DATA INTEGRATION AND VISUALISATION REQUIREMENTS FOR A CANADIAN MARINE CADASTRE: LESSONS FROM THE PROPOSED MUSQUASH MARINE PROTECTED AREA

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ABSTRACT

The coming into force of the United Nations Convention on Law of the Sea (UNCLOS) has forced the subdivision of the oceans into Territorial Seas, Exclusive Economic Zones and Continental Shelves, each with its attendant right and responsibilities. As it explicitly deals with the rights, restrictions and responsibilities to the physical offshore, UNCLOS has created a complex multidimensional mosaic of potential private and public interests. When coastal zone management programs, and internal jurisdiction and administration issues are added on, a clear understanding of the nature and extent of offshore interests is crucial for decision-making purposes.

One such coastal zone management program is the Marine Protected Area* (MPA) program in Canada. This paper reports on one of the objectives of the "Good Governance of Canada's Oceans" project: To highlight data integration and visualisation challenges in visualizing the complexity of rights in marine spaces. Specifically, this paper reviews the technical challenges of data integration and visualisation that were encountered as part of a case study involving the proposed Musquash MPA. These technical challenges are particularly important considering the spatial data scale, format, precision and accuracy issues intertwined with the jurisdiction and administrative uncertainty found in Canadian marine space. It is in this context that the authors view these technical challenges as synonymous with those to be encountered in building a marine cadastre.

KEY WORDS: Marine Cadastre, Marine Tenure, Marine Geospatial Data Infrastructure, Marine Parcel

1. Introduction

The coming into force of the United Nations Convention on Law of the Sea (UNCLOS) has forced the subdivision of the oceans into Territorial Seas, Exclusive Economic Zones and Continental Shelves, each with its attendant right and responsibilities. UNCLOS has provided a legal mechanism whereby a nation can extend its claims as far seaward as the limits of the continental shelf. As it explicitly deals with the rights, restrictions and responsibilities to the physical offshore, UNCLOS has created a complex multidimensional mosaic of potential private and public interests. When coastal zone management programs, and internal jurisdiction and administration issues are added on, a clear understanding of the nature and extent of offshore interests is crucial for decision-making purposes.

One such coastal zone management program is the Marine Protected Area (MPA) program in Canada. This paper reports on one of the objectives of the "Good Governance of Canada's Oceans" project: To highlight the importance of visualizing the complexity of rights in marine spaces. Specifically, this paper reviews the technical challenges of data integration and visualisation that were encountered as part of a case study involving the proposed Musquash MPA. These technical challenges are particularly important considering the spatial data scale, format, precision and accuracy issues intertwined with the various jurisdiction and administrative uncertainties found in marine spaces. It is in this context that the authors view these technical challenges as synonymous with those to be encountered in building a marine cadastre.

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* defined in Section 35 of Canada's *Oceans Act* [1996] as, "an area of the sea designated for special protection that forms part of the internal waters of Canada or the exclusive economic zone of Canada."

In this paper, the authors begin from the following assumption; that to attain informed decision-making for the governance of coastal and marine resources, there is the requirement to obtain and manage a range of information. This information would include (but would not be limited to) living and non-living resources, bathymetry, spatial extents (boundaries), shoreline changes, marine contaminants, seabed characteristics, water quality, and property rights. In one way or another these datasets all contribute to the sustainable development and good* governance of coastal and marine resources [e.g., Nichols, Monahan and Sutherland, 2000].

Subsequently, the authors suggest that the technical challenges of building the marine cadastre also include the specific challenges of data integration and visualisation. This paper begins by outlining the concept of a marine cadastre; then briefly reviews marine data sources in an international and Canadian context. The paper then outlines why MPAs are considered representative marine space and then outlines the specific data integration and visualisation challenges that were encountered in a project involving the Musquash MPA in New Brunswick, Canada. This paper concludes by outlining the future direction of this research project.

2. The Marine Cadastre Concept

McLaughlin [1975] defines a cadastre as " a parcel- based record of interests in land encompassing both the nature and extent of these interests". Extending this description further, the authors define a marine cadastre as an information system that not only records the interests but also facilitates the visualisation of the effect of a jurisdiction's private and public laws on the marine environment (e.g. spatial extents and their associated rights, responsibilities, restrictions, and administration). Other relevant information such as that regarding the physical and biological natures of the environment may be connected to the cadastre using spatial referencing to give the cadastre a multipurpose function.

The development of a cadastre depends on the several items [see McLaughlin, 1975; National Research Council, 1980, 1983; Niemann and Moyer, 1988]. Initially there must be a spatial framework, which should normally be in the form of a geodetic network, which makes it possible to establish spatial linkages between all relevant land information so that any one item can be related in space to another. The spatial framework should be supplemented by a series of large-scale maps or plans and should include a cadastral overlay together with a register of interests. In the oceans where resources and activities (and therefore rights, restrictions and responsibilities) can co-exist in time and space and can move over time and space, the authors have previously argued [see Nichols et al., 1999, 2000a, 2000b, 2001] that the definition of a parcel is even more complex. Furthermore, the authors suggest that a cadastre in the conventional sense may not be the best unit of representation for all interests. Until another framework is proven more useful, the cadastral concept continues to be considered in this paper as an initial point for exploring ideas.

In the specific case of Canada, there is no comprehensive plan to construct a marine cadastre nor to include it as part of the national geospatial data infrastructure. Although Canada is hampered in large part by legal and political issues, technical issues surrounding the collection, organization, integration, and dissemination of data are part and parcel of marine cadastre problems. In this paper then, the marine cadastre concept has been used to aid in exploring the answers to two questions: what type of cadastral information would be found in a marine cadastre; and how would this information be integrated and visualised?

