DETERMINING USER NEEDS FOR A MARINE CADASTRE[1]
The Musquash Marine Protected Area Case Study

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ABSTRACT
Most users view spatial data as a means to an end. They all desire reliable, up-to-date data as quickly and as inexpensively as possible. They have in most cases come to expect reliable transfer of graphics, text, audio and video without considering the special problems involved in spatial data exchange. In this paper we look at the special cadastral user needs when visualizing the marine space.

Visualization of the complexity of rights in marine spaces is of particular importance in understanding the multidimensional context in which marine activities take place. Most marine rights, such as aquaculture, mining, fishing, mooring rights and even navigation have an inherently multi-dimensional nature that makes a two-dimensional definition of these rights legally inadequate. This multidimensional information relative to a jurisdiction, regarding the effects of its private and public laws on the marine environment (e.g. spatial extents and their associated rights, responsibilities, and restrictions etc.) would be stored in a marine cadastre.

This paper uses Marine Protected Areas (MPAs) as a case study to identify some of the user needs in a marine cadastre. The authors propose that problems encountered in identifying user needs in MPAs are similar to those expected to be encountered in a marine cadastre. This paper reviews the concept of a marine cadastre; uses it as a starting point for identifying user needs; and then uses the example of the Musquash MPA in New Brunswick, Canada to develop a list of user needs. The paper concludes by outlining a webGIS[2] cadastral information sharing solution; based on CARIS Spatial Fusion™ software; whose real power lies in letting users control the display on the client interface.

Introduction
The World Bank predicts that by 2020 three-quarters of the world's population will live within 60 kilometres of the coast placing severe pressure on our ocean's resources. This intense use threatens global health, as well as the social and economic sustainability of these coastal and marine environments. Wetlands, which are used for essential fish breeding habitats, buffers against coastal erosion, and sediment sinks, are being filled for development at a rapid rate. Settlement along the coast leads to the construction of seawalls that accelerate the erosion of habitats. Pollution from land-based activities and ocean dumping is increasing, as is the world's population. Predictions of climate change and sea level rise also threaten populations that inhabit coastal areas. Governance of activities within coastal and marine spaces is therefore of utmost importance if resources are to continue being used with a sustainable development objective in mind.

Governance has been defined as the process of decision-making with a view to managing change in order to promote people's well being [Kyriakou and Di Pietro, 2000]. Governance is also about providing information to decision makers about the impact that certain decisions will have on the

[1] In this paper a marine cadastre is an information system that allows rights in marine space to be defined, recorded, visualised and managed

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[2] Defined in this paper as internet mapping and cartographic tools containing limited spatial analysis and allowing spatial information be shared among geographically dispersed groups via the worldwide web.

rights and interests of individuals. Together with other information, a record of the nature and extent of rights is what is contained in a cadastre. This paper uses Marine Protected Areas (MPAs) as a case study to identify some of the user needs in a marine cadastre. The authors suggest that problems encountered in identifying user needs in MPAs are similar to those expected to be encountered in a marine cadastre that would encapsulate all types of marine space. This paper reviews the concept of a marine cadastre; uses it as a starting point for identifying user needs; and then uses the example of the Musquash MPA in New Brunswick, Canada to develop an assessment of user needs. The paper concludes by outlining a webGIS cadastral information sharing solution; based on CARIS Spatial Fusion™ software; whose real power lies in letting users control the display on the client interface.

The Governance of Our Oceans

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 must be collected and managed. There is need to manage information on (but not 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[3] governance of coastal and marine resources [e.g., Nichols, Monahan and Sutherland, 2000].

Clearly, there is need for a wider dissemination of knowledge relevant to the importance of coastal and marine environments. Good governance (e.g., information dissemination, management.) is a key factor in the sustainable use of these environments and will require an integrated, coordinated and equitable approach [Crowe, 2000]. If governance is about decision-making and steering, then up-to-date, accurate, complete, and usable information (which feeds into the acquisition of knowledge) is indispensable to governance. This is especially critical in the information age of rapid changes, interconnectivity, and globalization that have brought more information to more people, making them acutely aware of the unsustainable nature of current social, economic and political use of marine and coastal spaces [Juillet and Roy, 1999; Miles, 1998]. But how is this to be accomplished? This paper looks at the marine cadastre as a starting point for the initial exploration of ideas.

