Working Towards a Multipurpose Marine Cadastre

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ABSTRACT: The Energy Policy Act of 2005 calls for The Secretary of the Interior to coordinate with other federal offshore agencies to establish an interagency comprehensive digital mapping initiative for the Outer Continental Shelf. The Minerals Management Service (MMS) is tasked as one of the lead federal agencies to develop a web-based Multipurpose Marine Cadastre (MMC) to provide for a comprehensive spatial data infrastructure whereby rights and interests, restrictions, and responsibilities in the marine environment can be assessed, administered and managed. The MMC will an online interactive map that will utilize a unique data harvester and web map services from all of the Agencies of Responsibility (AOR) for the various offshore features to be mapped. The MMC will provide a single location where managers (without GIS training or software) can go to view all existing activities and infrastructure features needed for decision making in any U.S. OCS area. Enhanced features include thematic data viewers for alternative energy and Google Earth applications.

KEYWORDS: Multipurpose Marine Cadastre, Minerals Management Service, NOAA, web map viewer.

Introduction

The Energy Policy Act of 2005, (Public Law 109-58) (Epact) was signed into Law on August 8, 2005. Section 388 – Alternative Energy-Related Uses on the Outer Continental Shelf, of the Act granted the Minerals Management Service (MMS) new authority to regulate energy uses on the Outer Continental Shelf (OCS). Moreover, it directed the Secretary of the Interior, in cooperation with the Secretary of Commerce, the Commandant of the Coast Guard, and the Secretary of Defense to establish an OCS Mapping Initiative to assist in decision making related to alternative energy uses on the OCS. The goal of the initiative is the identification of OCS locations of Federally-permitted activities; obstructions to navigation; submerged cultural resources; undersea cables; offshore aquaculture projects; and any area designated for the purpose of safety, national security, environmental protection, or conservation and management of living marine resources.

The primary objective is the development of a web-based Multipurpose Marine Cadastre to provide for a comprehensive spatial data infrastructure whereby rights and interests, restrictions, and responsibilities in the marine environment can be assessed, administered and managed.

To accomplish this, MMS is taking the lead to create the digital interactive web map, herein termed the "Multipurpose Marine Cadastre", (MMC), that will utilize data layers and/or web map services from Agencies of Responsibility (AOR's) for the various offshore features to be mapped. These agencies will include MMS, National Oceanic and Atmospheric Administration (NOAA), U.S. Fish and Wildlife Service (FWS), and others. These agencies and others are collaborating to fulfill Section 388 of the Epact to design, develop, and build the Digital Mapping Initiative. The Marine Boundary Working Group (MBWG, a subcommittee of the Federal Geographic Data Committee), will facilitate the effort, and is included in its work plan.

This service will provide a single location where managers (without GIS training or software) can go to view all existing activities and infrastructure features needed for decision making in any U.S. OCS area.

The Marine Boundary Working Group (MBWG, a subcommittee of the Federal Geographic Data Committee), will facilitate the effort. Part of the group's charter and work plan is to develop and implement the MMC. A subset of the MBWG has agreed to take the next steps in defining the Web interface and Internet mapping component of the multi-purpose marine cadastre. As part of the FY 07 work plan, the MBWG will:

1. Develop a comprehensive list of marine boundary data, restrictions and encumbrances, agencies of responsibility, and associated legislation and regulations.
2. Continue to make data and information accessible through the Web and the E-Gov Geospatial One-Stop Portal.
3. Coordinate with the Marine Protected Areas (MPA) Initiative to ensure that marine boundary source data are accessible through their inventory.
4. Develop minimum requirements for accessible data.
5. Develop and implement a project plan for the digital mapping component of the multipurpose marine cadastre initiative.

What is a Marine Cadastre?

"A marine cadastre is a system to enable the boundaries of maritime rights and interests to be recorded, spatially managed and physically defined in relationship to the boundaries of other neighboring or underlying rights and interests." (Robertson et al, 1999). A cadastre on the ocean is much like a land-based cadastre. In one sense, it is an official register of the location, quantity, value, and ownership of a feature. This definition refers to a grid system that features on the OCS can be tied to and located. For example, features can be tied to a UTM grid.

