OPEN SOURCE GEOSPATIAL TOOLS: ENABLING COASTAL DECISION MAKERS

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INTRODUCTION

Great benefit can be gained by utilizing Open Source geospatial tools in coastal science. Spatially explicit issues in coastal environments are unique, yet can benefit from the technology commonly used in terrestrial environments. Many of the large trends in environmental spatial science are toward open application frameworks, open data access and open formats. [Jolma et al. 2006] Open Source software can provide a unique benefit in these areas for the coastal sciences. The coastal sciences are ripe to exploit two main benefits of Open Source spatial software:

1) Spatial and modeling technology of terrestrial science is often applicable and adaptable to crossing coastal boundaries.
2) Open Source technology holds promise of solidifying communities within the coastal science field through open development and open solutions.

These key benefits will be realized in coastal science when there are alternatives to traditional systems that not only build on good science but are developed in an open environment. As the influence of Open Source software becomes more prominent it is important to take a step back and evaluate the importance of these tools to decision makers and what work is still to be done to allow improved decision support using these tools in the future. In the ever changing software environment there exists a core set of Open Source spatially-enabled technology that has achieved critical mass. Its history, adoption, practical application and technological basis have enabled it to now be viable for prime time in the coastal sciences.

This paper focuses on Open Source geospatial technology that can be utilized to provide enhanced decision making capability to environmental managers. Specifically, we will focus on GRASS and QGIS in the desktop arena, Mapserver and OpenLayers in the web-based arena, and finally GDAL/OGR and PostGIS in the server arena. While the traditional software stacks owned by proprietary companies supporting the desktop and web-based solutions have been closed and disjointed, Open Source solutions show great promise of unifying tool sets and creating integrated solutions. As a culmination of this idea, we present a web-based software stack that is utilized to create the next generation of Decision Support Tools (DST), integrating both desktop and server technologies.

First, we describe an Open Source toolbox of desktop, web-based and server geospatial systems. The second section focuses on two examples of applying this technology to coastal science. The final section provides a forward-looking discussion of lessons learned and visions for future developments that will more tightly integrate the Open Source geospatial software stacks.

OPEN SOURCE SOFTWARE

Utilizing Open Source software provides many technical and social benefits that we will touch on throughout this paper. [Open Source Initiative, 2007] The largest benefits can be summed up into the following recurring themes: 1) The dollar cost of software used in these systems is minimal; 2) The development community around these software products are active and robust; 3) The availability of source code provides opportunity to not only fix problems but to also enhance the capability of the software for others in the community; and finally, 4) Open Source solutions provide competitive analytical capability in the geospatial field that lends itself to coastal science.

We will briefly describe six key software tools used in this Open Source "toolkit," highlighting key functionality of individual tools. While many different software licenses surround the software being used, they are all considered Open Source, allowing for the basic rights and freedoms to copy, modify and redistribute the individual products. The Open Source tools presented here are just a small representation of tools available for use in the geospatial realm, but do provide an example of a complete stack useable in both the desktop and web-based arenas. [Ramsey, 2006]

DESKTOP TOOLS

QGIS – QGIS is a desktop Geographic Information System (GIS) solution targeted at the traditionally monopolized desktop GIS market, but with a fresh twist. Not only can you utilize the product based on the solid cross platform QT C++ development framework, you can do so without being bound to large licensing fees and restrictions. Freedom to deploy desktop solutions without restriction opens the door to greater community participation throughout the world in coastal science. [QGIS, 2007]

GRASS – Started in 1982, GRASS has evolved from a difficult-to-use GIS package into a robust and user friendly application. GRASS integrates with other applications such as QGIS, providing a powerful GIS analytical engine that, in many ways, exceeds the capabilities of the traditionally monopolized desktop/server GIS. GRASS is itself a cross-platform toolbox of vector, raster and visualization utilities and is under active development. The application of this desktop GIS to marine and coastal issues is limitless, as many of the terrestrial based algorithms are being adapted to marine environments. This package can be the analytical cornerstone of any Open Source GIS based project. [GRASS, 2007]

