RETHINKING RESPONSES TO COASTAL PROBLEMS:
AN ANALYSIS OF THE OPPORTUNITIES AND CONSTRAINTS FOR CANADA

by

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DEDICATIONS

For

My late father, Lewis Mercer

and

My best friend, John David Clarke

TABLE OF CONTENTS

CHAPTER 4: INTEGRATED COASTAL MANAGEMENT IN CANADA: AN ANALYSIS OF THE CONSTRAINTS TO PROGRESS....................69

PART III: SUSTAINING THE COASTS OF CANADA: TOWARDS IMPROVED SCIENCE AND MANAGEMENT

CHAPTER 5: ARE CANADA'S COASTS IN PERIL? AN ANALYSIS OF CURRENT COASTAL INFORMATION AND ITS RELEVANCE TO DECISION-MAKING 94

LIST OF TABLES

LIST OF FIGURES

ABSTRACT

This research challenged popular assumptions that Canadian coastal environments remain relatively un-impacted by human activities, and that current practices in coastal management are sufficient to ensure sustainability of coastal resources and communities. Using a systematic analysis of the literature, the performance of integrated coastal management, as reported for other nations, was examined, and shared impediments to progress were identified. Drawing from these insights, it was determined that past and current efforts to implement integrated management of the coasts in Canada have encountered similar constraints.

An intensive review of state of the coast information in Canada was conducted, including an assessment of the indicators used to monitor change in coastal environments and coastal communities. The research concluded that there was insufficient information to support expectations that Canada"s coastal environments remain un-impacted.

Information on actual conditions on the Atlantic coastal of Nova Scotia was supplemented with new research on the potential linkages between changing land cover and pressures on coastal receiving environments. Using geospatial technology and field investigations in local water quality, land cover ratios in primary watersheds were compared to nutrient concentrations in coastal waters. Working at a coarse landscape scale of data, in some embayments potential linkages were identified between reduced forest cover and increased nitrogen levels in rivers and bays. The research findings were also applied to the development of two practical tools for use in negotiated land use planning. To avoid adverse effects to coastal receiving waters, the GreenField Ratio proposes maximum and minimum thresholds for land cover types within primary watersheds. The Coastal Sensitivity Rating facilitates an improved understanding of the cumulative factors affecting the vulnerability of coastal ecosystems to impact.

Responding to the challenges faced by current initiatives in coastal management, the research proposes an alternative approach for Canada that does not require integration of coastal authorities. As outlined, the CoastWORKS framework relies on collaborative efforts within existing institutional and community organizations to achieve needed change in policy and practice. CoastWORKS defines coastal landscapes, sets principles to guide action, establishes a list of priority goals, and can be accomplished through individual local actions and collaborative governance.

LIST OF ABBREVIATIONS AND SYMBOLS USED

ACAP	Atlantic Canada Action Program
CBM	Community-based management
DFO	Fisheries and Oceans Canada
DPSIR	Driver-pressure-stress-impact-response framework
EC	Environment Canada
EEC	European Economic Community
EIA	Environmental impact assessment
ENGO	Environmental non-government organization
ESSIM	Eastern Scotian Shelf Integrated Management
EU	European Union
FAO	Food and Agriculture Organization of the United Nations
FOO	Four orders outcome framework
GESAMP	Joint Group of Experts on the Scientific Assessment of Marine Environmental Protection
GIS	Geographic information system
GOMC	Gulf of Maine Council on the Marine Environment
GPA/LPA	Global Programme of Action for the Protection of the Marine Environment from Land-Based Activities
HELCOM	Baltic Marine Environment Protection Commission
ICAM	integrated coastal area management
ICES	International Council for the Exploration of the Sea
ICM	integrated coastal management
ICOM	Integrated coastal and oceans management
ICZM	Integrated coastal zone management
IJC	International Joint Commission
IOC	Intergovernmental Oceanographic Commission of UNESCO
IOI	International Oceans Institute
IPCC	Intergovernmental Panel on Climate Change
JOCI	Joint Oceans Commission initiative
LOMA	Large ocean management area
MARPOL	International Convention for the Prevention of Pollution from Ships
μg/L	Micrograms per litre
μM/L	Micromoles per litre
mg/L	Milligrams per litre
NGO	Non-governmental organization
N	Nitrogen
NH_4	Ammonia
NO_3	Nitrate
OECD	Organization for Economic Cooperation and Development
OMRN	Oceans Management Research Network

P	Phosphorus
PO_4	Phosphate
TP	Total phosphate
TN	Total nitrogen
TIN	Total inorganic nitrogen
UN	United Nations
UNCED	United Nations Conference on Environment and Development
UNCLOS	United Nations Convention on the Law of the Sea
UNEP	United Nations Environment Programme
UNESCO	United Nations Educational, Scientific and Cultural Organization
WHO	World Health Organization

GLOSSARY

algal bloom: a rapid increase in the abundance of phytoplankton or benthic algae in a given area.

alien or invasive species (also called introduced, exotic, or non-indigenous species): a species that has been transported by human activity, intentionally or accidentally, into a region where it does not occur naturally.

anoxia: the absence of oxygen.

anthropogenic: originating from human activities.

aquaculture: the cultivation of aquatic organisms.

ballast water: water carried by a vessel to improve its stability.

benefit-cost analysis (cost-benefit analysis): a technique to compare the relative economic efficiency of projects or policies. A comparison is made between the gross benefits of a project or policy and the opportunity costs (the highest value a productive resource such as labour, capital or a natural resource could return if placed in its best alternative use) of the action.

benthic organism: bottom dwelling organism.

benthos: collective synonym for benthic organisms, but frequently also applied to the floor or deepest part of a sea or ocean.

biological diversity (also called biodiversity): the diversity of life, often divided into three levels: genetic (diversity within species), species (diversity among species), and ecosystem (diversity among ecosystems).

biomass: the mass of living matter per unit of habitat (e.g., volume of water or area of bottom).

biotoxins: naturally occurring toxic compounds produced by certain organisms.

coastal area: an entity of land and water affected by the biological and physical processes of both the sea and land and defined broadly for the purpose of managing the use of natural resources.

collaboration: an approach to planning and decision-making aimed at improving relationships and seeking resolutions that meet the needs and interests of all parties to the greatest possible degree.

co-management: a management approach in which responsibility for resource management is shared between the government and resource user groups.

conservation: the management of a natural resource for the protection, maintenance, rehabilitation, restoration, and/or enhancement of populations and ecosystems.

contamination: an anthropogenic increase in the concentration of a substance that does not normally occur in an environment, that normally occurs at significantly lower concentrations, and/or that can adversely affect the environment.

ecology: the branch of science studying the interactions among living things and their environment.

ecosystem: a community or several communities of organisms together with their physical environment.

environmental impact assessment (EIA): a process by which the consequences of planned development projects are evaluated as an integral part of planning the project.

epidemiology: the study of the factors that influence the frequency and distribution of diseases.

estuary: the region where a river meets the marine environment, characterized by variable salinity and often by high biological productivity.

eutrophication: the process of over-fertilization with nutrients of a body of water leading to excessive production of organic biomass characterized by large numbers of organisms but few species.

governance: the exercise of political, economic and administrative authority in the management of a country"s affairs at all levels.

habitat: the physical space where an organism, population or species lives.

imposex: a pseudo-hermaphroditic condition in female gastropods (snails) caused by TBT and manifested by the development of a false penis.

institutions: the prescriptions that humans use to organize all forms of repetitive and structured interactions including those within families, neighbourhoods, markets, firms, sports leagues, churches, private associations, and governments at all scales.

integrated coastal management (ICM): the management of sectoral components (e.g., fisheries, forestry, agriculture, tourism, urban development) as part of a functional whole.

intertidal zone: (often called littoral zone): the part of the shoreline that is submerged at high tide and exposed at low tide.

mangrove forest (or mangal): a community of salt-tolerant trees and shrubs, with many other associated organisms, that grows on some tropical and sub-tropical coasts in a zone roughly coinciding with the intertidal zone.

marine environmental quality (MEQ): the status and trends observed in physical, chemical and biological conditions within the marine environment.

nearshore receiving environment: the marine or estuarine waters into which rivers empty non-governmental organization (NGO): an organization, usually non-profit, that is not part of the central, local, or municipal government.

non-point sources of pollution (also called diffuse sources): multiple, not easily identifiable, non-discrete sources of pollution (e.g., agriculture, urban areas).

nutrient enrichment (nutrification): the effect of adding large quantities of organic and inorganic nutrients to the environment

nutrients: substances that are essential for the growth of marine organisms that perform primary production (algae, bacteria, and plants).

pathogens: organisms that cause (e.g., certain bacteria and viruses).

point source of pollution: single, identifiable, discrete source of air or water pollution.

precautionary approach: where there are threats of serious or irreversible damage, lack of scientific certainty shall not be used as a reason for postponing cost-effective measures to prevent environmental degradation.

protected area: a geographically defined area that is designed and managed to achieve specified environmental objectives.

seagrass beds: benthic communities, usually on shallow, sandy or muddy bottoms, dominated by grass-like marine plants.

siltation: the settling of fine mineral particles to the sea bottom.

stakeholders: individuals, groups of individuals and non-governmental and government entities that have either a direct or indirect interest or claim which may be affected by a particular decision or policy.

sustainable: a description of a process or state that can be maintained indefinitely.

sustainable development: sustainable development is development that meets the needs of the present without compromising the ability of future generations to meet their own needs

TBT (tributyl tin): a very toxic organic compound containing tin. It is used in antifouling paints on vessels and fixed marine structures.

trophic levels: successive stages of nourishment as represented by the links of the food chain.

upwelling: the slow upward transport of cold, nutrient-rich water masses to the surface from depth. Coastal upwelling is usually induced by surface winds.

vector organisms: organisms that transmit certain diseases.

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PART I: BACKGROUND, PURPOSE AND DIRECTION

CHAPTER 1: INTRODUCTION

1.1 The Problem

Despite global advances in the implementation of pollution abatement technologies and the growth of integrated coastal management initiatives, there is wide agreement among both scientists and the general public that the health of the world's coasts and oceans continues to decline (Bendell-Young and Gallaugher 2002, Boesch and Paul 2001, Doody 2001, EEA 2006a, 2006b, GESAMP 2001b, Klinger 2004, Lotze et al. 2006, MEA 2005a, 2005b, Steffen et al. 2004, UNEP 2008a). While fishing, offshore oil and gas production, and marine transportation have commonly been regarded as the primary sources of impact to marine species and habitats, the United Nations Environment Programme (UNEP/GPA 1995) has estimated that 80% of the human activities that threaten the health and productivity of the oceans take place on the land, not on the water. Over 30 years ago it was proposed that management of the complex issues affecting coastal areas required a new approach based on integrated planning and decision-making. Since that time there have been over 700 initiatives in integrated coastal management (ICM) world-wide (Sorenson 2002), yet coastal conditions continue to decline, our knowledge of coastal ecosystem dynamics remains limited, and there is even less understanding of the complex relationships between land-based activities and the health of sensitive nearshore environments (GESAMP 2001a). Perhaps even more disturbing, we are only beginning to comprehend the linkages between coastal pollution and human health (GESAMP 2001b, Kennish 2002).

It has been estimated that three billion people, more than half the global population, now live within 100 km of a coast, contributing to exponentially rising demands on coastal and oceans resources. Cohen et al. (1997) and others (UNEP 2002a, 2002b) have predicted that by 2025 over two thirds of the world"s population will live in coastal areas, with the greatest increases in population change occurring in developing countries where populations are shifting from rural areas to exploding coastal mega-cities. As human populations continue to grow in coastal areas, increased conflicts will arise over resource ownership, rights of access, and rights to develop, all of which will be exacerbated by rising expectations for sustainable resources, beautiful landscapes, and the healthy environments needed to support a high quality of life for both residents and visitors.

The Canadian population, like that of many developed countries, is moving from the rural based economies of the 19th century to the urban based economies of the 21st century. One of the products of this societal change is the growth in population of coastal cities and communities, and in the uptake of coastal lands for industrial and residential development, tourism and recreation (Manson 2005). In addition to the changing demographics of coastal communities caused by failing fisheries and the increased popularity of coastal living, the escalating non-resident ownership of shore lands in these desirable areas may bring dramatically differing perspectives on access and utilization of these formerly shared resources (RCIP 2003). When coupled with increasing pressures and shifts in resource exploitation, and growing concerns of the effects of sea level rise and severe storm events, Canadian social and natural scientists are struggling to better define existing conditions in our coastal zones, at a time when it is anticipated that significant change has already taken place (McNiven et al. 1997).

While Canada has a long and sometimes chequered history of fisheries and marine management, it has yet to make substantive progress towards the planning and management of its coastal areas. With the longest coastline in the world, and a relatively small population, the expectation is that much of our coasts remain relatively un-impacted by human activities. However, as information on the decline of coastal environments elsewhere in the world continues to accrue, and as climate change impacts become more visible and frequent along our shores, there is a growing concern that Canadian coasts may have been more impacted and vulnerable to change than had been anticipated.

1.2 The Research Questions

Given the deteriorating state of coasts worldwide, and the difficulties affecting implementation of ICM in other areas, this research challenged assumptions that Canadian coastal environments remained relatively un-impacted by human activities, and that current practices in coastal management were sufficient to ensure the ongoing sustainability of coastal resources and coastal communities. The research questioned whether Canada‟s coastal areas needed improved management, whether an integrated approach to management could be effectively implemented in Canada, and if not, what might constitute a workable alternative to current management theory and practice.

The research was structured so as to provide answers to the following questions:

- What are the reported constraints to implementation of ICM?
- Would similar obstacles impair ICM implementation in Canada?
- Is the state of knowledge of conditions along Canada‟s coasts sufficient to support the current expectations that our coastal environments remain relatively un-impacted by human activities?
- In developed areas of the Canadian coasts, have human activities on the land contributed to measurable effects in nearshore receiving environments?
- Are there alternative approaches for the management of coastal areas in Canada?

It was accepted that these questions individually and collectively contributed to a scope for research that was broad and complex. But to date, the application of empirical research principles to more narrowly define and examine discrete elements of coastal sustainability and management have not improved national understanding of the state of the Canadian coast, nor has the knowledge generated through science effected progressive change in government policy and societal action. The interdisciplinary approach adopted by this research program offered new opportunities for a more holistic examination of the issues and challenges facing coasts and coastal science and management in Canada.

1.3 The Research Perspective

> *With a mere three laws of motion and a universal law of gravitation in hand, Newton not only derived tides and orbits, but unleashed on the Western mind a clockwork universe. (Kauffman 1995, p 6).*

Too seldom have we reflected upon the fact that the dominant paradigms of modern scientific reasoning and research that have affected so much of academia and society, continue to rely on premises posed by philosophers and scientists who lived over 300 years ago. Much of our understanding of science has its foundations in the modernist world views derived from a Newtonian-Cartesian logic which sees the earth, society and even the individual as complex machines. To understand the functioning of the machine, modern science relies on reductionist approaches in which knowledge of the whole is dependent on understanding the cause and effect relationships of each component (McMillan 2004). McMillan believed that because of the continuing powerful relationship between modernist science and society, we have been encouraged to see our world as a relatively stable system that operates on an assemblage of linear relationships, any of which could be separated from the whole, assessed, comprehended and adjusted to meet our needs. This mechanistic world view is not only reflected in society‟s convictions about how organizations and governments should be run, it may have contributed to our inability to successfully steward the natural environment by fuelling expectations that what man damaged through exploitation, man could effectively repair and restore, should it become necessary to do so.

Clearly, within the last decade, as environmental, economic and social change has become consistent and pervasive, there has been a growing awareness that the universe might not be as ordered or predictable as we had contemplated, and that traditional ways of gathering and applying knowledge to solve problems may be inadequate to the challenges that now face society (Kay and Regier 2002). We are discovering that scientific knowledge about complex stochastic systems that characterize the natural environment is neither comprehensive nor sure in its conclusions on predicted future conditions, that the scope and rate of change has been misunderstood and underestimated, and that the acquisition of increased disciplinary knowledge may not provide us with needed answers to emerging issues. As Repko (2008, p 3) put it, there is a growing need "to answer complex questions, solve complex problems, and gain coherent understanding of complex issues that are increasingly beyond the ability of any single discipline to address comprehensively or resolve adequately". Nowhere is this complexity more evident than in coastal areas, where the processes of change can readily span the gaps between terrestrial and marine environments, impact natural, economic and cultural resources, and affect the wellbeing of both local and distant human populations.