2.1 Cadastral Information in Marine Space

Cadastral information in marine space can be found in the form of boundaries (or limits) of rights and interests. A small selection of some of these boundaries might include [Nichols, Monahan and Sutherland, 2000a; Nichols and Monahan, 1999]:

- Limits of private and public ownership on upland property (e.g., ordinary high water mark);
- Limits of private rights below high water (e.g., water lots, aquaculture site leases, oil and gas licenses and leases, fishing licenses);
- Municipal, county, provincial, and territorial limits of jurisdiction and administration;

* "Good" governance is a subjective term that assumes that the stakeholders have predefined goals and benchmarks for what is good.

- Other national boundaries (e.g., Territorial Sea, Contiguous zone, Exclusive Economic Zone) and international boundaries, including national coastal baselines;
- Government departmental limits;
- Environmental protection areas (e.g., wetlands, marine protected areas, coastal zone management)
- Military limits (e.g., disposal and weapons firing ranges);
- Pipeline and cable rights-of-way.

But scientific information can also be used as boundary evidence. The authors argue that this international precedent has been set by the defining what information can be used to prepare a claim under the United Nations Convention on Law of the Sea (UNCLOS). Several authors [e.g. Monahan and Mayer, 1999; van de Poll et al., 1999] indicate that the scientific and technical guidelines of the Commission on the Limits of the Continental Shelf (CLCS)[*] provide specific guidelines on the types of data that can be used. The interpretation of this guidelines leads to the general agreement that navigation data, raw water depth (bathymetric data), field values of magnetic fields, calculated water depths, free-air gravity and magnetic anomaly, should make up the data content of such a claim. This represents a new approach in boundary delimitation as scientific information is actually being used to provide evidence of the continental shelf juridical boundary. Clearly, such a boundary would be incorporated in a marine cadastre as it represents the spatial extent of a Nations' rights and interests. The authors suggest that this is tantamount to redefining the traditional hierarchy of evidence (found in English Common Law) to include scientific evidence: in this case, the physical location of the continental shelf as accepted by the CLCS.

The preferred data source for initial exploration of a UNCLOS claim is usually the joint IHO / Intergovernmental Oceanographic Commision (IOC) mapping information available as the General Bathymetric Chart of the Oceans (GEBCO). GEBCO contains 16 Mercator sheets covering the world from 72N to 72S, on a scale of 1:10 million at the equator. It also contains two polar stereographic sheets covering the polar regions (to 64N and 64S) on a scale of 1:6 million [British Oceanographic Data Centre, 2001]. In addition, this information is updated in digital form through the GEBCO Digital Atlas with new versions being published on CD-ROM at three yearly intervals by the British Oceanographic Data Centre. BODC maintains the GEBCO Digital Atlas on behalf of the International Hydrographic Organisation (IHO) and the Intergovernmental Oceanographic Commission (IOC) of UNESCO. It represents the first seamless, high quality, digital bathymetric contour chart of the world's oceans. To date 555 copies have been sold (or distributed as complimentary copies) in 55 countries.

The authors point out that GEBCO scale is too coarse to be considered practical for the purpose of a marine cadastre. Other regional mapping programs provide "less coarse" datasets; for example, arctic nations are participating in a joint mapping program to share data and expertise in the Arctic Ocean[*]. The US Navy has declassified under-ice nuclear submarine data collected prior to 1982, and are operating a modern submarine under the ice each year for scientific purposes in project SCICEX [Coakley et al., 1999].

From the foregoing discussion it can be concluded that there is a multitude of information about the marine space that is available, and that can be incorporated into a marine cadastre. In this paper, the authors view a marine cadastre as an important part of any nation's geospatial data infrastructure. No nation can claim to have complete, seamless, and comprehensive information on marine rights (public and private; formal and traditional) and marine jurisdictional limits in addition to the vast catalogue of most nations' scientific information. But most nations have the bits and pieces in place, albeit in various geographical locations; in different formats, scales, accuracies and precision; and in the custody of various agencies. In order to tackle the challenge of integrating the marine space datasets together, the major custodial responsibility for marine datasets must be identified. This is discussed in the following section.

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[*] Paragraph 8 of Article 76 of UNCLOS establishes an obligation on coastal states to submit information to the CLCS on the limits of the continental shelf beyond 200nm

[*] IASC/IOC/IHO Project for Arctic Bathymetry at http://www.ngdc.noaa.gov/mgg/aboutmgg/oceanmapping.html

2.2 Responsibility for Marine Data

Most nations find that the responsibility for marine data is scattered and shared over different jurisdictions, agencies and departments. International examples like the Ocean Planning Information System (OPIS) in the USA have highlighted how a federal agency (National Oceanic and Atmospheric Administration Coastal Services Centre) have worked in conjunction with the states of North Carolina, South Carolina, Georgia and Florida to accomplish their goal of building a marine cadastral information system [Fowler and Treml, 2001]. Hirst et al., [1999] provides a summary of 6 main agencies involved in Australia's marine boundary determination together with the role played by each of them.

