Esri News
for Oceans

Winter 2013/2014

ArcGIS Used to Raise Coral Reef Awareness

By Barbara Shields

Interacting with thousands of ocean species, coral reefs are one of the most productive systems in the sea and important for maintaining a healthy planet. Coral reefs are becoming less productive in an era when we need them most. To raise awareness of the need to preserve, protect, and restore these natural structures, a team of marine scientists has embarked on a six-year mission to study coral reef ecosystems.

As members of The Khaled bin Sultan Living Oceans Foundation's Global Reef Expedition, the team conducts scientific surveys that characterize and assess the condition of coral reefs throughout the world. Living Oceans Foundation is funded by Prince Khaled bin Sultan of the Kingdom of Saudi Arabia, who sponsors marine conservation programs and scientific research. The foundation uses Esri's geographic information system (GIS) software to map the geographic distribution of coral reefs.

↑ Select an island in Seychelles (D'Arros) on the viewer map and zoom to see the island's different habitat types.

↑ A diver captures data about the health of reefs in the Galapagos Islands.

GIS provides a means for creating ecosystem habitat maps and analyzing survey information. Scientists use it to collect and manage data, inventory species, depict benthic measurements, and provide a temporal record of the condition of reefs.

The same workflow is repeated at each project site. First, Global Reef Expedition

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Global Coral Reef Study Sets Baseline

continued from cover

scientists collect data with drop camera videos, scuba dives, and GPS. Next, the National Coral Reef Institute at Nova Southeastern University in Fort Lauderdale, Florida, processes the data using GIS algorithms, creates habitat maps, and returns them to the foundation. Upon completion, Living Oceans Foundation shares findings and maps with countries that host the expedition, including their government agencies and respective nongovernmental organizations (NGOs). They receive the dataset along with detailed reports that describe reef locations, resilience, stress factors, and so forth.

The Khaled bin Sultan Living Oceans Foundation's dataset has tremendously grown in the past three years. The foundation had been contracting with a data service to publish its data but now is migrating the data to an on-site ArcGIS for Server. This technology enables the foundation to grow its GIS capabilities, create web map viewers in-house, and develop geoprocessing tools. The objective is for users to access data through a portal, interact with the data using a data viewer, and download shapefiles at no cost.

↑ This map tracks the progress of Global Reef Expedition's vessel *Golden Shadow* during its exploration of the Rangiora Atoll in French Polynesia. The map is a geographic interface with the crew's blogs, photos, and videos.

↑ Reef life in Cay Sal Bank, Bahamas, was documented and will be used as a baseline for measuring habitat change in the future.

Habitat maps show the structure of the reefs and the substrates of their locations. Amanda Williams, the foundation's previous GIS analyst for the last four years, used the habitat maps, along with benthic habitat maps, bathymetry, imagery, and other relevant data layers, to understand relationships through the running of queries and models.

"With Esri's tools for spatial analysis, I have combined many different datasets and run queries," Williams said. "I also integrated datasets, layers, and tools within the mapping environment."

To study reef resilience, scientists look for certain characteristics in the environment. For instance, the optimum temperature for coral reefs is 22–28°C. By adding a sea surface temperature data layer to the map, Williams could see if temperatures were adding stress to the reef. Agencies such as the World Resources Institute also have coral reef risk data that can be added to the map.

Once project research is completed for an area, Living Oceans Foundation contributes the dataset to the Esri ArcGIS Online Ocean Basemap. For instance, the foundation contributed Red Sea data that includes a set of bathymetric grids derived from imagery. It is now available to ArcGIS Online users. Go to arcgis.com.

Follow the exploits of the Global Reef Expedition at www.livingoceansfoundation.org.

Clearwater Seafoods Improves Sustainable Operations and Lowers Costs by Using GIS