In some areas of science, modernist world views are being replaced by a new paradigm referred to as post-modernism. Post-modernism takes a larger view, seeing the earth and its ecosystem as an organism that cannot be wholly explained in terms of cause and effect relationships, and whose future is somewhat unpredictable. Post-modernism focuses less on describing the current state of things and more on understanding the processes of interaction and change. Modernism is about being, while post-modernism is concerned with becoming (Chia 1995).

Despite growing recognition of the need to tackle the linkages between changes on the land and impacts at the shore, oceans and coastal research continues to reside predominantly within disciplines focused on the management of marine environments and resources (e.g., marine biology, marine geology, oceanography, marine law, ocean engineering). Much of the research to date on oceans and coasts has been driven by reductionist approaches to science and focussed on the needs of sectors such as fishing, transportation and resource extraction. Oceans and coastal managers have based their planning and decision-making on the conviction that, through careful attention to understanding selected components of marine ecosystems, future conditions in oceans and coasts would become not only predictable but masterable (Vallega 2000a). As a result, little progress has been made towards improving our broader understanding of ecosystem health, and even less towards increasing our knowledge of the linkages between the land-based activities of human populations and the growing impacts to nearshore environments.

We know now that research in the natural sciences cannot by itself meet the challenges of coastal management, but needs to be coupled with disciplines that address the complexities of social transformations (Visser 2004). Vallega (2000, p 6) concluded that "ocean governance will conform to the sustainability principle only when an effective organic linkage between human communities and the ocean ecosystem is achieved and when humanistic and ethically sound visions of the ocean are adopted". To assist with this transition, there is a need for coastal research that is holistic, intuitive, deductive, flexible, capable of crossing disciplinary boundaries, and unafraid of the messy realities of complexity, chaos and clumsiness that characterize both our society and our present and future world. This research accepted that challenge and sought to find and employ both emerging and established methodologies in an interdisciplinary examination of the irrevocably linked aspects of human development and environmental well-being.

1.3.1 The Interdisciplinary Approach

> *Interdisciplinary studies is a process of answering a question, solving a problem, or addressing a topic that is too broad or complex to be dealt with adequately by a single discipline and draws on disciplinary perspectives and integrates their insights to produce a more comprehensive understanding or cognitive advancement.*
> *(Repko 2008, p 12)*
>
> *We are not students of some subject matter, but students of problems. And problems may cut right across the borders of any subject matter or discipline. (Popper 1963, p 88)*
>
> *However difficult ID research may be within and among the social sciences, it has long been recognized that between the natural and technical sciences, on one side, and the social sciences on the other, lies something akin to a cultural divide. (Salter and Hearn 1997, p 93)*

Interdisciplinary research is inspired "by the drive to solve complex questions and problems, whether generated by scientific curiosity or by society, and to lead researchers in different disciplines to meet at the interfaces and frontiers of those disciplines and even to cross frontiers to form new disciplines" (NAS 2004, p 16). Though respectful of the rigour and perspective of disciplines, interdisciplinary research is not constrained by empiricism, but rather mines the knowledge provided by disciplines to build a broader, more intuitive understanding of the issues. Interdisciplinary research is still evolving, but as described by Greckhammer (2008), Klein (1996), Repko (2008), Salter (1997) and others, an interdisciplinary approach can be an excellent basis for post-modernist research because it can be:

- holistic, presenting a long view perspective taken both spatially and temporally;
- flexible in application to a range of ecological and geographic scales and geo-political contexts;
- intuitive, inductive and deductive,
- sometimes non-empirical;
- qualitative as well as quantitative;
- purposeful in seeking out the solutions needed by society; and
- meta-analytical, often working with a suite of methodologies.

Both Klein (1996) and Repko (2008) agree that successful interdisciplinary research requires the active triangulation of disciplinary depth, disciplinary breadth (i.e., working across disciplines that are epistemologically distant to include fields of study from at least two of the natural, social and/or applied sciences), and synthesis or integration of knowledge and insights. As Klein (1996 p. 212) phrased it, "synthesis does not derive from simply mastering a body of knowledge, applying a formula, or moving in a linear fashion from point A to point B". While there are those that would argue the need for rules and step-wise logic in conducting interdisciplinary research (Szostak 2002a, Szostak 2002b), there is an ongoing debate in which there is support for the recognition of the value of intuition and creativity (McBurney and White 2004). Repko (2008) concluded that interdisciplinary research should be a combination of step taking and intuition, taking care to integrate not only knowledge, but also modes of thinking. Repko (2008) believes that in the context of interdisciplinary research, integration is more of a process than a method and is characterized by:

- identifying and blending knowledge to improve understanding of a specific issue whose temporal and spatial context resists its solution by traditional disciplinary methodologies;
- identifying, accepting and respecting the perspectives, rigour and application of research conducted within the relevant disciplines; and
- recognizing and confronting disciplinary and cultural differences over values such as research rigour, political agendas, and the role of uncertainty in decision-making.

1.3.2 Finding Value in Complexity and Chaos

If we can see what makes the difference, we can make the difference. (Byrne 1998, p 42)

Having evolved from its mathematical roots, complexity theory and chaos theory have generated interest in disparate disciplinary areas such as ecological, social and management sciences. As applied within these differing perspectives, the definitions of complexity and chaos can vary, sometimes significantly. In the description provided by Rosenhead (1998), complexity theory concerns itself with dynamic systems whose behaviours change over time. Some systems change in an entirely predictable and stable manner and, if disturbed, attempt to return to their original state. The systems of greatest interest to chaos theory are those which under certain conditions can perform in regular, stable and predictable ways, but as a result of seemingly inconsequential or undetectable change (i.e., the fluttering of a butterfly‟s wings), can depart significantly from the predicted path to create unanticipated, and sometimes wide-ranging effects (i.e., shift in weather patterns). (While the metaphor of the butterfly effect has been used since the late eighteenth century, it can also be associated with the work of the meteorologist Edward Lorenz). Allen (2001) considers a complex system as one that is not constrained to a single path or response but has the capacity to respond to the changing conditions in its environment in a number of different ways - hence its relative unpredictability. Within complex systems, unpredictable behaviours that fall between the boundaries we set for stability and instability are described as chaotic. A familiar example of a complex system exhibiting chaotic behaviour is the weather, which, despite all attempts to model and forecast conditions, defies accurate short-term prediction, operates with relative stability over seasons and exhibits some degree of change over decades and millennia.

Stability and instability are behaviours well recognized within the traditional disciplines where through the application of empirical research, cause and effect relationships are believed to be both understandable and predictable. However, in both the natural and social sciences, reductionist approaches that require all aspects of a system to be sorted into the simplest possible constructs before being reassembled to recreate and explain the whole, appear to be incapable of explaining or predicting the realities of change facing today‟s world and society (Byrne 2001). Alternatively complexity theory attempts to find new ways to explain "why the universe is greater than the sum of its parts and how its components altogether produce overarching patterns as the system itself learns, evolves and adapts" (Dann and Barclay 2006, p 21). It can be surprising that order and structure are paradoxical attributes of both complexity and chaos, found even at the edge of chaos where the parts of a system never quite lock into place, but also never quite break away (McMillan 2004). In the areas where modernist science has failed to provide answers, non-linear research methodologies supported by complexity and chaotic science appear to flourish, especially as applied to systems that have the capacity to adapt to change and to self-organize.

1.3.3 Interdisciplinary Research and Coastal Management

The interdisciplinary approach that formed the foundation for this coastal research program recognized the need to move efficiently through boundaries created by disciplinary rigour, by the physical land-sea divide, and by jurisdictional authorities and responsibilities. It was accepted that the pressures affecting coastal health and sustainability were likely to be derived from an ever-changing mixture of environmental and social conditions, and that effective solutions to the problems created had to rely on knowledge and intuition derived from disciplines that are neither traditionally linked, nor commonly applied to the management and resolution of coastal issues. Aspects of the research drew from the traditional disciplines of marine and landscape ecology, management and law, and from the applied sciences of landscape architecture and planning. Acknowledging the levels of complexity that would be inherent within a broad examination of coastal systems, conditions and management, the research principles were adapted from those established by Holling (2001) and were intended to ensure that the research was:

- as simple as possible but no simpler than was required for understanding and communication;
- dynamic and prescriptive rather than static and descriptive; and that it
- embraced uncertainty and unpredictability recognizing that surprise and structural change were inevitable in systems comprised individually and collectively of people and nature.

Finally, the research perspective recognized the principle of clumsiness as outlined by Thompson (2003) and Verweij et al. (2006). In setting out the case for clumsiness, Verweij et al. (2006) rightly concluded that there were few situations in complex systems where one argument was entirely right and the other entirely wrong. Yet in much of our management and decision-making, governments and organizations have required us to pick a dominant view and to proceed as though that were the only option for consideration. Clumsiness presents an alternative to the belief that where there are contradictory opinions, values, and definitions of problems and solutions, society must choose one and reject the others in order for progress to be made. While it may be inappropriate in application to readily understandable cause and effect relationships and practices, clumsiness provides a better appreciation of the need to address the potential for uncertainty and risk in daily decision-making. When clumsiness is embraced as an undeniable element of complex systems and of human behaviour, the reality of disparate viewpoints and conclusions is accepted, the discourse continues, alternatives are not discarded, and the process of scientific inquiry remains open, fluid and adaptive.

This research holds a respectful appreciation that there are and always will be differing perspectives, goals and solutions to coastal issues and that embracing clumsiness is an essential attribute for the successful completion of integrative, holistic and interdisciplinary research.

1.4 The Research Approach

The research employed a mixture of established and emerging tools. While the rigour developed within traditional disciplines was respected, the research was not constrained by the requirements of any one discipline (Johnson and Onwuegbuzie 2004, NAS 2004). Techniques and tools were drawn from fields of study that included meta-research, traditional ecological field investigations, and planning instruments, spatial modelling, and strategic management. Respecting that the application and findings of each research tool consistently informed and challenged other aspects of the research, the multi-method approach was strategically applied to the research questions in the following framework:

- Systematic review and meta-synthesis of experience-based practice in coastal management at the international, national and local scales.
  What demonstrable gains have been achieved by integrated approaches to coastal management? (Chapter 2)
  What are the commonly reported constraints to the implementation of ICM? (Chapter 3)
  Would similar obstacles impair ICM implementation in Canada? (Chapter 4)
- Systematic review and meta-synthesis of experience-based practice in determining the state of health of coastal environments within Canada
  Is the state of knowledge of conditions along Canada's coasts sufficient to support popular belief that our coastal environments remain relatively un-impacted by human activities? (Chapter 5)
- Field studies in marine and aquatic ecology and in spatial analysis of land cover change impacts to nearshore receiving environments.

In developed areas of the Canadian coasts, have human activities on the land contributed to measurable effects in nearshore environments? (Chapter 6)

- The application of emerging organizational theory to coastal management
  What might be an alternative approach for sustainable management of coastal areas in Canada? (Chapter 7

To successfully bridge the spatial, functional, and disciplinary divides among planning, management and marine science, the vision of the coast employed by this research was of necessity broad and inclusive. The coastal landscape was defined not as a marine ecosystem bounded by arbitrary distances from a shoreline, or depth of water, but holistically as a functioning ecological and cultural landscape comprised of a range of terrestrial and marine ecosystems and encompassing human communities, needs and activities. To assist with the management of complexity resulting from the broad scope of the research, the research followed the long established tenet of landscape ecology, and worked at times at differing scales as were appropriate to the question under study. When working within the international and national contexts, the emphasis was on data that reflected the coarse granularity necessary to inform knowledge and decision-making at a regional landscape scale. When working at the watershed and local scale, the data context was finer, paying more attention to locally significant conditions. Recognizing that much of the data on coastal issues and conditions can relate to a differing time periods, that the periodicity of change is a moving target, and that the future is a complex array of short and long term projections, the research moved across these temporal scales, to glean relevant information that was still appropriate to inform decision-making.

1.4.1 Systematic Review and Meta-synthesis of Evidence-based Practice

Where is the wisdom we have lost in knowledge? Where is the knowledge we have lost in information? T.S. Elliot, "The Rock" 1934

Paradoxically, sustainable management of coastal areas can be threatened by both too much and too little information. The rapid access to information gained through electronic resources and the Internet provides more information on a daily basis than coastal managers can realistically access, let alone assimilate and apply to planning and decision-making. New science and findings are to be found in an ever increasing array of academic journals, within government reports, and in other forms of the grey literature. Not all or even many of these sources have a focus on coastal management, but reflect other aspects of natural, social and applied sciences, in wide ranging but still relevant geographic, political and economic contexts. Too little of that information either directly informs decision-making, or can be considered trustworthy. However, there is much to be learned from the information already assembled, a great deal of which is lost in failures to relate the findings of individual studies to either an improved knowledge of the system or to a more strategic understanding of the needs for new research. In recent years, advances in computer technology, electronic publishing and on-line access to literature, data and documents have made possible a scale of research that would previously have been beyond the resources and time available to an individual researcher, and which is increasingly referred to as meta-analysis, and/or meta-synthesis of evidence-based practise.

Meta is derived from the Greek and is used in scientific research to mean either something which comes after or something which is a level above. In 1976, when Glass (1981) first used the term meta-analysis, he was applying it to systematic research based on information found in the primary literature, that enabled the interpretation, and potential integration of knowledge found in individual studies (Bangert-Drowns and Rudner 1991). Recognizing the explosion in information, the ease of access provided by the electronic media, and the cumulative nature of science, Cooper (1998) noted that trustworthy accounts of past research are a necessary condition for orderly knowledge building. Over the past thirty years meta-research approaches have become accepted as a valid tool to access the literature on complex issues and to assess the contributions of evidence-based practice. The review and assimilation of knowledge contained within the literature provides a means of aggregating the outcomes from a set of primary studies, in order to obtain a better understanding of the state of knowledge, to allow conclusions to be drawn from the collective wisdom, to develop alternative solutions, and to inform new research in the topic area (Alavi and Carlson 1992, Atkins and Louw 2000, Cox and Hassard 2005, NAS 2004, Petticrew and Roberts 2006, Zhao 1991). Meta-research techniques, whether they are quantitative or qualitative, employ a rigorous and systematic review of information to assess or combine new primary data with existing data previously gathered by others and generally intended for application to other purposes. The systematic literature reviews employed in this thesis were a qualitative investigative deconstruction and synthesis of the work of others as documented in the published and technical literature.

Systematic reviews are a “method of making sense of large bodies of information, and a means of contributing to the answers to questions about what works and what does not”. They are a method of mapping out areas of uncertainty, and identifying where little or no relevant research has been done, but where new studies are needed. Systematic reviews also flag areas where spurious certainty abounds (Petticrew and Roberts 2006). The goal is to ensure that the review will not be unduly influenced by the findings of any one study and that the subsequent analysis and conclusions are as objective and unbiased as possible. To satisfy the need for scientific rigour, systematic reviews employ a detailed prescriptive methodology intended to reduce the potential for error, and where possible, to reduce researcher bias (Atkins and Louw 2000).

Drawing on the work of others (Atkins and Louw 2000, Cox and Hassard 2005, Lewis and Grimes 1999, Moody 2003) , the methodological rigour for the systematic reviews undertaken in the research was based on the following framework:

- definition of a tightly focussed research question;
- definition of the scope, scale and methodologies employed in a targeted review of the literature that includes both published and grey (unpublished) sources;
- development of set of inclusion and exclusion criteria to be applied to all studies considered for review;
- accumulation and preliminary review of the literature relevant to the research question;
- compilation of relevant and usable studies which emerge from this process;
- integration and re-interpretation (meta-interpretation or meta-synthesis) of the consolidated information within a new context;
- development of a body of knowledge which may support an unambiguous answer to the original question; and
- development of guidelines for future practice, and/or recommendations for future research.

Petticrew and Roberts (2006) also concluded that, to properly and effectively undertake systemic reviews, the primary researcher must be widely read in the field, have an open mind with significant prior knowledge and experience in the subject area, and possess the ability to iteratively reorganize and assemble information so as to identify and extract commonalities and differences and to apply these attributes to better inform our understanding of practice to date.

Given the complexity and scope of this research, it is important to note that the systematic reviews were enabled both by my varied academic background in land planning, management and marine science (graduate degrees in Ecology and Landscape Architecture), and by more than thirty years of experience in environmental planning and design, as well as in an array of international, national and local initiatives in coastal management. Not only does this background ensure that I have a unique landward as well as seaward perspective of the coastal landscape, it has contributed to a deep conviction that the time available to implement change is growing shorter by the day.

