The Marine Cadastre: Legal and Spatial Data Contribution to Economic, Environmental and Social Development

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Key words: Marine cadastre; multi-criteria decision analysis; decision support; information system; marine information management; GIS; marine tenure; coastal tenure; property rights; sustainable development

SUMMARY

The concept of what constitutes a cadastre varies across jurisdictions. A marine cadastre is an even fuzzier concept. Generally, though, it is agreed among experts and interested parties that the administration of rights to marine and coastal spaces requires the management of legal and spatial information to these spaces. Depending on the jurisdiction and school of thought, this (formal) management of marine and coastal legal, environmental, and spatial information (among others) is ideally accomplished through an established marine information system, or a marine cadastre. In this paper, the term "marine cadastre" will be used as a matter of convenience to describe any information system established to manage legal (and even informal) marine and coastal tenure (and other) information, and its linked spatial quantity.

Legal and informal marine and coastal tenure contributes, negatively or positively to the economic, environmental, and social development of jurisdiction. This occurs whether the tenure and spatial dimensions are known or not. However, if these dimensions are known steps can be taken by the appropriate authorities to accommodate and improve formal and informal social arrangements, equitably allocate rights, monitor and mitigate the environmental impacts of social and economic activities among other things. Tenure information used, for example, in association with environmental and ecological information related to the same spatial extent enhances the decision-making process. A marine cadastre makes the achievement of these objectives easier by providing all appropriate information to support socioeconomic and environmental decision-making.

Using a case study, this paper underscores the point that data stored in a marine cadastre must be meet the test of desirable data quality (i.e. be complete, up-to-date, useful etc.), and be within the framework of collaborative governance to be of optimal use as support for the social, economic and environmental objectives of jurisdictions.

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1. INTRODUCTION

The concept of what constitutes a cadastre varies across jurisdictions. A marine cadastre is an even fuzzier concept to administrators of marine rights in some national jurisdictions. The preference among these persons is the term “marine information system”.

Generally, though, it is agreed among experts and interested parties that the administration of rights to marine and coastal spaces requires the management of legal and spatial information to these spaces. Depending on the jurisdiction and school of thought, this (formal) management of marine and coastal legal and spatial information is ideally accomplished through an established marine information system, or a marine cadastre. In this paper, the term “marine cadastre” will be used as a matter of convenience to describe any information system established to manage legal (and even informal) marine and coastal tenure (and other) information, and its linked spatial quantity.

Legal and informal marine and coastal tenure contributes, negatively or positively to the economic, environmental, and social development of jurisdiction. This occurs whether the tenure and spatial dimensions are known or not. However, if these dimensions are known steps can be taken by the appropriate authorities to accommodate and improve formal and informal social arrangements, equitably allocate rights, monitor and mitigate the environmental impacts of socioeconomic activities among other things. Tenure information used, for example, in association with environmental and ecological information related to the same spatial extent enhances the decision-making process. A marine cadastre makes the achievement of these objectives easier by providing all appropriate information to support socioeconomic and environmental decision-making.

The objective of the paper is to underscore the point that data stored in a marine cadastre must be meet the test of desirable data quality (i.e. be complete, up-to-date, useful etc.), and operate within the frameworks of a spatial data infrastructure and collaborative governance to be of optimal use as decision-support for the often conflicting social, economic and environmental objectives of jurisdictions. In other words, data must be in a state of having current utility and be accessible in order to optimally be made use of by those with socioeconomic and environmental objectives.

A case study will be used as the method of emphasizing the important points. The case study relates to the use of various thematic layers in a GIS to support multi-criteria decision analysis in relation to perceived socio-economic, environmental, and political feasibility of

establishing aquaculture sites in the Bay of Fundy, New Brunswick, Canada. The paper will outline the potential benefits of information in a marine cadastre to this process.

2. THE USE OF MARINE SPACES

Marine spaces are sources of wealth and environmental functions, and support many socioeconomic and political activities. These spaces provide, for example [Eckert, 1979; Prescott, 1985; Payoyo, 1994; Ng'ang'a, Sutherland, and Nichols, 2002; Sutherland, 2004]:

- Climate control;
- Sources of food from animals, plants and fish;
- Spaces for tourism and other recreational activities;
- Materials for construction;
- Habitat for endangered species, species breeding and resting areas;
- Functions of water treatment, groundwater recharge, and flood attenuation;
- Means of transportation;
- Sources of minerals and petroleum resources;
- Means of communication (e.g. cables);
- Areas for implanting fixed navigational installations (e.g. lighthouses and piers);
- Areas for the dumping of waste materials;
- Areas for scientific research on Earth's basic physical and biological processes.