Another definition says that a Marine cadastre is "A marine information system, encompassing both the nature and spatial extent of interests and property rights, with respect to ownership and various rights and responsibilities in the marine jurisdiction." (Nichols, S. et al, 2000). So in this sense, it is describing those attributes associated with features on the OCS.

The term cadastre has not often been used in the context of the marine environment. There are many similarities, but a few significant differences, between a marine and land cadastre. Many of the upland cadastral components such as adjudication, survey, and owner rights have a parallel condition in the ocean. These boundaries share a common element with their land-based counterparts in that in order to map a boundary; one must adequately interpret the language of the law and its spatial context.

Other typical cadastral processes such as demarcation become problematic when applied to marine boundaries. Marine boundaries are delimited, not demarcated, and generally there is no physical evidence of the boundary (US Dept. of Commerce, NOAA). Physical evidence of upland boundaries, such as monuments, pins, hedgerows, or fences are not always practicable in the marine environment.

We also need to consider the rights and ownership of many different and sometimes conflicting interests in a 3 dimensional space (figure 1).

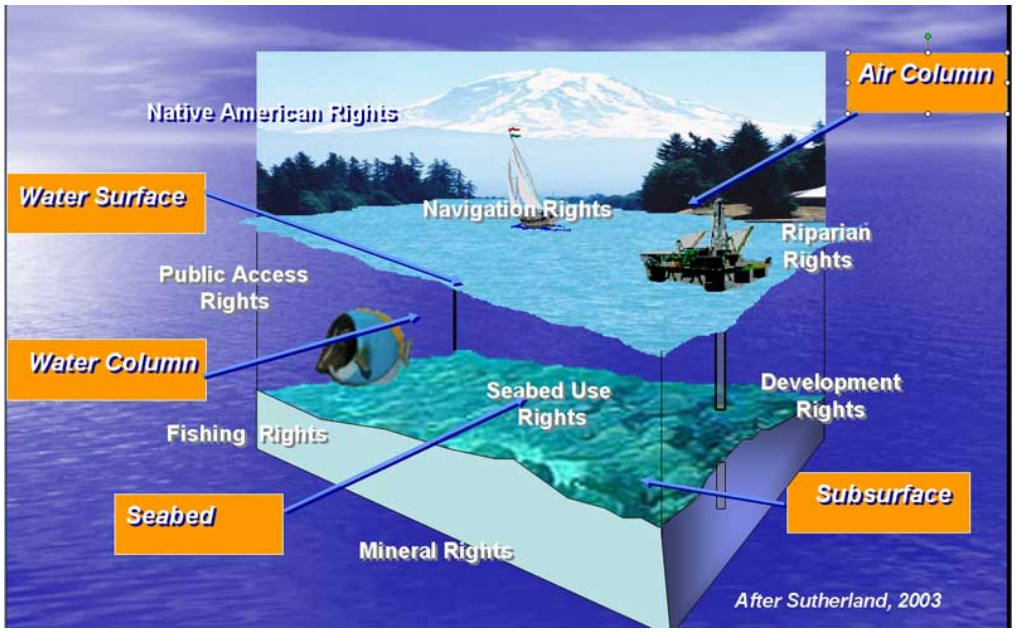

Figure 1: Three dimensional space

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There is not only the sea surface to consider, as in boundary computations, but other aspects of the three dimensional column. Many groups have interests in one or more areas. For example, a fisherman may be interested in not only fishing rights to a particular area, but also the navigation rights in order to get to that area. Also, one could even say that the fourth dimension of time has an influence, as some rights and restrictions may be in effect only during certain periods of time. For example, there may be seasonal restrictions in whale migrations and calving areas.

Why build a Multipurpose Marine Cadastre?

There are many individual places one can go to see these data layers. For example, MMS provides the SLA and 8g boundary lines, NOAA can provide the 200 mile Exclusive Economic Zone, etc., BUT:

- There is no one portal that brings all the data layers together in a seamless fashion that enables one clear, concise view of the rights and ownership on the OCS.

- It's this one "big picture" that will enable decision-makers to make better, more informed and timely decisions to better manage the ocean environment.

With the Energy Policy Act of 2005, the Multipurpose Marine Cadastre will also need to incorporate other entities on the outer continental shelf, such as wind farms (figure 2), and various proposals for wave-generated energy (figure 3).