To understand the strengths and weaknesses of ICM programs, the research identified the shared constraints to effective implementation as reported through the successes and failures of existing programs throughout the world, with an emphasis on developed nations. Then the focus turned national, questioning whether the same or other impediments have affected Canada"s progress towards a national framework for coastal management.

1.4.2 Improving our Understanding of the State of the Coast in Canada

Canada has for many decades been a significant participant in international scientific and management fora and initiatives intended to advance the sustainable use of coastal resources. However, much of the focus has been on marine environments, and most of that has been on the state of the deep ocean and the management of fisheries. Within the context of this research, the coast was considered not as a zone comprised predominantly of the marine environment, but from a more inclusive perspective as a complex landscape that also includes terrestrial, aquatic, and human ecosystems, and that is continually shaped by physical, biological and social phenomenon. While the term "landscape" continues to be employed in a number of contexts, the term has been used popularly in North America in reference to both wide expanses of terrain and to the backyard landscape of lawn and pool. Within ecological science, a landscape is the basic element of a region, formed from a mixture of linked ecosystems or land cover types (Forman 1995b). Landscapes are a mosaic of large and small pieces of land, water, and air space, all of which interact within myriad scales and hierarchies (Lapin and Burton 1995). Within a landscape you can find considerable heterogeneity, especially in those areas where ecosystems meet, such as at the land-sea divide. To view the coast as a landscape offers an alternative perspective to the predominant marine–based context, and ensures that human society is recognized not only as an integral component but also as a dominant agent of change. If you apply Wiens" (2002, p 14) contention that "the land in landscape should not be taken too literally", it is a relatively simple process to adapt the general characteristics proposed by Forman (1995a) to define the landscapes that comprise a coast:

- repetition of a recognizable and distinctive mix of local ecosystem or land-use types;
- identification of relationships, corridors and matrices within the landscape that determine the linkages, flows and changes in landscape patterns and process that occur over time;
- recognition of the inter-relationships between ecosystems, where the scope and context of those inter-relationships may diminish sharply with distance from each other, and where there are indispensible ecosystems and processes that provide ecological benefits for which there is no substitute;
- appreciation of the scale at which the patchiness of ecosystem types, land cover, and environmental resources and conditions occurs; and
- improved understanding that changes to the landscape are the result of both natural conditions and human activities, the consequences of which can result in an array of impacts to both ecosystems and human populations, some of which may overlap.

Within this research, the perspective of the coast as a landscape facilitated the move from a marine-based perspective, and enabled the application of a range of geographic, functional and temporal scales, entirely appropriate for the specific research questions under study. The coastal landscape approach respected the complexity inherent to the space and its functions, while providing an appropriate granularity of scale to the data, and supporting integration of findings into a more holistic view of the system and its functioning.

In seeking to improve our understanding of the state of information on coastal conditions in Canada, the research first drew on international and local efforts to develop a holistic suite of appropriate indicators of coastal well-being. These indicators were used as a baseline for the identification, acquisition and review of existing and available information on coastal environmental and social conditions in Canada. Conclusions were drawn on the adequacy of this information to improve understanding of the state of health of Canadian coasts, to identify important trends, to assist predictions of future conditions, or to aid current policy and decision-making especially as relates to land-based activities.

The research anticipated that current information on the linkages between land cover and land use change and the impacts to coastal waters would be limited. Field investigations were conducted to collect new data on nutrient concentrations within surface waters of embayments along the Atlantic shore of Nova Scotia. The information generated was compared to a spatial analysis of land cover types within the related primary watersheds, and conclusions drawn on the adequacy of our understanding of the impacts of land cover and land use change on this relatively sparsely populated area of the Canadian coast. The research, while admittedly coarse in scale, challenged assumptions that local waters remained relatively un-impacted by human activities. The research also proposed a simple negotiation tool useful to planners and resource mangers in land cover and land-use decision-making.

1.4.3 Setting a New Course for Coastal Management

Recognizing that the challenges presented by an integrated approach to management could be pervasive and enduring, the research sought alternative perspectives and approaches as developed within management theory, public administration and institutional change. The review sought opportunities for a refreshed approach to coastal management, one that could build on the work of the past while engaging both national and local interests in planning for the future. Like ICM, this new course for coastal management in Canada needed to respect the complexity of environments and institutions, embrace uncertainty and risk, and draw its success from the conjoined participation and contribution of all governments and sectors of society.

Key shifts in management theory and practice were assessed for the appropriateness of their application to coastal management. Where appropriate, these new paradigms were used to propose a new approach to managing coastal landscapes that directly addressed the challenges of scale, complexity, uncertainty, resilience to change, and the need for proactive, flexible planning. While I examined emerging tools such as soft path management of resources and e-governance, the most significant change in my perspective was derived from the concept of common-pool resource management as proposed by Ostrom and her colleagues (Ostrom 2005, 2007, 2008a, 2008b, Ostrom et al. 2007).

1.5 The Thesis Structure

The thesis is organized in three major parts. Part One (Chapter 1) presents the problematique and research approach.

Part Two (Chapters 2, 3, and 4) is a diagnostic examination of the contributions of current approaches to management of coasts and the issues that affect implementation throughout the world.

- Chapter 2 is a narrative literature review of efforts to assess progress in integrated coastal management throughout the world. The Chapter reviews the methodologies currently being employed in evaluation, and reports on the benefits which have accrued as a result of ICM advocacy and practice.
- Chapter 3 reports on the findings of a systematic review and meta-synthesis of evidence-based practice in integrated coastal management that focused on the identification of shared constraints to implementation.
- Chapter 4 assesses the existing and potential effect of these or other constraints to past, current and future efforts by Canada to implement ICM along its own coasts.

Part Three of the thesis (Chapters 5, 6, and 7) examines coastal health in Canada, as a precursor to the development of a proposed framework for improved coastal governance based on learned experience, existing frameworks and emerging management theory.

- Chapter 5 reports on the findings of an assessment of the indicators of environmental sustainability that are currently being employed, and the consequent state of knowledge of coastal environmental conditions across Canada.

- Chapter 6 reports on a landscape scale case study of watersheds and embayments of the Atlantic coast of Nova Scotia that seeks to identify relationships between land cover and land use change and nutrification of nearshore waters.
- Chapter 7 proposes an alternative approach to coastal management in Canada, structured so as to provide continuity and collaboration among all levels of government and society.

Chapter 8 presents the conclusions of the research, discusses its application and usefulness to society, and suggests additional research to further the development and implementation of the proposed governance framework.

PART II: PROGRESS TOWARDS INTEGRATION AN ASSESSMENT OF EXPERIENCE-BASED PRACTICE

CHAPTER 2: FINDING PROGRESS TOWARDS ICM: A POSITIVE PERSPECTIVE ON EFFORTS TO DATE

2.1 The Declining State of the World's Coasts

Despite global advances in pollution abatement technologies and the growth of coastal management initiatives, there is wide agreement among both scientists and the general public that the health of the world's coasts and oceans continues to decline (Bendell-Young and Gallaugher 2002, Boesch and Paul 2001, Cicin-Sain et al. 1995, Cicin-Sain et al. 2002b, Ducrotoy and Pullen 1999, EEA 2006b, GESAMP 2001a, 2001b, Kay and Alder 2005, Lotze et al. 2006, MEA 2005a, 2005b, Sorenson 2002, UNEP 2006c, 2007a, 2007b, UNEP/CBD 2006, UNU-INWEH 2008). For many years degradation of the marine environment has been the result of human activities that use resources beyond replenishment, that dispose of wastes in areas unable to assimilate pollutants, and that physically alter or convert habitats (Steffen et al. 2004). Coastal and marine habitats have also been degraded by nearshore coastal development, as well as by land use practices that occur at considerable distance from any marine shoreline. Point and non-point source pollutants from municipal, industrial and agricultural land uses carried overland in rivers, have been deposited into sensitive coastal embayments (GESAMP 2001a, Kennish 2002). Degradation of marine environments has also imperilled human health through the contamination of seafood and the pollution of recreational waters (GESAMP 2001a, 2001b).

Throughout the world, climate change is increasing water temperatures, melting polar ice, raising sea levels and affecting global weather (UNEP 2007b). The physical intrusion of sea water into low lying coastal areas is now anticipated to have wide spread ramifications such as contamination of potable water supplies, increased coastal erosion and deposition of sediments, changes to coastal hydrodynamics, steepening of shorelines and loss of beaches, resulting in billions of dollars of damage to coastal ecosystems, and coastal infrastructure (McLean and Tsyban 2001, Thompkins and Adger 2004, Turner et al. 1996). Ocean warming is contributing to seasonal changes in life cycles and food web relationships and has already resulted in bleaching of coral reefs at a pace unprecedented in our historical record. At least 37% of the world"s mangrove areas and 40% of the world"s coral reefs have either already been lost or have been degraded to the point where they are not expected to recover (MEA 2005a, 2005b, UNEP 2002, 2009).

In addition to supporting some of our most productive and sensitive marine ecosystems, coastal waters are home to nearly 80% of the species of fish on the planet. Sixty percent of the world"s fisheries are already in decline, some threatened with catastrophic failures similar to that of the ground fisheries of Newfoundland"s Grand Banks (Cicin-Sain 2002, Lotze 2004, Lotze et al. 2006, Myers and Worm 2003). Although the moratorium on the international cod fishery on the Grand Banks of Newfoundland was put into place over 15 years ago, there is little evidence of the recovery of those fish populations, and less hope that we will ever again see the massive stocks recorded by early European explorers. Scientists are now concerned that if current fisheries practices, especially those that are fishing down the marine food web, continue unchecked, there will be widespread and catastrophic collapses in other major fisheries throughout the world (Pauly et al. 1998; Worm et al. 2006).

Scientific apprehension over the degradation of ocean and coastal ecosystems is not new. For over 100 years, governments, academia and community-based organizations have monitored conditions in marine environments, collecting and recording data on a range of biological, chemical and physical parameters (Hameedi 2005). As early as the late 1970s, in response to the threats posed by marine pollution and over-fishing, climate change and sea level rise, coastal population growth and land-based development, governments sought a new mechanism to manage the complex matrix of aquatic, marine and terrestrial environments that together make up coastal areas. Over the past three decades, an increasing array of global initiatives to protect coastal and oceans environments have steadfastly proclaimed the need for integrated approaches that focus on halting and reversing the degradation of coastal and ocean environments and provide inspiration and leadership to nations concerned with the sustainability of coastal resources and their dependent communities (Ducrotoy and Pullen 1999, Kay and Alder 2005). As described by Cicin-Sain et al. (1998) *integrated coastal management* (ICM) proposes a multi-purpose approach to decision-making intended to overcome the fragmentation inherent in sectoral approaches to governance, reduce user conflicts and ensure better understanding and management of the interrelationships between physical processes and human activities. Internationally, ICM has become accepted as a promising framework by which complex management and sustainable development of coastal resources could be attained (Cicin-Sain et al. 1995, Cicin-Sain et al. 2002b, Sorenson 2002).

This chapter examines efforts to assess progress towards integrated coastal management throughout the world, as reported in the published and grey (unpublished) literatures. The chapter reviews the methodologies currently being employed in evaluation, and reports on the benefits which have accrued as a result of ICM advocacy and practice.

2.2 Integrated Coastal Management: The Core Elements

As human activities change the features and the functioning of ecosystems at scales that range from the neighbourhood wetland to the planet, the purposes, governing principles, rules and values that determine how natural resources and environments are used, conserved and restored become increasingly important. These are the functions of governance. Nowhere are the issues and conflicts more intense than along the coastlines that today contain nearly half of the world's people on 15 percent of the inhabited landspace.
(Olsen and Nickerson 2003, p 3)

Integrated coastal management is a continuous and dynamic process by which decisions are taken for the sustainable use, development and protection of coastal and marine areas and resources. The goals of ICM are to attain sustainable development of coastal and marine areas, to reduce vulnerability of coastal areas and their inhabitants to natural hazards, and to maintain essential ecological processes, life support systems, and biological diversity in coastal and marine areas. (Cicin-Sain and Belfiore 2005, p 854)

Governance is the process through which diverse elements in a society wield power and authority and thereby influence and enact policies and decisions concerning public life and economic and social development.

Governance is carried out by the state, as well as the private sector and civil society. With relation to ICM, governance refers to the structures and processes used to govern behaviour, both public and private, in coastal and oceans areas under the jurisdiction of a particular country, and the resources and activities they contain. (Cicin-Sain and Belfiore 2005, p 8)

These short paragraphs provide a glimpse of the vision and promise of integrated coastal management that in the past three decades has captured the attention and support of policy and decision-makers throughout the world. To attain this vision, most ICM approaches have been comprised of a process of governance equipped with the necessary legal and institutional framework to ensure that development and management plans for coastal zones are integrated with environmental (including social) goals and are developed with the participation of those affected (Post and Lundin 1996, The World Bank 1993). Situations requiring integrated approaches to governance have been described as occurring "where problems are highly complex, interests and objectives are numerous and often in conflict, information and knowledge are incomplete, ends and means are ambiguous, control is fragmented and the external environment is in a state of flux" (Lang, 1990, p3 as quoted in Bellamy et al. (1999)).

Recognizing that environment, economy and social equity are conjoined elements of sustainability, most ICM initiatives have focused upon moving government activities along a continuum from policy and actions that are single purposed, fragmented and sector-based, towards a system of governance characterized by coordinated policy and programs, improved communications and knowledge sharing, and collaborative decision-making (Barusseau et al. 1997, Cicin-Sain et al. 2000a, Kay and Alder 2005, Olsen et al. 1999, Olsen 2002, 2003, Post and Lundin 1996). According to GESAMP (1996), a successful ICM program would be comprised of at the least the following components:

- participation by the public, to ensure that the values, concerns, and aspirations of affected communities are discussed and future directions are negotiated;
- the development and implementation of policies, legislation and institutional arrangements (i.e., governance) that recognize national priorities while remaining relevant to local needs and circumstances; and

- collaborative efforts by managers and scientists to formulate policy and programmes, and to design, conduct, interpret, and apply research and monitoring programs.

In general ICM applications have been guided by commonly accepted principles such as (Cicin-Sain and Belfiore 2003):

- sustainable development and inter-generational equity;
- vertical and horizontal integration and harmonization of government policy and decision-making;
- openness and transparency in decision-making,
- the right to develop, but the polluter pays;
- and environmental assessment of the impacts of proposed initiatives.

Supplemental to these principles are others that recognize the special needs for planning and management of coasts such as:

- the linkages between inland activities and coastal well-being;
- the contribution of coastal landforms that buffer and protect sensitive areas;
- the impacts of changes in coastal hydrodynamics;
- the need to protect marine and terrestrial coastal biodiversity in general, and rare and endangered species and habitats in particular;
- the use of natural form and measures rather than built structures to stabilize coastal processes;
- respect for the shared ownership of marine resources and the rights of indigenous peoples; and
- the primacy of protection of living resources over exploitation of non-living, non-renewable resources.

Since the adoption of Agenda 21 (UNCED 1992), while many nations have used ICM to describe their efforts in coastal management, some initiatives have not included integration as one of the key elements (Sorenson 2002). Integrated efforts in coastal management are characterized by a scope that moves vertically through all levels of government as well as horizontally across all sectors of society (Kay and Alder 2005), capturing all necessary elements through careful attention to at least five scales of integration (Clark 1997, GESAMP 1996, von Bodungen and Turner 2001):

- **Geographic:** spatial areas that are sufficiently broad in scope to include the physical, chemical, biological, ecological relationships and dependencies that characterize interactions among the terrestrial, aquatic and marine ecosystems that comprise the coast;
- **Temporal:** planning and implementation strategies that are sufficiently long term to engage understanding of the patterns of change over time and the benefits and constraints of past practice, while informing management of current circumstances, and enabling prediction of future scenarios in both the natural landscape and in the patterns of human use;
- **Sectoral:** inclusion of the inter-relationships that exist among human users of coastal areas and resources, including the associated socio-economic interests and cultural values, and the patterns of demographic shifts, and societal change;
- **Political/Institutional**: wide consultation across all levels of government, society, and economic sectors during all stages of planning, management and evaluation of progress; and
- **Managerial:** harmonization of policy and planning instruments and coordination across all levels of government decision-making.

GESAMP (1996) appropriately and simply represented ICM as a public policy cycle comprised of a looping, repetitive, and adaptive process (Figure 2.1), in which each cycle or loop could take ten years or more to fully complete. Recognizing the benefits to be gained through adaptive learning, an ICM program in its early days might have needed to constrain its scope and actions in favour of building needed support and institutional capacity. As the process gained in strength and sophistication, the expectation was that the array of coastal issues under consideration would broaden (Olsen 2002).

