Esri News

for Federal Government

From Sensors to Sound Decisions

NOAA Helps NPS Collect and Analyze Imagery Data to Preserve Vital Seafloor Habitats

By Peter McIntosh, Solutions Engineer, Exelis Visual Information Solutions

The National Oceanic and Atmospheric Administration (NOAA) is using a combination of ENVI image analysis software with Esri's ArcGIS to process, analyze, and fuse different types of geospatial imagery and integrate information.

NOAA uses Esri's ArcGIS and remote-sensing technology for a variety of environmental management and conservation efforts including conserving and managing coastal and marine ecosystems and resources. The organization provides these services to

academic, state, federal, and private-sector partners. Recently, NOAA assisted one of these partners—the National Park Service (NPS)—to map and extract detailed information about seafloor habitats within a marine protected area. To do this efficiently, NOAA needed to develop a new semiautomated approach that would allow it to process, analyze, and fuse different types of imagery and provide NPS with the fundamental data needed to make informed decisions.

A Garden in the Sea

The detailed information that NOAA needed to extract and map encompassed seafloor habitats in Buck Island Reef National Monument off the US Virgin Island of St. Croix. This area has been dubbed one of the finest marine gardens in the Caribbean Sea.

The monument is one of only a few marine protected areas in the US National Park System and is home to a coral reef ecosystem that supports a large variety of native flora and fauna, including several endangered and threatened species such as hawksbill turtles and brown pelicans. The resources in Buck Island Reef National Monument are continually impacted by its visitors, boaters, snorkelers, and scuba divers as well as pollution,
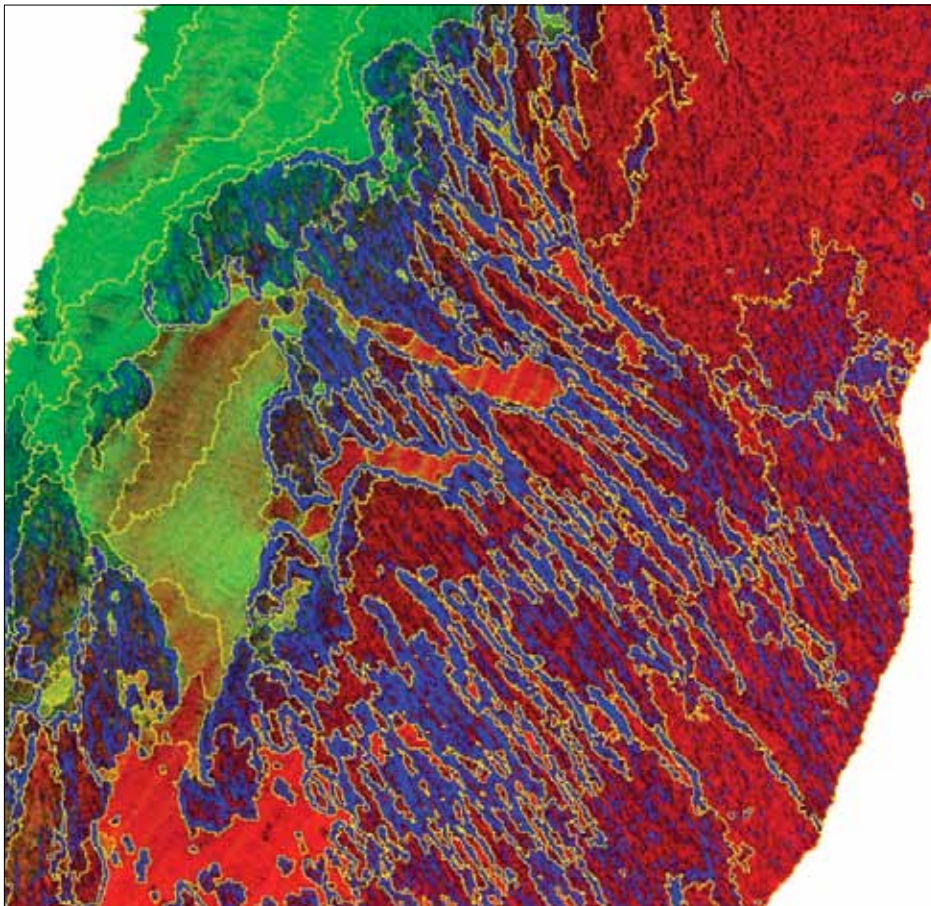
← The feature extraction process identifies unique objects and habitat types on the ocean floor from a depth-derived PCA surface. (Image courtesy of NOAA).

Contents

Big Data: The Three *Vs* and the Missing *L*

Richard Leadbeater,
State Government Industry Manager

Big data datasets are not necessarily big in terms of disk size; they can be big in terms of the combinations of their sources (sensors or feeds) as well as their flexible structures (often unstructured), making interrogation of the data difficult. Governments are sitting on some of the biggest needs for big data solutions.