Today, many societies are faced with balancing socioeconomic, political, and environmental objectives. This need for balancing these often diverging objectives is applicable both to land and marine environments [Hoogsteden, Robertson and Benwell, 1999]. Therefore, concepts such as sustainable development have become important. Key to the achievement of this balancing act is access to appropriate information garnered from both science and community knowledge on what ecological and biological resources exist, the spatial extent of the resources, and who has rights, responsibilities, and restrictions in relation to the spatial extents and resources [Nichols, Monahan and Sutherland, 2000; Ng'ang'a, Sutherland, *et al*, 2004].

3. MARINE CADASTRE AND THE USE OF MARINE SPACES

The term “marine cadastre” is fairly new. A number of definitions have been tendered, including:

- Marine cadastre is a system to enable the boundaries of maritime rights and interests to be recorded, spatially managed and physically defined in relationship to the boundaries of other neighbouring or underlying rights and interests [Hoogsteden, robertson, and Benwell, 1999];
- [A marine cadastre] is a marine information system, encompassing both the nature and spatial extent of the interests and property rights, with respect to ownership, various rights and responsibilities in the marine jurisdiction [Nichols, Monahan and Sutherland, 2000].

The two definitions are stated from different perspectives (i.e. one from a boundary perspective, and the other from a broader perspective). Regardless, they converge on the point that a marine cadastre is basically a marine information system in which the primary information held relates to rights and interests (along with related restrictions and responsibilities) to marine spatial extents. The use of "primary" to describe the type of information stored in a marine cadastre is not insignificant. In some jurisdictions a "cadastre" is a map, while in others it is a register of rights and interests in land. Academically, distinctions have been made among various types of cadastres such as a "juridical cadastre" (i.e. facilitates the administration of legal rights and interests), a "fiscal cadastre" (i.e. facilitates the administration of taxation) and a "multipurpose cadastre" (i.e. facilitates a broad range of types of information related to the administration of spatial extents). These terms represent evolutions in thought about what a cadastre is and can be. Advances in information technology have made the concept of a multipurpose cadastre much easier to realise, facilitating the sharing and combination of many types of information related to any defined marine spatial extent (including information related to rights, interests, restrictions and responsibilities) to support the allocation and administration of rights. Therefore, although the marine cadastre's primary focus is on rights, interests, restrictions, and responsibilities in relation to marine spatial extents, there is the desire for access to additional types of information related to those spatial extents including (among other things) [Sutherland, 2004; Ng'ang'a, Sutherland, *et al*, 2004; Sutherland and Nichols, 2004]:

- Laws and legislation impacting upon marine spatial extents;
- The identity of entities with statutory consent (i.e. those assigning rights and interests);
- Scientific information (e.g. geology, hydrology, biology etc.);
- Other marine-related information that has boundary implications.

The foregoing provides the basis for the marine cadastre being basically multipurpose in nature. This multipurpose function of the marine cadastre makes it an effective tool in the provision of vital information for decision-making and the good governance of marine spaces. In this regard, the marine cadastre is excellent support for socioeconomic development, and environmental protection and management. Administrators and other stakeholders could query a spatial extent and determine the composite of legal and customary rights (or absence thereof), geology, biology, ecology etc. and make decisions as to the contextual best socioeconomic or environmental use of that spatial extent.

However, the concept of a marine cadastre must be considered within the broader context of:

- Information that is more accurate, up-to-date, timely, complete and useful;
- Appropriate use of technology and data standards (e.g., a spatial data infrastructure) that supports hardware and software interoperability;
- Stakeholder relationships (i.e., cooperation, collaboration, data sharing etc.) that facilitate the sharing of information needed for better decision-making;
- Institutional arrangements (i.e. organizational structures, policies, laws etc.) that facilitate a higher probability those stakeholders will achieve their often varied objectives;
- The stochasticity of elements in the marine environment.

It is not sufficient to the optimal utility of a marine cadastre that data simply be available. The data ought to be of sufficient quality to augment effective decision-making. In this regard the data must be accurate, up-to-date, complete, timely, and useful. The quality of the decisions made is in part dependent upon the quality of the information used [Ng'ang'a, Sutherland *et al*, 2004].