Figure 2: Offshore Wind farm

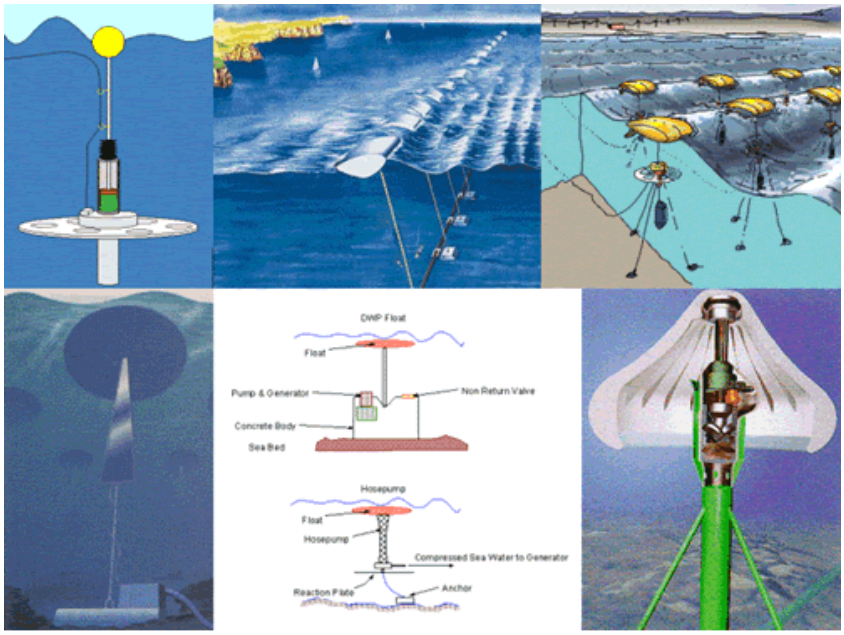

Figure 3: Wave energy generation devices.

Development

During a January, 2007 a workshop meeting was held at the NOAA Coastal Services Center (CSC) in Charleston, South Carolina. Several agencies were represented at the workshop, including NOAA, MMS, and US Fish and Wildlife. The workshop accomplished several goals:

- Developed a comprehensive project plan for a web portal that will support the MMC initiative.
- Identified data management strategies and are developing data/metadata standards.
- Decided to use a template from an existing ArcIMS application to speed proof of concept and testing.
- Formalized cooperative agreement between MMS and NOAA in the form of a memorandum of understanding to co-develop the viewer.

A proof of concept website was built during FY 2007 to demonstrate the feasibility of the website. MMS coordinated with NOAA and FWS to design and build the system. To build a working concept quickly, data layers from participating partners were sent either by CD or thumb drives to NOAA CSC. An ArcMap project was built from these layers, and an ArcIMS image service created from the project. Partners specified scale-dependant rendering, colors, etc. for their layers. (Figure 4).

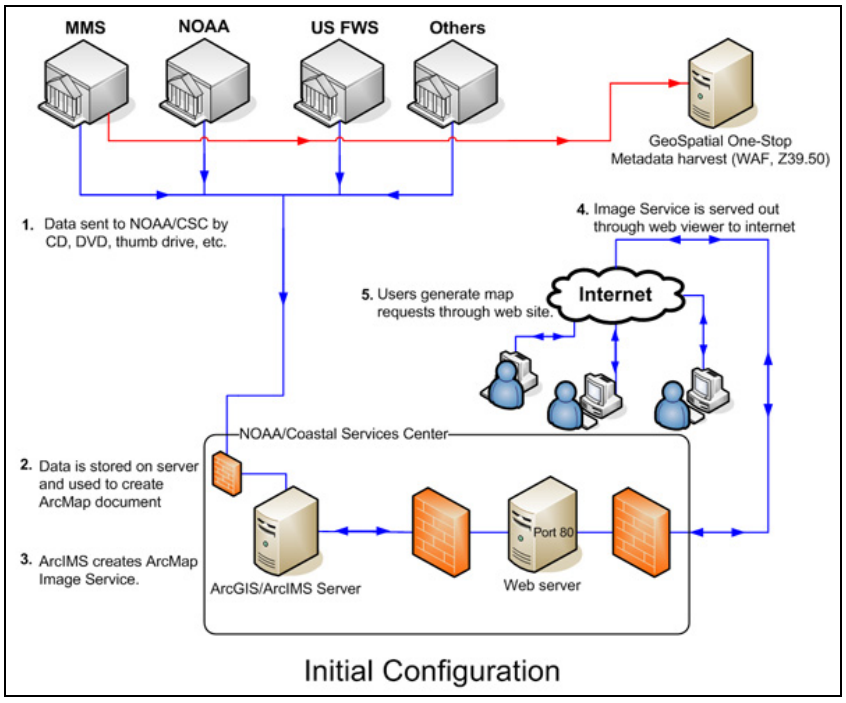

Figure 4: Initial Configuration.