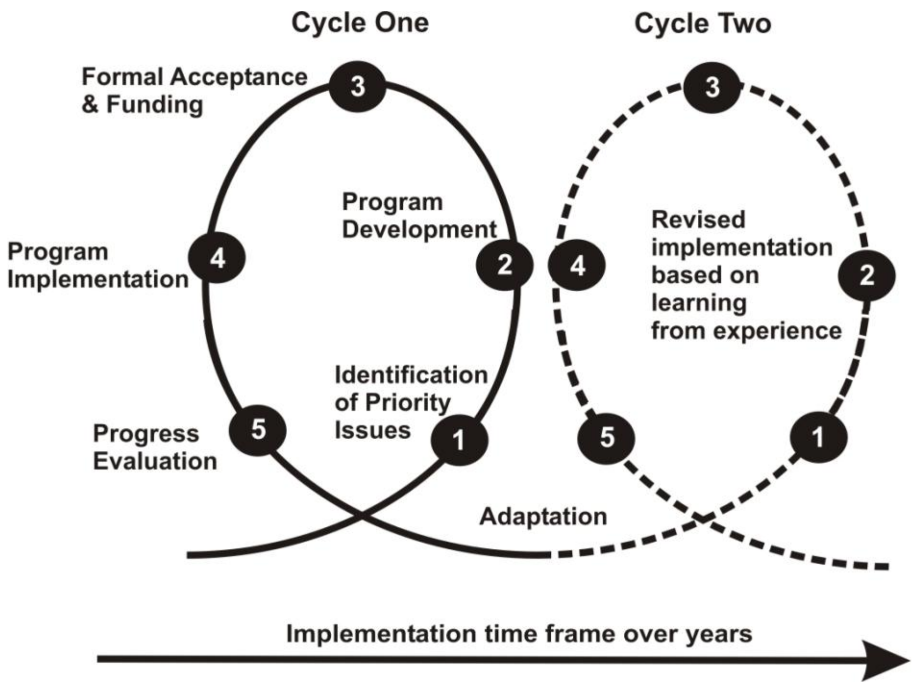


Figure 2.1: The Steps in the ICM Process (adapted from GESAMP 1996)

Although the first efforts to promote integrated approaches to management of the coast started in the seventies, the majority of international ICM guidance documents have been developed since the United Nations Conference on Environment and Development (UNCED) in Rio in 1992. These documents provide a relatively standardized basis for ICM policy and process development and implementation, while confirming the continued appropriateness of ICM shared values and reflecting the benefits of learned practice (Table 2.1).

Despite the growth and availability of this supporting literature, in the context of governance instruments ICM is still a very young process, with less than twenty years of documented experience either nationally or globally. ICM has continued to be applied as a strategic and learning-based management process that is highly responsive to new information gained during application (Lowry 2002, Tobey and Volk 2002). With the increase in applications throughout the world, there has been a growing body of knowledge gained from both research and experience. Most ICM theory and practice, as reported in the international literature, has remained true to the original vision and goals and the core principles have essentially been unchanged.

Table 2.1: Key International Guidelines and Manuals on Integrated Coastal Management

Year	Organization	Manual / Guideline
1992	ASEAN ICLARM	Integrative framework and methods for coastal area management. (Chua and Fallon-Scura 1992)
1992	UN	Agenda 21, Chapter 17 Protection of the oceans, all kinds of seas. (http://www.iisd.org/rio+5/agenda/chp17.htm)
1993	OECD	Coastal zone management: integrated policies. (OECD 1993)
1993	The World Bank	The Noordwijk Guidelines for integrated coastal zone management. (The World Bank 1993)
1993	IUCN	Cross sectoral, integrated coastal area planning (CICAP): Guidelines and principles for coastal area development. (Pernetta and Elder 1993)
1994	UNEP/MED	Guidelines for integrated management of coastal and marine areas: with special reference to the Mediterranean Basin. (UNEP 1994)(http://www.pap-thecoastcentre.org/pdfs/ICAMguidelines.pdf)
1994	FAO	Integrated management of coastal zones. (Clark 1994) (http://www.fao.org/DOCREP/003/T0708E/T0708E00.HTM)
1994	NOS/NOAA	A framework for planning for integrated coastal zone management (Bower and Turner 1998)
1995	UNEP/GPA	Global programme of action for the protection of the marine environment from land-based activities.(UNEP/GPA 1995) (http://www.gpa.unep.org/documents/full_text_of_the_english.pdf)
1996	UNCSD	Coastal area management in small island developing states. (UNCSD 1996) (http://islands.unep.ch/d96-20a7.htm)
1996	UNEP/CAR	Guidelines for integrated planning and management of coastal and marine Areas in the wider Caribbean region. (UNEP 1996)
1996	World Bank	Guidelines for integrated coastal zone management. (Post and Lundin 1996) (http://www-wds.worldbank.org/external/default/WDSContentServer/WDSP/IB/1996/08/01/000009265_3961219091924/Rendered/PDF/multi_page.pdf)
1996	GESAMP	The contributions of science to integrated coastal management. (GESAMP 1996) (ftp://ftp.fao.org/docrep/fao/003/w1639e/w1639e00.pdf)
1997	IOC	Methodological guide to integrated coastal management. (Barusseau et al. 1997) (http://unesdoc.unesco.org/images/0012/001212/121249eo.pdf)
1998	FAO	Integrated coastal management and agriculture, forestry and fisheries. (Scialabba 1998) (http://www.fao.org/docrep/w8440e/w8440e00.htm)
1998	IADB	Strategy for coastal and marine resources management in Latin America and the Caribbean. (Lemay 1998) (http://www.iadb.org/sds/doc/1097eng.pdf)
1999	UNEP	Conceptual framework and planning guidelines for integrated coastal area and river basin management. (UNEP 1999) (http://www.fao.org/docrep/w8440e/w8440e00.htm)
1999	EUDP	Towards a European integrated coastal zone management (ICM) strategy: General principles and policy options. (EUDP 1999) (http://ec.europa.eu/environment/iczm/pdf/vol1.pdf)
1999	Council of Europe	European code of conduct for coastal zones. (Council of Europe 1999) (http://www.coastalguide.org/code/)
2000	CBD	Review of existing instruments relevant to integrated marine and coastal area management and their implementation for the implementation of the convention on biological biodiversity. (UNEP 2000)
2001	UNEP	Good practices for integrated coastal zone management in the Mediterranean. (UNEP 2001) (http://www.pap-thecoastcentre.org/pdfs/Good%20Practices%20Guidelines.pdf)
2001	UNESCO	A methodological guide: Steps and tools towards integrated coastal area management. (Henoque and Denis 2001) (http://unesdoc.unesco.org/images/0012/001245/124596eo.pdf)
2004	CBD	Integrated marine and coastal area management (IMCAM) Approaches for implementation the Convention on Biological Diversity. (AID Environment 2004) (http://www.biodiv.org/doc/publications/cbd-ts-14.pdf)

Year	Organization	Manual / Guideline
2004	UNEP	The ecosystem approach: CBD guidelines. (UNEP/CBD 2004)
2005	MEA	Millennium ecosystem report: Living beyond our means. (MEA 2005b) (http://www.millenniumassessment.org/documents/document.429.aspx.pdf)
2006	UNESCO	A handbook for measuring the progress and outcomes of integrated coastal and ocean management (Belfiore et al. 2006) (http://unesdoc.unesco.org/images/0014/001473/147313e.pdf)
2006	Coastal Resources Centre	A handbook on governance and socioeconomics of large marine ecosystems. (Olsen et al. 2006b) (http://www.crc.uri.edu/download/LME_Handbook_FULL_FINAL.pdf)
2006	UNEP/GPA	Implementation of the GPA at regional level: the role of regional seas conventions and their protocols. (UNEP/GPA 2006a) (http://www.gpa.unep.org/documents/lbsa_protocols_for_the_english.pdf)
2006	UNEP	Protecting coastal environments from land-based impacts: A guide for national action. (UNEP/GPA 2006b) (http://www.gpa.unep.org/documents/2006_npa_handbook_for_english.pdf)
2008	UNEP	Protocol on integrated coastal management in the Mediterranean. The Mediterranean Action Plan for the Barcelona Convention. (UNEP 2008b) http://www.unepmap.org/index.php?module=news&action=detail&id=30

However, there has been a growing recognition that for the full value of ICM to be attained, implementation programs must continue to be dynamic and adaptable, capable of responding to differing cultures and circumstances and flexible enough to allow implementation efforts to vary from country to country. ICM continues to be challenged by the complex array of physical, chemical and biologic environments that comprise coastal ecosystems and the array of human activities that can directly and indirectly impair coastal well being, whether these activities take place in close proximity to the shore, or further inland. With growing certainty that the challenges posed by pollutants, over fishing, changes in population size and distribution, sea level rise and severe storm events that gave birth to ICM are now upon us, the pressure to achieve effective coastal management is increasing.

2.3 Assessing ICM Progress and Effectiveness

ICM processes as described by GESAMP (1996) must include evaluation as one of the five significant elements for implementation. If proceeding stepwise through the ICM process, evaluation (and monitoring) would normally occur as the final activity. However, given the time necessary to complete one loop of the GESAMP cycle, it has been accepted that more timely evaluations of ICM progress are required to inform needed changes in delivery. Consequently, assessment and reporting of progress was expected to take place throughout ICM implementation, with the results applied at all appropriate decision-making points. However, by 1996, although international funding agencies were estimated to have spent millions on ICM initiatives, few assessments of progress had been completed (Christie 2005, Olsen 2002). Where evaluations did exist, they had been largely internal in scope, intended only for the information and benefit of program managers and for reporting to the funding organizations. Uniform methods of evaluation were not used, and the results were generally poorly documented, compromising the ability of the learned experiences to contribute towards improvements in ICM theory and practice.

Recognizing that efforts to capture and learn from ICM implementation were fragmented and uncoordinated, the GESAMP (1996) identified the need to develop an accepted and commonly utilized methodology for ICM evaluation as a priority emerging issue. As Tobey et al. (1998) and others have noted, a common methodology for ICM evaluation is useful because it would:

- enable comparison of experience across projects, nations, and environments;
- facilitate identification of shared factors that had contributed to either success or failure;
- document progress towards achievement of ICM goals such as coastal sustainability; and
- provide readily comprehensible and comparable evidence of the benefits of integrated approaches to coastal management.

Early attempts to evaluate ICM programs measured indicators that most often focussed on outputs of process implementation (e.g., policies, legislation, programs, plans, permits, meetings, publications) rather than on outcomes of improved coastal management (e.g., improved water quality, protected species and habitats, secured public access, sustainable fisheries and tourism, empowered local communities) (Burbridge 1997, Hershman 1999). Assessments of the contributions of ICM to sustainability were more likely to refer to sustaining political and fiscal support for institutional arrangements than it was to sustaining coastal ecosystem health. Researchers tracking ICM progress concluded that for the benefits and constraints to ICM to be effectively understood and for adaptive change in ICM to take place, at least three kinds of evaluations were needed (Kay and Alder 2005, Knaap and Kim 1998, Olsen et al. 1999):

- Performance (Output) Evaluations: assess the efficiency and effectiveness of implementation and the success or failure in meeting goals and objectives. Findings are used to stimulate improvements in program delivery.
- Management Capacity (Output) Evaluations: assess the adequacy of the institutional structure and the assigned human and fiscal resources. Findings are used to stimulate improvements in program delivery.
- Outcome Evaluations: assess changes in coastal environmental conditions (including human well-being). Findings are used to calculate ecosystem benefits as well as socio-economic costs and benefits.

2.3.1 The Four Order Outcomes (FOO) Framework

Responding to the challenge posed by the GESAMP, Olsen and others at the Coastal Resources Centre at the University of Rhode Island built on the United States Environmental Protection Agency"s model for measuring progress in estuary programs (USEPA 1994), to develop a *Four Order Outcomes Framework* (FOO) for assessing progress in ICM. The FOO framework was intended to provide continuity to program evaluations and permit comparison of findings derived from ICM initiatives throughout the world (Olsen et al. 1999, 1997, Olsen 2002). The USEPA defined outcomes as actions or occurrences that occur outside the estuary protection program, but that are likely to have happened, at least in part, because of an activity of the program. In contrast, Olsen and Nickerson (2003) used the term to describe all products of ICM (including outputs), creating four categories or orders of outcomes defined as follows (Figure 2.2):

- **First Order Outcomes** create enabling conditions for change, including policy, institutional and resources support, and report on the actions that had been undertaken by a society committed to a plan of action to modify the course of events in a coastal ecosystem;
- **Second Order Outcomes** report on changes in societal behaviours, especially those which would affect the coastal resources or issues of concern,
- **Third Order Outcomes** report on measurable changes in socio-economic and environmental conditions that demonstrate progress towards sustainable development;
- **Fourth Order Outcomes** report on tangible evidence of progress towards sustainable development.

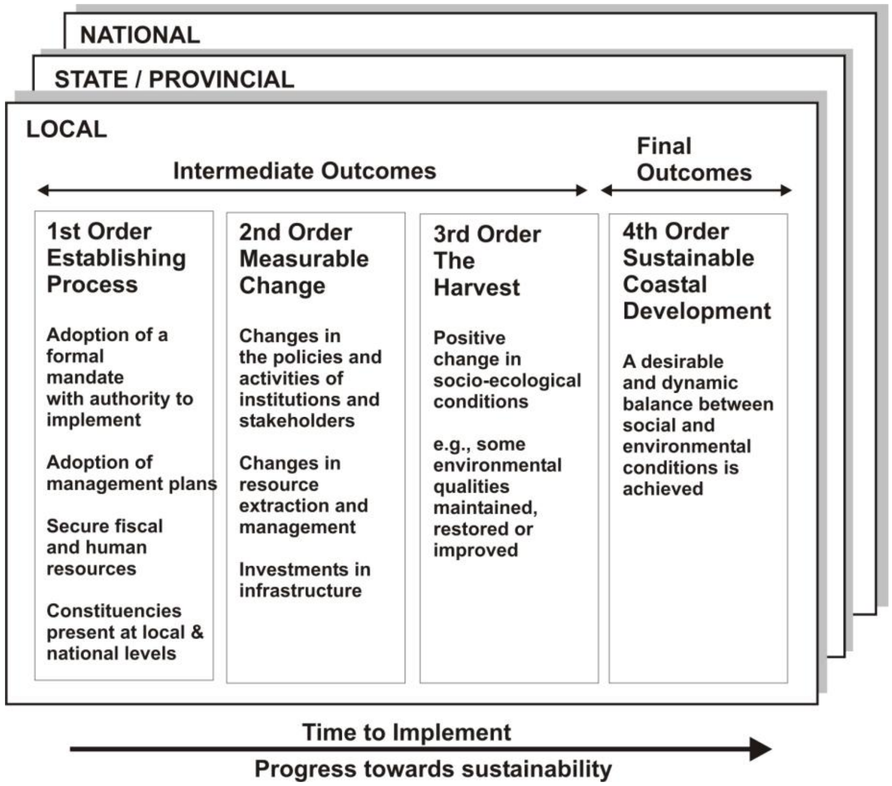


Figure 2.2: The Four Order Outcomes of Coastal Government (adapted from Olsen and Nickerson 2003)

The FOO framework responds to two primary goals: improving the health of the biophysical environment, and improving the quality of life of the human population. Recognizing that ICM was a process of negotiation and implementation of change in public policy and societal activities, the framework also accepts that for each change in the state of the biophysical environment, there had to be a correlated change in the behaviour of key decision-makers, partners and/or stakeholders (Olsen 2003). Progress on First and Second Order outcomes would be necessary before measurable change could occur in Third or Fourth Order outcomes. As well, Third and Fourth Order outcomes generally require significantly greater time frames before evidence of progress could be seen. As a result, Olsen anticipated that most of the early reporting on ICM progress would involve First Order outcomes, with expectations that with time and increased resources and commitment, greater progress would be made towards the sustainability of coastal environments and coastal communities (Olsen 2001, Olsen 2003). However, it is important to note, that there was no particular requirement for action on ICM to proceed in a sequential manner through governance structures. By example, as was reported in Cuba, it was not necessary for beneficial activities at the local level to wait until national programs on coastal management were fully established (Olsen 2002).