There is ample evidence to suggest that usable knowledge, gained from more up-to-date, accurate, complete and useful information, must be gleaned from scattered data stores that were built to support narrow public and private mandates. Consequently, incompatible data formats and structures pose significant obstacles to obtaining usable knowledge from these scattered stores of information. A spatial data infrastructure comprising computer networks, data exchange standards, interoperable and compatible databases, metadata, appropriate user interfaces etc. would enhance the utility of a marine cadastre.

A lack of capacity for horizontal and vertical integration among governance stakeholders is another obstacle to overcome. Governance research indicates that stakeholders with common interests should form relationships of information sharing (i.e. collaboration, cooperation, integration etc.) that is beneficial to all concerned [Paquet, 1999; Charette and Graham, 1999; Hoogsteden, Robertson and Benwell, 1999]. This is especially true in terms of information sharing in situations where each shareholder is in need of information held and maintained by another and each stakeholder desires the best available quality data. Beneficial also to this idea of collaborative, cooperative, or integrative governance is the establishment of appropriate laws and policies, as well as facilitative organizational structures that makes easier the sharing of information [Trebilcock, 1999].

Use of data in the marine cadastre must also take into consideration the stochastic nature of elements in the marine environment. Each data capture represents a temporal snapshot of dynamic elements (e.g., migrant fish stocks, benthic organisms affected by tides etc.), and therefore there is always, in these cases, uncertainties associated with the data. Keeping this consideration in mind contributes to the process of decision-making associated with governance of these spaces.

The social and economic potential of information in a marine cadastre will depend not only on a balance between the accumulation of new skills and investment in technology, equipment and infrastructure. It will also depend on changes made in governance compatible with local, regional and global conditions [Ford and Zussman, 1997; Manning *et al* 1998].

4. AN AQUACULTURE CASE STUDY

Aquaculture is now an important food product producer and employment provider. New Brunswick and British Columbia accounted for 83.2% of all Canadian aquaculture revenues in 2000. Total 2000 aquaculture gross output including sales, subsidies and growth in inventories was $722.47 million, up $25.1 million from 1999 [CAIA, 2003]. The benefits of

coastal aquaculture have been widely recognized and include increased income, employment, foreign exchange earnings and improved nutrition [Pullin, 1989]. However, aquaculture is competing for land and water resources and there is concern about the environmental implications of aquaculture development [Brag, 1992; Zhao, Lane, Michalowski *et al*, 2004].

Researchers at the University of Ottawa, Canada and the Department of Fisheries and Oceans (DFO) Saint Andrews Biological Station, New Brunswick, Canada are in the process of developing a model to support multi-criteria decision analysis with regard to the social, economic, political, and environmental feasibility of establishing aquaculture sites in the Bay of Fundy, off the coast of New Brunswick. The aim of the project is to facilitate decision-making to support the objectives of stakeholders with social, political, economic, and environmental concerns in relation to the establishment of aquaculture sites in coastal waters. The project is supported by the AquaNet Research Network Centre of Excellence [AquaNet, 2005].

The model utilizes thematic layers in a GIS to simulate real-world situations of proposed aquaculture sites in the marine environment. Layers are grouped according to four major categories [Zhao, Lane, Michalowski *et al*, 2004]:

- Biological/Ecological resources (lobster, scallops, herring, urchins);
- Socioeconomic activities (herring weirs, lobster traps etc.);
- Habitat (rockweed, salt marshes, benthic structures, current flow);
- Toxocology (chemical a, chemical b etc.).

The various layers are all overlaid to simulate a real-world situation of an aquaculture site established in a marine/coastal environment. According to pre-determined criteria (e.g. an assumption of uniform yield across the spatial extent of each polygon within each layer) yield/valuation results are assigned to each overlapping layer (Figure 1). Valuations of the composite layers are then analyzed according to the pre-determined criteria. The results are then exported to ExpertChoice™ multi-criteria decision support software. Using ExpertChoice™ the valuation data are then interpreted by each interested group of stakeholders, taking into account their own social, economic, environmental, and political positions (Figure 2). The collaboration of stakeholders would then make it possible to determine whether it is socially, economically, environmentally, and politically feasible to establish an aquaculture site in the area of interest [Zhao, Lane, Michalowski *et al*, 2004].

