

The Role of Bathymetry Data in a Marine Cadastre: Lessons from the Proposed Musquash Marine Protected Area

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Abstract

Bathymetric data collection techniques are used to provide vital depth input to navigation charts and bathymetric maps that now cover most of the water-covered areas of the earth. They have aided the safety of navigation, laying trans-oceanic telephone cables, exploring and drilling for offshore oil, locating important underwater mineral deposits, and improving our understanding of the earth's geological processes. While bathymetry remains one of the most often requested marine data products, rarely is its use in coastal and offshore management of property rights, or marine administration, emphasized.

In this paper, the authors argue that bathymetric data, when combined with other geographic data and information, adds an important dimension to marine boundary delimitation principles. These principles are instrumental in furthering our understanding of how natural and anthropogenic phenomena affect property rights in marine space - and by extension, the important role that bathymetry data can play in coastal and offshore management of property rights. This paper will show how bathymetry data was used in a sample coastal zone management program, the proposed Musquash Marine Protected Area, to amplify issues surrounding the establishment of boundaries. The paper will also use this case study to advance discussions on the role of bathymetry data in a marine cadastre.

Keywords: bathymetric data use, marine protected area, boundary delimitation, marine property rights, UNCLOS, marine cadastre.

1 Introduction

Bathymetry is the measurement of the depths of water bodies from the water surface. It is the marine equivalent to topography and in the context of this paper will be referred to as such. This paper does not differentiate between single beam and multibeam echosounder data collection techniques but it does categorize sidescan sonar as a different category of products. This is

simply because while Sidescan sonar data might be used in visualising the seafloor (and other objects in the water column) it is never used in the measurement of the depths.

The premise that bathymetric data can be used for coastal resource management is not a new one. There is legal precedent that bathymetry data has historically been used to determine thalwegs in ownership disputes. However, the use of bathymetry for property rights management is not only historical but also has a current context. One only has to look at the regulations under the United Nation Convention on the Law Of the Sea (UNCLOS), where bathymetry and other scientific information must be used in delineating a boundary of rights in marine space, the juridical Continental Shelf, to realize the “evolving” potential of bathymetry data.

1.1 UNCLOS, Bathymetry and Juridical Boundaries

Article 76 of the United Nations Convention on Law of the Sea (UNCLOS) allows coastal States to claim a continental shelf beyond 200 nautical miles from the baselines from which the territorial sea is measured. Section 1.2 of the scientific and technical guidelines of the Commission on the Limits of the Continental Shelf (CLCS), indicates that the purpose of providing the guidelines is to “provide direction to coastal States. ...clarifying the scope and depth of admissible scientific and technical evidence to be examined by the Commission during its consideration of each submission...” Section 4.3.1. suggests that the submission include the necessary cartographic products derived from the compiled bathymetric database to portray the 2,500 metre isobath which plays an important role in the implementation of Article 76. The guidelines also provide directions on reporting the quality of data being supplied as part of a submission. Section 4.3.4 indicates that metadata about the bathymetric data should be included as part of the submission by the coastal State¹ while Section 9.2 deals specifically with form, format and content of the bathymetric data to be used in formulation of a claim for the continental shelf.

From a juridical boundary perspective, the foregoing has set precedent regarding boundary delineation in marine space. UNCLOS has “muddied the waters” by proposing that scientific information can also be used as evidence of a boundary. Several authors [e.g. Monahan and Mayer, 1999; van de Poll et al., 1999] are in agreement that the scientific and technical guidelines of the CLCS can be interpreted as endorsing bathymetric data (raw water depth and calculated water depths) as important data content in a Nations claim for the continental shelf. This represents a new approach in boundary delimitation as scientific information is actually being used to provide evidence of a juridical boundary.

