic University, Pomona; the Ohio State University; the University of Minnesota; and the University of Texas, Austin.

In the end, projects that listen to the land, such as the Greenprint for Puget Sound, better identify and prioritize which landscapes are most conducive for protection. By understanding the intrinsic landscapes and shorelines that people value the most, groups such as TPL can use GIS to help reconnect communities to the water and the land.

(Reprinted from the Winter 2005/2006 issue of *ArcNews* magazine)

CASI Data Provides Better Picture of Coral Reef Threats

By Michael Plakos, GEOMAR Research, Inc.

Written for the Khaled bin Sultan Living Oceans Foundation

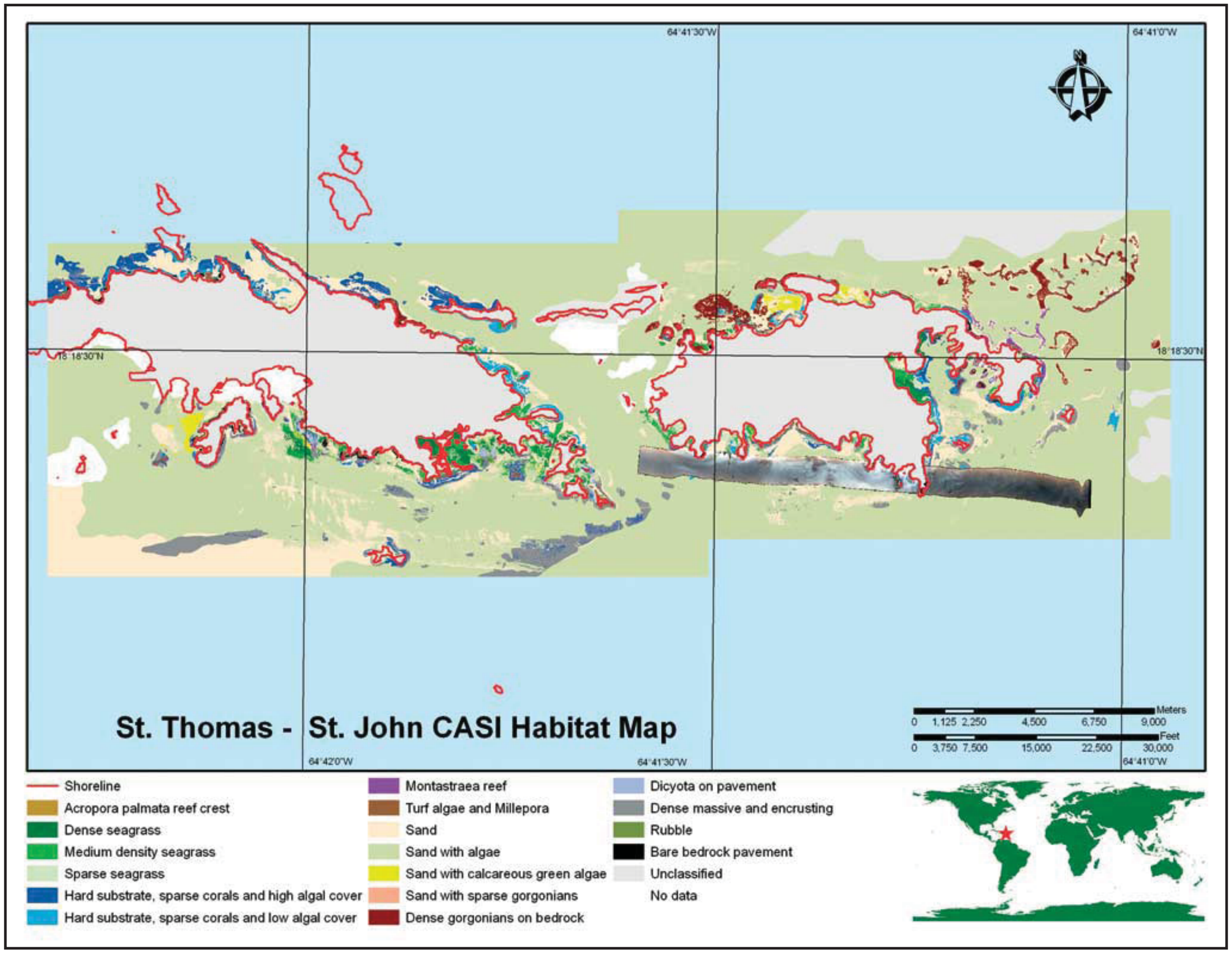
Data from a programmable imaging spectrograph, captured as part of a mapping program sponsored by an ocean conservation organization, is helping researchers better understand threats to the health of coral reefs in the U.S. Virgin Islands (USVI) and elsewhere.