The Marine Cadastre

The reliability and completeness of information on the marine environment, its resources, and uses is critical in identifying, evaluating, and managing resources in marine space. Resource management does not exist in isolation; it balances the objectives of conservation with property rights (both public and private) associated with the resource. This implies that two boundaries must be delineated:; one defining the resource extent and the other defining the extent of rights within, or in the vicinity of the resource. This latter boundary is referred to as the legal or administrative boundary. The primary objective of a legal boundary is to ensure that it gives notice of the spatial extent of rights of individuals (or groups of individuals). This provides information to decision makers about the impact that certain decisions will have on the rights and interests of individuals. Together with other information, a record of the nature and extent of rights is what is contained in a cadastre.

Grant [1999] defines a marine cadastre as a "system to enable the boundaries of marine rights and interests, to be recorded, spatially managed and physically defined in relationship to the boundaries of other neighbouring or underlying rights and interests". Extending this definition, this paper

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

further defines a marine cadastre as an information system that facilitates the visualisation of the effect of a jurisdiction's private and public laws on the marine environment (e.g., rights, responsibilities, restrictions, and administration and their associated spatial extents). 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. In this paper then, the marine cadastre is viewed as a tool to facilitate good governance of marine spaces.

What we know today about Canada's ocean frontier is similar to what Canadians knew of the Prairies and the Arctic in the 18th and 19th centuries [Ocean Mapping Group 1999]. We have made scattered explorations of our marine territory, primarily in pursuit of narrow goals, e.g., development of identified oil and gas reserves, communication infrastructure, and coastal navigation. The oceans - their resources, their potential, and their current use - therefore remain uncharted territory for the most part. This lack of knowledge is complicated by the fact that exploration and knowledge of the oceans must be conducted in four dimensions. A fifth dimension, jurisdictional uncertainty, is a major factor in the lack of comprehensive approaches to ocean resource problems. Hoogsteden and Robertson [1998,1999] note that in many ways the development of the offshore (or marine cadastre) parallels the pioneer role of land surveying during the settlement phase of new world development. A lack of comprehensive and detailed knowledge about prospective tracts of new territory and the resources that they contain was prevalent. Reconnaissance, resource use and development are still being undertaken spasmodically in the oceans. Any marine cadastre would therefore have to take these special shortcomings into consideration. Another issue in the oceans is the fact that there are many levels of often ill-defined jurisdiction and rights involved. The proposed Marine Protected Area for the Musquash Estuary is an example of the marine cadastre challenges.

Marine Protected Areas in Canada

Marine Protected Areas (MPAs) are becoming important tools for encouraging the sustainable use and conservation of marine resources around the world. There are currently over 1,300 MPAs around the world [Canada, 1997a] ranging from small, highly protected reserves that sustain a particular resource or habitat type to larger, multiple-use areas in which conservation is balanced with various socio-economic activities. MPAs are established for numerous reasons, and as a result, take a variety of forms and approaches[4]. As the marine environment faces increasing threats from human activities on land and sea, marine protected areas (MPAs) are becoming important tools for promoting the sustainable use and conservation of natural resources [Canada, 1997a, 1997b].

MPAs in Canada are 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". An area can be designated as an MPA to conserve and protect one or more of the following:[5]

i) Commercial and non-commercial fisheries resources, including marine mammals and their habitats;
ii) Endangered and threatened marine species, and their habitats;

[4] Generally, it is accepted that MPAs are established for: helping to preserve important fisheries, for protecting historical and cultural resources, for conducting scientific research, for preserving natural communities and freeing them from exploitation, and for establishing parks for diving [Canada, 1997a].

[5] This is very close to the definition of MPAs developed at the 4th World Congress and adopted by the International Union for the Conservation of Nature (IUCN): "Any area of intertidal or subtidal terrain, together with its overlying water and associated flora, fauna, historical and cultural features, which has been reserved by law or other effective means to protect part or all of the enclosed environment".

iii) Unique habitats;
iv) Marine areas of high biodiversity or biological productivity;
v) Any other marine resource or habitat as is necessary to fulfill the mandate of the Minister of Fisheries and Oceans.