1.2 Thalwegs, Bathymetry and Boundaries

Historically, the thalweg concept has been used to delineate boundaries between individuals e.g. when used in the context of property boundaries in tidal waters. The thalweg is also considered as a boundary between jurisdictions. Mukherjee and Gray [1987] indicate that G.V. La Forest, has commented that this rule was devised to ensure that countries on opposite sides of a river constituting an international boundary would have equal access to the navigable channel of the

¹ Wherever the bathymetric information presented to the Commission may be a filtered or smoothed subset of the original data, a full description of the methodology employed to produce it will be reported by the coastal State [section 4.3.4, Scientific and Technical Guidelines of the CLCS]

river. Mukherjee and Gray [1987] provide anecdotal evidence that in the early stages of negotiations with Canada in the Georges Bank dispute, the United States attempted to use the thalweg concept to define the Gulf of Maine as a natural divider of fish stocks. Regardless of the nature of the property boundary, the thalweg concept is generally accepted to be the deepest navigable channel in a body of water and its delineation based on economic, equitable and practical considerations.

It can be argued that the thalweg line can be approximated using bathymetric data e.g. on the basis of isobaths depicted on bathymetric charts. However, thalwegs as boundaries delineating ownership depend on survey monumentation as the prime record of the location of a boundary. From a survey perspective, the re-location of the boundary by another surveyor is of paramount importance. The assumption is that in case of dispute, another surveyor will neither have the time nor resources to conduct another hydrographic survey in order to relocate the thalweg. At the same time, the deepest channel represented by the thalweg can change with time (thus making the boundary ambulatory), or there could be more than one thalweg. In any case, using bathymetry to indicate the thalweg line would suffer from too much uncertainty including depth sounding and position fixing uncertainties associated with bathymetry data collection process [Hare and Monahan, 1993].

The preceding observation should not detract the reader from the point being made-that the thalweg line is used as a *legal* boundary line in marine space and theoretically, can be approximated using bathymetry data. This is an important point that will be used as a starting point to expand the use of bathymetry in property rights information management.

2 Bathymetric Data and Resource Management

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 managers have traditionally tended to rely more on scientific information, regarding the quality and quantity of resources. Apart from identifying the location of a resource, bathymetry data is also used to identify how much of the resource is available at the location and what quality (or in what condition) is the resource.

Scientists are increasingly combining bathymetric data with other geographic data and information in order to include a new dimension to their view of marine space. Importing bathymetric data into Geographic Information Systems (GIS) and using the GIS model to manage and analyze layers of information is now unveiling a “sea” of application possibilities. Whether the purpose is just to visualize sea floor topography, or predict the trajectory of pollutants by combining bathymetry data with tidal flushing patterns, GIS has allowed bathymetric data to become more widely used by scientists. But resource managers are not being left behind. Use of bathymetry data in resource management is being partly driven by the need to allocate rights, assign restraints and allot responsibilities to resources by taking advantage of the latest products and technologies available.

But what is a resource and what is resource management? For the purposes of this paper, resources refer to both living and non- living things, found on land, that have cultural, social or economic value. Although there are several different taxonomies that describe resources, in this

paper the authors define a resource as falling into two general categories i.e. natural or artificial resources. Natural resources can be referred to as the “stock” of the land e.g. hydrocarbon deposits, natural gas, minerals and fish. Artificial resources include infrastructure for transport and communication e.g. cables and pipelines, navigation lanes, oil rigs, harbours etc. Any reference to resources in this paper will follow the taxonomy outlined above.

Resource management is concerned with the inventory, allocation, development and conservation of land resources. Resource management balances several objectives including the social objective of respecting existing property rights (both public and private) associated with the resource. To be able to accomplish this objective, information about two classes of boundaries is required: one boundary defining the resource extent and the other defining the extent of rights within, or in the vicinity of the resource. The former boundary is referred to as the resource boundary while the latter boundary is referred to as the legal 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) with respect to the resource.

Framing the above observation in information management terms, the authors deduce that the following assumptions exist: a) it is possible to provide information regarding the identity and location of the resource b) the information can be used to allocate or identify private or public rights (and restraints) to the resource and c) information on resource location and associated interests is easily accessible in an easily understandable form to decision makers.