WEB/WEBSERVER TOOLS

Mapserver – Mapserver is the most stable and most used Open Source web-based server technology available today. Based in academia and adopted by the Open Source community, it is now the basis for many corporate, governmental and education-based efforts in coastal science. Features of note include OGC-compliant WMS/WFS client and server capabilities, integration with PostGIS, utilization of the GDAL/OGR libraries and support for many scripting environments. Mapserver is one of the most well known and well respected open implementations of core components needed to translate GIS data into a map image to be viewed by a web client. [Mapserver, 2007]

OpenLayers – A relatively new project, OpenLayers is growing at a viral pace similar to that of many other tiled mapping clients. The difference between OpenLayers and the proprietary counterparts is on two fronts. First, the open API and code architecture are modern, well thought out and extensible. Second, the interface is developed to allow for integration into all other tile-based servers (i.e., OpenLayers is able to integrate Google Maps, Microsoft Virtual Earth, Yahoo, World Wind and any other arbitrary WMS server). These are powerful concepts and true differentiators compared to other Ajax driven mapping clients. Support for vector-based feature display and editing will be supported in the future. Moving forward these types of smooth panning interfaces surely will become a key technology for integrating and interacting with coastal science data. [OpenLayers, 2007]

SERVER TOOLS

GDAL/OGR – The "Swiss Army Knife" of GIS, GDAL and OGR are integrated into most active GIS projects today, including the latest 9.2 version of ESRI products. [ESRI, 2007] Translation between data formats is a fundamental issue in all GIS related problems, yet most people do not have to worry about that issue due to the incredibly stable and diverse GDAL/OGR utilities and libraries. [GDAL/OGR, 2007]

PostGIS – Spatially-enabled relational databases are one of the most powerful geospatial tools to understand and utilize. Typical SQL statements take the form "SELECT something FROM xyz table WHERE this condition is met." The power of spatial operations in a relational database comes in the form of being able to ask questions like "SELECT area of all polygons FROM spatially enabled table WHERE polygons intersect these features." PostGIS presents the ability to integrate hundreds of spatial operators on your spatial data in a relational database. PostGIS integrates with Postgresql to create an enterprise ready database for fast and robust spatial interaction. [PostGIS, 2007]

EXAMPLES - ECOTRUST

The need to have a GIS analyst or scientific modeler produce unique output based on scenario driven alternatives is often a great limitation to policy makers trying to understand complex systems. The introduction of web-based DSTs has brought about a new and innovative approach to decision making. A shift in focus toward tools that allow users to run targeted scenarios based on user defined requirements is starting to bear fruit. The introduction of "toolkits" and "plug-ins" for many of the mainstream desktop GIS systems has paved the way for a new class of web-based DST. Through the integration of web-based GIS interfaces with server-side GIS systems, we have started to see the birth of real-time decision support tools on the web, focusing on scenario-based decision making. [Racicot 2006] We build on the hypothesis that real-time DST development using Open Source tools will enhance usability and reduce cost of many environmental management tasks. Presented here are two case studies that exemplify this concept: OpenZone and the Gulf Project.

OpenZone – Ecotrust is currently integrating Marxan, a terrestrial sighting algorithm based on simulated annealing, into a web-based marine focused system capable of running simulations, interacting with the user, and interacting with simulation results all in real time over the web. A new version of Marxan, termed Marzone, is being embedded in an Open Source framework allowing real-time simulations to be run by

decision makers in web-interactive time frames. One of the greatest benefits of this Open Source based framework is the long term transferability to other coastal zones.

Gulf Project – Ecotrust, in collaboration with The Ocean Conservancy, has built a new tool deployed in the Gulf of Mexico that incorporates commercial fishing effort data into spatially constrained scenarios. Through the use of web-based GIS, users are able to spatially select arbitrary areas of interest in the study region, as well as relational criteria about the fishing effort (i.e., percentage of large boats to remove) to produce real-time analysis of over 1.5 million effort records in a 10-year time frame. This tool provides new views into data essential for decision making.