Courtesy of Esri Canada Limited

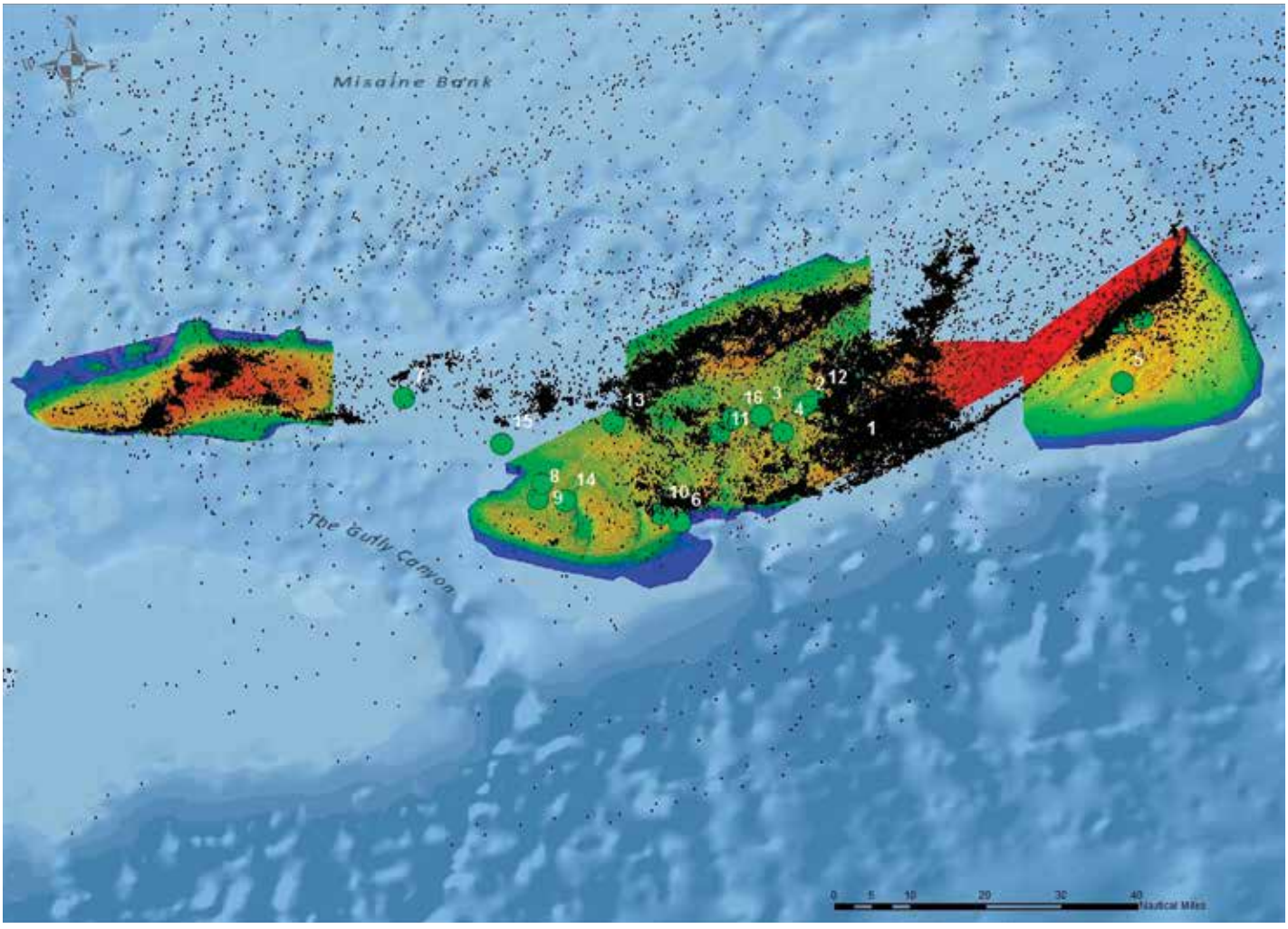
Clearwater Seafoods Limited is a global leader in the seafood industry and the largest harvester of wild shellfish in the Atlantic Ocean off Canada. The award-winning company has built its business around a core commitment to long-term sustainability and responsible fishing.

Always looking to improve operations, Clearwater invests significantly in technologies that enable top-quality seafood to be delivered from ocean to plate. A recent investment in GIS has resulted in significant cost savings, minimized impact on ocean ecosystems, and promoted a sustainable approach to fishing.

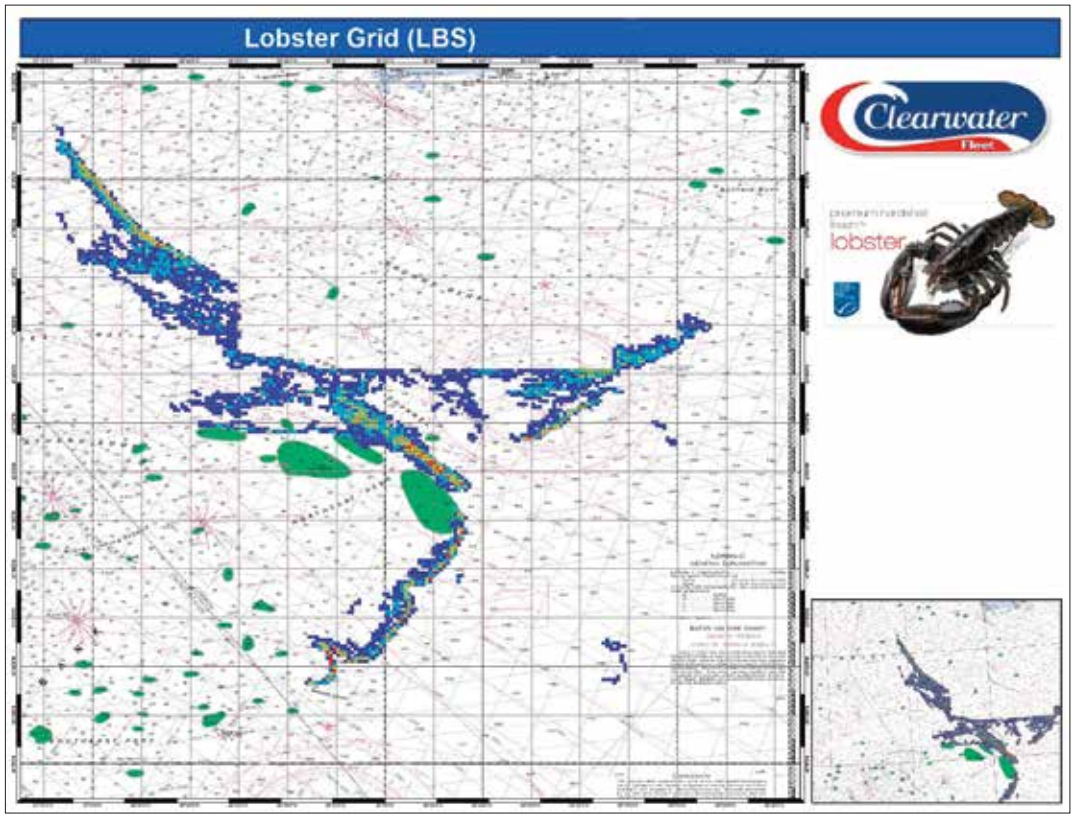
Based in Nova Scotia, Clearwater harvests, processes, markets, and sells premium shellfish and seafood to a variety of markets worldwide. The company must balance a high level of production with a commitment to responsible fisheries management—a method that draws on science to ensure sustainable practices.