MPAs can be considered a laboratory for developing and testing elements of the marine cadastre based on the following:

i) There are several clearly defined objectives for MPAs. These objectives are used to design a management plan and evaluate the success or failure of the MPA.
ii) MPAs usually contain a multitude of resources that are simultaneously the focus of economic and conservation objectives. The management of these resources in an MPA is therefore representative of those found in any marine space.
iii) Some 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.

Defining MPA Cadastral User[6] Needs

MPAs are being implemented to address a wide range of marine resources and management dilemmas. Well-planned MPAs not only protect critical habitats and general ecosystem functions, but also meet the needs and even enhance the opportunities of many different stakeholders living in the region [National Research Council, 2001]. The user requirements therefore vary substantially depending on whether there is a primary objective, or whether there is a ranking of the different MPA objectives. To further illustrate this point, marine conservation management principles are briefly reviewed.

A number of management principles have been enumerated in the *Oceans Act* [1996] and the MPA program policy in order to facilitate the development and implementation of the MPA programs. They include the principles of sustainability, precautionary approach, consultation, integrated management, adaptive management, ecosystem, regional flexibility, and partnering[7]. The principles are seen as acknowledging the importance of balancing several conflicting objectives (e.g. economic development and environmental protection) in marine space. However, the precautionary approach is generally considered a priority in MPA establishment and management. It advocates for errors to be made on the side of caution in making decisions about sensitive marine resources and habitats. Therefore, even though the consultation principle may encourage the participation by parties with a stake in the resource[8], in the end ecological values may be more important [Canada, 1998].

In this paper, MPA user requirements are separated into 2 broad categories: those dealing with the location of a system of MPAs, and those dealing with the management of an MPA once it is nominated and accepted as a proposed MPA. User requirements for the first category are driven predominantly by scientific objectives. This means that collected information is strongly disposed towards science. The Report from the Roundtable on Marine Protected Area System Planning [Fenton and Westhead, 2000] supports this observation by indicating that a strong emphasis is

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[6] This paper specifically defines the user as an individual who is interested in, consulted on, or is responsible for decision making in the MPA.

[7] See Appendix B at http://www.dfo-mpo.gc.ca/oceanscanada/newenglish/library/discussion/discussion.htm for a description of the management principles.

8 The consultation principle has been observed to increase the level of understanding and support for marine protection, thereby reducing potential conflicts and the need for heavy enforcement [Brody, 1998].

placed on the collection of biological and ecological information. Although several sources of information are usually considered[9], acknowledgement of the importance of cadastral information is not at the same level as biological and ecological information. This is to be expected since ecosystem[10] overviews are seen as enabling MPAs to be developed in a systematic manner, assist in the evaluation and selection of MPAs, and have indicators that can be used to evaluate the success of MPAs [Canada, 1998].

User requirements for the second category deal with the tenure and administration of MPAs. The focus is on being able to visualize how the MPA will affect the rights of community, stakeholders and the general public. Clearly, public and private rights in the MPA have to be taken into consideration. The user requirements for the decision maker in this category have to include those living adjacent to, or relying on, resources in need of protection, together with all those interested in, or affected by, the MPA designation. For example, where existing and proposed activities within, or near an MPA, may conflict with the conservation objectives of an MPA, a management plan can be used to provide for a phasing out of these activities. A scallop dragger may therefore have a provincial lease for related fishing activities within the proposed MPA but an agreement may be sought with the lease--holder (with regard to the restriction of scallop dragging) in order to accomplish the objective of protection of the MPA resources. This is an acknowledgement of the interplay between public and private rights in an MPA; and by extension highlights the importance of cadastral information.

The Musquash MPA Project

On February 8, 2000, the Department of Fisheries and Oceans (DFO) announced publicly that Musquash Estuary had been accepted as an Area of Interest (AOI), the first milestone in the official Marine Protected Areas (MPA) process[11]. Musquash is the Maritimes second inshore "Area of Interest" in the Marine Protected Areas (MPA) Program under the *Oceans Act*. On June 23, 1999 DFO announced support for conservation efforts in Basin Head P.E.I, the first inshore Area of Interest. Identification of a site as an "Area of Interest" is the first step in the Department's evaluation process to identify and protect important ecological areas in the marine environment. The proposed MPA outer limits included all subtidal and intertidal areas inside a line drawn from the Musquash Head through the southern tip of Gooseberry Island, and extending to the coastline at the western tip of Gooseberry Cove. The inland limit was the head of the tide at the Musquash Hydro Station.[12]