Project Plan and Action Items

In FY 2008, MMS and NOAA CSC entered into a memorandum of Understanding (MOU) that details a project plan, application development, outreach, and technology transfer. In May of 2008, the beta (production) version of the MMC went on-line. For this version of the viewer, the project team has included organizing and making accessible all U.S. Maritime Boundaries and Limits (U.S. Marine Cadastre) and critical supporting data. These data are available for viewing through the Internet and desktop mapping applications and for download through the MBWG data portal. (http://www.csc.noaa.gov/mbwg/htm/multipurpose.html)

While the long-range goal of the project is to utilize web services, the state of technology and partner capacity necessitates an intermediate step. The data harvesting routine serves to automate the process of data retrieval from the participating AOR's to a centralized spatial database. The Data Harvesting Routine (Figure 5) ensures that the data that exists the MMC's mapping applications is kept current.

In order to ensure the correct operation of the harvester, all datasets identified by the project team will need to be placed in a web-accessible public directory within each agency's network infrastructure. In addition, each participating agency will be responsible for ensuring that these datasets exist in an ESRI shape file format, their spatial reference in Geographic Coordinate System (GCS) North American Datum of 1983 (NAD83), and contain the attribute schema created for the project and based on FGDC standards.

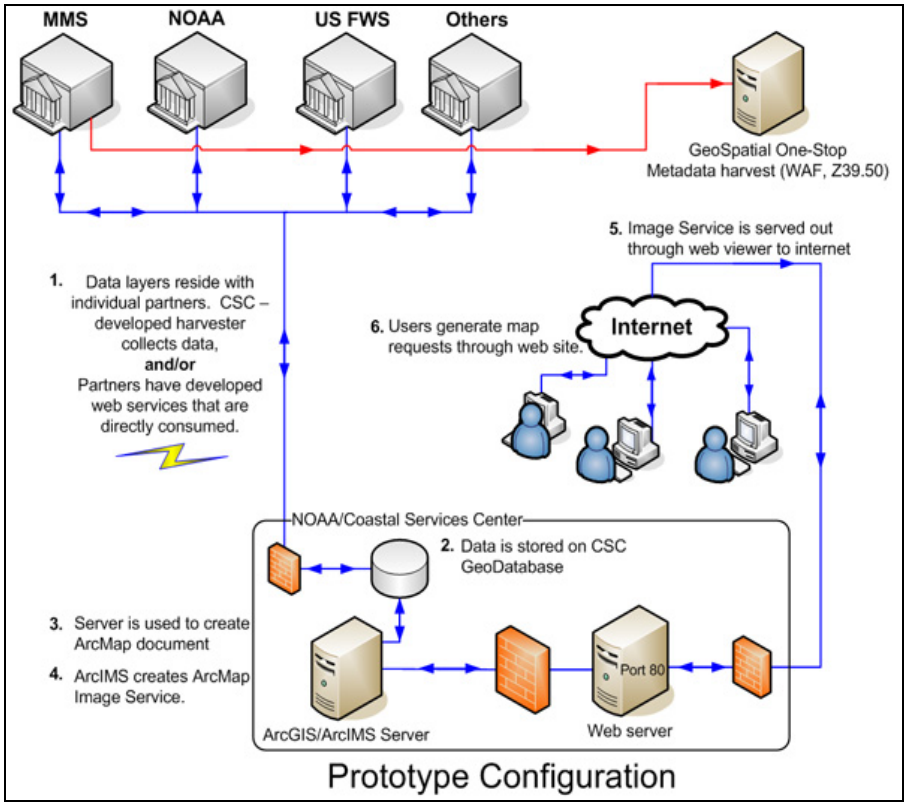

Figure 5: Prototype Configuration (Harvesting).