I should add that big data is not a new fad. From the moment we exceeded the limitations of the first programs' file size or hard disk storage, IT professionals started developing solutions that allowed us to see and consider more and more data. As early as 2001, we were concerned about controlling the volume, velocity, and variety—the three *Vs*—of data.[1] What is different today is the number of sensors feeding us data, our ability to deploy them, the ability of these sensors to collect larger amounts of data, and their ability to quickly stream this data onto the Internet and into our decision-making processes. While there is much attention applied to these three *Vs*, I would add one *L*: location.

Although it is often unrecognized, we experience and benefit from governments' use and deployment of big data processes and their output each and every day. Did you watch the news or check the Internet from your mobile device last night—and again this morning? Was weather one of the items you checked? Imagine both the thousands of weather stations required to model and forecast local conditions and the hundreds of thousands of inputs required to model a national weather map. Would you be as informed if the TV weather reporter displayed a spreadsheet of weather station data, read the results, and described the forecast? Probably. But instead of really listening to the report, do you just view and study the map and make your own conclusions? Definitely. This example shows how we judge the value of location—a spreadsheet is just as informative, but a map provides understanding and reference.

Maps have always played the role of an assemblage of massive amounts of data—often, types of data that are unrelated except for their geographic location. GIS technology continues this role in providing understanding and reference, furthering government's ability to exploit the ever-increasing volume, velocity, and variety of data. GIS provides the foundation for information integration. An approach that incorporates location into big data efforts—using geography as a platform—offers additional possibilities that data alone can't provide.

[1] Laney, Doug. 2001. "Application Delivery Strategies." Meta Group. http://blogs.gartner.com/doug-laney/files/2012/01/ad949-3D-Data-Management-Controlling-Data-Volume-Velocity-and-Variety.pdf.

A Reception to Remember

The Esri Federal Civilian and Sciences User Reception has been a long-standing tradition at the Esri International User Conference (Esri UC). Over the past two years, the reception has undergone a transformation and renaming, and it continues to get better.

"The Esri federal event provides a great opportunity for government staff to interact with each other from various agencies and with their Esri contacts in a social setting," said Timothy Trainer, chief of the Geography Division, US Census Bureau. "The 2012 event was the best I have experienced!"

The invitation-only reception took place Tuesday, July 24, at the Hilton San Diego Bayfront's Vela Restaurant and Promenade. The cool breeze, large space with breathtaking views of the bay, and impeccable food and drink set the tone for a wonderful evening. More than 900 federal-civilian users attended. Raffle prizes were awarded throughout the night thanks to six sponsors that helped make the reception possible.

"I look forward to this event each year and the new ideas it offers," said Ivan B. DeLoatch, executive director of the Federal Geographic Data Committee. "It's the one event where you can catch up with all your colleagues and old friends in a relaxed and productive setting."

If you are a federal-civilian customer, be sure to join us next year during the 2013 Esri UC. Watch for your e-mail invitation as the conference approaches, or contact your Esri account manager. The next conference will be in San Diego July 8–12.

Special Thanks to Sponsors

Special thanks go to sponsors of the Federal Civilian and Sciences User Reception at the Esri International User Conference:

Inside Esri's Innovation and Collaboration Studio

Esri solution engineer Owen Evans shares his firsthand insights on the new Innovation and Collaboration Studio at the Esri federal office in Vienna, Virginia.

Why did Esri create this studio?

We created this studio to help people get hands-on experience with Esri technology. It's a resource for Esri's existing customers and a way for people new to mapping to get started. It shows people how easy, valuable, and fun Esri technology can be. We listen to our visitors' requirements, share best practices, and show them how to use our latest tools to tell stories with maps.

What can you see and do when you visit?

When you visit Esri, we enjoy showing you the latest in professional GIS software, but the studio focuses on how GIS enables simple mapping on the web, on mobile devices, and also in cloud-based systems like ArcGIS Online.

Many visitors leave the studio with 10 or more web maps and applications to show their colleagues and bosses.

What's the most popular aspect of the studio so far?

So far the feedback indicates that people really like our "working sessions," when a small group visits the studio for guidance on a specific project. We connect them with a solution engineer with expertise in the area of focus of their particular project. This is a great way for people to quickly learn about new technology and see how new capabilities can be directly applied to their work.

What are some examples of projects visitors have worked on in the studio?

Several visitors have come to learn how to share their maps on the web and configure web applications using tools from ArcGIS Online. We really love to work on these types of projects. Creating and sharing maps are easier than ever, but there are a lot of best practices that we have learned by going through this process many times. We can help people new to web mapping get up to speed very quickly. Many visitors leave the studio with 10 or more web maps and applications to show their colleagues and bosses. Another popular topic related to more traditional GIS workflows is configuring ArcGIS for Windows Mobile projects for field data collection.

To learn more, visit esri.com/studio. Esri partners and customers and those new to mapping are welcome to contact dcstudio@esri.com to schedule a session.

USDA and Esri Build Geospatial Portal Mapping Service

The US Department of Agriculture (USDA) and Esri worked together to implement a fully cloud-based geospatial portal. USDA's prototype portal, Enterprise Spatial Mapping Service (ESMS), is built with Esri's new product Portal for ArcGIS, managed by Esri, and hosted on the Amazon cloud within USDA's web environment.