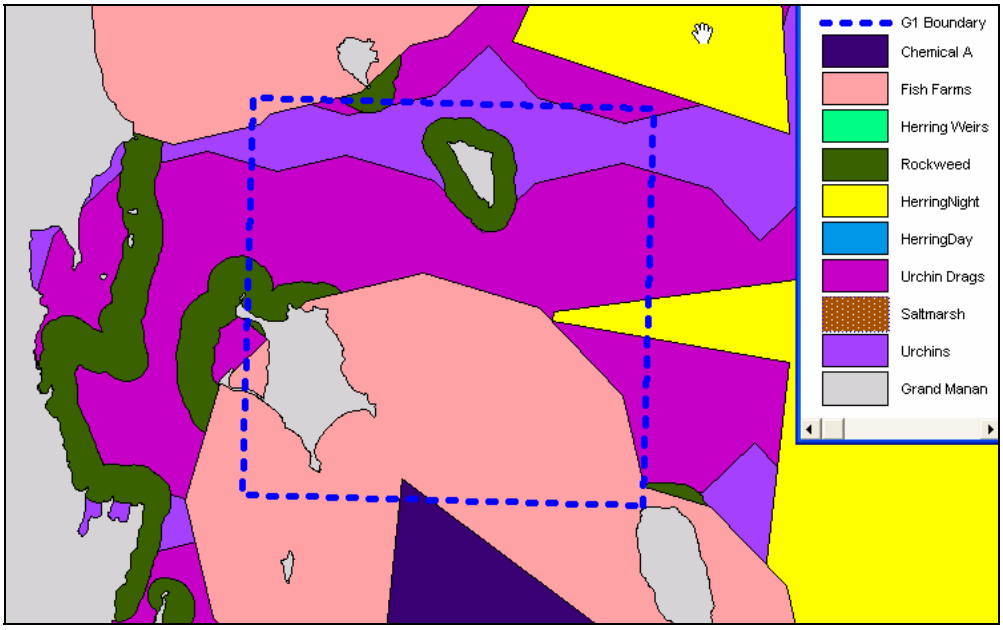

Figure 1: Selected area from composite overlay (After Zhao, Lane, Michalowski *et al*, 2004)