In June 2000 a team of researchers from four universities (University of New Brunswick, Memorial University, University of Ottawa, and University of Victoria) initiated a project with the Geomatics for Informed Decisions (GEOIDE) Research Network under the National Centres of Excellence.[13] The project is entitled ”Good governance of Canada’s Oceans: the Use and Value of Marine Boundary Information.” The research aims to address some of the marine boundary issues in Atlantic Canada using case studies [Ocean Governance, 2000]. One of the case studies in the research focuses on private, public, municipal, environmental, and coastal zone boundaries associated with Marine Protected Areas (MPA) for DFO under the new *Oceans Act*. It specifically

[9] e.g. traditional knowledge, ecological knowledge, scientific survey data and various data modeling techniques.
[10] Used to characterize ecosystem types; and includes biological and ecological studies.
[11] There are 6 steps in the framework for establishing and managing individual MPAs; AOI identification, initial screening, evaluation and recommendation, development of a management plan, designation, and management.
[12] These are general boundary descriptions of the proposed Musquash MPA. The boundaries are described as including all salt marshes, mud flats and estuary below the high water mark [Singh et al., 2000].
[13] Funding sources included: GEOIDE NCE, DFO, NRCan and Service New Brunswick

deals with the management of the proposed Musquash MPA in the Bay of Fundy in Atlantic Canada.

Management of the Proposed Musquash MPA

As part of its MPA co-management strategy, DFO put together a Musquash Marine Protected Areas Planning Group (MPAPG)[14] in a bid to facilitate stakeholder and community input into a management plan for the proposed MPA [Singh et al., 2000]. The overall objective of the management plan was described as the "protection and restoration of the Musquash estuary and surrounding salt marshes". The following goals were identified [Singh et al., 2000]:

- Maintain biodiversity of the area;
- Maintaining a healthy fishing industry;
- Protecting highly productive habitats;
- Increasing the natural habitat and bird life in the marsh and surrounding land;
- Preserving the area for future generations;
- Ensuring the conservation and the sustainable use of the marsh.

What was unique about Musquash was that it was a coastal MPA and therefore issues related to property rights, administration, and jurisdiction were extremely important. There was a possibility that there would be multiple and unclear jurisdictional boundaries representing federal-provincial, inter-provincial limits, or even provincial-county boundaries. Since the MPA program was still new[15], issues surrounding the co-management arrangements for the proposed MPA were still being tested at other proposed MPAs. At the same time, there lacked a single agency that would be the focal point for managing marine rights and boundaries. This meant that information about the boundaries and rights would have to be shared across departments and agencies. Musquash was therefore an opportunity to address the resulting complexity of data integration issues (involving scale, datums, projections etc) within the mandate of the Ocean Governance project.

Previous MPA designations had focused more on developing the science requirements that would be needed to monitor MPAs. In the beginning, the focus of information collection (and summary) in the Musquash was scientific data; including, area morphology, oceanography, water quality (i.e. nutrients and contaminants), plankton and fish larvae, marsh ecology, birds, and terrestrial plants [Singh et al., 2000]. Later on, it became clear that in order to obtain the information required for the evaluation of the proposed MPA, as well as for the development of an appropriate management plan, existing information about public and private rights within the MPA (and in the surrounding vicinity) would have to be collected, summarized and used to form the management plan for the MPA.

Cadastral Information Collection

To provide the base for analyzing the boundary and other cadastral issues, a hydrographic, oceanographic and geophysical survey was carried out by the UNB Ocean Mapping Group. Undergraduate students were responsible for collecting the information as part of a 5th year Hydrographic Field Operations undergraduate course. As outlined in the following sections, the hydrographic survey information proved important in providing evidence of tenure in the proposed Musquash MPA.

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[14] See http://www.musquashmpa.ca/mpa/index_mpa.htm for more information on the MPAPG.

[15] Race Rocks, the first Canadian MPA to be proposed as an AOI, was declared a pilot MPA in September 1998 and officially designated in September 2000.

Visits to the Musquash estuary indicated that private fishing rights (in the form of herring weirs) had at one time been effective in the estuary. In fact, sidescan imagery also indicated that some fishing weirs had been abandoned and were neither visible at high nor low tide[16]. These weirs could easily be indicative of present, abandoned or expropriated private fishing rights within the spatial extent of the fishing weirs. Evidence of other public rights observed while traversing the Musquash estuary as part of the Musquash hydrographic survey was in the form of ship wreckages. Some of the wreckages could not have been detected without multibeam and sidescan technology. These shipwreck sites could easily have been earmarked for protection under the Historic Sites Protection Act, but on further investigation this was not the case.