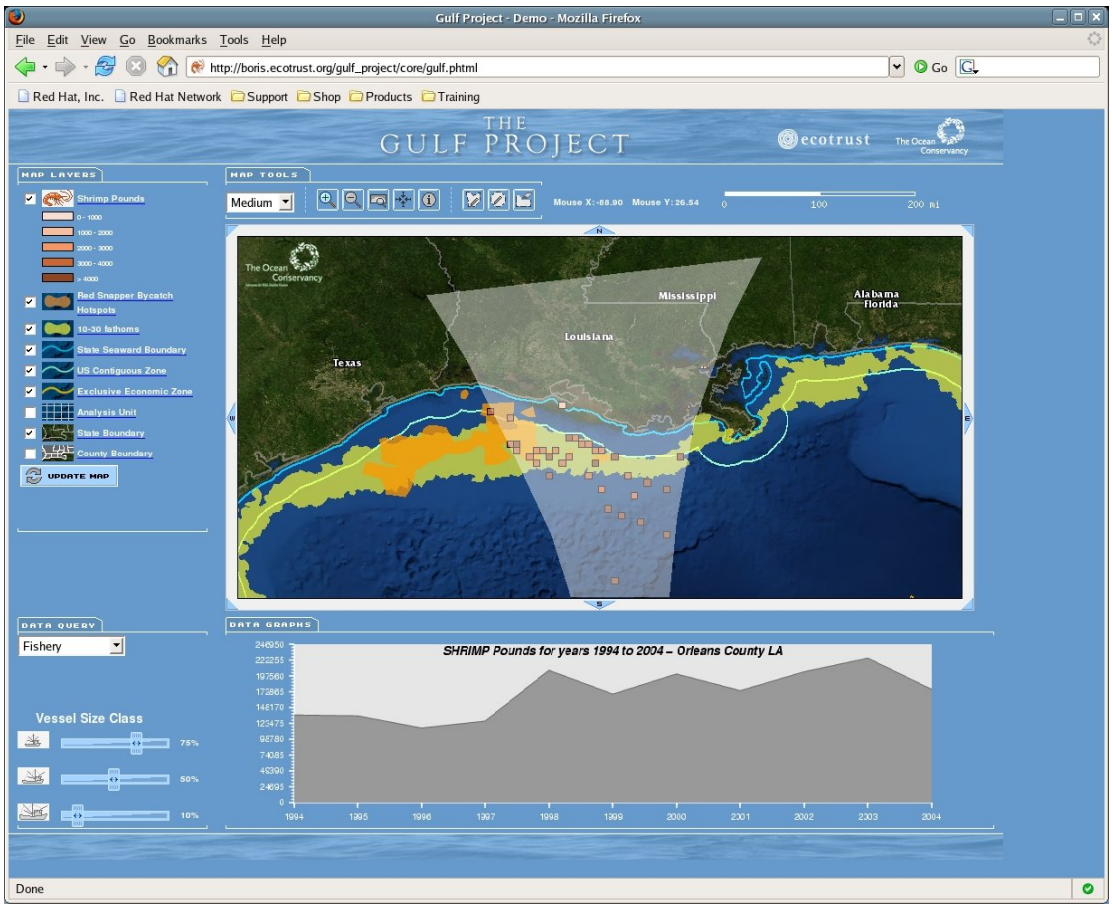

Figure 1 - The Gulf Project DST

SYNTHISIS AND CONCLUSIONS

Possessing a toolbox of Open Source geospatial software, we can now envision how to utilize these tools in complete solutions. The time has come for DST development to make the leap from desktop to the web. With the cost and complexity of desktop GIS analysis remaining high, it is necessary to take a new approach to presenting analysis options to environmental managers. Specifically, it is no longer acceptable to pre-generate scenario-based analysis for complex systems. Scenarios inevitably will be missed, analysis will not meet criteria, and re-analysis will be necessary. Distilling analysis techniques into discrete products and translating those into web-based applications alleviates the need for costly analyst time and brings a sense of real-time interaction to the manager. It is the synthesis of desktop GIS workflows encapsulated into web-based applications that creates real opportunity for increases in usability and

decrease in cost. Building this application base on an Open Source software stack only reinforces those ideas by including community-based development into the framework. We have yet to see the complete convergence of Open Source geospatial tools into a truly "cohesive toolbox". Our goal at Ecotrust is break down the remaining barriers that exist between Open Source GIS projects and bring the power of server-side GIS to the web through the creation of web-based DSTs.

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