The previous assumptions can be summarized as follows: In essence, one is able to access information on *where* the resource is, *who* has *what* rights to the resource, and how the information can be provided to decision makers (whomever these may be). In the following sections, the authors will discuss bathymetric data in the context of these three assumptions and frame their arguments in the “language” of property rights information management.

2.1 Identifying the Location of the Resource

Bathymetric data has traditionally been used to delineate the resource boundary. One need only look at the long list of applications for bathymetry data to understand the diverse nature of the resources being located. For example,

1. Navigation - In navigation, the resource to be located is the safe transportation path represented by a navigation lane. Echo sounding has been used since the 1920's to provide depth input that allows navigation in water covered areas. Classical ocean mapping has developed from hydrography, which was originally concerned with bathymetry and tides.
2. Pipeline and cable laying - In pipeline and cable laying, the resource to be located is the pipeline or cable which is the conduit for transporting natural resources e.g. oil or gas, or for communication purposes. The construction and laying of pipelines and cables can usually be classified into 3 stages; pre-lay, construction and as-laid surveys which rely on bathymetric data to ensure that there are no obstructions on the route, that the pipe or cable is not under considerable stress, for trenching purposes, and to ensure that the pipe or cable is properly buried.
3. Exploring and drilling for offshore oil and gas - In offshore oil exploration and development, the resources to be located are the hydrocarbon deposits and the infrastructure used to exploit the deposits. The exploration and drilling of offshore oil generally involves several phases

that might utilise bathymetry data. The data is used to anticipate subsurface hazards, anchoring problems, to ensure that well is located at the optimal location for drilling, and when performing engineering surveys for artificial islands requires that seafloor topography be mapped.

4. Locating important underwater mineral deposits - In underwater mineral exploration and development, the resources to be located are the mineral deposits and the infrastructure used to exploit the deposits. During mining, a vessel mounted swath bathymetry system is used for seabed surveys and visualization. These systems provide information to ensure that the area is adequately covered and that any obstacles are avoided.
5. Fisheries Habitat - Fisheries research and industry benefits greatly from bathymetry data. Fisheries use bathymetric data products for aquaculture, seabed classification, habitat mapping, ecosystem mapping, and environmental impact assessment (among other applications). In fact, fisheries projects that focus on habitat mapping are in themselves a great source of bathymetric information that can be used for navigating and charting.

2.2 Allocation of Private and Public Rights Based on Resource Location

Allocation of rights and responsibilities can occur in one of two general ways. Once a resource has been identified or located with the help of bathymetric data products, those involved in resource location might choose to exploit the resource to the exclusion of others and might seek a legal document to this effect. Alternatively, bathymetry data collection might also locate the misuse of resources e.g. rights to dispose waste might have been allocated, prior to bathymetric data being available, but after seafloor topography indicates the amount and location of the waste disposal, responsibilities for cleaning up might be allotted. In either case, bathymetry data is instrumental in determining the allocation of positive and negative property rights associated with the resource.

As observed in the preceding argument, implicit in the allocation of rights is the assumption that there will be restraints and responsibilities that will be put in place to help accomplish resource management objectives. McLaughlin and Nichols [1989] indicate that the institution that affects resource use in this manner is referred to as land tenure which,

“...may be distinguished in terms of how rights-whether productive, development or pecuniary-are allocated; how responsibilities are attached to these rights; and how restrictions are imposed by law, by custom, or through natural constraints.”

Resource management can be viewed from three general perspectives: institutional, economic and environmental. Information about property rights is important in all three perspectives. Since the economic perspective views property rights as a commodity that can be traded in a market then property rights information can be used to facilitate the existence and effectiveness of a market by providing crucial information to the actors in the economic system. A good example is the oil and gas industry that views the bathymetry data collected as an investment that is to be guarded jealously lest it provide an advantage to competitors. The institutional perspective views property rights as a means to provide access to resources especially to poor (or disadvantaged) groups. In this perspective, property rights information can be used to show inequity in the distribution of rights to resources. Property rights information on farm fisheries such as aquaculture (as opposed to wild fisheries) might show great inequities in who owns aquaculture licenses or (among other things) how the location of such licenses denies access to fishing

habitat. The environmental perspective focuses on the conservation and protection of resources. In this perspective, property rights information can be used to assign restrictions and allot responsibilities to individuals with regard to the exploitation of a resource. Revisiting the aquaculture example, bathymetry can be used to show whether the location of an aquaculture site, and the disposal from such a site, negatively impacts on the fishing habitat and hence on the positive rights of fishermen in the area. In all the perspectives outlined, bathymetry data is critical in providing the necessary information needed for resource inventory and subsequent allocation of rights.