The Khaled bin Sultan Living Oceans Foundation (LOF) sponsored the program. LOF is a 501(c)(3) nonprofit organization dedicated to the conservation and restoration of living oceans. The effort, carried out by Dr. Peter Mumby of the University of Newcastle upon Tyne, United Kingdom; LOF; the U.S. National Park Service; and Hyperspectral Data International (HDI) of Halifax, Nova Scotia, mapped more than 41,000 hectares (101,313 acres) of the waters surrounding St. John and St. Thomas with a Compact Airborne Spectrographic Imager (CASI) mounted in an amphibious Cessna 208 Caravan aircraft. CASI is a product of ITRES Research Limited.

Although coral reef ecosystems occupy less than one quarter of 1 percent of the marine environment, they provide refuge for a quarter of the world's marine species. Among the most biologically diverse, oldest, and species-rich ecosystems on earth, coral reefs are often referred to as the rainforests of the marine world.

Coral reefs play an important role in the coastal environment and provide many benefits to mankind. The diverse and abundant species living in coral reefs produce chemicals used in medicines and medical research. Reefs also form natural barriers that protect nearby shorelines from the eroding forces of the sea. Currently one of the endangered ecosystems on the planet, coral reefs are most threatened by land-based pollution and overfishing. At the present rate of destruction, 70 percent of the world's coral reefs will be killed within our lifetime.

To help reduce, and possibly reverse, this astonishing rate of destruction, LOF, Mumby and his team at the University of Newcastle, and the U.S. National Park Service collected multispectral imagery using a CASI spectrometer over waters surrounding St. John and St. Thomas. This data will help researchers better understand local ecological and disturbance factors. These insights could be expanded regionally and globally. This data has been distributed to the recipients initially targeted. LOF is now trying to reach a much wider audience by using ArcGIS to integrate the data and serve it to remote users using ArcIMS.



CASI Imagery

Coral reefs are dynamic and are affected by environmental changes, both natural and man-made. Understanding changes in an extremely localized environment may be possible by using conventional methods such as underwater video and direct observation. Changes that have occurred on a larger scale and have had a greater impact are much more difficult to study. In recent years, technologically advanced instruments and methods for studying coral reefs have been developed. An increasing number of researchers are turning to remotely sensed imagery from satellites and aircraft equipped with advanced imaging sensors.