Stephen Lowe, geospatial information officer for the USDA Enterprise Geospatial Management Office, and Esri product and professional services teams designed the prototype's geospatial interfaces with a focus on search and discovery, managed service hosting, and web service publishing of USDA-owned data. The portal introduced GIS productivity services for provisioning and consumption of web map services and the capability to geoprocess, display, and analyze data. The private cloud GIS makes the central repository for authoritative content accessible to users within the department as well as other public agencies. ESMS provides a platform to do the following:

- Quickly create maps and apps using templates and web mapping APIs.
- Form groups to collaborate on projects or common activities.
- Exchange maps and apps with private groups or the entire organization.
- Embed maps and apps in custom web pages or blogs.
- Eliminate transaction costs in reusing and repurposing spatial assets.

USDA and other external government agencies go through the portal to access valued agricultural datasets and maps from a browser and perform spatial analytics. Esri Managed Services maintains and supports the GIS and infrastructure for USDA. Users have the same collaboration and sharing tools as those provided in the public cloud mapping environment ArcGIS Online, but the site retains the USDA customization and brand. Esri's Portal for ArcGIS is a geospatial content management system that can be hosted on premises or as an off-premises cloud environment to provide a private, multitenant, geospatial content management system. USDA will soon integrate its security environment e-Authentication access and identify control system with the private cloud solution to extend the platform's value to diverse user requirements.

In May 2011, the prototype USDA portal was tested at the New Madrid National Level Exercise, which is an event for assessing and developing regional catastrophic response and recovery capabilities. USDA representatives from the Animal and Plant Health Inspection Service (APHIS), Farm Service Agency (FSA), Natural Resources Conservation Service (NRCS), and other USDA agencies worked within the ESMS portal environment to rapidly create, locate, and elaborate on disaster response spatial presentations, templates, and briefings. Furthermore, the single ESMS portal framework enabled USDA to crowdsource complex map product design and development problems among multiple subject matter experts to quickly benefit from enterprise solutions and knowledge.

Learn more about Portal for ArcGIS at esri.com/portal.

Esri Online

Get on the Fast Track to ArcGIS 10.1
If you missed the ArcGIS 10.1: Transform Your Organization Seminar in a city near you, you can see a recording of it along with the materials distributed during the seminar at: esri.com/seminarresources.

Check Out Election Maps
Esri has created a series of maps used to poll public opinion on the 2012 presidential election. Voters weighed in on topics such as their voting personas (democrat, republican, independent, other, etc.) and election issues including budget and economy and health care.

esri.com/electionmaps
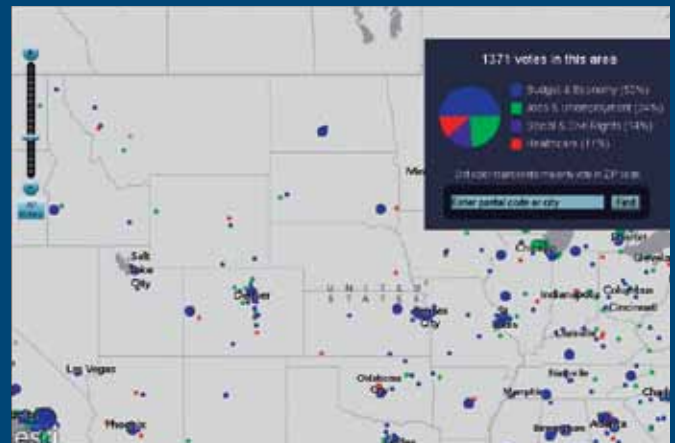
↑ In an area near Chicago, 50 percent of those polled are primarily concerned with budget and economy issues.

Register for the Esri Federal GIS Conference
Elected officials, government executives, nongovernmental organization (NGO) leaders, and GIS professionals will gather in Washington, DC, February 25–27, 2013, to learn how the latest geospatial technology helps accomplish missions.
The Esri Federal GIS Conference is the place to gain the expertise you need for the trends and initiatives that impact your work. There will be more than 100 sessions, networking opportunities, and valuable technical training.
Federal employees attend at no charge.
esri.com/fedcon

USDA's KYF2 Initiative Uses ArcGIS to Promote Local Food Systems throughout US

As part of the ongoing commitment of the US Department of Agriculture (USDA) to support local and regional food systems, USDA recently released the Know Your Farmer, Know Your Food (KYF2) Compass map. The interactive, web-based map provides information about these food systems and is a component of the Know Your Farmer, Know Your Food Compass, which was recently announced by agriculture secretary Tom Vilsack and deputy secretary Kathleen Merrigan of USDA. The map uses Esri's ArcGIS technology and web

map services designed and developed by VSolvit LLC.

USDA originally launched the KYF2 initiative in 2009 to help revitalize rural communities by identifying the resources needed to grow, market, and distribute local food. The KYF2 Compass map was created to carry that momentum forward by providing the public with a way to access information about where food is grown and the availability of local markets.

"USDA has shown how legacy GIS content can be rapidly organized to benefit broad groups of constituents," said Jack Dangermond, Esri president. "We are pleased that USDA has mapped local food systems and extended the use of government data to all stakeholders."