2.3.2 The Drivers-Pressure-State-Impact-Response Framework (DPSIR)

To assess the costs and benefits of ICM program implementation, the Drivers-Pressure-State-Impact-Response Indicators (DPSIR) framework relies on indicators that measure progress towards sustaining coastal ecosystems and human quality of life. DPSIR indicator programs were developed in the late 1980s by the Organization for Economic Cooperation and Development for use in environmental management (OECD 1994). The DPSIR approach is based on causality in which human activities pressure, or place stress upon, physical, chemical and/or biological components of the environment, resulting in changes in the quantity or quality of natural resources, a situation that, in turn, requires some form of regulatory or management response to limit or remedy impacting activities (Figure 2.3).

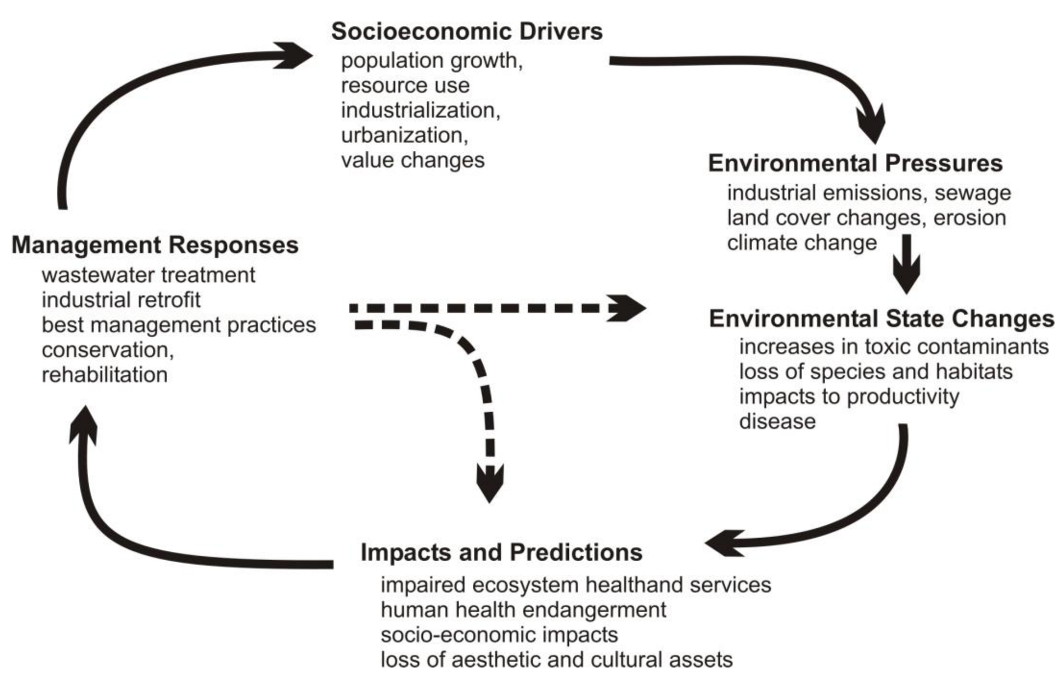


Figure 2.3: The DPSIR Framework (adapted from Hameedi 2005)

As it has evolved, the DPSIR framework groups indicators in the following categories (Cordah Ltd. 2001, Hameedi 2005, OECD 1994):

- Drivers: the demands placed by society on living and non-living resources
- Pressure indicators: stresses on the coastal environment caused by human activities
- State indicators: current environmental conditions
- Response indicators: measures taken to correct or improve environmental problems

The DPSIR framework recognizes the importance of ongoing monitoring of progress and the application of science as tools to assist efficiency and effectiveness of program delivery (von Bodungen and Turner 2001). However, DPSIR does not require that a process fully integrate socio-economic indicators within the framework for management, nor does it take into account the differences between indicators of program success, and indicators of ecosystem and community sustainability.

While DPSIR based approaches have been used to evaluate progress in coastal management initiatives in a number of countries including the European Union (Cordah Ltd. 2001, Cox et al. 2004), the approach has seen only limited application in coastal management practices of countries such as the United States (Hameedi 2005). In addition to the complexity of application in countries where there is no central agency responsible for coastal management, there have been concerns that the DPSIR approach may result in an overly simple presentation of cause and effect relationships, that could result in failures to identify or address important contributing factors leading to misleading conclusions and misdirected policy (UNEP 2006a).

2.3.3 Limitations to ICM Evaluations

Despite the often reported need for additional evaluative studies of ICM progress, and the opportunities posed by both the FOO and the DPSIR frameworks, the body of information on ICM performance has remained fragmented and limited. Ironically, one of the more significant barriers to the development and establishment of standardized methodologies may be the growing diversity in ICM implementation. In 1999 Bellamy et al. reported that Australia was having problems translating the concept of integrated management into practice, and that proactive evaluations of progress and performance were still needed. In Burbridge"s (2004) review of progress towards implementation of ICM in the Baltic Sea region, he noted that the assessment literature still predominantly measured outputs, and provided little information on either the effectiveness of the investment in ICM, or on its ability to provide solutions to coastal problems and issues. Similarly, in their reviews of ICM performance in the United States, Hershman et.al. (1999) and others (Bernd-Cohen 1999, Good et al. 1999, Goodwin 1999, Hershman 1999) reported that assessment of progress in coastal management was constrained by the lack of data. This was especially true for data on the linkages between ICM processes and desired changes in coastal environmental conditions, a situation further exacerbated by the lack of a common set of indicators to link management activities to coastal health.

2.3.4 Recent Initiatives

In the past decade there has been a growing body of knowledge reflected in the literature on coastal management, focussed on the development of new approaches and indicators for use in determining what constitutes effective ICM, how we assess and measure efficiencies, and perhaps most importantly, how can what has been learned be applied to improving implementation (Ehler 2003, EUDP 2000, IOI 2006, Lowry 2002, Lowry et al. 1999, Payet 2006, Stojanovic et al. 2004, US/NOAA 2006, US/NOAA 2008). To overcome some of the most immediate challenges to ICM monitoring and assessment, there are new global initiatives to identify holistic, integrated indicators of ecosystem health, change and sustainability that can address the complex interactions of human activities and the natural environment of the coastal zone (Belfiore et al. 2003). Belfiore et al. (2006) combined much of the current state of knowledge in ICM evaluation in their new handbook which provides a highly detailed guideline for identification of output (governance) and outcome (ecosystem sustainability and socio-economic) indicators of progress against which to chart the inputs, processes and products of ICM programs. The new guideline provides sufficient flexibility for its application to any of the current frameworks for ICM implementation, and should advance needed coordination and standardization of both monitoring programs and results reporting.

Despite these new tools, assessments of ICM performance are still done somewhat infrequently. Sorensen (2002), Burbridge (2004) and Belfiore et al. (2006) have suggested that evaluative efforts still face challenges that include:

- a lack of consensus on appropriate indicators for measuring the contributions of ICM;

- difficulties in matching the scope and scale of ICM goals and objectives to the reality of available resources;
- a reluctance among ICM managers to permit process and performance evaluations by outside parties;
- the costs and time required to conduct monitoring programs, many of which produce results that are poorly packaged and communicated to decision-makers or to society, and/or have controversial conclusions based on incomplete science;
- a pervasive absence of good quality time series and baseline data on accepted indicators of coastal sustainability;
- limited understanding of cause and effect relationships between human activities and environmental health and sustainability,
- difficulties in securing funding for short and long term coastal research;
- poorly documented and/or reported linkages between ecosystem health and human health and well-being;
- the lengthy time period before negative (or positive) effects attributable to human activities are measurable in the environment;
- difficulties in making the case that benefits to sustainability are the direct result of ICM policies and practice; and
- (as a consequence of most of the above), anecdotal rather than empirical reporting on the effectiveness of ICM initiatives.

New efforts to evaluate, assess and adapt ICM have emphasized that while there is a need for a holist0ic understanding of the complexities that typify most efforts in coastal management, it is equally important to report with clarity on the findings and conclusions to all levels of governance and to the public. It must be recognized that development and conservation activities in most coastal areas fall under some aspect of governance and management, whether there is an ICM initiative in place or not. Environmental regulatory, development planning and resource management agencies have been at work in coastal areas for some time, and may directly or indirectly derive benefits towards the achievement of their own objectives from aspects of ICM implementation. Consequently, the effectiveness of ICM programs should be assessed in the context of all advances in existing governance, as opposed to in isolation from other institutions and programs with equally demanding responsibilities to sustainably manage coastal areas.

2.4 The Achievements of Integrated Approaches to Coastal Management

Despite the limitations in ICM evaluation studies, sufficient information has been generated from the past 35 years of ICM practice to recognize that progress towards ICM has been made globally, regionally and locally. It is, however, important to recognize that much of the literature has focussed on what Olsen would term First and Second Order Outcomes, and reports on progress towards changing the processes associated with coastal management.

Taking into account the diversity of ICM initiatives that have occurred, researchers and practitioners have identified a suite of factors that individually and collectively are considered important to successful ICM implementation (Burbridge 2004, Tobey et al. 1998):

- sufficient political (international, national and local) knowledge of coastal issues to support ICM policy and action;
- a shared vision for sustaining coastal environments;
- strategic, issue-driven objectives and action-oriented solutions;
- communication of the ICM issues, priorities and actions to key constituencies in coastal management;
- sufficient and long-term fiscal and human resource investment towards building individual and institutional capacity;
- program activities matched to the capability and resources of the people and institutions involved;
- strong linkages vertically across levels of governments and horizontally among sectors;
- mechanisms to promote sharing of data and integration of scientific information and expert knowledge;
- applied research to better inform ICM planning and actions;
- implementation actions that occur concurrently with research and planning;
- ownership of ICM programs at the local level, where much of the critical decision-making and implementation take place;
- transparency of process, and stakeholder participation in all phases of the program;
- identification and monitoring of outcome and output indicators; and
- reliance on learning from experience to inform adaptive management.

Stojanovic et al. (2004) in their examination of the peer literature on ICM successes to date were convinced that, as ICM continued to evolve, it was profoundly affected by a change in philosophy from modern to post-modern thinking, broadening its ability to cope with inconclusive science and myriad values and perspectives. Post-modern approaches to ICM acknowledge that successful programs vary considerably in their application, generally in direct response to the situation they encounter within their country or their region. Post-modern approaches also allow decision-making to address values other than those supported by scientific fact. It has been proposed (Stojanovic et al. 2004, Vallega 2000a) that success in ICM may be based on management styles that respond to these changing paradigms and that include, in addition to the factors identified above, the following attributes:

- participation: providing opportunities for contribution and balanced sharing of activities;
- co-operation: coordination and harmonization of policies and activities of all levels and sectors of government to achieve shared goals and objectives;
- contingency: responsiveness to and adaptability to local conditions;
- precautionary: proactive responses that protect against possible danger or failure;
- long-term time frames: recognition that more than brief views of current conditions are needed to understand and manage the links between human and natural environments;
- focussing: structured consideration of critical issues and acts of intervention;
- incremental change: iterative management that proceeds in a step-by-step manner, building on successes and responding to failures; and
- adaptability: the capacity to adjust to new information, new goals and/or changing conditions.

The following sections identify some of the commonly reported benefits attributed to an integrated approach to coastal management.

2.4.1 Global Support for Improved Coastal Management

Although the principles of integrated coastal management have been promoted for over thirty years, the most remarkable progress towards implementation of ICM has been achieved in the years since 1992. In many countries throughout the world, ICM is now accepted as the organizing framework by which sustainable development of coastal resources can be attained (Cicin-Sain et al. 1995, Cicin-Sain et al. 2002b, IOI 2006, Sorenson 2002). Since UNCED in 1992, there has been an increasing array of global initiatives to protect coastal environments that includes: the ongoing ratification of the United Nations Convention on the Law of the Sea; growing support for Agenda 21 (Chapter 17); the Rio Declaration on the Environment and Development; the Global Programme of Action for the Protection of Marine Environments from Land Based Activities (GPA); the 1994 Jakarta Mandate of the Convention on Biological Diversity; the 1994 International Coral Reef Initiative; the 2001 Intergovernmental Review Meeting of the GPA (Montréal); the 2002 Global Conference on Oceans and Coasts at Rio+10 (Johannesburg); the 2001 Bonn Freshwater Meeting; the 2005 Millennium Ecological Assessment; and the 2008 Barcelona Protocol on Integrated Coastal Zone Management in the Mediterranean. In addition, ICM has been selected as the key implementation strategy for global and regional environmental treaties such as the Convention on Biological Diversity and the Convention on Climate Change. And in 2002, in response to a World Summit on Sustainable Development recommendation to keep the oceans under permanent review, the first phase of a regular process for global assessment and reporting on the state of the marine environment was initiated. In 2009, the first comprehensive report (the Assessment of Assessments) was released by the Group of Experts, who included within their recommendations the need to continue a process that offered sound and sustainable solutions to the challenges being faced by marine environmental and resource managers (UNEP/IOC 2009). These important global initiatives have steadfastly proclaimed the need for integrated initiatives focused on halting and reversing the degradation of coastal and oceans environments and have provided inspiration and leadership to nations concerned with the sustainability of coastal resources and their dependent communities.

Since the early nineties, the number of coastal nations that have implemented some form of integrated coastal management has nearly doubled and was estimated as 98 in 2000 (Cicin-Sain and Belfiore 2005, Sorenson 2002). The largest increase has come from developing nations where ICM initiatives have often been supported by multi-lateral and bilateral international assistance institutions such as the Global Environment Fund, the World Bank, the Inter-American Development Bank, and national institutions such as the United States Agency for International Development and the Canadian International Development Agency. In developed nations it would appear that there has been general acceptance of the potential benefits of implementation of ICM, but perhaps because of the sheer size and complexity of the bureaucracies, progress towards implementation has been slow, but gaining in momentum. Cicin-Sain (2002), in her review of progress towards ICM in the United States, notes that there are functioning processes in 34 of the 35 coastal states and territories, where important progress has been made in the protection of biodiversity, the implementation of wastewater treatment processes, and the reduction of point source pollutants.

2.4.2 Recognition of the Role of Science in Management

Since GESAMP (1996), it has been acknowledged that if we are to achieve sustainable management in coastal areas, the contributions and roles of science and management must be deeply entwined (Ernst 2004, Kullenberg 1995, Mercer Clarke and Bard 2007, Rees et al. 2008, Taussik and Gilbert 2002, UNEP/IOC 2009). As Doody (2003) pointed out, information when presented in context, with meaning and purpose, nourishes the analytical process to produce an improved understanding of ICM issues. The role of science cannot be limited to the provision of technical information, and managers must accept scientists as partners in problem-solving, as Olsen (2000) put it, integrating good science with good governance, and increasing the potential for success in coastal sustainability.

In the early literature on ICM, science was often taken to mean the natural sciences in general and the marine sciences in particular. As experience with ICM implementation has grown, so has the general conviction that the social sciences are equally essential to ICM. Social sciences play an important role in advancing understanding of the motivating factors for human activities that harm the environment. The knowledge and skills of social scientists and professionals also contribute to the formulation of more effective programs intended to alter impacting human behaviour and to promote positive organizational change. Indeed, current views of the role of science and management see the need to move beyond existing multi-disciplinary research programs to inter- and trans-disciplinary approaches to information sharing and problem-solving (Chircop 2000, Turner and Bower 1999). These collaborative efforts support a more rigorous use of current knowledge, respect the contributions gained from inclusion of traditional and local knowledge, embrace collaboration with the social sciences, as well as with applied research and professional practice, and fuel the demand for the development and application of new technologies to enhance problem solving capabilities (Kullenberg 2001, Le Tissier et al. 2004). As von Bodungen and Turner (2001, p 12) concluded, ”the ambitious but key requirement for a future, more sustainable coastal zone management is that both scientists and managers need to be involved in a continuous interactive process, such that scientists gain a better appreciation of policy formulation and implementation, while managers better understand the functioning and variability of natural systems and the consequences of socio-economic activities”. This increasingly sophisticated approach to ICM will become more important as ICM processes move from their early focus on nature conservation and protection to a more complex role in managing for sustainable development (Burbridge 2004).

2.4.3 Growth in ICM Training and Governance Capacity

In their 1995 review of the growth in capacity for ICM since UNCED, Cicin-Sain et al. (1995) acknowledged that the need to build in-country capacity for integrated coastal management had been a common thread throughout all of the discussions at the Rio Earth Summit and was strongly emphasized in Agenda 21. In the years since UNCED, most of the major UN organizations involved in coasts and oceans have continued to increase their internal resources in ICM. As well there are a growing number of training and education efforts at the international, national and local levels (Belfiore 2000, Belfiore 2003, Cicin-Sain et al. 2000a, Le Tissier et al. 2004, Wescott 2002). Independent organizations such as the International Oceans Institute (IOI) provide training through its network of centres throughout the world. IOI (Canada) at Dalhousie University in Nova Scotia will this year deliver its 26th annual training program in oceans governance, a significant portion of which is devoted to ICM. This program has demonstrated the practical benefits of partnering among universities, governments, communities and the private sector, drawing on an interdisciplinary cadre of professionals who act as faculty to the program. IOI Canada has over 1000 alumni, most of whom work in senior management positions in developing countries (South 2006, Wescott 2002).