As a largely geographic undertaking, sustainable fisheries management requires the ability to intersect and analyze many layers of data including species abundance and composition, feeding and reproduction, historical fishing efforts, and oceanographic/ecosystem conditions.

Forecasting where and what type of harvest will be available is also a key component of responsible fishing. This can be achieved through assessment models that predict the location, stage of growth, and populations of various biomasses. Access to this information improves fishing success rates and also helps protect the



↑ Footprint of clam harvest distribution with survey positions helps Clearwater Seafoods make better business decisions.



↑ Historic data depicts the spatial distribution of lobster catch per trap along the southern coast of Nova Scotia.

ocean's diverse ecosystems by minimizing impact on nontarget species.

"GIS serves as the ideal platform to analyze, model, and forecast outcomes so that we can significantly reduce the cost of harvesting," says Jim Mosher, director of harvest/science management, Clearwater Seafoods Limited. "More importantly, it enables us to plan our activities in a much broader context so that we can fulfill our core commitment to long-term sustainability."

In addition to resource analysis, fisheries must strategically route ships to ensure sustainability and reduce fuel emissions. With a large and diverse fleet of oceangoing vessels along with rising fuel costs, Clearwater decided to invest in technology that could serve as a platform to intersect and analyze diverse data.

Clearwater selected Esri ArcGIS for Desktop and the Spatial Analyst extension to study fish resources and population dynamics. This technology enables the company to overlay spatial and temporal fishing data, including bathymetry (the study of underwater depth and ocean floors), sediment types, survey data, harvest areas, and benthic habitat, to quickly identify potential growth areas. Staff can also factor in weather influences, species biology, lunar cycles, and other relevant data to determine the most effective methods of harvesting resources.

ArcGIS Spatial Analyst is used to facilitate interpolation techniques. Leveraging this tool, complex surfaces can be analyzed to reveal patterns that may not be readily apparent in raw data. The density, magnitude, and concentration of underwater harvest species can be measured at strategically dispersed sample locations and then extrapolated to accurately predict values in other locations. This makes it significantly easier to uncover high concentrations of harvest species and take a more targeted approach to operations.

Through access to a geodatabase of historical data, the company can identify trends based on what was accomplished in previous years and plan fishing activities to maximize output. Historical data can also be analyzed to ensure that harvest species are not overfished, a critical objective of responsible fishing practices.

A more strategic approach to vessel routing has enabled Clearwater to significantly reduce harvesting costs and take steps toward effectively reducing its carbon footprint. By equipping its fleet with sophisticated habitat imaging and vessel monitoring systems, the company has also been able to ensure that only targeted areas are fished.

Access to a GIS-based database further supports targeted activities by enabling analysts to review historic data. Overlaying this historical information with survey data makes it easy to readily identify areas that have already been harvested, supporting the spatial management of resources. They can also leverage patterns in the data to model and predict where there is most likely to be an abundance of harvest species.

As an environmental leader, Clearwater recognizes the importance of long-term sustainability and works toward ensuring that all harvesting activities promote a healthy ocean environment. GIS provides the company with a cost-effective tool to intersect diverse datasets so that Clearwater can better understand targeted resources and their connections to the broader ecosystem. As a result, the company is able to take an informed approach to harvesting that limits the impact of fishing activities and promotes sustainability both at sea and on land.

See what you can do with ArcGIS Spatial Analyst at esri.com/spatialanalyst.

Sea Level Rise Maps Show Cities that will Be Underwater in 2100 and 2200

Rising sea levels will change US coastline in the next 100–400 years.