2.3 Information is Accessible and Understandable

Citizens are increasingly feeling left out of the decision making process. Most feel that matters pertaining to development and use of resources are becoming the exclusive domain of scientists with professional training. With more citizens being involved in advocacy efforts and words like “stewardship of resources” increasingly being used to rally the general public into participation in the decision making process, provision of information about the space that citizens inhabit is becoming critical.

There exists in every jurisdiction a public policy issue associated with information collection [McLaughlin, 1991]. This issue is related to the notion of providing ready and efficient access to information about resources, and rights associated with them, to all members of the community. The public is defining itself as an individual property owner – the property being the marine commons and its resources – and are re-aligning themselves to be primary decision makers. Most people are therefore interested in how resources are being utilised and whether resource use is being policed effectively.

Underlying the public policy issue is the concern that citizens are increasingly unable to access or make effective use of the available information resources. With regard to access, issues such as cost recovery, security considerations, and privacy are examples of restraints that make it difficult for companies involved in bathymetry data collection to make these products available to the general public. With regard to effective use of information, issues such as data integration and visualisation still pose great challenges that need to be addressed. The form, format and content of information about marine resources begs to be interpreted for the general public. More so in the case of bathymetry data, which provides the public with two products: raw soundings that beg for generalization, or colourful bathymetric charts that tend to distract rather than assist. The challenge is twofold: how to make the information accessible, and how to make it more comprehensive to the general public.

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. In

participating in the proposed Musquash MPA case study, the authors rationalized that this investigation into data integration and visualisation challenges in marine space would provide insight into potential solutions.

Having briefly discussed the role of bathymetry data in resource management the authors will now review their experiences in a sample coastal zone management program. A brief background to the Marine Protected Area (MPA) program in Canada is provided as an introduction to the proposed Musquash MPA.

3 Marine Protected Areas in Canada

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:²

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

3.1 The Proposed Musquash MPA

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) process³. 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. Musquash is located in the province of New Brunswick, and borders the Bay of Fundy. It is Atlantic Canada's second inshore "Area of Interest" in the Marine Protected Areas (MPA) Program under the *Oceans Act*.

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., 2000]. One of the case studies of the Good Governance project involves the proposed Musquash Marine Protected Area (MPA).

² 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".

³ 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.

3.1.1 Mapping the Spatial Extent of the Resources

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. 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.⁴

To provide the base mapping for analyzing the MPA resources and to provide scientific information that could provide boundary location alternatives, the University of New Brunswick's Ocean Mapping Group carried out a hydrographic, oceanographic and geophysical survey of the Musquash. Undergraduate students were responsible for collecting the information as part of a 5th year Hydrographic Field Operations undergraduate course. Bathymetric data collection at the Musquash involved a Simrad EM3000S multibeam transducer mounted on the CSL Plover, a 31 ft hydrographic survey launch operated by the Canadian Hydrographic Service⁵. As outlined in the following sections, the hydrographic survey information proved important in providing evidence of tenure in the proposed Musquash MPA.

3.1.2 Identifying Patterns of Allocation of Rights to Resources in the Musquash

Although there were several types of information identified in the Musquash that had negative and positive implications for rights allocation, in this section the authors outline those that depended on the bathymetry data collected.