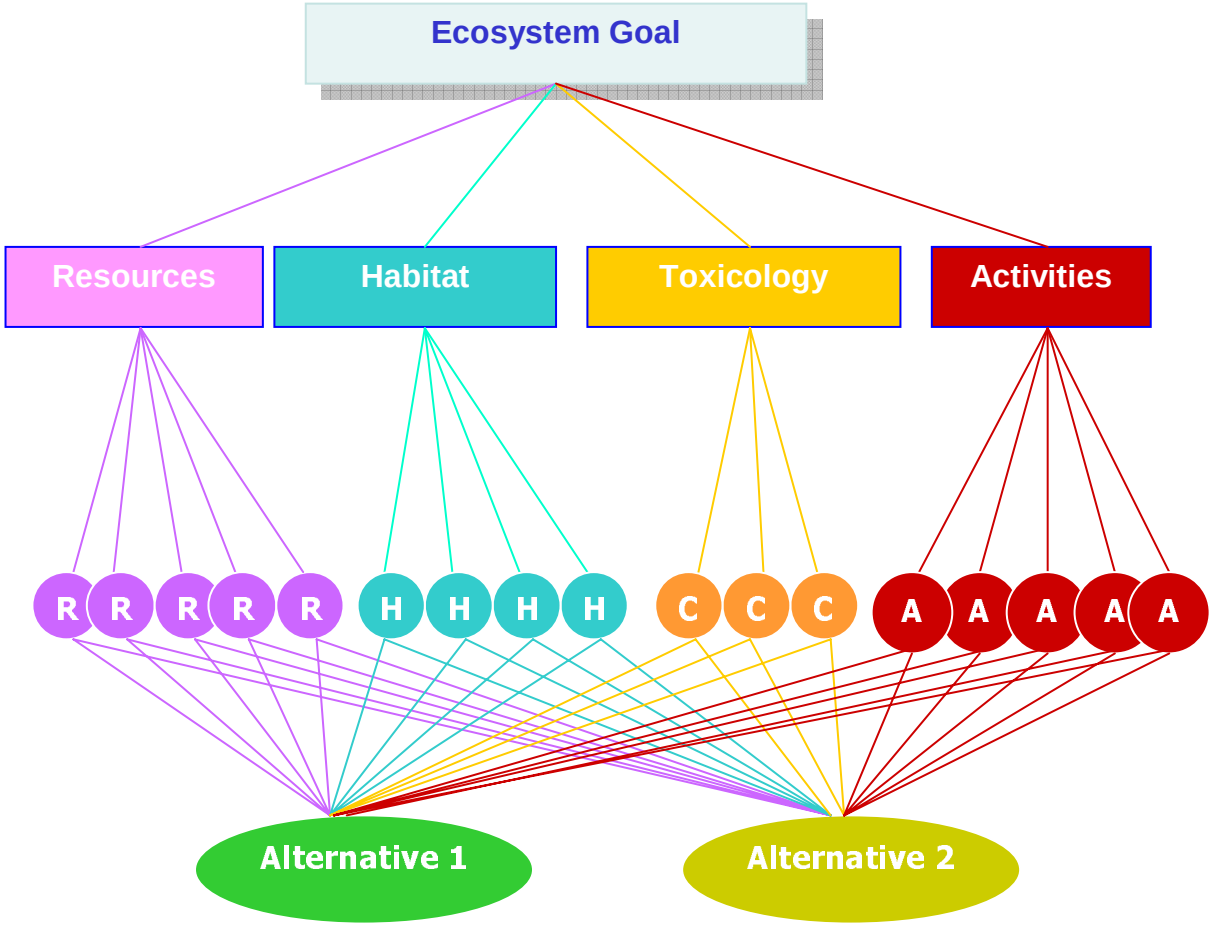

Figure 2: Determination of stakeholder alternatives (After Zhao, Lane, Michalowski *et al*, 2004)

There are some issues that impact on this case study. These issues are:

- Access to real-world data;
- Access to data of appropriate quality;
- The nature of stakeholder relationships that facilitates data sharing;
- The stochastic nature of some elements in the marine environment.

The datasets in the described model are a mix of real and simulated data, used to test the viability of the model. The model is sound, but assumes an ideal of stakeholder relationships, institutional arrangements, easily accessible data, and high data quality. In a real-world situation the various thematic layers of spatial information would most likely reside among the datasets of a number of government, private, and community stakeholders with different objectives and mandates. Of necessity the governance arrangements among these stakeholders would have to be one of integration, cooperation or collaboration to enable the rights and privileges associated with data sharing.

Data standards (i.e. data formats, structure, and metadata etc.) as well as appropriate technologies would also have to be in place to ensure that the spatial and thematic data associated with the site of interest is useful, up-to-date, complete, timely, and accurate. For instance, if either the position of the spatial data or the accuracy of the thematic data is in question, then the quality of the decisions made based on these datasets could also be questioned. The quality of the decisions made is in part dependent upon the quality of the information used. Once the data is of acceptable quality then it can be appropriately used in decision-making to support the socioeconomic, environmental, and political objectives associated with the site of interest [Ng'ang'a, Sutherland *et al*, 2004].

The marine environment is dynamic and data representing temporal snapshots inherently incorporate spatial-temporal uncertainties. Some of the layers (e.g., layers representing herring stocks) utilized in this case study are subject to these uncertainties, and this must be taken into account in the decision-making process.

A multipurpose marine cadastre, within the framework of cooperative/collaborative governance structures and arrangements, data quality and standards would allow for easier access to the needed spatial information of acceptable quality to facilitate the multi-criteria decision-making process in this case study's site evaluation exercise. In this way data in the marine cadastre contributes to the stakeholders' social, political, economic, and environmental objectives.

5. SUMMARY AND CONCLUSIONS

A marine cadastre's primary focus is the recording of rights, interests, restrictions, and responsibilities in relation to marine spatial extents. A multipurpose marine cadastre would store additional types of information related to those spatial extents including (among other things) [Sutherland, 2004; Ng'ang'a, Sutherland, *et al*, 2004; Sutherland and Nichols, 2004]:

- Laws and legislation impacting upon marine spatial extents;
- The identity of entities with statutory consent (i.e. those assigning rights and interests);
- Scientific information (e.g. geology, hydrology, biology etc.);
- Other marine-related information that has boundary implications.

However, much of the data that would constitute a multipurpose marine cadastre is scattered among data stores that were built to support narrow public and private mandates. A multipurpose marine cadastre can provide easier access to the spatial information and the various associated thematic information needed to facilitate multi-criteria decision-making processes that are often the situation in reality. However, this would ideally have to occur within the framework of cooperative, collaborative or integrative governance structures and arrangements, data quality and standards. From this perspective a marine cadastre would supply data to support the sustainable development goals of socioeconomic and political development balanced with environmental protection and management. In other words, once the data is accessible and of acceptable quality then it can be appropriately used in decision-making to support the socioeconomic, environmental, and political objectives of jurisdictions.