In Canada, the Department of Fisheries and Oceans (DFO) is in charge of many of the marine datasets that could conceivably be used in a marine cadastre. Although other agencies within DFO may be in charge of collection of scientific information about marine space and the administration of many of the marine datasets, the Canadian Hydrographic Service (CHS) is involved in collecting most of the information relating to ocean mapping. CHS has approximately 1000 charts in its inventory. On average, 26 new charts were produced between 1972 and 1993 with 87 new editions being issued as well as 96 reprints [Nichols and Monahan, 2000b]. This impressive tally can be misleading since new chart editions do not represent sequential replacements. Areas in some charts tend to change substantially every couple of years while others remain unchanged and consequently, an examination of the charts available at any one time will show some related inconsistency. Attempts to remedy this situation are tempered by equipment, time and financial constraints. The contents of each chart should therefore be considered in this light in ascertaining their use in the proposed Canadian marine cadastre.

Several other federal, provincial, and private organizations hold various datasets that could also find their way into the proposed Canadian marine cadastre. In fact, a spatial index of existing marine information has been provided under the auspices of the Atlantic Coastal Zone Information Steering Committee (ACZISC)*. This index provides information on existing data sets and their metadata. Rather than follow the individual links to the various datasets and contact the individuals in charge of the data distribution, the authors suggest that a more cooperative data integration model is needed for marine space.

3. Data Integration in Marine Space

Clearly, there is a lot of information among geographically dispersed groups that can be shared in order to make decisions about marine space. Good governance of resources in marine space requires that stakeholders cooperate and share whatever information they have in their possession. Recent developments in internet communications, band width and transmission speeds, and web-GIS and internet cartographic tools have made it possible for spatial information to more easily be shared among geographically dispersed groups via the worldwide web. Specifically, developments in internet-enabled spatial data integration and analysis tools are now allowing decision-makers the opportunity to have access in real-time (or near real-time) to data stores critical to them, but not necessarily managed or maintained by them. The authors rationalized that a case study, such as the proposed Musquash MPA, would allow the investigation of data integration challenges in marine space.

3.1 Canadian Marine Protected Areas as Representative Marine Space

The Canadian Government currently has three formal protected area programs for the marine environment administered by Canadian Heritage (Parks Canada), by Environment Canada and most recently by Department of Fisheries and Oceans [Canada, 1998]. The DFO Marine Protected Area program is unique in two respects. First, it allows the designation of MPAs under broader guidelines unlike those provided by other programs, which deal with specific habitats or species. Secondly, designation of MPAs provides protection that is much greater than that afforded by other programs. MPAs can be considered a laboratory for developing and testing elements of the marine cadastre based on the following:

- There are several clearly defined conservation and protection objectives for MPAs. At the same time, a number of management principles have been enumerated in the *Oceans Act* [1996] and the

* This organization provides a guide to the myriad of coastal information found in Atlantic Canada and is made up of 7 federal departments/agencies, the four Atlantic Canada Provinces, the private sector, academia, First Nations, and the International Oceans Institute of Canada. The web address of ACZISC is http://www.dal.ca/aczisc/

MPA program policy in order to facilitate the development and implementation of the MPA programs. These objectives are used to design a management plan and evaluate the success or failure of the MPA;

- MPAs usually contain a multitude of resources that are simultaneously the focus of economic and conservation objectives. The authors argue that these resources (and their management) are therefore representative of those found in any marine space;
- In addition, coastal MPAs are adjacent (or in close proximity) to upland owners and private property rights. This scenario further complicates tenure in marine space and provides an ideal site for testing tenure issues to be found in any marine cadastre.

3.2 The Musquash MPA Case Study

Since the winter of 2001, the Land Studies and Ocean Mapping Groups at the University of New Brunswick have been involved in a Geomatics for Informed Decisions (GEOIDE) project dealing with Good Governance of Canada's Oceans. This project focuses on providing information on what resources (living and non-living) there are to govern; who holds the rights and responsibilities for their safe and orderly conservation, distribution and exploitation; and the spatial limits (boundaries) of those rights and responsibilities [Nichols et al., 2000a]. One of the case studies of the Good Governance project involves the proposed Musquash Marine Protected Area (MPA) in the Bay of Fundy in Atlantic Canada. Musquash Estuary is located approximately 20 kilometers west of the city of Saint John, New Brunswick. The estuary, which is approximately 1km wide at the mouth, empties into the Bay of Fundy, the site of one of the highest tides in the world. The site was originally proposed as a protected area because it represented one of the last ecologically intact estuaries in the Bay of Fundy.

In the initial stages of the project, it became clear that a standardized model for sharing data among the various private and public agencies would have to be proposed and implemented. Several partners in the project were willing to provide access to datasets in their custody. The Department of Fisheries and Oceans (DFO), St. Andrews Biological Station, made available ecological information collected in the Musquash. The Province of New Brunswick, through Service New Brunswick, provided the project with the Enhanced Topographic Databases (ETDB), the Coastal Topographic Database (CTDB), the Orthophoto Imagery and Property Databases. The Ocean Mapping Group at the University of New Brunswick was able to provide the project with tidal, Multibeam, Sidescan, and Acoustic Doppler Current Profiler (ADCP) data.

The separation of responsibilities between government departments and agencies provides a multitude of different marine information, in different scales, formats, accuracy, completeness and precision because it is collected for various uses. Cadastral Information identified in the Musquash includes: private fishing rights (herring weirs); legal limit of upland property (individual deeds of upland parcels); public rights in conservation areas (Shipwreck sites, Heritage sites etc); Restrictions on private property rights (e.g., Coastal Land Use Policy); Private use rights (Mining leases, Pipeline and cable laying licenses, Oil and Gas production etc).

Identifying and obtaining the different types of cadastral information was one issue; being able to obtain and analyse the information was a totally different challenge altogether. CARIS, a project partner, provided the CARIS Spatial Fusion™ software that was used to provide the data integration and visualisation solution. This solution is described in the following section.