1. Spatial extent and Scallop zone

While there were several reasons for the hydrographic and oceanographic survey of the Musquash, the focus for the data collection campaign was backscatter and bathymetry that might indicate natural features on the estuary floor. These were to be used to justify or rebuff the preliminary delimitation of the both the outer boundary of the Musquash MPA and the limit of the special scallop zone. From an inspection of the bathymetry, backscatter, and tidal flushing patterns it became evident that while there might be sediment distributions that closely tracked a preliminary straight-line land-terminating boundary (see Figure 1), this was considered coincidental evidence, as over time the sediment distributions would vary with changing flushing patterns in the estuary. If this boundary were then used as the outer boundary of the Musquash, it would in effect be an ambulatory boundary of undefined uncertainty. With regard to the scallop zone boundary neither the backscatter nor bathymetry data offered any indication of scallop habitat and consequently any evidence supporting the location of the previously proposed straight-line boundary. For an in-depth description of this investigation the reader is directed to Byrne et al [2002].

⁴ 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].

⁵ a branch of the Department of Fisheries and Oceans (DFO), Canada.

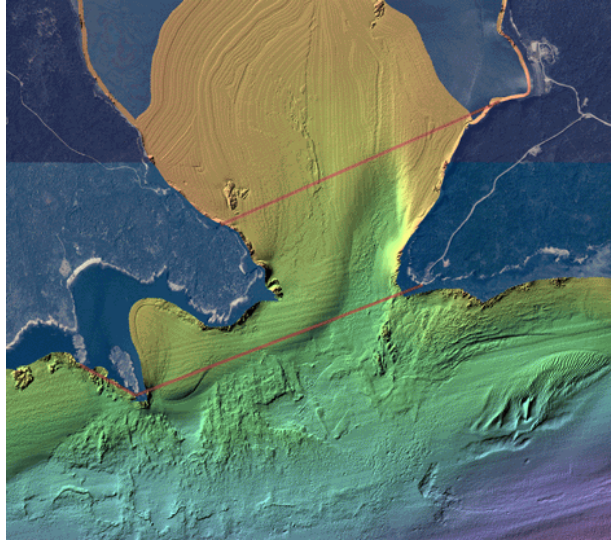


Figure 1: Colour coded bathymetry showing proposed scallop zone (inner red straight line) and outer boundary (outer red line) of the proposed Musquash MPA. North is to the top of the image (background orthophoto imagery courtesy of Service New Brunswick and bathymetry image courtesy of Ocean Mapping Group at UNB).

2. Herring weirs

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. Prior to the data collection campaign the authors were able to view what they perceived to be all the abandoned fishing weirs at high and low tides. On one bathymetry image however, the remains of abandoned fishing weir posts were clearly visible (see Figure 2). This weir could neither be seen at high nor low tide and was the focus of considerable excitement to the research groups. The weirs in the estuary could easily be indicative of present, abandoned or expropriated private fishing rights and might prove quite valuable. Marshall [2001] describes how the development of aquaculture in the Bay of Fundy created a demand for historical fishing weirs, and hence market value for the sites.

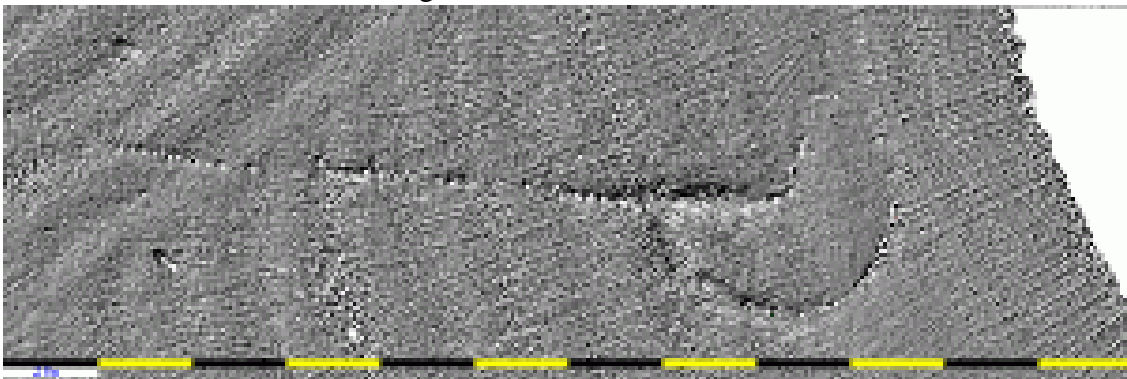


Figure 2: The remains of a Fishing weir on the southwest corner of the old Musquash Harbour (image provided by the Ocean Mapping Group at the University of New Brunswick).