Cicin-Sain et al. (2000a), Sorensen (2002) and Westcott (2002) provide excellent overviews of both the available academic programs and the inter-institutional networks that have become established to encourage sharing of resources, information and knowledge. However, perhaps as a reflection of the diversity by which ICM education is approached, there is as yet no standard methodology for either the development of core curriculum or for instruction of ICM university programs. There has been a growing allegiance to the designation of ICM as a field of study rather than as a single discipline. As Chircop (2000), Leon and Robles (2002) and Smith (2002) point out, ICM requires both the knowledge of an array of disciplines, and the experience gained from professional practice. This inter-disciplinary approach speaks best to the need for a holistic understanding of the underpinning issues of ICM (Cicin-Sain et al. 2002b) and prevents any one discipline from overshadowing or conditioning the approach to learning (Chircop 2000). Interdisciplinary programs in ICM education are growing, despite the challenges posed by traditional academic approaches to focused learning.

Capacity building in ICM still faces a number of challenges including reaching consensus on core concepts, training for flexibility in implementation of the ICM framework, building inter-disciplinarity in structure and content, and ensuring that training programs increase the availability of local experts in the developing world (Cicin-Sain et al. 2000b, Lowry 2002).

2.4.4 Growth in Information and Tools for Implementation

With nearly 100 coastal nations participating in integrated management there has been a corresponding growth in information not only on guidelines for implementation but also on coastal environments and coastal communities. In addition to earlier documents, many of which still hold considerable relevance to ICM today, there are a multitude of newer texts and manuals available to guide and inform ICM implementation, including but certainly not limited to the Intergovernmental Oceanographic Commission frameworks (Barusseau et al. 1997, Henoque and Denis 2001), and recent texts by Barnabé and Barnabé-Quet (2000); Beatley et al. (2002); Harvey and Caton (2003) ; Kay and Alder (2005); and Smith and Potts (2005) . The literature on ICM is expanding rapidly to include information on current projects, on specialized technologies to aid implementation and on regional conditions within coastal environments. Information on ICM can be found in the peer-reviewed literature and global and national government publications.

With the astonishing expansion of the Internet over the past decade, a significant proportion of ICM information has become available as electronic documents accessible from a myriad of websites, including online access to most academic journals. The Internet has also provided an inexpensive, powerful and accessible medium for ICM communication and sharing of information, locally, nationally and globally. Bookman (2000), using the Internet to promote coastal stewardship in the United States, engaged the participation of over 7000 people who shared their views on the future of the coast through a web site. Kay and Christie (2001), in their snapshot assessment of primary and secondary impacts of the Internet on coastal management, found at that time, that there were a total of 77 websites worldwide dedicated to ICM. Nearly a decade later, the expectation is that not only has the number of web-sites expanded dramatically, but the use of other web-based technologies has greatly enhanced communication and knowledge sharing on coastal management throughout the world.

Tele-learning, the process of learning at a distance through courses and training offered on the internet, offers considerable opportunity to broaden both the scope and availability of university programs of study in coastal management (Ducrotoy et al. 2000). However, despite the rapid growth of Internet users, access to the Internet is not available to everyone. The digital divide identified by Kay and Christie (2001) refers to the lack of Internet access to marginalized people throughout the world. It is a formidable barrier that, though mainly felt in developing nations, also occurs in developed countries where it can be derivative of economic constraints, age, gender and race.

As the scope of available data increases and the use of common protocols broadens the potential for collaborative efforts and sharing of information, there is an accelerating need for the development and application of technologies in ICM information management and analysis and in coastal problem-solving. For years, scientists and regulators have struggled to develop computer data bases capable of storing, retrieving and analyzing complex data associated with coastal management. In the early days of desk top computers, these programs were costly, single purposed, and had limited ability to provide information comprehensible to anyone other than the software initiators or users. The arrival of off-the-shelf geographic information systems (GIS) provides ICM practitioners with an adaptable new tool for converting complex and sometimes seemingly unrelated data into useful information on changing conditions and management options within the coastal zone (Capobianco 2003). GIS has been described as a synergy of hardware, software, data and people with considerable potential for application in ICM (ESRI 1990). Coastal GIS systems are now used in ICM programs throughout the world and are “increasingly integrative of scientific and socioeconomic elements, increasingly dynamic, temporal and predictive, and are often the tool that effectively brings stakeholders together” (Bartlett and Smith 2005, p 296). But more work is needed to further develop GIS and other tools that will adequately capture necessary and appropriate data, as well as store, manage and transform it into information that nourishes understanding and leads to resolution of ICM issues (Doody 2003, Strain et al. 2006, Vallega 2005)

2.4.5 Recognition of the Role of Land-based Activities

Following from the initiation of the Global Programme of Action for the Protection of Marine Environments from Land Based Activities (GPA) (UNEP/GPA 1995), there has been increasing recognition throughout the world that, if we are to attain coastal sustainability, there is an immediate need to address the impacts of land-based activities (GESAMP 2001a, IOI 2006, Mercer Clarke 2001a, 2001b, Mercer Clarke et al. 2008). Interestingly, the GPA was not immediately linked to existing or proposed efforts in ICM, probably because many coastal management initiatives still limited their landward boundary to either the high water mark or to a relatively thin band of nearshore lands. But as the boundaries of coastal areas or zones are being moved further inland, initiatives such as the Hilltops to Oceans (H2O) Partnership initiated in 2003, have focussed on improving understanding of the linkages between the land and coastal waters, and advancing the mitigation of water pollution and resource degradation across the continuum from hilltops to oceans (Cicin-Sain et al. 2002a). Like the GPA on Land Based Activities, H2O is led by UNEP and promotes working together with ICM as well as with river basin management initiatives to end the unsustainable exploitation of water resources (UNEP 1999).

2.4.6 Recognition of the Value in Local Participation

There has been an increasing awareness by the public who live, work or enjoy the coast that they have the right to participate in the development and implementation of policies which affect them (Doody 2001). Broadening of participation in decision-making has been a fundamental principle of most ICM processes since their inception, requiring democratization and transparency of decision-making (Ehler et al. 1997, USAID 1996). Since UNCED in 1992, there has been considerable movement towards participatory decision-making, with special appreciation for the potential contribution that can be made to monitoring, education, and advocacy by local, often expert, volunteers from the community. The ICM community appears to support the premise that the best pathway for implementation of national coastal management policies and initiatives is through local participation (Burbridge and Humphrey 2003, NAS 2008, Payet 2006, Treby and Clark 2004). At the same time national leadership in setting ICM policy, principles and goals may be needed to help in overcoming local parochial interests. As was recognized by the Atkins Project Team (2004) in their review of ICM implementation in the United Kingdom, coastal management ideals will only be achieved with the full support of all interested parties.

2.4.7 Movement towards Ecosystem-based Management Approaches

Despite the increased acceptance throughout the world of the need for sustainable development, many governments continue to focus on the delivery of short-term gains from resource exploitation rather than on longer-term benefits that provide for continued future use of resources and protection of the environment. Management of resources continues to be challenged by a lack of information on the diversity, functioning and interconnectivity of ecosystems, by spatial and functional areas that transcend jurisdictional boundaries, and by prevailing public perceptions that the risk of future ecosystem damage is outweighed by the immediate social and economic benefits of resource exploitation (Christensen et al. 1996, UNEP/IOC 2009). To overcome these obstacles and to provide an alternative approach for management, there has been since the early nineties a concerted movement towards the adoption of more holistic, ecosystem-based approaches to coastal management (Belfiore et al. 2006, ICES 2006).

Ecosystem-based management (EBM) has been defined as “a strategy for the integrated management of land, water and living resources that promotes conservation and sustainable use in an equitable way” (UNEP/CBD 2004, p 6). An ecosystem approach to management is based on the application of appropriate scientific knowledge of ecosystems, including an understanding of the dynamic nature of ecosystem functions; adaptive management techniques that can function in the absence of complete knowledge and understanding of all ecosystem processes; and an ability to collaborate with other forms of management and conservation approaches. Ecosystem approaches are guided by principles that include, among others: conservation of ecosystem structure and functioning; understanding ecosystems in an economic context as a delivery mechanisms for services and benefits; adoption of appropriate spatial and temporal scales for management; recognition of the inevitability of change; inclusion of all forms of relevant information; involvement of all sectors of society, and the decentralization of management to its lowest level (AID Environment 2004). For many nations, the adoption of an ecosystem approach to the management of coastal areas, while requiring changes in the criteria for scientific assessment as well as changes in governing policy and legal instruments, is seen as entirely compatible with the principles of ICM (Wang 2004).

2.5 Why Process isn't Enough

Integrated coastal management continues to be grounded in the belief that the development of a shared vision of sustainability, coupled with effective implementation of instruments that promote integrated governance, will result in the reduction of environmental impacts and improvements to coastal well-being. Because assessments of ICM effectiveness have also focused on measuring progress towards changes in institutional arrangements, few situations exist where measurable benefits to coastal sustainability have been attributed to integrated approaches to management.

Despite the growing support for ICM worldwide, and the array of tools and instruments that have been developed to assist implementation, we continue to have only limited knowledge of the complex dynamics of most coastal ecosystems. Knowledge is constrained not only by a lack of data on current conditions, but also by the paucity of information on the scope and pace of change, further reducing our ability to comprehend the complex relationships between land-based activities and the health of sensitive nearshore environments continues (GESAMP 2001b).

Perhaps even more disturbing, we barely understand the linkages between coastal pollution and human health (GESAMP 1996, Kennish 2002). While we are waiting for science to catch up, and for ICM processes to demonstrate their ability to enact positive change, there is mounting evidence that conditions in oceans and coastal environments around the world are continuing to decline, some dramatically (EEA 2006a, 2006b, Lotze et al. 2006, MEA 2005a, 2005b, Steffen et al. 2004, UNEP 2007a, 2007b). In the United States, where coastal management programs have been in place for several decades, the USEPA (2005) reported that 27% of estuarine areas of the northeastern coast is impaired for aquatic life; 31% is impaired for human use, and an additional 49% is threatened. And in a recent assessment of estuarine conditions on all their coasts, the USEPA (2007) rated environmental quality as fair at best. As ICM passes its thirtieth birthday, there are rising concerns that, in their current form, integrated frameworks for coastal management have neither been effective at fostering needed societal change, nor in slowing ecosystem degradation along the coasts (Hershman et al. 1999, JOCI 2006, 2007, Shipman and Stojanovic 2007).

In the context of governance and public administration, ICM is still a relatively young paradigm for governance. Much of the international and national guidance on implementation of integrated approaches to coastal management has assumed that over several decades, the process of learning by doing would enable incremental improvements in ICM performance as it is applied throughout the world (Turner 2000, Walters 1997). However, evaluations of ICM practice continue to face challenges generated by widely disparate conditions in ecosystems, in the scope and scale of implementation efforts, in funding and support, and in the time frames allotted for program development. When these factors are exacerbated by the inherent complexities in the range of political, social and economic conditions to be found throughout the coasts of the world, it has been difficult if not impossible to find a commonly effective and appropriate model for ICM implementation (Burbridge 2004).

Recognizing that benefits to coastal environments may take years to become visible, ICM practitioners have focused on providing feedback on their successes in changing policies, administration and management practice. As well, by following the premise that „what counts is what works", ICM evaluations sought to identify the factors that have contributed to success (Tranfield et al. 2003). And to be clear, the progress reported to date in generating international awareness and support for changes to coastal management, supports current optimism that over time, ICM initiatives could significantly contribute to coastal sustainability. However, the world is now faced with two enormous challenges: the scope and pace of coastal degradation that continues even in those areas with established coastal management initiatives; and the current global economic crisis which is likely to capture the attention, commitment and resources of governments for some time into the future. For existing and proposed ICM initiatives, it is now critical that the constraints to effective ICM implementation are also identified, so as to ensure that appropriate and needed adaptation of policies, principles and programs can take place. If, as Shipman and Stojanovic (2007) concluded, ICM would still need more time to mature before it can become an effective alternative to current governance practice, it may be time to reassess the capacity of integrated approaches to coastal management to actually achieve change in the activities of a society preoccupied primarily with economic not environmental concerns.

Stephen Olsen once described a nightmare in which he awoke in 2002 to a world in which the costs to implement ICM had out-weighed the benefits, the goal of integration had been discarded, and society was seeking a new paradigm for coastal management (Olsen 1996). While there have been demonstrable successes in ICM, the coasts are still in trouble, and there are significant, perhaps even severe, shortcomings to ICM effectiveness. Too much of Olsen‟s nightmare may have become our reality.

CHAPTER 3:
EXPERIENCE-BASED PRACTICE IN ICM:
A PRAGMATIC ANALYSIS OF THE SHARED CONSTRAINTS TO IMPLEMENTATION

3.1 Facing a Hard Reality: Mounting Concerns over the Effectiveness of Integrated Coastal Management (ICM)

In recent years, the optimism that integrated approaches to coastal management (ICM) could deliver coastal sustainability has been challenged by mounting evidence of the continuing and pervasive decline in oceans and coastal environments (Steffen et al. 2004). Despite its relatively short global history, questions have arisen over the ability of ICM to deliver promised harmonization of policy and decision-making, to improve coordination of environmental and economic interests, or to reverse or even to slow coastal deterioration (Bellamy et al. 1999, JOCI 2006, 2007, Nichols 1999, Shipman and Stojanovic 2007, Vallega 2000). As much of the ICM evaluation literature has focussed on measuring progress in the establishment of programs, information on the effectiveness of ICM in improving coastal environmental conditions has remained limited (Hershman et al. 1999). As a result there has been too little progress in improving understanding of the complex cause and effect relationships between land-based activities, the deterioration of nearshore environments, and the direct and indirect impacts to human health and well-being (GESAMP 2001a, 2001b, Kennish 2002).

Although it has been accepted that integrated approaches to governance will face obstacles, there is less understanding that some constraints may pose significant and enduring impediments to effective ICM practice. Following a comprehensive review of global progress, Sorenson (2002, p 8-1) observed that ICM was still "a long and tiring swim against a continuous current of political and socio-economic interests with short-term visions, usually tending to protect the status quo". Program initiation, preparation, adoption, and implementation were recognized as invariably taking longer and requiring more financial and non-financial resources than was originally anticipated. Hugget (1998) concluded that limitations in financial resources, technical capacity and political willpower were all slowing the pace of development of a European Union strategy for coastal management. In their review of ICM in Europe, the International Oceans Institute concluded that while gains had been made in creating policy and awareness at the national level, progress towards ICM implementation remained fragmented, especially at local and regional levels (IOI 2006). These findings were echoed by Shipman and Stojanovic (2007) who concluded that ICM had not yet matured sufficiently to effect needed change towards a more sustainable use of coastal resources. Perhaps more troubling, the initial stimulus provided by the EU Demonstration Program (1996-1999) had waned, and there were few nations that had continued their ICM initiatives. In the United Kingdom, the Atkins Project Team (2004) reported that while some local projects had done well, there was little consistent application of ICM principles, long-term funding remained elusive, and the development of planning and control legislation was proving difficult. In the Spanish Mediterranean, neither established land planning processes nor coastal management initiatives had been able to curb the adverse effects of pressures exerted by a wide spectrum of socio-economic activities that provide short-term social benefits and immediate political returns (Suarez de Vivero and Rodrigues Mateos 2005). Similar concerns for the effective implementation of ICM have been raised in France (Billé 2007, 2008, Dauvin et al. 2004) in the Baltic Sea, Burbridge (2004), and even in Norway, with its long coastline and relatively low population density (Jentoft and Buanes 2005).

In the United States, the federal Coastal Zone Management Act was adopted by Congress in 1972, providing one of the longest running national frameworks for improved management of coastal lands and waters. By 2000, there were functioning coastal management programs in all but one of the 35 coastal states and territories, contributing significant benefits towards managing coastal development, protecting coastal resources and ensuring public access (Cicin-Sain et al. 2002b). But earlier in 1999, the authors of the comprehensive Coastal Zone Management Effectiveness Study concluded that while there was sufficient evidence of progress towards implementation of ICM processes, there were insufficient data to determine the effectiveness of these processes towards protecting or improving the health of coastal environments (Hershman et al. 1999).