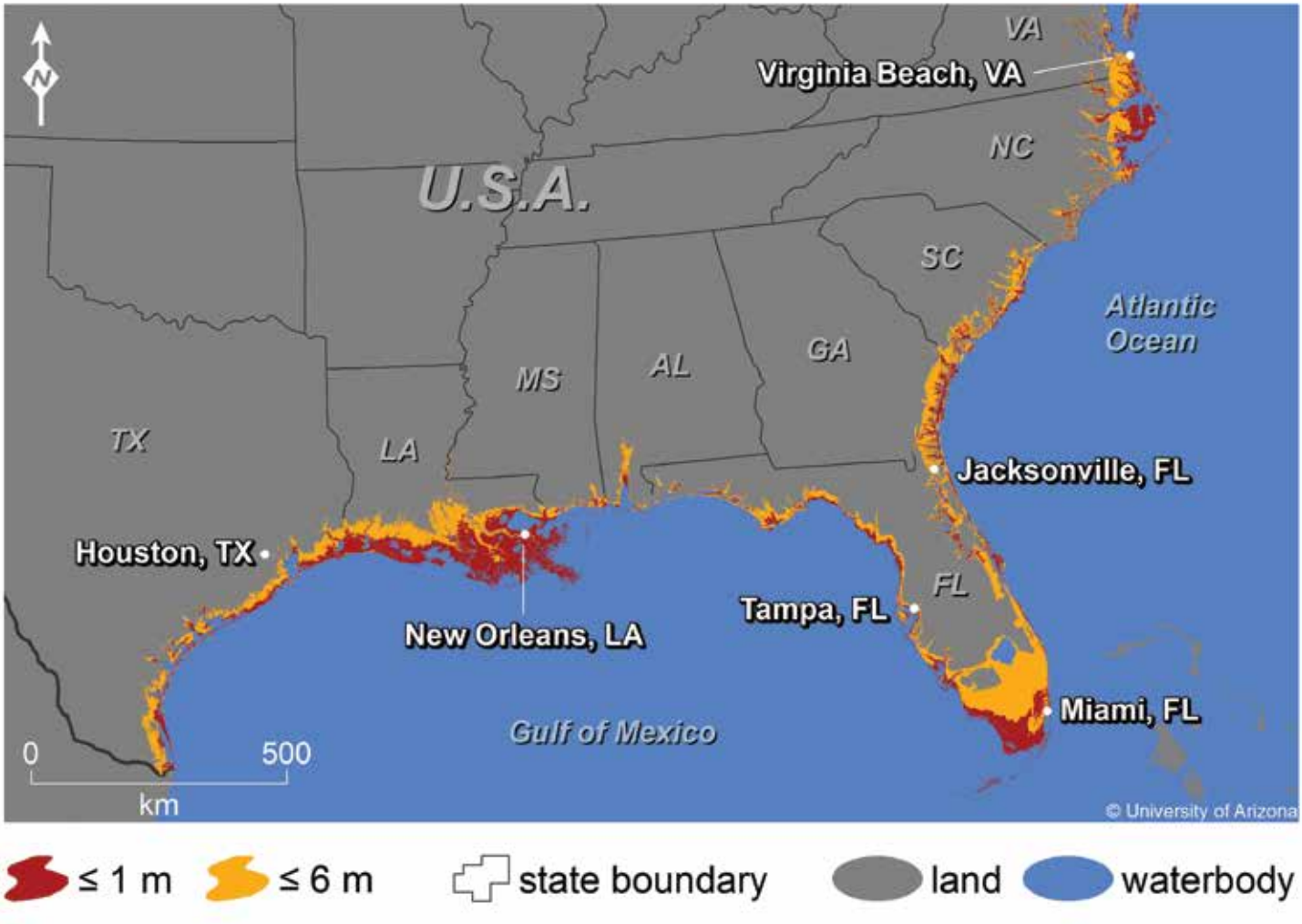
Researchers and decision makers are using GIS to answer important questions and take action. How is the ocean changing? What will the US coastline look like? Which cities need to be ready for sea level rise? Researchers at the University of Arizona use Esri ArcGIS to answer these questions and publish their findings as an online mapping application.

Because US coastlines have become embattled by unprecedented weather-related disasters, people are taking a hard look at the results of climate change such as sea level rise. Independent scientific studies are confirming current predictions of a one-meter rise in sea level by 2100. Furthermore, global greenhouse gas emissions over the twenty-first century will not only influence sea level rise (SLR) in the relatively near term of the next ~90 years but will also continue to drive sea level rise over subsequent centuries. Temperatures by 2100 may be warm enough to commit earth to at least four to six meters of global rise over following centuries. This is because polar ice sheets will adjust to the comparatively rapid and largely irreversible global warming that will occur this century.