3. Landing craft

While participating in the survey of the Musquash, various WWII landing craft were observed in the areas north of Five Fathom Hole in the Musquash River. Byrne [2002] observes that one

landing craft lurks just over a metre from the surface at high tide and poses a potential navigation hazard. Sun illuminated bathymetry (taken during high tide) clearly captured this wreck. These wreck sites could in the future be earmarked for protection as historic or heritage sites.

4. Fisheries habitat

Bathymetry and backscatter evidence of the location of a habitat for scallops, and therefore the presence of a scallop zone in the Musquash, was inconclusive. Byrne et al [2001] indicate that while sidescan sonar data showed marginal changes in backscatter as one moved north of the proposed scallop zone boundary, these same changes were not reflected in the multibeam backscatter nor present by inspecting the bathymetry. On a positive note however, bathymetry data for an area at the mouth of the Musquash estuary indicated existing and misplaced lobster fishing pots. This was obtained after the area was gridded and a consistent signature observed in the general location where lobster fishermen usually placed the pots.

5. Pipelines

Since the survey launch used for multibeam data collection was docked at Saint John, extra multibeam coverage was obtained as it transited to and from the Musquash. Apart from expanding the bathymetry and backscatter coverage in the Bay of Fundy area, the transit was also used to detect any features that might be of interest in the Bay of Fundy. Two pipelines licensed to transit crude oil from the Bay of Fundy to Mispec Point (on the mainland) were clearly visible on the multibeam imagery collected.

6. Sand wave features

Interesting sand wave and whaleback features can be observed on inspecting the bathymetry of the area off Musquash Head (see Figure 1- south east section). While there is undoubtedly a geological explanation covering the history of these features, the local community and conservation groups in the area claimed “ownership” of these features and were exploring means of using them to advance their case for protection of the Musquash.

7. Navigation areas

From the bathymetry of the Musquash it was quite clear that the area around Musquash Head was deeper than the area around Western Head. An analysis into the tidal flushing patterns indicated that the incoming tide into the estuary had a predominant signature on Musquash head while the outgoing tide, depositing sediments from the estuary, was biased towards Western Head. This was particularly interesting to fishermen and other persons who operated craft in the estuary as it presented a visually pleasing justification for navigation lanes into the estuary.

From the foregoing discussion it is evident that there were a diverse group of rights to be allocated to different resources in the Musquash. It is also clear that bathymetry was instrumental in identifying the location of existing, future and abandoned rights in the estuary.

3.1.3 Access to Information

Bathymetry proved to be an important part of the base mapping of the Musquash. When colour coded bathymetry imagery was overlaid over the orthophoto imagery, it provided crucial information on other rights in the Musquash and allowed depth information to be viewed from the “lens” of property rights. This proved to be particularly important in communicating the implications of the bathymetry data to the local community by framing the data in terms of how it negatively or positively impacted their rights to resources in the Musquash.

There are two challenges that emerged prominently:

1. Information access vs. private data holdings - It became clear that there would be caveats placed on access and availability of some datasets. Some of the data provided, notably from Government departments, was usually provided to the general public through a cost recovery model and therefore the public paid to access these datasets.
2. Data integration vs. data collection standards -The separation of responsibilities between government departments and agencies together with the independent nature of the private data collection provides challenges in the form format and content of the data collected. In the case of the Musquash there was a multitude of different marine information, in different scales, formats, accuracy, completeness and precision because it is collected for various uses.