The conclusions of Hershman et al. (1999) became more compelling when concerns over the declining state of coastal health were echoed in the midterm report of the Oceans Commission of the United States, which confirmed that the “pressures and problems in coastal areas continue to increase and that lack of organizational coordination and coherence in government efforts are still very much in evidence" (Juda 2003, p 169). By 2005, the Chair of the U.S. Commission on Ocean Policy (Watkins and Gopnik 2005) noted that both national and international experts had warned the Commission that major changes are urgently needed in how we manage, protect, and study the oceans, coasts, and marine resources and that their message was startling and urgent. Despite these urgings, in its 2006 report to the United States Senate the Joint Ocean Commission Initiative (2006) reaffirmed that the well being of American coasts and oceans was still threatened, and that efforts to better manage marine resources were plagued by the lack of a coherent national ocean policy, fragmented laws, overlapping jurisdictions, lack of federal support and funding, overexploited fisheries, and dwindling investment in coastal research, science and education. In their recent evaluation, while noting that some gains had been made in the reform of ocean policy at the state and regional level, the JOCI recognized the potential for staggering economic costs and ecological ramifications of climate change, and stressed that better understanding of ocean processes and impacts was needed to aid the development of mitigation and adaptation strategies (JOCI 2007).

There are a number of reasons why coastal scientists and managers have chosen to ignore, or at least to set aside, these growing concerns over ICM effectiveness. Evaluative studies of ICM progress remain limited, and often vary in focus, scale, methodologies and style of reporting, reducing the ability of researchers to conduct valid comparative reviews of case studies. Then too, much of the focus has been on assessing process implementation and too little effort has been placed on assessing beneficial changes in coastal environments. Measures of ICM success have been complicated by the realization that insufficient time may have elapsed for ecological and socio-economic benefits that could be directly attributable to ICM to become apparent, or that ICM benefits have been attributed to other environmental planning and regulatory agencies (Burbridge 2004, Rivera-Arriaga 2005). In some areas, there have been concerns that open discussion of ICM short-comings could compromise or eliminate the hard-won support of upper levels of government (Christie 2005, Christie et al. 2005, McFadden 2007, Rivera-Arriaga 2005).

In his review of ICM in the Baltic Sea, Burbridge (2004) suggested that, given the differences in political, social and economic conditions encountered in coastal areas, there may be no commonly appropriate way to manage our coasts. The important question continues to be whether ICM processes can adapt to accommodate differing governance and environmental systems, adjust to meet the demands of climate change, and be flexible enough to respond to the needs of a rapidly changing society. Much of the ICM guidance literature continues to assume that, over several decades, the process of learning by doing and the application of adaptive management would support incremental improvements in ICM performance as it is applied throughout the world (Turner 2000, Walters 1997). And as noted by Tranfield et al (2003), much management attention, including reviews of ICM performance, has rightfully been paid to the principle that „what counts is what works". But it is equally if not more important, especially when time is tight, to gain a better understanding of what is not working, why, and can we fix it.

This chapter seeks to identify the significant and shared constraints to ICM implementation, to improve understanding of the significance of these impediments to current and future ICM practice, and potentially, to challenge commitments to integration as a positive force in coastal management.

3.2 Systematic Review and Meta-Synthesis of Experience-Based Practice in ICM

> *There are known knowns. These are things we know that we know. There are known unknowns. That is to say, there are things that we know we don't know. But there are also unknown unknowns. There are things we don't know we don't know. Donald Rumsfeld 2002*

Convoluted though it may first seem, on careful examination there is much in Rumsfeld"s speech that makes sense, especially when applied to the pace and scope of change in today"s world. Within the coastal management community, it is clear that we are both drowning in data and starving for knowledge. The rapid access to information gained through electronic resources and the Internet provides more information on a daily basis than coastal managers can realistically access, let alone assimilate and apply to planning and decision-making. Within other fields of study, the growing recognition that considerable knowledge lies buried within the experience-based reporting of primary studies has led to the development of new deductive approaches to research, that are intent on mining primary studies for important information that can be used to draw new conclusions on overarching issues (Petticrew 2001, 2003, Sutherland et al. 2004, Tranfield et al. 2003, Weed 2005, Zhao 1991).

Drawing from these methodologies, this chapter employed meta-research techniques to conduct a systematic review of the practice literature on ICM implementation as well as a meta-synthesis of their findings and conclusions (Pullin and Knight 2009, Pullin and Stewart 2006, Tranfield et al. 2003, Weed 2005). The systematic review involved a comprehensive survey of both the published and unpublished literature on ICM practice, focused predominantly on studies reporting on successes and failures at the national and regional scale of implementation. Over 1000 documents were identified, collected and screened. Each study was examined for relevance to the research question, trustworthiness of the reporting, and timeliness. Studies that met these criteria were examined in detail, and useful information was consolidated and re-interpreted within the context of the research question. A meta-synthesis was conducted to extract the knowledge contained within reports on seemingly disparate ICM activities to document, validate and improve our understanding of the shared constraints to ICM practice. While providing valuable insight into ICM implementation, reporting on individual case studies at a local level was generally not included in this research due to the potential for a significant array of confounding factors unique to the local setting.

3.3 What is Holding us Back? Constraints to Integration at the Coast

While there is a growing body of knowledge in both the published and unpublished literature on guidelines, initiatives and successes in the implementation of ICM processes, information on the constraints to ICM implementation is more limited. Where studies do exist, they generally offer predominantly qualitative information, many providing *ad hoc* reports on the observations or conclusions of government managers, academics and participants in ICM projects. In their report to the UN Convention on Biological Diversity, members of the Ad Hoc Technical Expert Group on the Implementation of Integrated Marine and Coastal Area Management (IMCAM) recognized that ICM faced obstacles that appeared to be common, recurring and significant (UNEP/CBD 2006). Whether derived from political, social, institutional, financial, or even natural conditions, these constraints have individually or collectively frustrated efforts to move ICM forward in an effective and timely manner. A number of other authors reflect similar conclusions to those drawn by the IMCAM report, providing international, regional and national overviews of the benefits and constraints to ICM practice (Belfiore 2000, Bernal and Cicin-Sain 2001, Burbridge 2004, Clark 1997, Dauvin et al. 2004, Ducrotoy and Pullen 1999, ICES 2006, IOI 2006, Jentoft and Buanes 2005, McGlashan 2002, Nakashima 1997, Nichols 1999, Sorenson 2002, Suarez de Vivero and Rodrigues Mateos 2005, UNEP/CBD 2006). Recognizing that many of the impediments to ICM are complex, and inter-related, the constraints identified in this assessment were compiled into the following ten categories that appear to be shared across nations, ecosystems and cultures:

- confusion over coastal boundaries;
- lack of political will and long-term support;
- lack of vertical and horizontal integration in government;
- differing perspectives and conflicting goals;
- failures to identify the economic benefits;
- lack of interdisciplinary science and science to management collaboration;
- limitations on spatial and temporal data;
- lack of capacity in coastal science and management;
- limitations to participatory management and implementation; and
- conflicting time scales.

3.3.1 Confusion over Coastal Boundaries

There is still no universally accepted definition of coastal areas, or indeed of integrated coastal management, and some nations have deliberately avoided spatial definition of coastal boundaries (Ballinger et al. 1994, Cicin-Sain et al. 1995, ICES 2004). Failures to achieve consensus on coastal boundaries hindered progress in some countries, given sceptics an opportunity to delay implementation in others, and resulted in the inappropriate application of the term ICM to initiatives which were so designated only because of their proximity to a shoreline (FCR and GSES 2000, Hildebrand 1995).

In early ICM guidance documents, the area designated for coastal management was defined as the interface where the land meets the ocean, encompassing shoreline environments as well as adjacent coastal waters (The World Bank 1993). Interest in integrating coastal management was often triggered by a marine crisis that required the immediate response of many levels or sectors of government, and resulted in spatial boundaries that responded to the need to establish jurisdictions and responsibilities for action in the international as well as national and local contexts (Post and Lundin 1996, The World Bank 1993). It is not surprising that coastal boundaries have continued to reflect this focus on marine environments, and that the landward boundary of coastal areas has largely been limited to the high water mark on the shoreline. In recent years there has been increasing support for moving coastal boundaries further inland, to capture land-based activities that can have devastating effects on nearshore environments, and to provide for an ecosystem based approach to coastal management (Belfiore 2000, Cicin-Sain et al. 2002a, Kay and Alder 2005, UNEP 1999, Vallega 1999). It has been accepted that coastal landscapes are complex environments, comprised of terrestrial, aquatic and marine ecosystems, as well as human communities, and should more accurately be seen as transitional areas, not easily defined by lines on a map, and certainly not limited to boundaries defined by the reach of marine waters.

But it has been increasingly recognized that whether the spatial boundaries were based on political divisions, sectoral responsibilities, ecosystem requirements or watershed areas, they would still be insufficient to encompass all issues that affect coastal areas. Where coastal areas are limited to a thin strip of nearshore water and shoreline there are few opportunities either for proactive management of land-based activities, or for the protection of all the habitats used by sensitive species during their life cycles. But when spatial boundaries were drawn too broadly, to include all watershed lands as well as extensive ocean areas, the complexities to be addressed by management increased dramatically, and consensus on priorities did not always include the issues of primary concern at the local scale (Crowder et al. 2006, Mercer Clarke 2001a, 2001b, Sorenson 2002).

The ongoing debate on boundary definition has resulted in myriad conceptions of the coast, derivative of governance structures, jurisdictional divides or stakeholder perspectives, and continues to delay ICM implementation in some areas (Hildebrand 1995). Where it is important to establish spatial boundaries for coastal areas, whatever criteria are utilized must not knowingly exclude the participation of necessary levels and/or departments of government, or impair the access of other stakeholders. If we are to effectively manage coastal areas we must learn to function well within a range of boundaries developed using both ecological and human criteria, and defined functionally as well as spatially (Griffis and Kimball 1996). Given the pace of environmental and societal change, it is unlikely that today"s consensus on coastal boundaries would still work tomorrow. A better approach would be to define the coasts as a dynamic natural and built landscape, thinking more in terms of the land-sea interface problems that need to be addressed, and the mechanisms that would support collaborative action across existing jurisdictional boundaries, rather than waiting for consensus on coastal definitions before work could begin (Chircop 2000, Vallega 1999).

3.3.2 Lack of Political Will and Long-term Support

While long-term, uninterrupted support from the national level of government is considered to be a critical and obligatory first step towards successful ICM implementation, it has continued to be elusive in many countries (Cicin-Sain et al. 1998, UNEP/CBD 2006). Even in nations with established national commitments to ICM, and successfully completed short-term demonstration or pilot projects, the long-term viability of ICM initiatives has continued to be challenged by insufficient fiscal, human and institutional resources (Ballinger 2002, Shipman and Stojanovic 2007). In some developing countries, where progress in ICM has been dependent on the support of outside donors, there have been insufficient financial and human resources to sustain newly created coastal management infrastructures when donor support was completed or withdrawn (Christie 2005, Sorenson 2002). Political support for ICM may also have been optimistically reported, based more on the opinions of environmental and fisheries departments than the policies of sectoral departments responsible for economic development (Bellamy et al. 1999, Burbridge and Humphrey 2003). Sorenson (2002) also recognized that there can be an imbalance in some societies between the priorities, power and resources wielded by pro-development organizations, and organizations whose primary responsibility is environmental protection and conservation. Other imbalances have occurred when support for ICM voiced by national or local environmental organizations and community volunteers has been insufficient to offset the opposition from institutional and industrial stakeholders (Buanes et al. 2004).

3.3.3 Lack of Vertical and Horizontal Integration in Government

Even where coastal boundaries have been established, and there has been national support for ICM, profound failures in intergovernmental and inter-sectoral integration and collaboration have continued to be the most pervasive and seemingly insurmountable constraint to effective implementation (Belfiore 2000, Burbridge and Humphrey 2003, Burbridge 2004, Cicin-Sain et al. 1998, GESAMP 2001b, ICES 2006, JOCI 2006, Juda

2003, Olsen et al. 1999, Shipman and Stojanovic 2007, Sorenson 2002, Taussik and Gilbert 2002, UNEP/CBD 2006, Vallega 2001b). Burbridge and Humphrey (2003) in their introduction to the special issue on the European Demonstration Programme on ICM noted that the continued degradation and mismanagement of many of Europe"s coastal areas was related to insufficient coordination between different levels and sectors of administration, insufficient participation and consultation of all relevant stakeholders, and insufficient or inappropriate information about the state of coastal zones and the impact of human activities.

Starting as early as Underdahl (1980), many ICM guidance documents have stressed the importance of a unifying national coastal policy, overarching coastal management legislation, new institutional frameworks and the integration of goals and decision-making across all levels and sectors of government and, to some degree, civil society (French 1997). Even within small countries, integration on such a scale would be at best an extremely complex task, placing insurmountable burdens on limited staff. Within developed nations, where legislative frameworks and bureaucracies are large, complex, and resilient to change, the development of overarching legislation and ICM institutional frameworks empowered to enforce across all levels of government has perhaps been an unachievable expectation.

It is realistic to conclude, as Cicin-Sain et al. (1998) did, that there have been two realities in coastal government. The first has focused on management of the marine environment and generally fell under the jurisdiction and responsibility of national or state/provincial governments. The second has focused on the land, and the land-sea interface, and has largely been controlled by local governments. The need to involve local governments in ICM efforts, especially early in goal-setting and in the identification of priority issues, has been well recognized as an important precursor to effective implementation of coastal management guidelines and plans. But nowhere has the failure to integrate ICM principles been more apparent than across the land-sea divide (Atkins Project Team 2004, Ballinger et al. 1994, Burbridge 2004, Clark 1997, IOI 2006, Mercer Clarke 2005). It appeared that more effort had been spent on engaging citizens, publics, technical experts and other stakeholders, than on building working relationships with local governments, or on adapting sub-national legal instruments to assist with ICM delivery (Tuler et al. 2002, Vallega 1999). And as Davis (2004, p 91) noted in his review of the use of regional planning tools in the United States,

> *despite the fact that the negative impacts of coastal development were listed as the most significant threats in every plan surveyed, little attention was paid to land development management tools such as growth boundaries, cluster developments, planned unit developments, and alternative transportation. In addition, few mechanisms were established to improve coordination among regulatory authorities, even though this was a specific goal of many of the plans.*

In the United Kingdom, while there had been gains in environmental awareness and regulation, there was considerably less progress in either the planning or management of development in coastal areas (Ballinger 2002, Ballinger et al. 1994, LGA 2001a). Where management plans were developed for the coast, there was no consistent coverage. Even more disturbingly, these locally derived coastal management plans, developed largely through the efforts of local governments and community volunteers, were neither respected nor adequately funded by the national government, leaving communities with insufficient resources for implementation. As concluded by the Local Government Association for England and Wales (LGA 2001, p. 15)

> *the current system for managing our coasts remains sectoral and relies on local initiatives which are performing modestly well but are unlikely to meet the challenge facing us due to increasing conflicts. There is a grave risk that our natural and cultural coastal heritage will be irreparably damaged and, as a result, will close future development options.*

Traditionally, land use management has employed proactive governance tools such as land use and watershed planning, zoning to control undesirable activities and to reduce impacts, protected area designation, and municipal development bylaws for specific requirements such setbacks and buffer zones (Ballinger et al. 1994). The principles of ICM, could be effectively applied through these established tools, guiding future development, and providing a mechanism for remediation of impactive activities (Clark 1997, PlanCoast 2008).

3.3.4 Differing Perspectives and Conflicting Goals

No matter how the coast was defined, or whether the scale was regional, national, or local, differing perspectives over jurisdictional, environmental and economic issues have led to conflict (Mercer Clarke et al. 1999, Thompson 2007, Vallega 1999, Vallega 2001a). When coastal management boundaries moved inland, the complexity of governance increased, sometimes proportionally to the distance from the shore, and public perceptions of ownership and rights of access changed proportionally. Since the emphasis of ICM initiatives was seen to be on conservation and development control, coastal citizens anticipated that controversy would develop over access to resources, and rights to either protect or develop property. In some areas the rights of the private owner constrained public access to resources and the ability of regional and local authorities to establish protected areas. Conflicts also arose over new limitations on the kind and location of development, establishment of setbacks and shoreline buffers, regulation of water-extraction, prevention of clear-cutting, and implementation of hazard zoning for sea-level rise and flood plain areas. Throughout the world, as coastal communities face significant demographic change, it is anticipated that there will also be major shifts in cultural and economic goals and valuation of coastal resources and environments. Ironically, as a result of these changes, it has been suggested that national ICM programs may have inadvertently altered traditional peer to peer mechanisms that have for generations been sustainably managing local resources such as fisheries, through locally sanctioned and enforced harvest areas and quotas (Nichols 1999). By encouraging new industries and investment in coast areas, ICM has facilitated the increased penetration of local markets by global and national developers and investment firms. Introduction of these new players has undermined accepted local practice, resulting in both unsustainable exploitation and protectionist agendas.