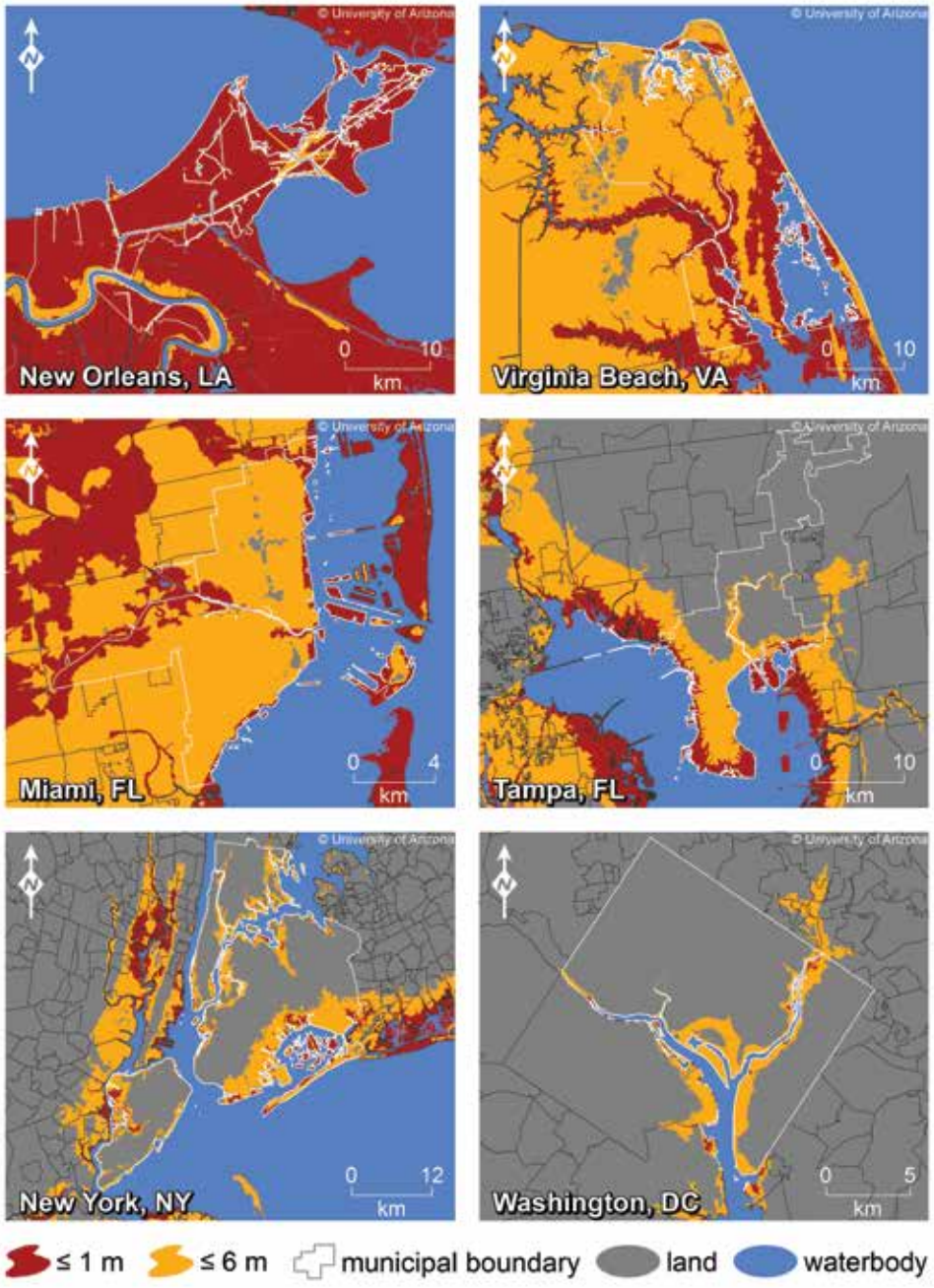
Jeremy Weiss, PhD, research scientist, Department of Geosciences, University of Arizona, Tucson, and his team used Esri ArcGIS to create scientifically sound geospatial datasets of low-lying coastal areas and use them in geospatial environmental modeling (GEM).

Using different data resources

For this study, low-lying coastal areas were identified by using the US Geological Survey (USGS) National Elevation Dataset with about 30-meter horizontal resolution (NED_{1arc}). The USGS digital elevation models (DEMs)



↑ Sea level rise is predicted to change the look of the US coastline by the end of the century.



↑ Sea level rise maps depict areas where residents and city planners need to give immediate attention.

are digital representations of elevation information, which are downloadable from the web.

Land area within coastal cities at or below one to six meters of elevation was created using GIS shapefiles of municipal boundaries from US Census Bureau. Data about municipal land areas where estuarine and marine wetland types appear came from the US Fish and Wildlife Service.

Performing calculations

The team created a geoprocessing algorithm that performs an iterative, cell-by-cell analysis of DEMs. It selects all cells with elevation values less than or equal to a particular value and with locations adjacent to or connected by cells of equal or lesser value to the sea. Team members applied this algorithm to the NED_{1arc} data for each integer value from one to six meters to delineate areas potentially impacted by sea level rise over the current and following centuries. The team members selected coastal cities meeting their criteria. They separated out the portions of municipalities that only occur over areas designated as land by removing parts where estuarine and marine wetland types appeared. They overlapped and calculated the land portion of each municipality with areas having elevations at or below one to six meters.

Creating maps

"Maps are the best medium for telling the story of the potential impacts of climate change and sea level rise," said Weiss.

The maps show where one-meter increments of sea level rise could affect coastal areas. Users can see municipal land boundaries, land, water bodies, and color-coded coastal elevations from one to six meters.

Serving maps online

To raise awareness about the possible implications of sea level rise, Weiss decided to publish the data on the web. First, he built a GIS web application by using ArcGIS tools. He selected the map layers, functionality, and map layout he wanted to include. Next, he published the map application climateGEM SLR on a GIS server. Weiss's operation is small, so he keeps his GIS server under his desk. If he decides to expand its capacity, he could add another server, join the campus network, or publish to the Esri map service ArcGIS Online.

The climateGEM SLR web application has been live for over two years. Since the website's launch, Weiss has received very positive feedback.

Read about more GIS applications for oceans at esri.com/oceans.

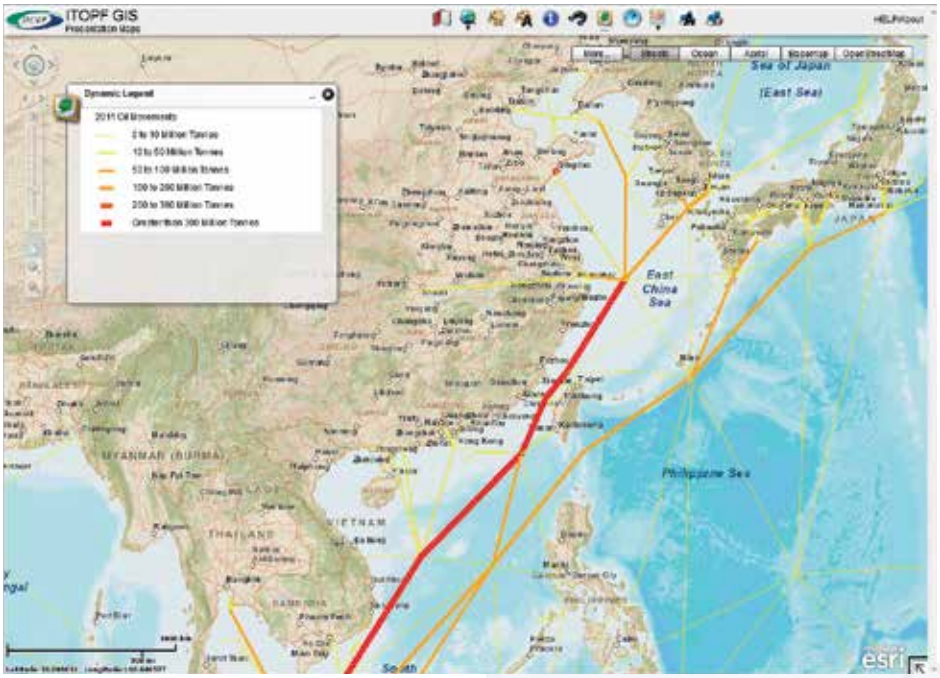
Oil Tanker Maps Help Tanker Owners and China Coastal Communities Be Prepared