Despite the previously mentioned challenges, three standard avenues of information dissemination were finally adopted. A website has been set up detailing the hydrographic campaign together with the analysis of the results from the data collection⁶. Several papers have also been presented at conferences outlining the research in the Musquash. Online access to data collected has been made available using the CARIS Spatial Fusion™ web mapping technology. For a description of the web mapping application the reader is directed to Ng'ang'a et al [2002b].

4 Towards a Marine Cadastre

The Musquash MPA case study provides interesting insight. While the research had focused on using bathymetry data in a scientific manner it became clear that the data was more important in the context of what property rights implications arose from an analysis of the data. This was more evident when bathymetry was used as a base map on which to overlay other datasets. Because of the large number of datasets that were available in the Musquash, it became clear that overlaying them would result in “noise” - the use of this combined information in decision-making being severely diminished. It is becoming more evident that there needs to be a common denominator, perhaps a filter, that allows the general public to perceive this datasets as providing information that they can use for decision making. This “filter” would allow Musquash datasets to be described in property rights terms: 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).

To construct this “filter”, the authors draw from a land-based resource management principle-the cadastre. The cadastre is defined as “ a parcel- based record of interests in land encompassing both the nature and extent of these interests” [McLaughlin, 1975]. Broadening 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. In this paper, cadastre principles are viewed as being instrumental in furthering our understanding of how natural and anthropogenic

⁶ Site maintained by Ted Byrne at <http://www.unbf.ca/eng/GGE/Research/OceanGov/musquash/home.html>

phenomena affect property rights in marine space - and by extension, the important role that bathymetry data can play in coastal and offshore management of property rights.

The authors have argued in a separate paper that parallels can be drawn between the cadastre approach to land information management and the governance of our marine spaces [Ng'ang'a et al., 2002a]. After all, the definition of the land parcel is broad enough as to also include water that lies above or below the physical entity that we commonly perceive to be land i.e., that which is the product of “geological and geomorphological processes of the earth”. And although there may be arguments advanced about the need to differentiate between approaches regarding the governance of our land and marine spaces, there is clearly a pressing need for harmony when proposing governance structures, as one moves from onshore to offshore spaces

It is impossible to talk of a cadastre without defining the spatial dimensions and type of interests that are represented in a parcel. And therein lies our problem for 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 definition of a parcel is even more complex. When (and if) a parcel is ever defined, bathymetry data is expected to play an important role. After all, land-based definitions of the cadastre have depended on base mapping to provide a primary medium by which the locations of parcels can be related to natural and artificial features. To this end, base maps for the land-based cadastre have traditionally combined large-scale topographic maps with orthophoto imagery.

Would bathymetry data perform a similar role to traditional base mapping on land? Does bathymetry indicate the location of boundaries associated with a parcel? In response to these questions, the authors invite the reader to recall UNCLOS and the step-by-step procedure encapsulated in the guidelines of the CLCS. Clearly, such a boundary would be incorporated in a property rights information system as it represents the spatial extent of a Nations' rights and interests. And while not having legal precedent, the work of Byrne et al., [2002] can be used to show the potential of using bathymetry data to delineate boundaries of “parcels” that have previously not been encountered.

5 Other Issues to Consider

In view of the growing intensity of ocean uses, and the diversity of use in marine space, there is a clear risk of interference with other resource uses. The proposed Musquash MPA is providing insight and advancing the discussion on the cadastre approach to managing marine space.

1. Alternative forms of cadastre exist in marine space – The cable, oil and gas, and navigation industries usually conduct comprehensive seabed bathymetric surveys to plan routes in order to avoid areas susceptible to disruption by earthquakes, munitions, dumps, canyons, or even traditional fishing areas. As activities on the seabed increase, additional sites may have to be avoided for environmental sensitivity reasons, or for conflict avoidance with resource-based activities. This is possible because the information that is collected is analysed in the context of how rights to exploit a resource conflict with other rights or are restrained by other rights.
2. A cadastre can enhance dispute resolution – The management of the Musquash is to be designed around regulations that restrict certain activities in the proposed Musquash MPA. Management decisions regarding marine space e.g. the Regulations Impact