The KYF2 Compass map is deployed using Esri Managed Services. Future plans include updating and adding new datasets and offering dynamic map views and map services. As the map evolves, it will ultimately benefit farmers, educators, businesses, and other

organizations by aggregating many sources of data about local and regional food supply chains.

Part of the USDA mission is to help build a national dialog about local food systems. To promote this dialog, Esri supports the Twitter campaign around the compass and encourages those Twitter users involved with local food projects to include the hashtag #KYF2 when referring to the KYF2 initiative and talking about the KYF2 Compass map.

"USDA has shown how legacy GIS content can be rapidly organized to benefit broad groups of constituents."

Jack Dangermond, Esri President

Try the KYF2 Compass map at esriurl.com/kyf.
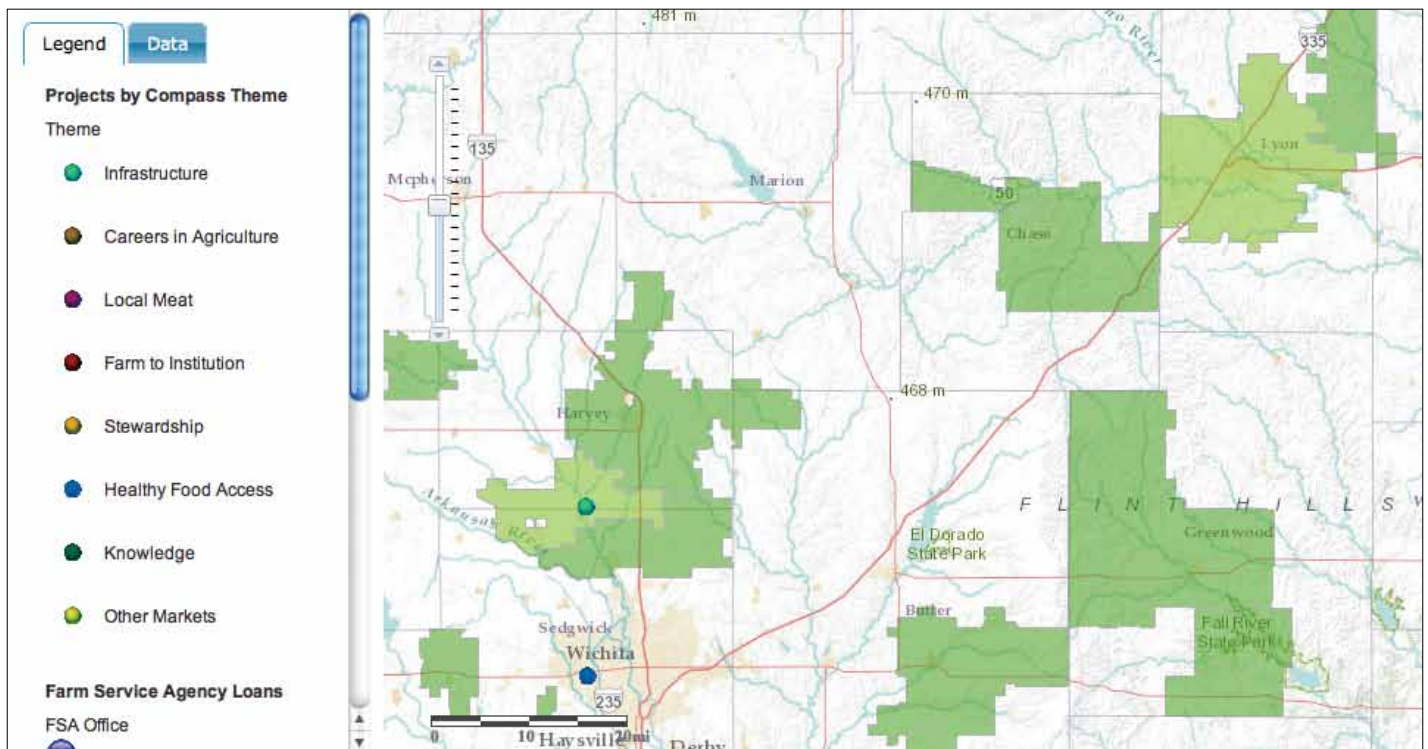
↑ USDA's interactive Know Your Farmer, Know Your Food Compass map provides information about local food systems throughout the United States.

Massive Research Center Uses GIS to Optimize Space Utilization and Cut Costs

NASA Langley Research Center

The National Aeronautics and Space Administration (NASA) Langley Research Center (LaRC) in Hampton, Virginia, has a reputation for solving difficult problems. So in 2004, when confronted with the possibility of dramatically reduced future budgets, LaRC came up with forward-thinking options to downsizing the infrastructure on the 800-acre campus.

Scenarios that addressed budgetary reductions of 25 percent and more meant that a widespread area of real property, including many aging and obsolete facilities, needed to be reassessed. To address these issues, LaRC became one of the first NASA centers to benefit from Esri's GIS technology for real property management.