Figure 6 shows the proof of concept website. The table of contents on the left side of the image show the available data layers. If a particular data layer is not available at the current scale, a small magnifying glass icon appears in the checkbox. Data is symbolized in the ArcMap MXD file and the symbology is continued when the ArcMap image service is created.

Figure 6: Proof of Concept website

Alternative Energy and Google Earth viewers

As part of the implementation plan for FY 2008, the project team has also developed an Alternative Energy implementation of the cadastral data viewer. During development, it was realized that there are many additional data themes that need to be considered for comprehensive analysis and decision making. These data exist in a variety of formats and include: human use data, physical oceanographic data, and biophysical data sets.

This version of the viewer contain data that are deemed appropriate for use in helping to site possible alternative energy development on the outer continental shelf, and contain the cadastral layers, along with submarine cables, pipelines, and similar layers.

The Alternative Energy Viewer application (Figure 7) was developed to allow for the inclusion of these additional data layers into a mapping application that uses ESRI's Arc Reader software, which moves the map creation tasks off of the centralized server user's desktop. As a result, additional data themes and layers can be added to the MMC project with no effect on the project's supporting IT infrastructure. The same basic map tools employed in the U.S. Marine Cadastre are included in the Alternative Energy Viewer.

In addition, data sets in KML format contain core cadastral data layers for the nation in a Google Earth KMZ.

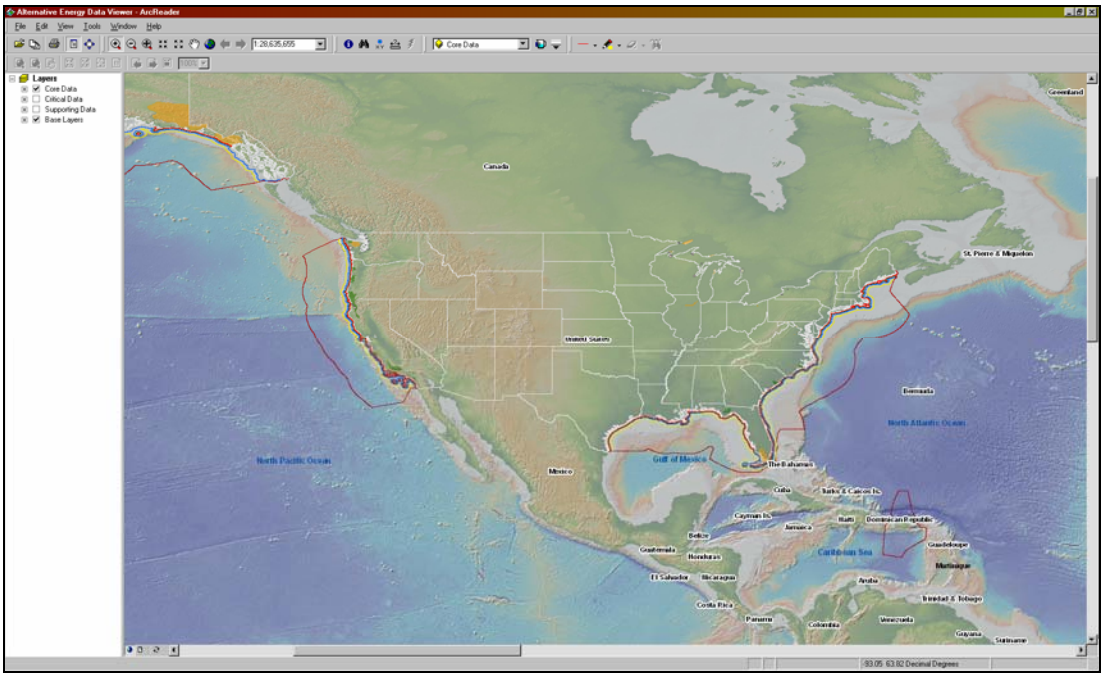

Figure 7: Arc Reader Document

Future Direction and Development

The project team intends to develop a more robust version of the viewer, with enhanced web and GIS analysis tools. More partners will be encouraged to participate as the project grows. During FY 2009, it is proposed by the development team to assess the feasibility and usefulness of the following tools:

- **Custom reporting tools**: In consultation with MMS' Alternative Energy Program, custom tools will be developed that will assist with the review of permit applications.
- **Identified Custom Map Generation tools**: Incorporate custom tools for generating maps within ArcIMS that support permit review and alternative energy siting.
- **Get Cadastral Record**: This utility will allow the users to view a cadastral record based on standardized attributes.
- **Get Legal Description Tool**: This utility will allow users to click on a marine boundary to obtain the associated legal description. Functionally, this tool will exist as a modification to the Hyperlink tool, and will necessitate the addition of an attribute which will contain a link to the legal description itself.
- **Multiple Data Viewers:** Based on user feedback, additional viewers will be developed. These could include open source, Google Maps, and/or additional functionality within the Arc Reader environment. The goal of these viewers will be lightweight client-side applications that shift data processing to the desktop.

Data Management and Standardization

The MMC data access and visualization tool will contain various marine and coastal data sets from a variety of federal agencies. As such, distributed data management is critical to ensuring that all data included within the MMC project is kept current. Figure 5 illustrates the next

proposed configuration of the MMC system, which facilitates distributed data management through the data harvesting routine. In order to ensure the correct operation of the harvester, all datasets identified by the project team will need to be placed in a Web-accessible public directory within each agency's network infrastructure.

In addition, each participating agency will be responsible for ensuring that these datasets: exist in an ESRI shape file format, have a spatial reference defined as a Geographic Coordinate System (GCS) referenced to the North American Datum of 1983 (NAD83), and contain the attribute schema created for the project and based on FGDC standards. The implementation of these standards, to be facilitated by the project team, will ensure that all data sets within the MMC system contain the same information, which will greatly enhance their utility to the end-user.

Figure 8 illustrates the larger vision for the MMC project configuration. As the volume of data included with the MMC project increases, the current and near-term project configurations will become more of a bottleneck in the system architecture. This is due to the fact that they rely on centralized server-side applications to manage the necessary spatial data – as you increase the load on these applications, system performance suffers.

The inclusion of Web services into the project configuration, such as Web Mapping Services (WMS), allows for easy expansion of the MMC data holdings in a way that de-centralizes the system, and minimizes bottlenecks. WMS services essentially allow each partner agency to serve their own data via commonly-available tools such as GeoServer, MapServer, and ArcGIS Server. WMS services can be consumed by the U.S. Marine Cadastre and Alternative Energy Viewer applications. In FY 09, a WMS-based data model will implemented for select partner agencies as a test case. A significant amount of partner agency capacity building will be conducted by CSC to ensure that these agencies have the necessary tools and technology to implement WMS services.

Eventually, the goal is for each partner to establish web services that the viewer can consume. Also, a Z39.50 connection can be made to the Geospatial one-Stop that will enable the metadata for the project to be harvested.

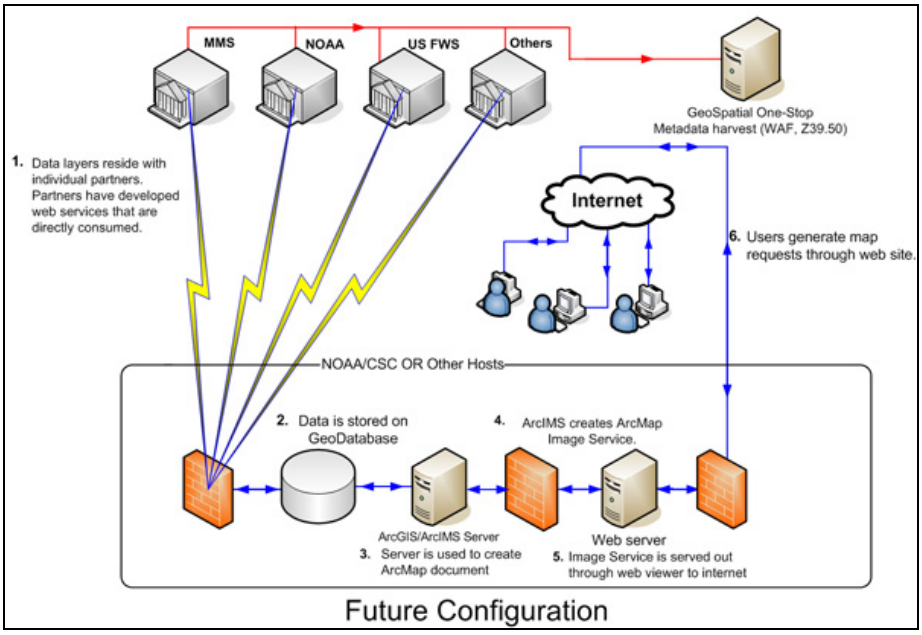

Figure 8: Future Configuration (Distributed web services

The following tasks, supporting data management and standardization, are proposed for FY 2009:

- Complete technology and web portal transfer to MMS.
- Jointly develop and disseminate data publishing guidelines to partner agencies.
- Hold an MMC working meeting to present guidelines and to get buy in from partner agencies.
- Implement data harvesting for 3 partner agencies.
- Develop a test case whereby a WMS/WFS client is installed and implemented at 3 partner sites.

Technology Transfer

To enable MMS to be the host agency for the alternative energy viewers and supporting information, NOAA will provide consultation services and technical assistance to MMS' IT group in New Orleans. The purpose is twofold: 1) assist the New Orleans office with standing up an infrastructure to ultimately support the MMC applications and data provisioning for alternative energy; and 2) to physically transfer the applications (IMS template, data schemas) and data to the New Orleans office. As this technology transfer task is completed, CSC staff will work with MMS staff in New Orleans to ensure that all applications implemented within their server architecture adhere to current federal security protocols. In addition, CSC staff will provide lessons learned from any security issues they have encountered when working with the technology that currently supports the MMC project.

As a result of existing partnerships and outreach conducted in FY 2008, several opportunities for collaboration have been identified. These partnerships have the potential to provide some of the critical data sets needed to better inform decision making for alternative energy siting and permit review. The data themes include oceanographic, biological, human uses, and conservation.

Partnerships

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NOAA Fisheries (Oceanographic, in situ, biological data). The habitat conservation division is developing a hydrokinetic inventory in California State waters. The web based product will provide an outreach and scientific tool for to inform decisions regarding the placement and impact of hydrokinetic projects.

The Nature Conservancy (Conservation data, ecological assessments). TNC is currently testing MMS' lease block grid as a mapping unit for their ecological assessment data. A pilot project is being conducted off of the Oregon Coast.

NOAA MPA Science Center (Socio-economic and human use data). The MPA Science Center is developing a Human Use Atlas for California State waters.

Each of these groups has expressed interest in collaborating with the MMC project team in the development of the MMC. To leverage data and resources from these activities, NOAA proposes

to conduct a case study in a location off of California. The case study will add critical data sources to the MMC and further research and management efforts in California. Additionally, the methods and data management techniques will be documented to ensure they can be transferred to other locations in the U.S.

Outreach will be conducted to ensure that the products developed in support of the MMC reach the intended audience, future customers, and potential partners. Additionally, the team will focus on researching and learning about other similar activities that are taking place around the world and in the U.S. Outreach will be conducted through conferences, meetings, and publications.

Opportunities that exist in FY 2009 include venues such as the International Submerged Lands Conference, International cadastral conferences such as with the International Hydrographic Organization, ESRI User conferences, The Interagency Workgroup on Ocean and Coastal Mapping, Coastal Zone and Geotools 09', and so on.

Issues, Challenges, and Conclusion

During development, there were several issues to consider. Although ArcIMS is capable of reprojecting on the fly, it is better for performance to have all the data in the same projection. Metadata is an important component to this information system. All partners must agree and abide to the same metadata standards, taxonomies, etc., as well as a "core" set of fields. Some partners might have security/sensitive data, and accommodation for access to authorized partners will need to be made. Some data has not been in a format that does not lend itself readily to presentation on the web. For example, one partner may have the locations of hundreds of features on the outer continental shelf, but the data is in ASCII format. The complex multi-dimensional nature of the marine environment (both physical and legal) makes the geospatial display in a seamless manner difficult. Related to that is lack of adequate spatial coverage, resulting in gaps. Perhaps most challenging is the lean budget environment.

The Multipurpose Marine Cadastre is truly a multi-agency, multi-use tool that will enable ocean and coastal managers, technologists, and the public to get a one-stop view of the Outer Continental Shelf to enable them to make informed, effective decisions for "Good Ocean Governance" (Thormahlen, 2006).

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