4. The Caris Spatial Fusion™ Data Integration And Visualisation Solution

CARIS Spatial Fusion™ is a "web-mapping" technology that lets users integrate distributed data sources, in various data formats[*], using a web browser. Raster images such as BSB and HCRF raster charts as well as digital orthophotos in Tiff or GeoTiff can be brought in as backdrops to vector and point data. CARIS Spatial Fusion™ is made by fusing Java Bean technology with Orbix[*] [Fitzgerald, 2000]. This combination makes it possible to have a link between distributed services and thin customizable clients. The data is not downloaded and processed by the web browser but this is instead performed by the Fusion services

[*] Supported formats include CARIS, Oracle 8i Spatial, ESRI Shape files, and MapInfo Mid / Mif files

[*] Orbix is the leading CORBA Object Request Broker (ORB) from IONA technologies

[Fitzgerald, 2000]. Not only does this keep the client thin, but also it secures the data itself by keeping it on the server.

Spatial Fusion™ consists of a customized Java client and a number of Fusion Data Services. On the server side, Spatial Fusion™ is made up of the following components [Fitzgerald, 2000]: Web server; Orbix runtime; The catalog service; The data service; and configuration utilities. In the preceding sections, this paper discusses these components in the context of how they were used to provide the data integration and visualisation solution for the proposed Musquash MPA.

4.1 The Web Server

The Web server is not usually bundled with Spatial Fusion™ installation and one must already be running on the network. For the Musquash MPA case study the Microsoft Personal Web Server was installed and used to run the Spatial Fusion™ Data Service. The Spatial Fusion server was running on Windows NT operating system and had the Windows NT Option Pack 4 installed. Part of process of setting up the Web server included setting up the usernames and passwords of individuals that would access the Musquash data service. Another element of setting up the web server was identifying the location of the html page that contains the Spatial Fusion applet and setting up the home directory of the Web Server to point to it.

Figure 1 shows a screen capture of the process of selecting the Web Server home directory using the Personal Web Servers' Internet Information Service (IIS). It is important to set the home directory high up on the folder hierarchy so that it includes the java sub directory since some of the jar files used by the Applet are physically located there.

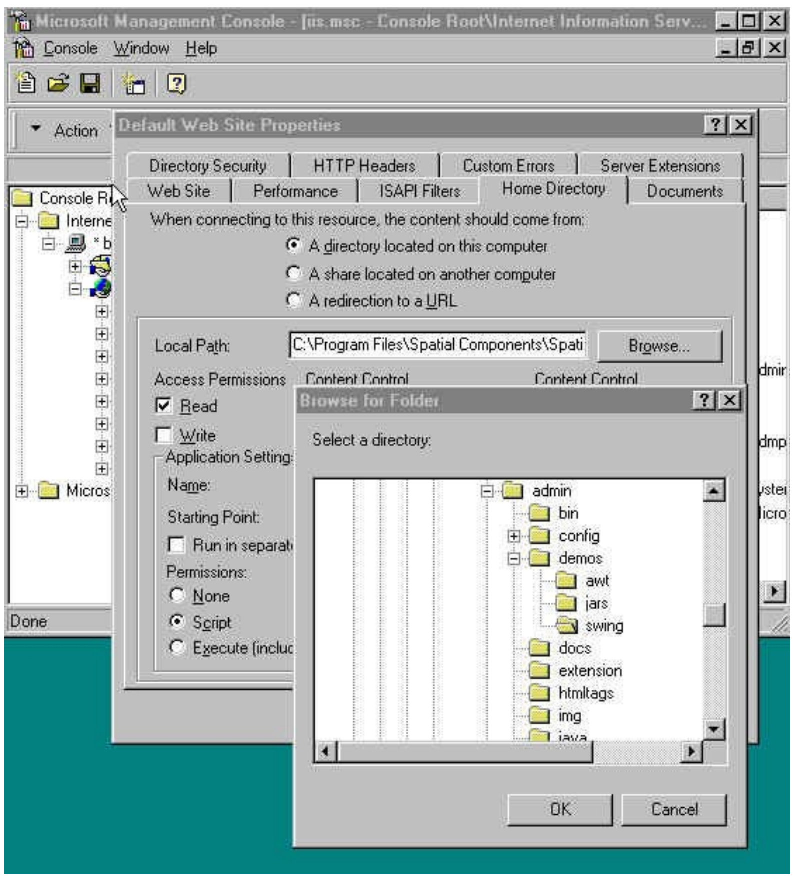

Figure 1: Setting the Home directory on the Musquash Data Service Web Server

4.1.1 Orbix™ Runtime

This component needs to be installed on every machine that hosts a Fusion Data Service. The Orbix™ Runtime lets the Spatial Fusion applet and the Data Services communicate across the Internet. Since the project was using CARIS Spatial Fusion Version 2.5.1 and running on a Windows NT computer, Orbix™ service was configured to start automatically when the data server computer was rebooted.

4.2 The Catalog Service

This service is used to list all of the available Fusion Data Services. The catalog service was an integral part of the data integration solution that for the Musquash MPA. It provides an index of all the datasets that can be accessed from a particular Internet Protocol (IP) address.

To highlight the importance of the catalog service in data integration, consider the following example. Assume that marine cadastral information is located at computers running Spatial Fusion at various locations i.e. Government departments, agencies and private organisations. Using the host selection window shown in Figure 2, the Spatial Fusion Administrator could connect to all the data services. It would then be possible to create a catalog service that pointed to the different IP addresses (and associated data services) of each location. A web browser could then be used to access the geographically dispersed cadastral information by referring to a single catalog service.