Space Utilization Optimization

The Center Operations Directorate's GIS team is responsible for spatial data and associated technical support at NASA LaRC. To facilitate reorganization scenarios, the team extended Esri's technology by developing space utilization optimization tools to map out and analyze the use of each area.

The team was then able to propose solutions to reduce the number of buildings in use and increase efficiency, with a goal of ultimately reducing operation and maintenance costs by $1 million per year.

GIS team leader Brad Ball recalled the stringent requirements placed on his team to reorganize a building for a long-term satellite research project, which required extensive collaboration between researchers to be successful. The satellite project manager wanted his team to be located on a single floor. Using a GIS space optimization model, the GIS team was able to show how the satellite project team could work together on one floor of a building.

This required two other organizations to relocate within that building, but the GIS team identified new locations for them as well. "I am pushing [for] space optimization. I think that's probably the most valuable tool we've developed in the time I have been

↑ The NASA LaRC facility contains 800 acres of housing and 280 facilities with an estimated replacement value of approximately $3.5 billion.

driving the GIS efforts here," Ball said. "I think it has value across the entire federal landscape and in industry and academia."

Cost-Cutting Benefits

In addition to the savings the agency will realize from more efficient property use, Ball believes the system is paying dividends in terms of effectiveness. He said the system's ability to integrate data from various sources allows the agency to make better decisions, resulting in opportunities for further operational improvements and reduced costs. "We can come up with new approaches to do things that we couldn't do previously because the data was not readily available," he said.

Ball cited janitorial and grounds maintenance contracts as examples of additional efficiencies and cost savings that GIS enabled.

"We were able to identify the square footage for grounds maintenance," he said.

"Previously, we were just telling the contractor to cut [the grass in] this area, and we would say we have 800 acres. Well, by the time you take out the parking lots, the roads, the buildings, and wetlands, that tremendously reduces the area."

On a Path to Success

Ball said NASA LaRC's efforts to downsize are on course. The center was so successful in using GIS for real property management that now other NASA centers, such as the Johnson Space Center, use it too. Other government and private facilities and countries are showing interest as well.

"NASA Langley's master plan is being very well received," Ball said. "We're going to demolish the old buildings. We're going to have a smaller carbon footprint. We're going to compress . . . [but] we will still support most of the areas of work that we have [had] over the last 40 to 50 years."

USGS Provides Geographic Information to the Masses

Topographic Maps, *National Map* Viewer, and the *National Atlas* Bring Maps to the People

The United States Geological Survey's (USGS) mission is to provide reliable scientific information to describe and understand the earth in an effort to improve quality of life. A critical component of achieving this mission is mapping the features of the nation, which the organization has been doing since 1879. USGS now provides geographic content in topographic maps, the *National Map* Viewer, and the *National Atlas*.

USGS began producing its popular topographic maps soon after its inception. By 1991, the organization provided complete coverage of the lower 48 states.

Today, USGS updates its 54,000 7.5-minute quadrangle topographic maps (US Topo) for the conterminous United States every three years. The map production system is built on ArcGIS. This prepackaged and standard national topographic map series remains important for many applications, including land management, emergency response, and outdoor recreation.

For those who want to access USGS's wealth of geographic data, there is the *National Map* Viewer. USGS continually updates its viewer and works to make seamless data for the nation easy to access and use. Available data layers include imagery, transportation, structures, and land cover.

The organization is currently working to fully cache the viewer's basemap to make navigating it even faster. The cached basemap and web services are served with ArcGIS. People can use the web services to consume data from the map and use it in their own mapping projects.

"Instead of having three or four viewers that people can access to get data, our effort over the last few years has really been to provide one place for people to get all our current *National Map* data," said Robert Dollison, project manager, USGS.

"Typical users of the *National Map* Viewer are engineers and GIS managers—people who want to download the data," he continued. "They're usually building a GIS product
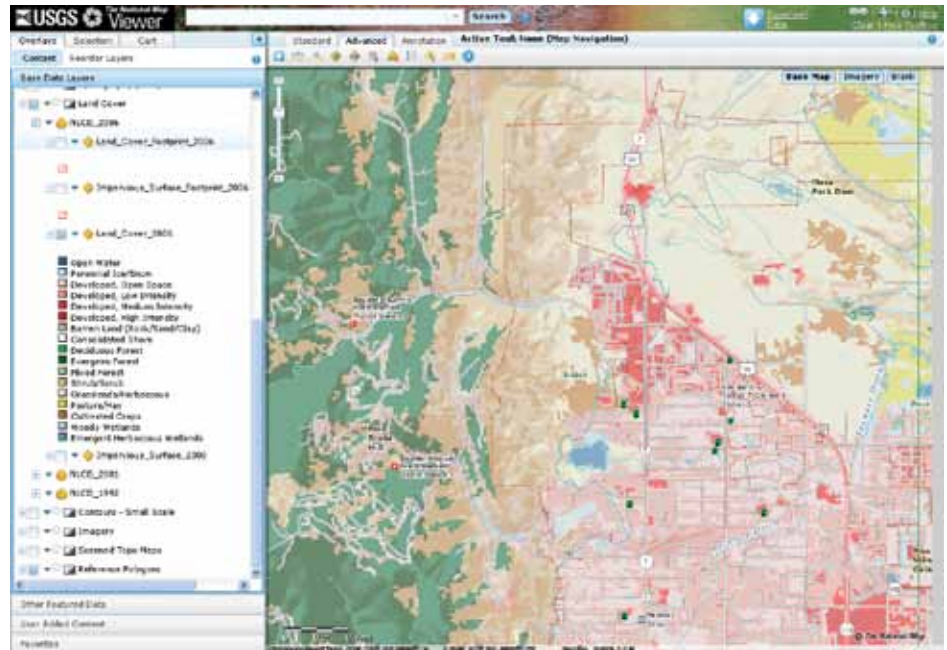
↑ The *National Map* Viewer includes downloadable land-cover and transportation data.