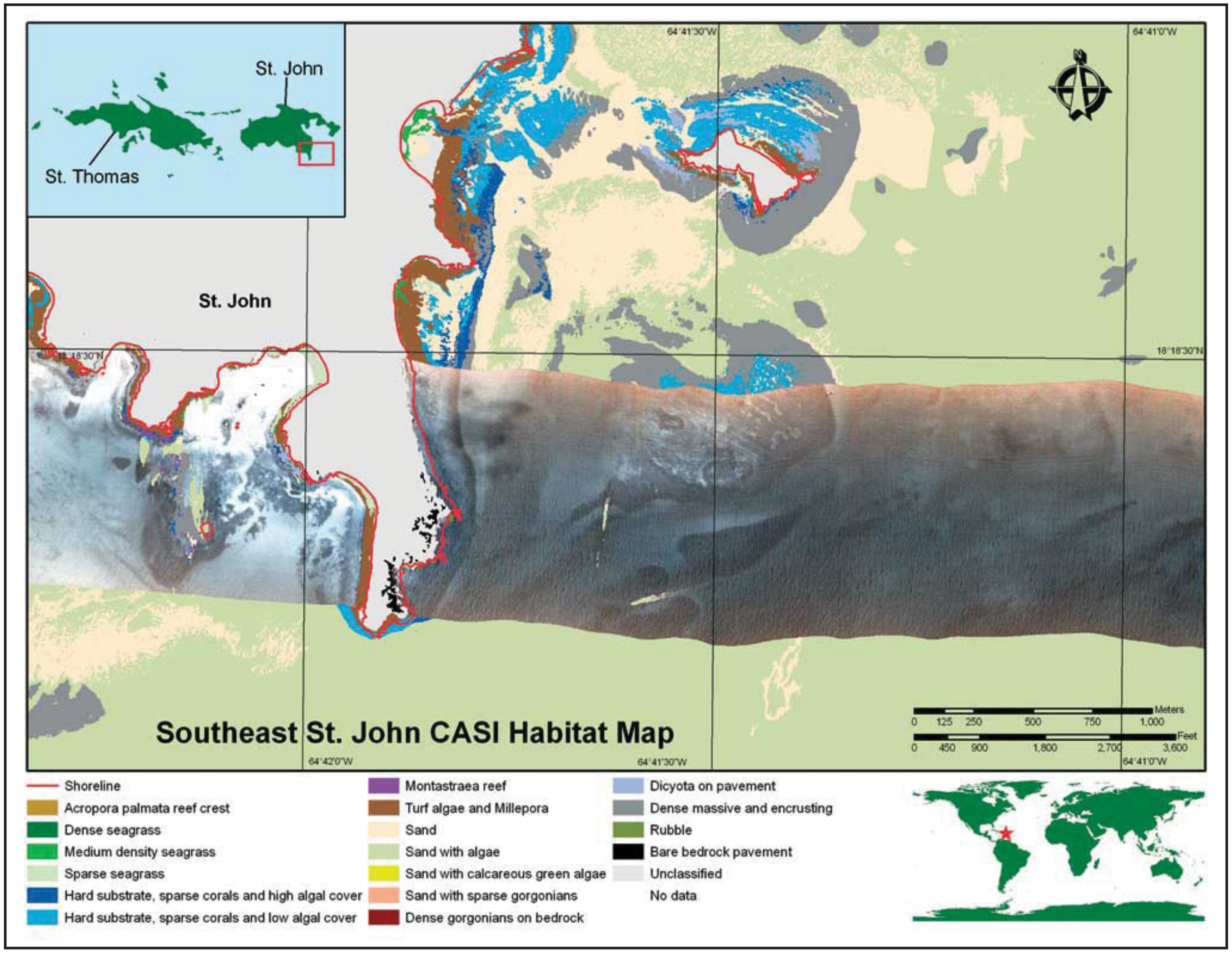
CASI imagery, while not as widely known as Lidar, aerial photography, and satellite imagery, has proven extremely useful, especially in recent years. A CASI spectrometer can measure radiation with as many as 288 spectral bands at user programmable intervals from 400 to 1,000 nanometers of the electromagnetic spectrum. Essentially, CASI imagery combines the digital multispectral capability of satellite imagery and the high spatial resolution of aerial photography.

Satellite imagery typically offers 15- to 30-meter resolution and cannot be used to distinguish detailed reef structure. As light attenuates through the water column, the ability to distinguish features with increasing depth is severely hampered, a common limitation with aerial photography. However, if proper altitudes are maintained, CASI can achieve resolutions of 0.5 to 1 meter. Because CASI's spectral collection is programmable, it can also be calibrated to better match the environmental setting. Digitally collecting each band individually also allows light attenuation to be modeled, enhancing bottom feature signatures.

Putting Imagery to Work

Of the many products that can be derived from overhead imagery, habitat maps are probably one of the most useful and essential tools to researchers and coastal environmental managers. In its most basic form, a habitat map delineates the boundaries of different bottom types such as coral cover, sea grass, and sand.

Generating a series of habitat maps for the same area over a period of time allows the detection and measurement of the changes in habitat boundaries. Integrating other data, such as commercial fishing data, water profiling, storm patterns, and runoff from nearby land masses, can make habitat maps even more powerful and help answer why changes occur in coral reef ecosystems. This data is integrated in a GIS database. Habitat maps, linked and integrated with other datasets in a GIS, bring information closer to decision makers and those tasked with managing these essential resources.