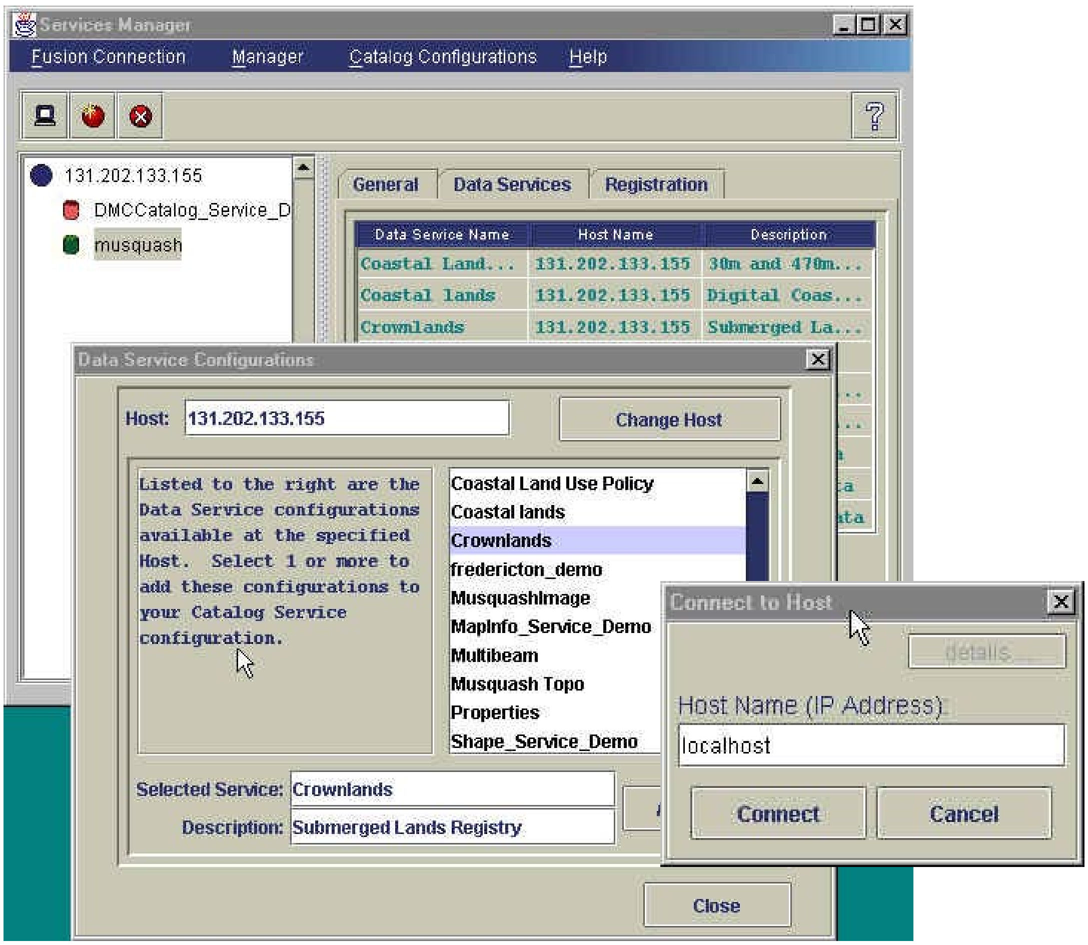

Figure 2: Adding a Data Service to a Catalog

In the Musquash case study, the catalog service definition includes the following:

- The catalog service name – This information is used to access the catalog service once the Spatial Fusion applet is started. The catalog service name " musquash" was selected and used in this project.

- Adding data services – The catalog service name is just an index of the locations of the data services. References to the configured and registered datasets have to be added. This is referred to as adding the data services. When adding the data service to a catalog, the administrator is able to configure the description of the data service so that it provides a more informative description of the data service. In the case of the “crownland” dataset shown in Figure 2, the description used was “submerged lands registry information” corresponding to a description of the submerged provincial crown land. This description was what a web browser would allow someone connecting to the Musquash catalog service to see.

- Registration – The administrator then registers the catalog service with the Orbix daemon. This allows the daemon to respond to requests for the data services registered under it. A request from a web browser for a catalog service is checked by the Orbix daemon against the registered catalog services.

4.3 Fusion Data Services

These services are registered with the OrbixWeb™ Implementation Repository. They contain an accompanying configuration file that has the name used to register the service and the location of the data source. The Data service definition for the Musquash case study includes the following information:

- Data service name- this represents how the name that the data service will be accessed by. The Spatial Fusion administrator in this project selected the name “crownlands” as this could be easily related to the submerged lands registry information.
- The data source information – this is the location of the SAF file that was created using the CARIS MapSmith™ tool. In this case this was the “crownlands” spatial agent file.
- Registration information – this allowed the Orbix daemon service, installed as part of the spatial fusion installation, to register the data service into its repository and therefore be able to respond to requests for the data service.

Figure 3 provides a screen capture of the data services that were configured for the Musquash Data service application.