for a customer and they need raw data for an area—our elevation data, hydrography data, and imagery are some of our most popular datasets."

People who want to take maps out into the field typically opt for the USGS topographic maps. "The US Topo maps really deliver content in a simple format for public use," said Dollison. "Any resource manager could take a topo map into the field and spread it on the front of her car to understand the work area."

Additionally, USGS provides the *National Atlas*, a collection of maps that reflect the nature of the country from physical features like forest cover types and principal aquifers to presidential election results from 1789 to 2008.

"The *National Atlas* has a very wide user base—more educational," said Dollison. "It's a lot of maps about America at a small scale, so it often provides a quick map in a publication, like congressional districts, or a teacher might use it in a class."

The data for USGS basemaps, whether part of the *National Map* Viewer, topographic maps, or *National Atlas*, comes from many government organizations and some private data providers. For example, the Federal Aviation Administration provides airport data, and the Federal Railroad Administration contributes railway data. From the private sector, TomTom adds street centerline data for the basemaps. This coordinated effort provides rich geographic content for people of all ages and for countless uses.

For more information, visit nationalmap.gov or contact Robert Pierce, USGS National Geospatial Program Office, at rrpierce@usgs.gov.

New USDOT Application Presents State Facts and Figures

The US Department of Transportation (USDOT) has leveraged GIS technology for years to share information with the public and among transportation organizations. USDOT applications enable transparency and bring together transportation information from a variety of sources into easy-to-understand maps.

In 2010, USDOT launched its own transparency application to illustrate how the department is spending American Recovery and Reinvestment Act of 2009 (ARRA) funds on transportation projects. Recently, the department deployed its State Facts and Figures application to bring together data from individual states, supporting analysis of a wide variety of transportation issues.

The State Facts and Figures application allows users to compare and contrast transportation facts between states. When a user selects the state of California, data about the state, such as public road miles and the percentage of functionally obsolete bridges, appears in a pop-up window. Then, hovering over another state, such as Louisiana, brings that state's statistics into the pop-up window so that the user can make comparisons. USDOT employed ArcGIS API for Silverlight to implement this unique functionality and to develop the overall application.

The State Facts and Figures application allows legislators, the public, and transportation officials at all levels of government to find state-by-state transportation facts and rankings on key topics such as fatalities and injuries, distracted driving, and energy and environmental issues. For example, now congressional leaders can quickly find information on deficient bridges in their districts rather than requesting hard-copy reports from the department.