LOF chose the St. John and St. Thomas CASI dataset to prototype an initial GIS database. CASI data collected during the USVI project contains 16 spectral bands with a two-meter resolution. HDI performed the corrections and georectification and delivered more than 60 GB of imagery to LOF in ERDAS IMAGINE format. Processing this data revealed reefs, previously unknown, that had not been detected by aerial photography or satellite imagery. In addition to the CASI data, Mumby's group delivered raster habitat maps for St. John and St. Thomas that display each bottom type at a two-meter resolution. The deliverable also included video clips captured by divers that illustrate examples of each bottom type.

The CASI imagery and habitat maps were integrated into a functional database. Shoreline, bathymetry, coastal features, adjacent land cover, and other layers are being sought and added to the database. With this data, advanced overlay and spatial analysis can be performed. Although CASI flight line averages 1 to 1.5 GB, they don't necessarily capture the required geographic phenomena and must be mosaicking with adjacent imagery.

It immediately became apparent that quickly accessing, redrawing, and querying the CASI data would be challenging. Upgrading hardware is often the first step taken to improve computing performance. However, displaying multiple flight lines or a mosaic of all flight lines simultaneously can tax even the most capable workstations. To address these challenges, LOF began building a GIS laboratory by investing in a Dell Dimension 670 with dual Xeon processors and 1 GB of RAM. LOF also selected ArcGIS for its ability to display and analyze large raster datasets and integrate the data with other data layers into a database.

The CASI Database

Preparing the database began with examining CASI imagery specifications and determining how best to display the data. Since the imagery was intended to support further research and analysis, images needed to be stored at full resolution using a lossless compression method. The database also needed to quickly draw imagery in the display. Because the study area was limited to St. John and St. Thomas, the extents could be minimized. This easily allowed the full imagery, with a resolution of two meters, to be used.

Having identified the geometry and extents, CASI flight lines were then imported into a raster catalog within an empty geodatabase. Although this was a laborious process, the benefits of working in the geodatabase environment were immediately realized. Drawing the imagery from the raster catalog was much faster than drawing the raw flight line files. Identifying items and executing queries also took less time.

The CASI raster habitat maps were also added to the geodatabase as a raster dataset. The raster maps were converted to polygons and a new field added to the polygon layer's attribute table. That field was populated with field-based links to the video clips of bottom types. The polygon layer provides a way to geographically link tabular data to the database using joins.

Future Development and Objectives

A functional CASI GIS database is currently being populated, but it is only accessible to users at the LOF GIS laboratory. LOF has investigated several options for disseminating this information ranging from simply posting static maps on the LOF Web site to creating a fully interactive online GIS. In keeping with its mission, LOF determined that furthering coral reef research would benefit most if the data was made available through an interactive online GIS. While hard-copy maps and other types of output products will be generated, the online GIS will be the first priority as it makes the most recent data accessible to more people.

Plans to make this data available to the public are well underway. However, several critical components must be acquired and deployed. One of the most important, but missing, components is the capability to publish and serve interactive maps. LOF chose ArcIMS as the tool for this task because its out-of-the-box functionality would make this data available in a timely manner without waiting for the researchers' more elaborate Web portal to be developed. ArcIMS also allows for highly customized interfaces and the development of Web portals. Two other LOF-sponsored projects in other parts of the world will undergo similar development.

This mapping project will help create and disseminate information on threats to coral reefs, which can help decision makers and slow the rates currently projected for coral reef destruction.

About the Author

Michael Plakos received a master's degree from East Carolina University in maritime studies (i. e., maritime history and underwater archaeology) and a bachelor's degree from Western Washington University. He is co-owner and senior scientist for GEOMAR Research, Inc.

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Since 1969, ESRI has been giving customers around the world the power to think and plan geographically. The market leader in geographic information system (GIS) solutions, ESRI software is used in more than 300,000 organizations worldwide including each of the 200 largest cities in the United States, most national governments, more than two-thirds of Fortune 500 companies, and more than 5,000 colleges and universities. ESRI applications, running on more than one million desktops and thousands of Web and enterprise servers, provide the backbone for the world's mapping and spatial analysis. ESRI is the only vendor that provides complete technical solutions for desktop, mobile, server, and Internet platforms. Visit us at www.esri.com.

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