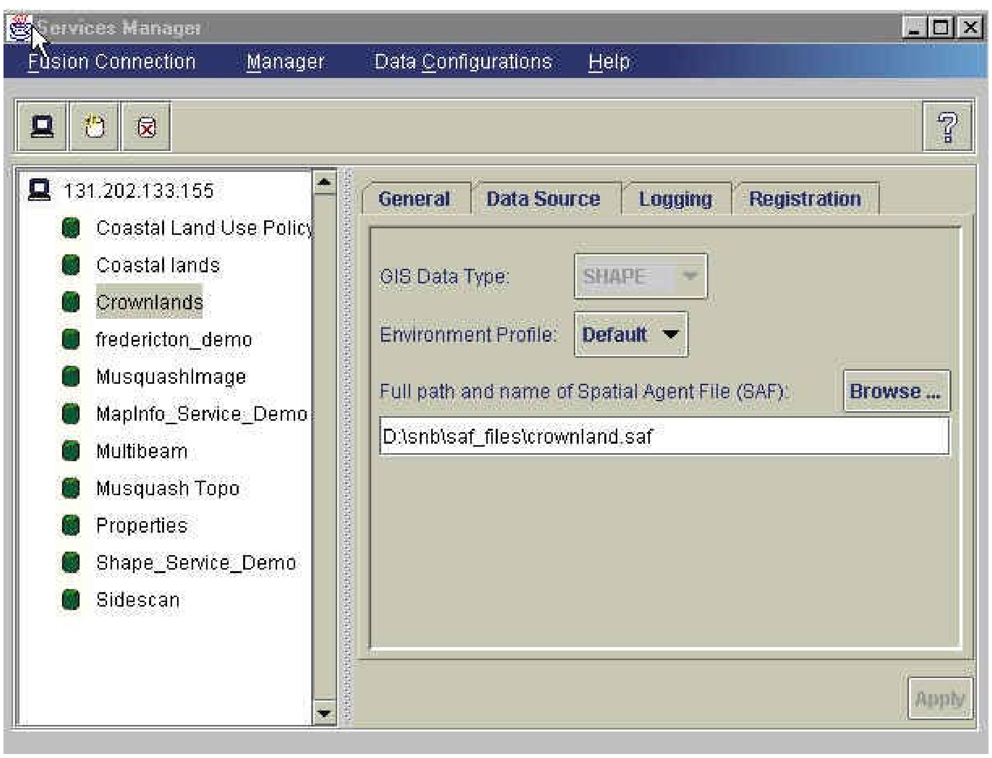

Figure 3: Data Services for the Musquash MPA

4.4 Configuration Utilities

CARIS MapSmith™ is provided together with CARIS Spatial Fusion to help customize the display of the supported data formats. Mapsmith helps create a spatial agent file (SAF) that catalogues the database name, data format (e.g., ESRI Shapefile), coordinate system, data location, mapscale and information on the specific data layers. This process had to be followed for all the individual data services that were created for the proposed Musquash MPA.

Figure 4 is a screen capture of the CARIS MapSmith™ tool being used to configure the layer types and associated database for the submerged lands registry (”crownlands”) data service. In MapSmith, this involves defining:

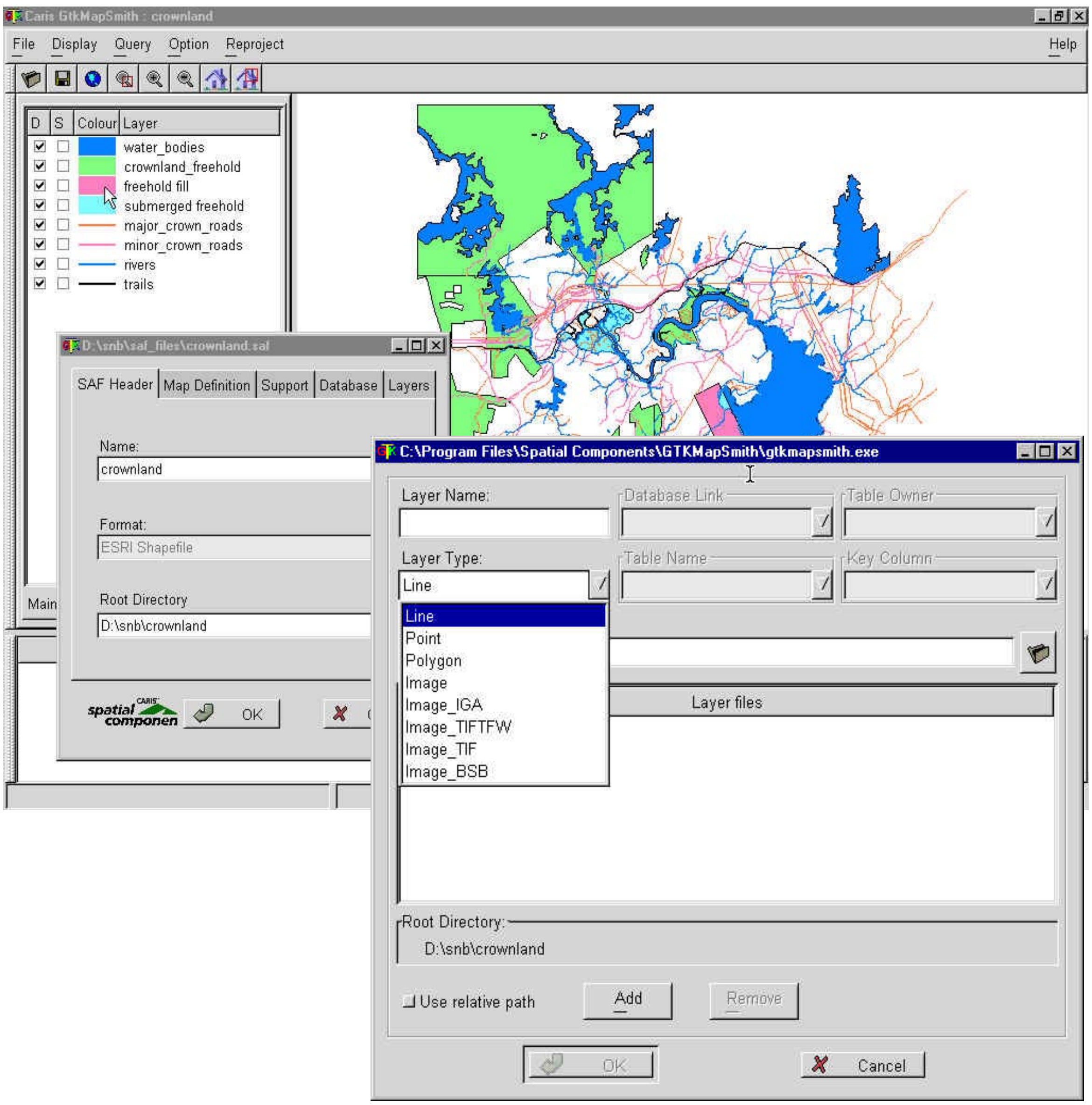

Figure 4: Configuring the Musquash MPA Datasets Using MapSmith

- The SAF header definition - This includes the name and the root directory where the data resides;

- The map definition - This includes the coordinate system used in the map and the map scale settings. By default, maps are displayed at all scales. However one can configure the map to be viewed only at specific scales;
- The database definition - This includes the specification of an ODBC compliant database that is connected to the Map, the ODBC name, the username and password used to access the dataset.
- Definition of the map layers - This includes the name of the layers, the database link, and the table owner (e.g., administrator). The map layer definition also includes the layer types (e.g., line, point, polygon or image), the table name associated with each layer type, and the key column used to retrieve information from the database.

4.5 User Access to the Musquash Spatial Fusion service

In order for a user to access the Musquash Spatial Fusion data service, they have to point their browser to web server location. Their browser has to be java-capable (e.g. Netscape Navigator 3.0, Internet Explorer 3.02 or later versions of either browser) since the Musquash fusion service runs on a Java applet. The user also has to download and install the Java Runtime Environment 1.2.2. Further, the user has to download the CarisFusion jar file that contains the class files used by the applet. This jar file download improves browser performance because the jar file is not downloaded every time the html page with the applet is browsed. These jar file is installed into an extension directory that the user creates in the java home directory (usually located at C:\Java-Soft\Jre\1.2\lib\ext).

Figure 5 shows what the user would see after pointing their web browser to the Musquash Spatial Fusion data service. As can be seen, the applet facilitates access to the catalog and data services for the Musquash MPA. The catalog service to the right shows the available data services while the legend window on the left shows the data services that are currently being browsed by the user. The highlighted parcel in the main window indicates that a query has been run against the property dataset. The result of the query is displayed in the bottom left window and indicates who owns the highlighted property.

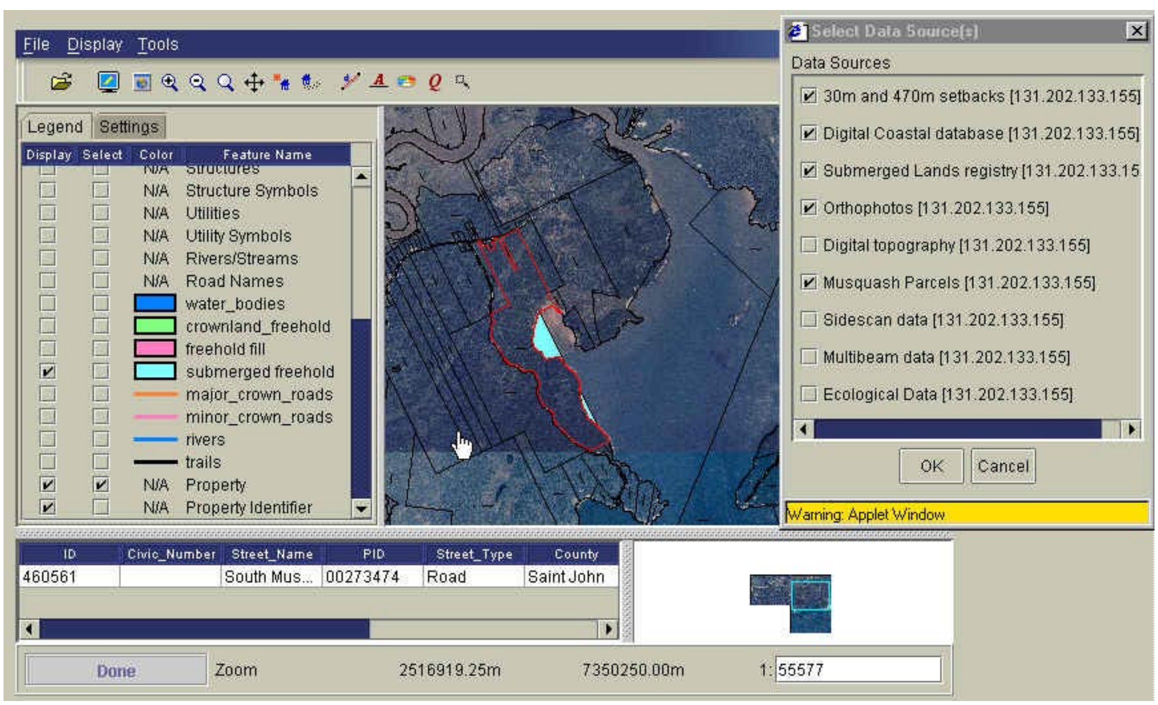

Figure 5: The Musquash Spatial Fusion Data Service

It is interesting to note that concerns' regarding the data integration challenges of different data formats, scale, datum, and coordinate systems are handled by this solution. This is because Spatial Fusion supports native formats of data as long as they are configured using the MapSmith tool. Spatial Fusion also offers two options when handling data that is in different coordinate systems; re-configuring using the MapSmith "reproject" option or allowing Spatial Fusion to re-project "on the fly". With regard to scale, the MapSmith configuration tool allows one to set the effective scale of a particular data service. This means that at that at that scale and below, the data services will be turned on and the layers associated with the data service will appear on the legend window. This is particularly important especially when attempting to restrict the overlay and use of low-accuracy data with high-accuracy ones.