By Barbara Shields

A fisherman casts his net into the South China Sea, as did his father. Here the waves are calm, the waters shallow, and the fish abundant. In the past decade, he has seen more and more cargo ships and oil tankers cross his span of ocean, but he is unaware of the risk they bring to his livelihood.

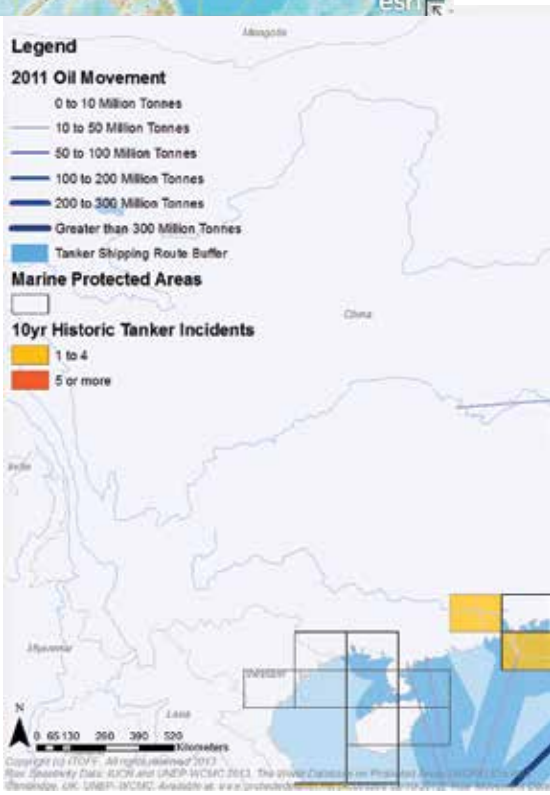
In its current industrial age, China has huge shipbuilding yards, some of the busiest ports in the world, and a thirst for oil. The majority of oil is delivered to China by tankers coming from Saudi Arabia, Angola, and Iran. Globally, the number of accidental oil spills has continued to decline even though there is increased shipping traffic, but the risk of an incident occurring due to factors such as increased traffic, outdated navigation charts, and the number of oil tankers is a major threat to the ecology and economy of coastal cities. Governments and commerce use GIS to understand the risk of oil spills along shipping routes.

Collisions and groundings for medium and large incidents account for 50 percent of tanker spills worldwide; however, in China, they account for 78 percent. Knowing this, the International Tanker Owners Pollution Federation (ITOPF) is working to build awareness in China about the country's oil spill risk. The London-based, not-for-profit organization offers technical advice and information about pollution response and effects of oil spills on maritime environments. Its small response team is in constant readiness to assist at marine spills anywhere in the world.

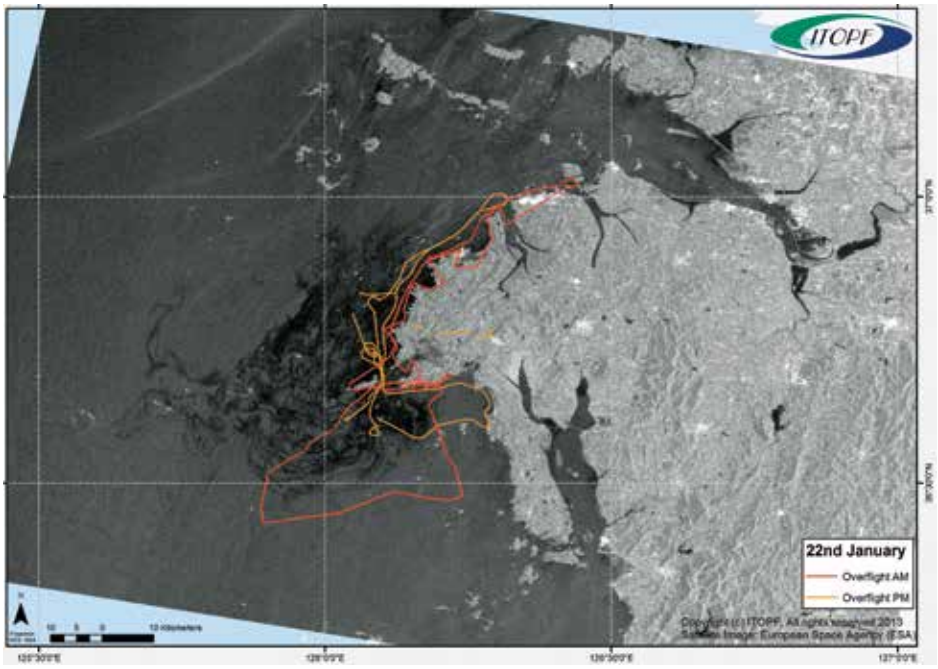


↑ Figure 1. The schematic map of oil tanker traffic provides an uncluttered view of transport tonnage and routes. Maps are available to members on ITOPF's web GIS.