To use the application, visit http://gis.rita.dot.gov /StateFacts/.
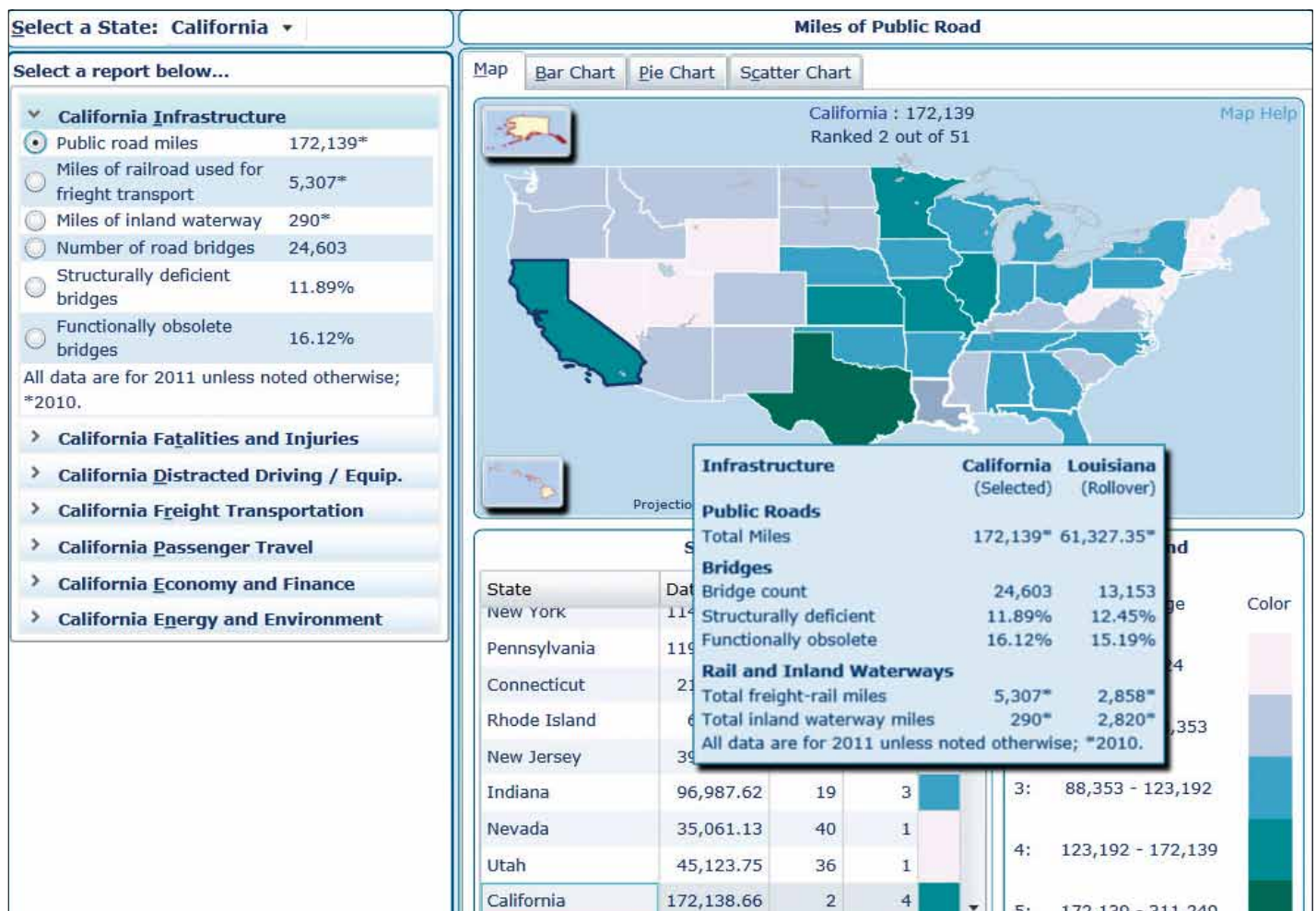
↑ The USDOT State Facts and Figures application supports comparative analysis of data such as infrastructure in California and Louisiana.

climate change, and extreme weather events like hurricanes.

NPS called on NOAA's Biogeography Branch, which creates educational products about ecosystem-based management in the monument, to help out. NPS needed an efficient and effective method to teach others about the distribution and ecology of living marine resources. The habitat map that NOAA created for monument resource managers will be used to understand the current state of the area and how things are changing so that they can determine the best rules, regulations, and practices to preserve and conserve its habitats well into the future.

When One Sensor Isn't Enough

After evaluating the area, NOAA determined that traditional marine mapping methods that rely on the manual interpretation of optical imagery derived from satellites couldn't produce a comprehensive habitat map of the monument given its depths, which extend from the coastline of Buck Island to 1,800 meters at its deepest extent.

"We had a very unique problem," said Tim Battista, an oceanographer at NOAA. "There is no one technology or sensor that allowed us to collect the data we needed in the range of depths present at the monument. We had to devise an innovative method that would allow us to both measure seafloor depths and characterize its habitats across the entire seascape in the monument."

After much testing and innovation, NOAA ultimately devised a new method that fuses four different sonar, lidar, and optical imagery sensors to gather the information

it needed. NOAA chose to use ArcGIS and ENVI image analysis software to tackle this unique challenge. This combination allows the processing and image analysis of the latest spectral image types such as radar, lidar, optical, hyperspectral, stereo, thermal, and acoustic. Using ArcGIS and ENVI software, the strengths of these different sensors can be exploited together, which creates a rich context that aids in decision making.

NOAA recorded depth and other characteristics of shallow areas in the monument using multispectral and lidar imagery. This imagery was acquired from planes that flew over the areas needing mapping. Multispectral and lidar mapping can be used for water up to about 30 meters in depth, the point at which light is unable to penetrate to the seafloor.

NOAA chose to use sonar technology at depths of more than five meters using vessels and ships, such as the NOAA ship *Nancy Foster*, to scan the seabed. The *Nancy Foster* emits more than 3,500 pings a second, and receivers on the ship record the time and angle of the echoes returning from the seafloor. Days spent sailing and employing sonar technology yielded bathymetry, or depth information. The intensity of the echo also provided information about the seafloor, such as how hard, soft, rough, or smooth it is, which often indicates discrete habitats such as coral, sand, and sea grasses.