A survey[17] of the ordinary high water mark was also carried out in order to determine whether the actual surveyed limit of upland property coincided with provincial mapping in the coastal lands database. The resulting inconsistency was not surprising, as the delimitation of features and limits in the coastal lands database was based on interpretation of orthophoto maps[18] [Nichols and Monahan, 1999]. The uncertainty caused by the inconsistency between the mapping and legal limits of private property rights is currently under investigation especially in light of the fact that the description of the boundaries in the proposed MPA had referred to the ordinary high water mark. The New Brunswick Department of Municipalities, Culture, and Housing Draft Proposal for a Provincial Land Use Policy [NB, 1996] for New Brunswick's Coastal Lands further compounds this uncertainty. In the proposed coastal zone policy any new development within 30 meters of a coastal feature is restricted. Clearly this represents a governance problem involving the infringement of private property rights by public policy. This is an issue of great importance in any cadastre. As Nichols and Monahan [1999] observe,

> …The major problem for the upland owner still remains…if the policy was enacted, upland owner rights of use to a large proportion of the average land parcel, including lands within the intertidal zone, would be extremely limited. Owners of grants to low water or of water lots are similarily restricted. Yet no compensation is provided. Furthermore, the uncertainties involved in delimiting both the intertidal limits, marsh boundaries, etc., in addition to the seaward property boundary of the upland leave the path open for much litigation.

The province of New Brunswick considers some lands below the ordinary high water mark as provincial crown lands and records information about them in a separate registry referred to as the submerged lands registry[19] [Canada, 1997b]. Tenure information regarding submerged lands was subsequently obtained from the Crown Lands Branch, Department of Natural Resources and Energy (DNRE). In addition, the research group was able to obtain information from DNRE on mineral leases in the vicinity of the estuary. DNRE also authorizes permits and licenses to operate pipelines in the province. The research group observed that there are currently two pipelines licensed to transit crude oil from the Bay of Fundy to Mispec Point. The exact location of the pipelines was clearly visible on the multibeam imagery collected during the hydrographic survey.

One partner[20] in the project, Service New Brunswick (SNB), was also able to provide access to cadastral information about parcels adjoining the proposed MPA. This allowed the group to inspect the nature of tenure surrounding the proposed MPA and determine whether any water lots had in fact been granted in the Musquash estuary. Further, it was important to determine (through an

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[16] To obtain a copy of the echogram contact Dr. John Hughes Clarke, Ocean Mapping Group, University of New Brunswick at jhc@omg.unb.ca

[17] This was done as part of the survey camp for GGE undergraduate students at UNB. For more information contact Dr Peter Dare at dare@unb.ca , Geodetic Research Laboratory, University of New Brunswick.

[18] From a large coastal mapping project carried out by the Department of Municipalities, Culture, and Housing.

[19] Submerged lands are currently registered as provincial Crown lands in county registries. New legislation is being developed that will see all lands covered by a central registry.

[20] For a complete list of project partners go to www.unb.ca/gge/research/OceanGov/partners.html

inspection of individual deeds) the individual rights of riparian owners on land adjoining the Musquash River. As the project progressed then, it became increasingly clear that there was a multitude of tenure information sources held in different locations that could be used to build the Musquash MPA cadastre. Table 1 provides a roadmap of provincial marine cadastral information.

Table 1: Roadmap of Provincial Marine Cadastral Information [after Canada, 1997b]