ITOPF researchers analyze seaborne transport data, such as Lloyd's List, about tanker types, movement, and incidents. They use Esri's GIS technology to map tanker routes and their proximities to sensitive environments. Hopefully, the



← A China coastal community works to clean its beaches after an oil tanker spill.



↑ Figure 3. An oil spill site aerial surveillance map shows a satellite image of the site and the flight paths of aerial surveillance planes.

information will persuade local governments to become involved in preparing for disasters.

↑ Figure 2. Atop a basemap, a researcher overlays data layers for tanker traffic, oil spill incident history, and shallow water.

At one time, the organization's researchers manually processed sea transit data to create risk maps. Lisa Stevens, senior technical support coordinator at ITOPF, and consultants from Makina Corpus, a web applications design company, created a geoprocessing routine that speeds the process of mapping oil tankers' journeys.

"Maps tell the story," Stevens said. "The analysis is not complicated, but GIS makes problem areas obvious."

ITOPF uses GIS to create schematic maps showing how much oil is transported along any particular coastline and shipping route and publishes them on its website (see figure 1). Map data includes tanker and vessel types, tonnage, and the number of journeys. In addition, the user can see a geographic history of major tanker oil spills since the 1970s. Adding data from the United Nations Environment Programme (UNEP) about the world protected areas to the map, along with tanker traffic over or near these areas, makes a strong visualization (see figure 2).

Stevens added widgets to the web maps so her colleagues who are not GIS professionals can easily create maps, print, and go. They use these maps during presentations to local governments and other interested organizations to show areas of potential risk.

"Some countries don't know the amount of oil that is going past their coastlines and its potential threat," Stevens noted. "Seeing this geographically helps people realize the scale of the risk and that they need to be prepared with contingency plans and equipment stockpiles."

Whenever and wherever oil spills occur, ITOPF technical advisers use GIS as a tool for providing objective technical advice. Suppose a tanker runs aground off the coast of our fisherman's South China Sea province and oil begins to seep into the water. At the office in London, scientists create and publish a GIS web map that highlights the areas of sensitivity near the ship.

Once technical advisers arrive at the scene, depending on the available infrastructure, they instantly access basic GIS maps that show sensitive areas and reference oil spill case histories. Everyone involved in the incident sees the same data published on the GIS server. The map interface links to information so users can access information about key organizations involved in similar cleanup operations, review their efforts, and meet with them to discuss response activities. Furthermore, ITOPF puts reconnaissance efforts into geographic context by mapping the routes of surveillance flights over the spill site (see figure 3).

GIS presents information in a way that educates thousands of ITOPF members and helps them prepare for oil spills. They can see the amount of oil tonnage and journeys in areas that their own vessels transit and consider their preparedness plans should an incident occur in those waters. Moreover, countries whose shores are at risk of oil spill disaster can design response plans specific to local needs.

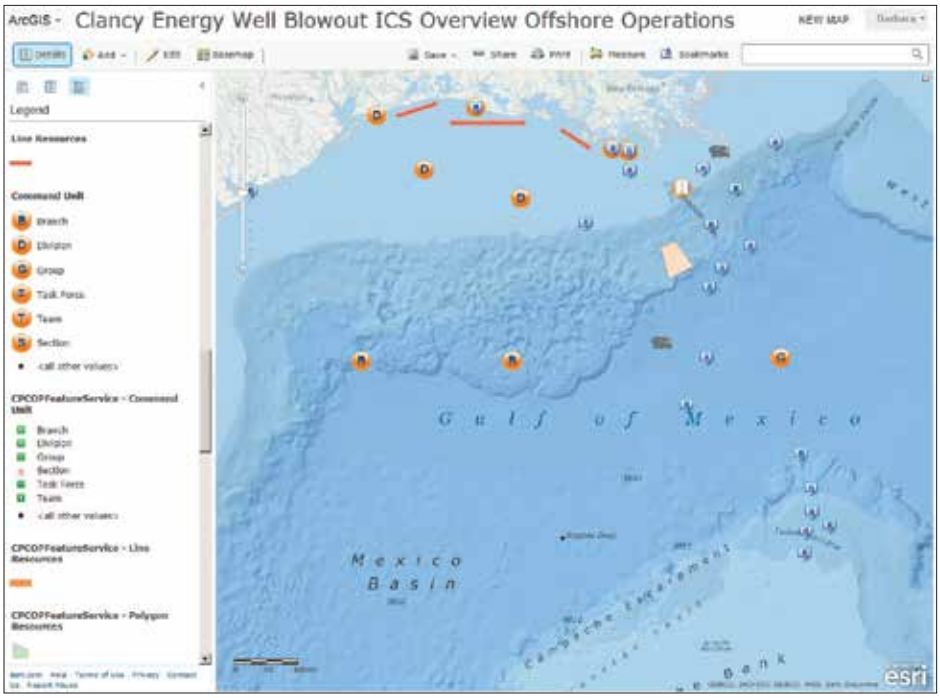
Read other ocean GIS user stories at esri.com/oceans.