REFERENCES

AquaNet (2005). http://www.aquanet.ca/English/index.php. Accessed, January 2005.

Barg, U.C. (1992). “Guidelines for the Promotion of Environmental Management of Coastal Aquaculture Development”. FAO Fisheries Techical Paper, 328, Rome.

CAIA (2003). Canadian Aquaculture Industry Alliance. http://www.aquaculture.ca. Accessed 2004.

Charette, N. and A. Graham (1999). "Building partnerships: Lesson learned." In *Optimum*, Vol. 29, No. 2/3.

Eckert, R. D. (1979). *The Enclosure of Ocean Resources: Economics and the Law of the Sea*. Hoover Institution Press, Stanford University, Stanford, California.

Ford, R. and D. Zussman (1997). "Alternative service delivery: Transcending boundaries." In *Alternative Service Delivery: Sharing governance in Canada*. Eds. Ford, R. and D. Zussman, KPMG • The Institute of Public Administration • University of Ottawa Libraries.

Hoogsteden, C., B. Robertson, G. Benwell (1999). "Enabling sound marine governance: Regulating resource rights and responsibilities in offshore New Zealand." In *Proceedings of the New Zealand Institute of surveyors & FIG Commission VII conference & Annual General Assembly*, October 9-15.

Manning, E. *et al* (1998). "Renovating governance: lessons from sustainable development." In *Optimum*, Vol. 28, No. 3, pp. 27-35.

Ng'ang'a, S. M., M. Sutherland, and S. Nichols (2002). "Evolving Terminology: From Managing Property Rights in Marine Space to the Marine Cadastre." In *Hydro International*, 2002, Volume 6, Number 9, pp. 44-47.

Ng'ang'a, S. M., M. Sutherland, S. Cockburn and S. Nichols (2004). "Toward a 3D marine cadastre in support of good ocean governance: A review of the technical framework requirements." In *Computer, Environment and Urban Systems*, 28 (2004), pp. 443-470.

Nichols, S., D. Monahan and M. D. Sutherland (2000). "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.

Paquet, G. (1999a). *Governance Through Social Learning*. University of Ottawa Press.

Payoyo, P. B. (1994). "Editor's introduction." In *Ocean Governance: Sustainable development of the Seas*. Ed. Payoyo, P., United Nations University Press, Tokyo • New York • Paris.

Pullin, R.S.V. (1989) "Third World aquaculture and the environment". In *NAGA ICLARM Quarterly*. 12(1):10-3.

Prescott, J. R. V. (1985). *The Maritime Political Boundaries of the World*. Methuen, London • New York.

Sutherland, M. (2004). "Why a marine cadastre is important." In *Geomatics World*, Issue No. 3, March/April 2004, Volume 12, pp. 26-28.

Sutherland, M. and S. Nichols (2004). "The evolving role of hydrography in ocean governance and the concept of the marine cadastre." In *The Hydrographic Journal*, No. 111, January 2004 p.13.

Sutherland, M., K. Wilkins and S. Nichols (2002). "Web-Geographic Information Systems and Coastal and Marine Governance." In *Optimum Online*, Issue 3, Spring 2002, http://optimumonline.ca/article.phtml?id=23.

Trebilcock, M. (1999). *The Prospects for Reinventing Government.* University of Ottawa Libraries.

Zhao, Y., D. Lane, W. Michalowski, R. Stephenson, and F. Page (2004). "Integrated Systems Analysis for Coastal Aquaculture." In *PRISM*, 04-28.

BIOGRAPHICAL NOTES

Michael Sutherland obtained in 1995 a Master of Science (Engineering) in Land Information Management from the Department of Geodesy and Geomatics Engineering, University of New Brunswick, Canada. He is currently pursuing a Ph.D. at the University of New Brunswick where he is developing global boundary requirements models in coastal and ocean management. Mr. Sutherland is also currently at the University of Ottawa as part of an AquaNet project doing multi-criteria decision analysis with regard to the placement of aquaculture sites in the Bay of Fundy, Canada. He has more than 18 year's international experience in land information management including the development of land information management software in both Canada and Jamaica. He has also lectured in land and coastal administration, and real property law at the University of New Brunswick. Michael is a member of the Canadian Institute of Geomatics, and is a Vice-Chair of the International Federation of Surveyor's Commission 4.

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