Assessment can be made after consulting the information available and evaluating the risk associated with restricting use in the Musquash MPA. The Musquash MPA information portal was designed to provide central access to property rights information in the Musquash. Although not viewed as a cadastre prototype (in the strictest sense of the word) the information portal is providing great insight into property rights information management issues. Similar information prototypes have aided in reducing conflict regarding multiple ocean use. Submarine cables provide a good example. Socio-economic effects are more pronounced in areas where cables are unburied (and information unavailable) since the cables effectively exclude fishers from fishing grounds by posing a risk to accessing the fishing habitat and causing a threat for legal liability for cable damage.

3. Lack of access to information can cause perceptions of social inequity – In the Musquash MPA it has become increasingly clear that all the information collected by, or in the custody of, partners in the Ocean Governance project has rarely made its way in a comprehensive form to the local community. Only recently with the set-up of websites dedicated to the Musquash MPA campaign, and attempts at an education awareness plan, is the information becoming accessible to a spectrum of the community. Recent interviews have indicated that the local community feels some exclusion especially when an outsider informs them of “the wonderful sand wave features to be found on the seafloor of the Bay of Fundy - at the mouth of the Musquash Head”. The implications of the sand wave feature to social or economic well being of the Musquash MPA remains unclear especially to those of the community who have not had a chance to view the colour coded bathymetry that shows the sandwave feature.
4. Bathymetry data can be used to strengthen a community’s inclusiveness in the decision making process - It is becoming increasingly clear that bathymetry data is crucial to people’s appreciation of the unseen side of Musquash and potential for providing arguments regarding the protection of the “aesthetic seafloor beauty of the Musquash Estuary”. The Conservation Council of New Brunswick provided a slogan to rally the local community to support the Musquash MPA initiative. The slogan read “ Musquash – worth protecting”. Bathymetry data is perceived as providing additional visual proof of the unseen worth of the Musquash estuary, and consequently strengthened their case for protection.
5. Information collection and management enhances buy-in to co-management approaches– In the case of the Musquash, several different stakeholders were brought together under the Ocean Governance project and contributed information to the project. The local communities as stakeholders are also capable of contributing local knowledge property rights in the Musquash. For example, signatures that were ignored in the processing of the raw water depths can easily turn out to be fishing weirs or dump sites.
6. The dilemma of parcels - Marine systems are what are referred to as a “common pool resource” involving a dual challenge: to organize in a way that the withdrawal of benefits within a system of multiple and competing users; and to allocate production units amongst them [Marshall, 2001]. As she points out, there have been important questions that have been raised about the moral and philosophical justification for effectively creating “property” out of, and a market for, public goods by partitioning marine space. As the authors have previously pointed out [see Nichols et al., 2000, Ng’ang’a et al., 2002a] it may be more useful in the long term to look at broader contexts such as

property rights infrastructure, MGDI, and environmental or ecological units in order to ensure that we are not asking the resources and their management to follow our sometimes arbitrarily straight surveyed lines in space.

6 Summary

This paper has provided a synopsis of the use of bathymetry data in a marine cadastre. The paper makes three main points: (1) bathymetric data can be used to identify the status (quality and quantity) and location of a resource; (2) bathymetric data can be used to assist in locating and identifying rights - specifically the allocation of rights, allotment of restraints and assigning of responsibilities; (3) bathymetric data provides a visually appealing medium for disseminating information about resources and the rights to resources.

The authors do not suggest that bathymetry data is the only medium that can be used to accomplish the above-mentioned goals. In fact this paper has shown that backscatter can be used for similar purposes (especially in the context of describing sediment distributions). This paper suggest that although using bathymetry for property rights management is still perhaps an evolving frontier in Hydrography, instead of only using bathymetry data to identify quality and quantity of resources in resource management, an approach that also utilizes bathymetry data as possible source for property rights information should also be used. After all, coastal resource management is about making decisions that respect to people's rights, restrictions and responsibilities in marine space.

7 References

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8 Legislation Cited

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