Incident Management in the Cloud to Improve Emergency Operations

Esri and Witt O'Brien's have built a new GIS cloud service to increase an organization's capabilities to prepare for, respond to, and recover from ocean oil spill incidents. Emergency management personnel can visualize an integrated incident command system (ICS) through a common operational picture (COP) and systematically command, control, and coordinate multiagency emergency response.

CommandPro helps disaster managers do these important tasks:

- Develop a complete Incident Action Plan (IAP)
- Geographically display response tactics
- Publish interactive ICS-driven maps
- Utilize COP software delivered as a service
- Access published ICS forms from ArcGIS Online
- Leverage easy-to-use tools for making and sharing maps
- Capture and update information directly from a mobile device



↑ A situation map that contains real-time information can be viewed from Esri Operations Dashboard for ArcGIS and can be the primary display in the operation room. (Data has been skewed for demonstration purposes.)

The combined technologies in the COP simplify the complex process of ICS and increase the agility and capabilities of managers dealing with disasters of various sizes and scopes. Witt O'Brien's CommandPro automates the emergency management processes. The Esri ArcGIS Online platform provides user access to fit-for-purpose maps and workflow-enabled apps (e.g., mobile). The integrated solution aligns real-time data with the systematic approach of ICS. An added value is that COP users can access Esri's emergency management map templates, which incorporate adopted standards for spatial data and real-time incident management.

"The ability to communicate real-time situational awareness across both the incident management organization and those affected stakeholders is key to a successful response and recovery," James Lee Witt, executive chairman of the board for Witt O'Brien's, said. "The integration of our emergency response management technology solutions, coupled with Esri's online GIS platform, will help our partners in government and the private sector better manage their response effort while enhancing collaboration across geographic and organizational boundaries."

First responders, government agencies, and private/commercial industries will have the combined ability to respond faster, control resources better, and generate timely incident reports accurately. The new COP will improve their vital communication and coordination capabilities and give them complete enterprise visibility.

"The integration of real-time information provided by Witt O'Brien's ICS software with Esri's GIS platform, via online services, will transform the future of incident management," Jack Dangermond, president of Esri, said. "Already, Witt O'Brien's and Esri's advanced cloud service is proving itself within the oil and gas contingency planning and response theater. We expect this success to open up new possibilities that have positive implications across many other sectors of the incident management and response industry."

The prototype of CommandPro and ArcGIS Online COP has been used for various high-profile projects and incidents. These include many oil and gas readiness projects in which it adhered to heightened government efforts for deepwater operations safety.

Get a free trial of ArcGIS Online at arcgis.com.

Ocean Exploration 2020

The Aquarium of the Pacific hosted the first forum to develop a United States national exploration program. The program, Ocean Exploration 2020, was formed in response to a charge by the US Congress to recommend an oceanographic agenda and specific research goals and objectives to be taken by 2020. Esri participated in the invitation-only event convened by the National Oceanic and Atmospheric Administration (NOAA) as a forum partner. Other forum partners were the Bureau of Ocean Energy Management, the National Aeronautics and Space Administration (NASA), National Geographic Society, and other notable organizations.

About 95 percent of the ocean remains unexplored, leaving new species, historical artifacts, medicines, and other resources potentially undiscovered. Among the scope of ideas and technologies discussed were observation networks, data visualization, and platforms. Shifts in research techniques were presented, such as remotely operated vehicles (ROV) that include sensors, cameras, and data capture devices. GIS will play an essential role in tracking, accessing, and analyzing data for greater understanding.

Esri Ocean Industry Manager Takes the Helm

↑ Drew Stephens, Esri Ocean Industry Manager

Esri has hired Drew Stephens to expand the market for GIS within the ocean industry. Esri has accelerated the development of its ocean technologies via the Esri Ocean GIS Initiative. As Esri's industry manager for ocean and coastal environments, Stephens will play a key role in this effort through his diverse background and GIS experience.

"Stephens has worked with Esri for many years promoting the use of GIS to design sustainable practices for land and sea," Esri chief scientist Dr. Dawn Wright said. "By stepping into the industry manager role, he is helping us place geospatial technologies into the hands of many more ocean scientists, fleet managers, and government analysts for decision making, planning, and policy implementation."

Skilled in database design, training, and consulting, Stephens brings to Esri more than 20 years of GIS experience and knowledge. He will open opportunities for applications of Esri technologies in research and exploration, marine ecosystems, aquaculture and fisheries, coastal protection, and ocean use planning.

Arc Marine Data Model Is Improved

The Esri Arc Marine data model, widely released in 2007, is in extensive use by organizations as the basis to standardize their ocean data. The data model is being improved to provide a community-based information model/template.

One objective for the update is that the physical data structure need not be constrained by any one category. For example, it is now common for people to use netCDF as a container not only for gridded model data but also for time series points and trajectories. Emerging standards, such as netCDF, are considered in the model. In addition, the model's Unified Modeling Language (UML) compliance is being improved to better accommodate Esri's latest software releases. Other significant objectives are to develop a data input tool for Arc Marine, improve interoperability with other standards, and advance the data model's ability to work well with existing and emerging web services.

Esri's Resource center is a go-to site for people who use GIS for the ocean. Find the ArcMarine Data Model and other essential information at resources.arcgis.com.

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