Mapping the Seafloor

The lidar and acoustically collected bathymetry was also used to calculate a suite of complexity metrics in ArcGIS, such as slope, rugosity, and curvature, which emphasize the difference
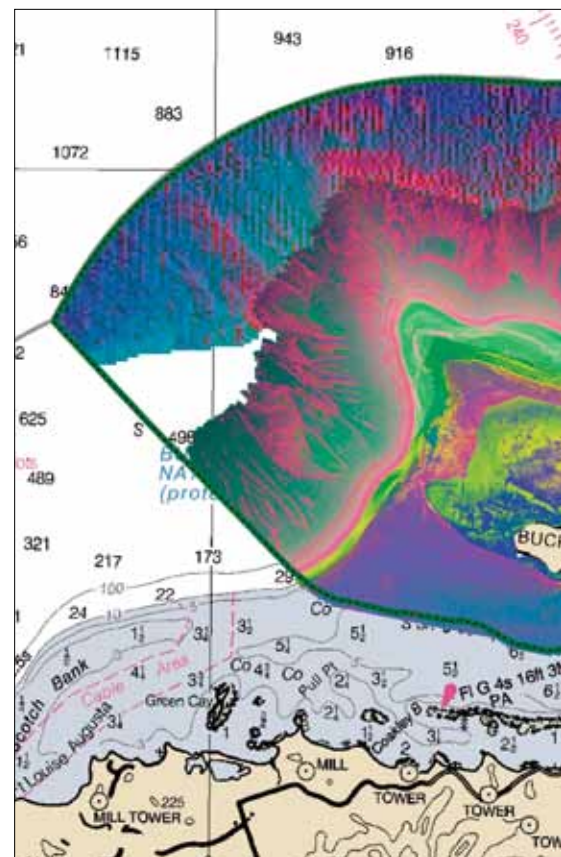
↑ NOAA used ENVI to produce a PCA surface—the foundation for its mapping methodology—from four different acoustic and multispectral datasets spanning the monument's 20,000-acre extent. (Image courtesy of NOAA.)

between habitats on the seafloor. As part of its preprocessing work, NOAA used principal component analysis (PCA) to reduce redundancy in the data and better understand the complexity on the seafloor. This information, along with ancillary data including intensity, was loaded into ENVI, allowing the researchers to draw distinctions between softer and harder sediments in flatter areas of the seafloor.

Using an automated workflow, NOAA staff segmented the imagery data in ENVI using the software's extraction tool. Following image segmentation, users classified and assigned attributes to the features in their imagery. NOAA staff classified features by selecting locations with unique acoustic or optical signatures and performed ground validation using still and video cameras operated by divers and remotely operated vehicles (ROVs). NOAA's classification scheme used to describe these sites takes into consideration what the seafloor is made out of, what is growing on top of it, and the quantity of cover.

→ *Nancy Foster*, one of the most operationally diverse platforms in the NOAA fleet, was originally built as a navy yard torpedo test (YTT) craft. In 2001, the navy transferred the vessel to NOAA, which outfitted the ship to conduct research along the US Atlantic and Gulf coasts and the Caribbean Sea. *Nancy Foster* is named for Dr. Nancy Foster in tribute to her outstanding leadership within the National Marine Fisheries Service and National Ocean Service from 1986 until 2000.

↑ ENVI's feature extraction tool allows an analyst to see the results in real time in a preview window. (Image courtesy of NOAA).

NOAA then took the segments and classified ground validation points. The points were classified using a free add-on tool to ENVI called RuleGen that was developed by an ENVI user. RuleGen includes a classification and regression tree that was well-suited for NOAA's acoustic datasets. Afterward, NOAA staff returned to the field and verified the accuracy of the output using a draft classified habitat map.

"Acoustic data is often very noisy and heterogeneous, which makes classification difficult using traditional pixel-based approaches," said Sam Tormey, marine spatial analyst contracted with NOAA through CSS-Dynamac. "We were able to overcome these challenges, so we are no longer classifying a pixel but rather an object. We are now able to more objectively and efficiently deal with heterogeneity and make products that meet our partners' needs."

Effective Analysis for Ecosystem Management Decisions

As a final step, NOAA took the habitat maps and other information derived from the imagery and moved these into ArcGIS for more analysis and the creation of applications. Information extracted from imagery and added to ArcGIS provided a complete picture of a geographic area of interest that includes pertinent, current information. Using ENVI for this step made the process to update ArcGIS with information from geospatial imagery seamless by delivering image analysis tools directly to both desktop and server environments.

Analysis included looking at the structure, biologic cover, and percentage of cover—key pieces of information that resource managers need to make effective ecosystem management decisions. One application that NOAA develops for some partners is a web-based mapping portal so that partners have the option of displaying each habitat class separately, overlaying ground truth points, viewing videos and images that were captured, and creating custom maps. These portals are especially useful for partners that may not be familiar with GIS software.

"The seamless integration of ENVI and ArcGIS allows us to leverage the image analysis capabilities of ENVI with the geospatial tools and statistics in ArcGIS, which gives us tremendous analytical power," said Battista." It also allows us to put our habitat maps on the web for anyone to see and use."

Previously, NOAA staff could only monitor limited areas because the process was time-intensive and depended on the experiences and interpretation skills of the analyst, which aren't highly replicable.

"Our past mapping efforts were conducted by manually digitizing and interpreting optical imagery," said Tormey. "The new methods that were developed allow us to integrate the strengths of multiple acoustic sensors and multispectral and lidar imagery and produce a seamless product across the entire extent of our study areas."

NOAA is now able to also produce products at a much finer spatial scale, so maps are more reflective of the true features on the ground.

For more information on how GIS can help better analyze remotely sensed data and imagery, visit esri.com/imagery.

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