Data visualisation of the marine space datasets is accomplished in this solution by overlaying different datasets. This can be quite confusing especially if there are very many data sets in a particular jurisdiction needing to be turned on. A 2D representation will not show whether particular interests refer to resources found in the water column, seabed or subsurface; or to resources that move or vary with time. Stakeholders, communities and decision makers would like to visualize the interaction of information (including cadastral information) in multidimensional marine space. Research in the Ocean Governance project is now evolving to address these multidimensional data integration and visualisation requirements. This work is currently in progress.

5. Summary

In Canada's case, there is no comprehensive plan to construct a marine cadastre nor to include it as part of the national geospatial data infrastructure. Although Canada is hampered in large part by legal and political issues, technical issues surrounding the collection, organization, integration, and dissemination of data are part and parcel of marine cadastre problems. In the case study outlined in this paper, the data integration and visualisation solution was provided using CARIS Spatial Fusion software. The geographic location of the datasets remained unknown, as was the coordinate system in which the data was collected. Re-projection of the datasets into a "base" coordinate system was done on the fly, as was access to data services in various native formats. Cadastral information in the proposed Musquash MPA could be browsed, overlaid and used using a web browser. Clearly, the marine cadastre technical challenges of data integration and visualisation can benefit from the results of this work.

6. Acknowledgement

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7. References

British Oceanographic Data Centre-BODC (2001) The GEBCO Digital Data Atlas. http://www.bodc.ac.uk/frames/index2.html?../projects/gebco/index.html&2, accessed September 2001

Canada , Department of Fisheries and Oceans, Communications Directorate (1998) Marine Protected Areas Program. Ottawa: Supply and Services, Canada.

Coakley B and D Monahan (1999). A refinement of Arctic Ocean bathymetry: from GEBCO to SCICEX. EOS, Transactions American Geophysical Union, Apr 27

Fitzgerald J (2000) CARIS Spatial Fusion: an Internet GIS. White Paper #7 http://www.spatialcomponents.com/techpapers/fusion.pdf accessed February 4.

Fowler C and E Treml (2001) Building a Marine Cadastral Information System for the United States – A Case Study. International Journal on Computers, Environment and Urban Systems Special Issue: Cadastral Systems (In Press)

Hirst B, B Murphy, and P Collier (1999) An Overview of Australian Maritime Zone Boundary Definition. In Proceedings of the International Conference on Technical Aspects of Maritime Boundary Delineation and Delimitation, International Hydrographic Bureau, Monaco, September 8-9, pp 191-199

McLaughlin, J D (1975) The Nature, Function and Design Concepts of Multipurpose Cadastres. Ph.D. Thesis, University of Wisconsin

Monahan D and L Mayer (1999) An Examination of Publicly Available Bathymetric Data Sets Using Digital Mapping Tools to Determine their Applicability to Article 76 of UNCLOS. In Proceedings of the International Conference on Technical Aspects of Maritime Boundary Delineation and Delimitation, International Hydrographic Bureau, Monaco, September 8-9, pp 183-190

Nichols S, and D Monahan (1999) Fuzzy Boundaries in a Sea of Uncertainty: Canada's Offshore Boundaries. In Proceedings of the New Zealand Institute of Surveyors Annual Meeting, Bay of Islands, NZ, Oct 9-15, pp. 33-43

Nichols S, D Monahan and M D Sutherland (2000a) Good Governance of Canada's Offshore and Coastal Zone: Towards and understanding of the Maritime Boundary Issues. In *Geomatica*, Vol. 54, No. 4, pp 415-424

Nichols S, and D Monahan (2000b) The Contribution of Hydrographic Charting to the Resolution and Portrayal of Offshore Property and Jurisdictional Boundaries. Proceedings of the Canadian Hydrographic Conference 2000, Montreal, Canada, Un-paginated CD-ROM

Niemann B J Jr, and D D Moyer (ed) (1988) A Primer on Multipurpose Land Information Systems. Wisconsin Land Information Report 4, Institute for Environmental Studies Report 133, University of Wisconsin-Madison

National Research Council (1980) Need for a Multipurpose Cadastre. Panel on a Multipurpose Cadastre, National Academy Press, Washington DC

National Research Council (1983) Procedures and Standards for a Multipurpose Cadastre. Panel on a Multipurpose Cadastre, National Academy Press, Washington DC

Van de Poll R, M Halim, M D'arcy, J Harding, R Macnab, and D Monahan (1999) Integrated Procedures for Determining the Outer Limit of the Juridical Continental Shelf Beyond 2000 Nautical Miles. In Proceedings of the International Conference on Technical Aspects of Maritime Boundary Delineation and Delimitation, International Hydrographic Bureau, Monaco, September 8-9, pp 235-246