Provincial Government Department	**Department / Branch and Program**	**Cadastral Information**
Department of Agriculture and Rural development		i) Land use location and animal manure management affecting pollution of the marine environment ii) Location of dyked land
Department of Economic Development and Tourism	i) Beach development Program ii) Day Adventure Program	i) Location of beach improvement programs ii) Area affected by licenses for Marine ecotourism
Department of Environment	i) Environmental Evaluation Branch ii) Assessment and Approvals Branch iii) Municipal Services Section	i) Freshwater aquaculture and fishwaste disposal ii) License to store dredged materials and approval for salt marsh proposals iii) License to construct and operate municipal and private water and wastewater systems
Department of Fisheries and Aquaculture	i) Resource Management Team	i) Responsibility for site allocation and tenure administration at marine aquaculture sites and associated facilities
Service New Brunswick	i) Coastal Mapping Program ii) Submerged Lands Registry	i) 1:10000 complete digital orthophotography of province's coastal lands ii) Future location of central submerged lands registry
Department of Health and Community Services		i) Issues permits to install septic systems and on-site sewage disposal ii) Recreational Waters testing
Department of Municipalities, Culture and Housing	i) Coastal Land Use Planning ii) Archeological Services Branch under *Historic Sites Protection Act*	i) Administration of Coastal Lands Management e.g. Coastal Land Use Policy ii) License for archeological explorations and location of protected shipwreck sites
Department of Natural Resources and Energy	i) Under the *Aquaculture Act* ii) Crown Lands Branch iii) Fish and Wildlife Wetlands and Coastal Habitat Program - Parks and Recreation Branch iv) Under *Mining Act* and *Oil and Natural Gas Act* v) Under the *Pipeline Act and General Regulation*	i) Responsible for other submerged land management activities e.g. previous commitments, conflicting land uses, protection of native fish, interference with riparian rights ii) Leases, licenses or easements for permanent developments or improvements iii) Conservation Areas and Coastal Parks: issues such as permits for gravel extraction iv) Minerals, Oil, Natural Gas exploration and production v) Permits to construct and licenses to operate pipelines

Department of Transportation		i) Bridge rehabilitation, shore protection and related structures ii) Operation of Ferries iii) Operation of Wharves and Ramps

Accessing the Cadastral Information

Identifying the different types of cadastral information was one issue; being able to obtain and analyse the information was a totally different challenge altogether. From Table 1 it can be seen that the separation of responsibilities between government departments and agencies is going to provide a multitude of different marine information, in different scales, formats, accuracy, completeness and precision because it is collected for various uses. In practice, each department or agency would have acquired their own Geographic Information System (GIS) specialists to process data, often dealing with the complexities of data formatting, structuring, analyses and presentation. Specific land and marine software would also have been acquired in order to carry out these tasks. Increasing limitations in resources would have forced agencies to focus primarily on their immediate responsibilities and be rarely interested in collecting and managing marine cadastral information for a broader marine cadastre.

Accessing Information through the Internet

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. Some of the above technologies handle only vector data (e.g. MapGuide, MicroStation GeoGraphics) while others like MapObjects, Spatial Net, GeoMedia Web Map and CARIS Spatial Fusion™ handle both vector and raster data. Certain web-GIS technologies now facilitate the transmission, integration, visualization and analysis via the worldwide web of spatial information stored in geographically dispersed locations. Some of these new technologies also support different data formats (e.g. ESRI shape files, CARIS, Oracle 8I, orthophotography etc.), projections, scales, datums etc., with conversions and visualization being done "on the fly."

In some instances data will have to all reside on one server and then be geographically dispersed via the worldwide web. Some web-GIS technologies however allow for data to reside on potentially any number of geographically dispersed map servers, which is a most beneficial feature. A user with permission to access the geographically dispersed data sets need only have access to a web browser in order to view, query, and analyze the data sets. The full range of analytical capabilities available in most contemporary desktop GIS however is not available on the web browser (or WebGIS client) since they are built on the thin-client concept. To include more functionalities at the client end would seem to defeat the concept of the low cost and convenience of utilizing only a web-browser to access spatial data.

Although still effectively in their infancy, these new technologies show remarkable promise for rapid development. Major potential benefits to stakeholders from the use of web-GIS technologies include having access to another's data set and thereby affording cost-effective data sharing and integration to support the pursuit of each stakeholder's mandate. Also, having access to another stakeholder's data set facilitates combined decision support toward the sustainable development of whichever resource is of interest. Additionally all this can be done without the costs associated with maintaining a wide range of data sets outside of one's mandate, as well as the costs associated with maintaining computer networks, and employing a large body of qualified human resources among other things [Shu-Ching et al, 2000].

The CARIS Spatial Fusion™ Web Mapping Solution

One of the objectives of the "Good Governance of Canada's Oceans" project was to develop and enhance visualization tools for marine boundary delimitation. CARIS, a project partner, provided the CARIS Spatial Fusion™ software that allowed the project to access marine cadastral information from different locations. CARIS Spatial Fusion™ is a "web-mapping" technology that lets users integrate distributed data sources, in various data formats[21], 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. The software also allows flexibility to expand the functionality of the software through customization with CARIS Spatial Fusion™ Developer tools [Fitzgerald, 2000].

CARIS Spatial Fusion™ is made by fusing Java Bean technology with Orbix, that is the leading CORBA Object Request Broker (ORB) from IONA technologies [Caris, 1999]]. This combination makes possible to have a link between distributed services and thin customizable clients. The data is not downloaded and processed by the web browser but is instead performed by the Fusion services [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 [Caris, 1999, Fitzgerald, 2000]:

1. *A Web Server:* The web server is not bundled with Spatial Fusion and one must already be running on the network. For the Musquash MPA the Microsoft Personal Web Server was installed and used to run the Spatial Fusion Data Service.
2. *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, Orbix™ service was configured to start automatically when the data server computer was rebooted.
3. *Catalog Service:* This service is used to list all of the available Fusion Data Services. For the Musquash MPA, this was analogous to providing an index service to the various geographical locations of the marine cadastral information identified in Table 1.
4. *Fusion Data Services:* These services are registered with the OrbixWeb™ Implementation Repository and contain an accompanying configuration file that contains the name used to register the service and the location of the data source.
5. *Configuration Utilities:* CARIS MapSmith™ is provided together with CARIS Spatial Fusion to help customize the display of the supported data formats. The data is prepared into the different data layers, and can be re-projected into a different projection.

The Musquash MPA Spatial Fusion™ Application

The Musquash MPA Spatial Fusion™ Application was built in conjunction with Service New Brunswick and CARIS. The site is password protected and only authorized users are able to gain access to the services provided. As far as the authorized user is concerned, they simply download the Fusion applet from the Musquash MPA Spatial Fusion web server and they can easily open data

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[21] supported formats include CARIS, Oracle 8i Spatial, ESRI Shape files, and MapInfo Mid / Mif files.

from any fusion service they have access to, providing them with a secure and fully scalable environment. The browser lets users customize the client, by letting them select which datasets they want to appear on their legend, which data sources they want to connect to, and the order in which the want the datasets to be overlaid. Figure 1 shows a screen capture of the Musquash Spatial Fusion™ Application.

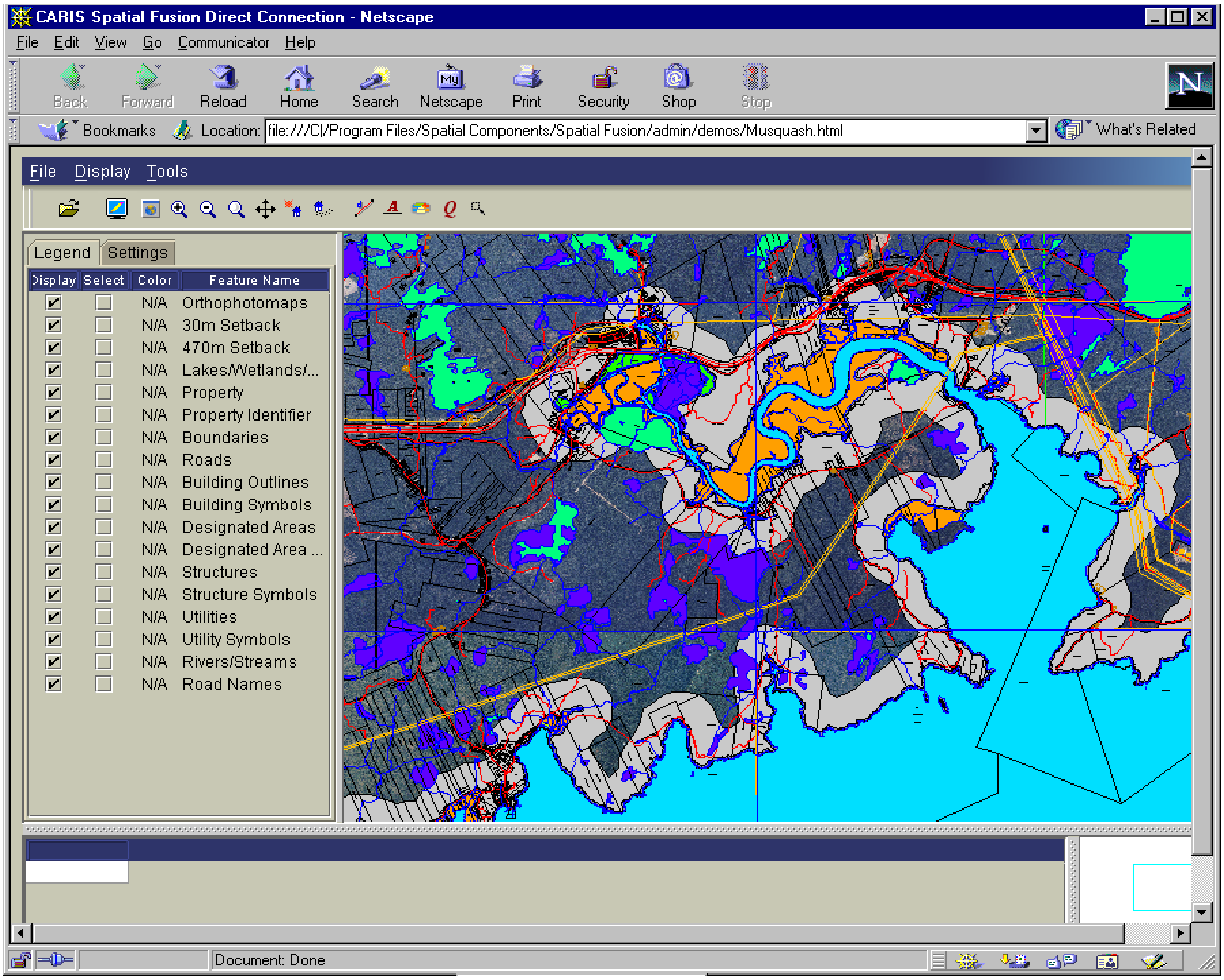

Figure 1: Screen Capture of Musquash MPA CARIS Spatial Fusion Application

In this example the user has selected 18 different layers of cadastral (and non-cadastral) information to view. Here, the user determines what kind of information they want need for their specific problem while having the luxury of adding and dropping other layers at will. The order of layer drawn is usually from top to bottom, but the user is also able to change this order by pointing to, clicking, and dragging each layer up or down. The user can also turn on and off the display layers by selecting the layer and placing a check mark against it. The user is therefore able to determine what information is relevant for making a particular decision without having to worry about the issues surrounding data formats or the geographical location of data.

From Figure 1, it is clear that the representation of the different boundaries in marine space is only partially appreciated by a 2D representation. For example, the nature of interests in the existing water lots in the Musquash estuary can only be obtained by running a query on the database and reading through a text-based report. This is comparable to automating an existing registry of information rather than allowing users to be able to view the interaction of the interests in multidimensional marine space by for example, showing how the designation of the MPA would affect these interests. At the same time, 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.

Subsequently, research in the Ocean Governance project has evolved to address the multidimensional nature of marine cadastre requirements. This is an attempt to allow stakeholders, communities and decision makers to be able to visualize the interaction of interests in marine space. In future this might involve the creation of a prototype that allows the visualization of the physical marine space (i.e. sea surface, water column, seabed, and subsurface), the laws and regulations in effect, and the spatial extent of static and dynamic (i.e. time varying interests e.g. fisheries closures) interests. This is important because in the oceans where resources and activities, and therefore rights and restrictions, can co-exist in time and space and can move over time and space, the interaction of public and private interests is rarely captured by a static 2D view. Results on this phase of the project will be made public as they are obtained.

Summary

Interested persons, and those who would in any way be affected by the designation of MPAs, should be consulted in decision-making. This is encapsulated in the consultation principle of the *Oceans Act* [1996] and in the Marine Programs Policy. This paper has used the Musquash Marine Protected Area case study to identify marine cadastral information user needs. Cadastral information captures the interest of stakeholders and communities in the MPA vicinity. This information would allow users (e.g. MPA planning groups and other decision makers) to attempt to ensure harmony between competing objectives in marine space; such as, the environmental objective of MPA designation, economic objectives of existing activities in the area, and public/private rights of stakeholder and the community. Together with other marine information, a record of the nature and extent of marine rights is what would be contained in a marine cadastre.

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