Despite the growth in scientific knowledge, and the increasing awareness and concerns of the public for environmental well being, even people living and working on the coast have had limited knowledge of coastal health, and the threats posed to human communities and ecosystems by climate change, pollution, and loss of biodiversity (Steel et al. 2005, UNEP/CBD 2006). ICM programs have suffered from a lack of internal and external communication at all levels, but of special concern were the difficulties encountered in the clear articulation of ICM goals and the failures to convey to the populace the need for immediate and effective resolution of conflicts over resource use (Atkins Project Team 2004, UNEP/CBD 2006, Vallega 2001a). The concepts of coastal health and coastal sustainability continued to be presented as relatively undefined and ideal goals for society, making them difficult concepts to either comprehend or embrace (Olsen 2003). The development and communication of appropriate and achievable goals has been critical for successful ICM implementation, because as Hershman et al. (1999, p 118) concluded, effective coastal programs must "show a clear link between the goal they deem important, the processes they set up to achieve that goal, and the outcomes resulting from those processes that advance the goal". Too often ICM goals have focused on measuring progress in process implementation (Olsen and Nickerson 2003), failing to recognize that gains in coastal health was the goal of interest to stakeholders.

3.3.5 Failures to Identify the Economic Benefits

While there are many guidance documents for ICM, most have accepted that the industry and commerce sectors play a major role in ensuring the sustainability of our coasts. However, as Vallega (2000, p 3) noted, in many applications of ICM, even those that were based on an ecosystem approach to management, coordination between environmental and economic goals was "superficial and ambiguous". There are few examples where there has been significant private sector participation in ICM initiatives, or in training and education programs (Ballinger 2002, Burbridge and Humphrey 2003, Burbridge 2004, Wescott 2002). Failure to educate and to enlist the voluntary participation of industry has led to an inability to translate environmental successes into commercial and economic well-being, relegating efforts at more sustainable management of coastal areas to an even lower priority in the development process (McGlashan 2002, UNEP/CBD 2006). As Rivera-Arriaga (2005) noted in her review of ICM efforts in Latin America and the Caribbean, the private sector was largely unable to understand the economic contribution to the region that would be made by improvements in coastal management. And along the Spanish Mediterranean coast, anticipated restrictions to development from ICM practice were seen as negatively impacting the economic well being of both individuals and communities (Suarez de Vivero and Rodrigues Mateos 2005). In coasts facing globalization of their economies, many of the changes, challenges and declines in environmental conditions were being driven by economic interests external to the country, evidenced by intensive new agricultural practices, urbanization, non-resident land ownership, and increases in tourism and tourism-related development.

Given the length of time that has been required for socio-economic as well as ecological changes to become evident, it has been difficult to quantify the benefits of ICM processes at least until the latter stages of project initiation (FCR and GSES 2000, Tol et al. 1996, Williams et al. 2006). It has been argued that many of the benefits of ICM (e.g., improving environmental quality, protection of important landscape features, and long-term sustainability of fish stocks and biodiversity) are comprised of qualities that are neither directly measurable nor easily translated into monetary terms (Sorenson 2002, UNEP/CBD 2006), and can be overlooked by a society faced with more tangible evidence of the direct and indirect costs of ICM processes (e.g., restrictions on access to resources, limitations on coastal development, and reductions in fisheries quotas). In some countries, concerns were raised that the benefits accruing as a result of ICM may have been attributed to other government departments responsible for development planning and environmental protection (Billé 2007).

It is also important to note that the economic costs of inaction towards improving management in coastal areas are only rarely calculated or presented to governments or to the public, a situation made especially critical by the lack of adequate cost accounting of the failures to address the potential impacts of climate change (McLean and Tsyban 2001, Skourtos et al. 2005). While the loss of important habitats and species can impact tourism as well as the quality of life of local residents, failures to manage development or to protect significant coastal environments and resources can result in significant if not catastrophic impacts to coastal communities (Austin et al. 2007, Pendleton 2008). In 2001, Charles Groat, the director of the United States Geological Service (USGS) in Louisiana, reported that scientists had long been concerned that failures to better manage the pace of coastal development or to reduce the losses of natural buffers like coastal wetlands, marshes and barrier islands had left the coastline and the city of New Orleans at great risk from severe storm events and flooding (Zaffos 2006). When Hurricane Katrina hit the coast in 2005 the subsequent devastation validated the findings of Groat and others, wreaking economic as well as social havoc from which the region may never recover.

3.3.6 Lack of Interdisciplinary Science and Science to Government Collaboration

Coastal research continued to be challenged by limitations in funding support, open access to data, too few knowledge networks, and impediments to regionally scaled, long-term interdisciplinary research. Communication and linkages among academia, government, the private sector and community organizations were not working effectively, resulting in basic failures to share information, to set priorities for research, and to develop good practice (Degnbol et al. 2006, Doody 2003, French 2004, GESAMP 1996, Mercer Clarke and Bard 2007, Rees et al. 2008, UNEP/CBD 2006). As ICM evolved, efforts focused more on new governance processes and democratic participation in the setting of goals and priorities, and the role of science became increasingly marginalized (McFadden 2007, UNEP/CBD 2006). Science to management linkages eroded at a time when managers badly needed improved understanding of environmental threats and socio-economic pressures, accurate predictions of future scenarios and workable alternatives for action (Ernst 2004, Mercer Clarke et al. 2008, NRC 2000).

GESAMP (1996) and others (Cicin-Sain et al. 1998, Smith 2002) have long recognized that science played an important role in ICM and should be deeply entwined not only with policy and priority setting, but also with the identification and evaluation of options, and with decision-making on complex issues (Ducrotoy and Pullen 1999, NAS 2004, NRC 2000, Taussik and Gilbert 2002, Wells et al. 2002). As well success in ICM was considered to be dependent not only on the integration of the natural, social and applied sciences, but also on “interweaving the knowledge and insights that science can provide with the messy, value-laden processes of democratic participation and debate”(Olsen and Nickerson 2003, p 27). Despite these convictions, ICM initiatives continued to be challenged by limited funding and impediments to collaborative research especially at appropriate spatial, functional and temporal scales (ICES 2004, Mercer Clarke and Bard 2007). As the National Research Council (2000) noted in their report on *Bridging Boundaries through Regional Marine Research,* assessing and understanding the effects of natural changes and human-induced stresses on coastal ecosystems requires a broad perspective that can link local changes not only with local causes, but also with large scale changes in climate, physical processes, fishing, and land use practices. The report also concluded that “there is a dearth of regional programs with approaches to research and monitoring that are integrated and sustained sufficiently to develop an understanding of processes and changes that occur on the timescale of decades" (NRC 2000, p 68).

While there is open discussion of the inherent value to ICM of the social and applied sciences, coastal research and management has continued to be dominated by marine science disciplines (Endter-Wada et al. 1998). As a consequence, there have been concerns that rather than developing appropriate measures for social change, the focus has been on the protection of relatively un-impacted coastal ecosystems. Collaboration across academic disciplines was also complicated, especially in initiatives that included the applied sciences and the professions (planning, management, engineering, landscape architecture and architecture). Scientists and professionals desirous of working in interdisciplinary coastal research, especially on projects with a regional context, faced traditional academic disincentives to working with other stakeholders, and a lack of interest and support from governments and funding agencies (Chircop 2000, Taussik and Gilbert 2002, Turner and Bower 1999, UNEP/CBD 2006).

Uncertainty has been one of the most difficult and frustrating challenges facing productive interchanges between science and coastal managers. Effective collaboration between scientists and managers has been complicated by the inabilities of scientists to overcome data limitations, and to translate complex research findings into information of use to policy makers and the public (Turner 2000). Even when accepting the limitations of coastal data, governments continued to expect scientists to predict ecosystem change with absolute certainty (Sorenson 2002, Turner 2000). Browman and Stergiou (2004) found that all too often where there were inconclusive or dissenting scientific opinions, decision-makers would adopt a do-nothing response rather than act on the advice of inconclusive science. At the same time, in assessing the risk associated with forecasting of severe storm events, society has learned to accept that weather forecasting is not an exact science, and the path and intensity of storms can remain unpredictable. Faced with this level of environmental uncertainty, governments and individuals will still take action to protect populations and to avoid or minimize storm-related damage to infrastructure. Society is significantly less understanding of the limitations of coastal science, and less willing to apply precautionary approaches to management and conservation of resources, perhaps because we have been too cautious in our predictions of the intensity and fury of the gathering storm.

3.3.7 Limitations on Spatial and Temporal Data

One of the most enduring challenges to managing coastal areas was the pervasive lack of spatially and temporally relevant data on changing conditions (Burbridge and Humphrey 2003, ICES 2004, IOI 2006, Mercer Clarke and Bard 2007, UNEP/CBD 2006). The paucity of information on coastal change was not limited to developing nations or remote areas, but has been widely reported by countries throughout the world, including Canada and the United States (Brylinsky et al. 2005, Steel et al. 2005). Research initiatives remained fragmented and monitoring programs were poorly coordinated, reducing the potential for collaborative use of available data. Both Pauly et al. (2001) and Sorenson (2002) noted that not only was there inadequate time-series data to provide useful insight into the scope and pace of change in coastal ecosystems, there were too little data to support understanding of how coastal ecosystems function at a regional scale, and too few predictive models that could assist coastal managers to better understand the relationships between human activities and impacts to ecosystem resources and services.

Solving the dilemma on data limitations will not occur overnight, and while efforts are made to improve and standardize current information, ICM efforts should also utilize existing and emerging tools and technologies, be they remote-sensing, state of coast analyses, cost-benefit analysis, or resource valuation and accounting (Capobianco 2003). Predictive models operating at an appropriate regional or local scale could provide decision-makers and other stakeholders with an improved, albeit imperfect, understanding of existing conditions, the patterns of change, the opportunities and constraints of alternative management and development policies, and the consequences of do-nothing scenarios. With the rapid evolution of geographic information system (GIS) technology, there is considerable potential for the development of models that can do more than manage data, but that could also transcend the barriers between terrestrial and marine environments, link ecosystem services and flows and provide greater insight into the cause and effect relationships of individual and collective human activities (Bartlett and Smith 2005, Vallega 2005).

3.3.8 Lack of Capacity in Coastal Science and Management

Despite the availability of ICM education and training programs throughout the world, implementation of ICM principles and processes continue to be challenged by a lack of local and national capacity in coastal science and management (Burbridge 1997, Cicin-Sain et al. 2000b, Harvey et al. 2002, UNEP/CBD 2006). Effective ICM implementation relies on a range of professional skills and resources, and capacity short-falls could include not only insufficient university level training in the principles and practices of coastal management, but also limited technical resources (e.g., water quality monitoring and analysis), and enforcement instruments and staff (Burbridge 1997, Shah et al. 2007). Within governments, lack of capacity in understanding coastal issues and programs was reported at the national level where the policy and priorities for government were developed, in sectoral departments responsible for resource management, and at the local level where much of ICM implementation took place. Despite the real potential for effecting change in development decision-making, there were few examples where the principles or tools of coastal management were being taught within the professions of planning, architecture, engineering or landscape architecture (Sorenson 2002, Wescott 2002). In the developing world, where local staff can be well educated and trained in coastal management, there have been problems with work loads and access to resources that have resulted in over-reliance on non-local expertise and funding which contributes to program instability and can also impair efforts to capitalize on or to enhance local knowledge and skills (Cicin-Sain et al. 1995, Cicin-Sain et al. 2000b, Sorenson 2002).

3.3.9 Limitations to Participatory Management and Implementation

Broadening of participation in decision-making has always been a fundamental principle of most ICM processes, requiring not only democratization but also transparency of decision-making (Doody 2001, Ehler et al. 1997, IOI 2006, USAID 1996). However, as Cicin-Sain and Knecht (1998) discovered from their survey of coastal managers, only 47% had used consensus driven processes. And in the United Kingdom, where public participation is considered a keystone to success, Treby and Clarke (2004) concluded that after more than 30 years, efforts to broaden participation had limited effect. Clearly, to be considered successful, public participation in ICM must entail more than top-down communication of expert knowledge and opinions, or participation in lengthy discussions to decide upon ICM goals and priorities (Chaniotis and Stead 2007, UNEP/CBD 2006). Where the contribution of stakeholders to decision-making processes was ill-defined or non-existent, definition of goals and priorities proved elusive, sometimes spending too much resource on the viewpoints of the louder and more persistent voices. As a result, concerns were raised in some areas, including the United Kingdom, that consensus building processes had taken such a toll on time and resources that real progress towards coastal management had been sidelined (LGA 2001). Confusion over stakeholder responsibilities has also led to disillusionment when non-government participants were limited to advocacy and advisory roles, with decision-making authority retained by government. Even where local stakeholders were significantly involved in the development of coastal management plans, interest and momentum were lost when national governments failed to incorporate their advice, to adopt their plans, and/or to ensure long-term resources for local projects (Ballinger 2002, Belfiore 2000, Bennett 2000, Burbridge and Humphrey 2003, Burbridge 2004, Harvey et al. 2001, McGlashan 2002, Shipman and Stojanovic 2007).

When Poitras et al. (2003) surveyed coastal managers on the barriers to using and/or achieving consensus through participatory management approaches, the major issue citied was getting all parties to the table. A lack of trust among participants had led to non-participation and disenfranchisement. Whether the ICM initiatives encompass international, national or local communities, to be successful participatory management efforts must first build positive personal relationships, to foster shared trust in the process. Efforts required not only early engagement, but also commitments that the goals, benefits, incentives for collaborative action, and achievable milestones would reflect as far as possible the needs and aspirations of all participants (Mercer Clarke 2001a, 2001b). Ducrotoy and Pullen (1999) also recognized the linkages between trust and public participation and suggested that community-based organizations could play a more significant role by providing a credible voice for the dissemination of important information. This view is in keeping with the findings of Treby and Clark (2004) who believe that reliance on the traditionally accepted linear model whereby scientists turn facts directly into policy is detrimental to the inclusion of local knowledge and insights. They suggested that an alternative approach to effecting change through participatory management required a more complex view of societal behaviours that took into account cultural values and influences.

In their research on socially cooperative choices, Crance and Draper (1996) found that in addition to structural solutions such as legislation and institutional support, ICM processes needed to identify and implement behavioural solutions to social barriers.

ICM only rarely draws on the expertise vested in disciplines such as sociology, management and psychology to assist in the design of public participation programs. As a result there continues to be both a lack of knowledge on organizational dynamics and the drivers for human behaviour, and continued reliance on outdated methods to induce societal change (McKenzie-Mohr 2000, Ommer 2007). Community-based social marketing, which merges knowledge from psychology with the expertise and skills developed in marketing, is evolving as an important tool in many environmental management initiatives and could be equally effective in addressing behavioural barriers to ICM implementation (McKenzie-Mohr 2000).

3.3.10: Conflicting Time Scales for Management

As Crowder et al. (2006) noted, temporal mismatches between biological systems and human institutions have played a significant role in the continued degradation of marine and coastal ecosystems, especially when ecosystem changes were too gradual to be noticed or prevented, or too fast to be addressed within the time lags between policy and action. Natural scientists readily comprehended the need to allow appropriate periods of time to elapse before claiming either success or failure in ventures intended to achieve positive environmental results. Unfortunately, those time frames could be incompatible with political needs and/or terms of office, or with the funding time frames of national and international agencies (Nakashima 1997). Conversely, planning decisions that responded to political realities such as terms of office could focus primarily on short-term development gains, without sufficient consideration for development options that could contribute more positively towards achievement of long-term sustainability (Belfiore 2000).

In his review of progress towards the goals of ICM in Latin America and the Caribbean, Olsen (2002) reported that effective ICM implementation required adequate time and resources for the development of policy and planning frameworks, especially in those countries where ICM took on a broad geographic scope, in countries emerging from turmoil, or where available government infrastructure was limited. If ICM was to capture the attention of important decision-makers, it was concluded that coastal management plans based on long-term planning horizons (5, 25 or 100 years) should also include measurable objectives that could be achieved and reported upon within shorter terms more reflective of political time frames and program funding requirements (O'Riordan et al. 2006). Addressing both short and long term objectives and deliverables would allow sufficient opportunity for the benefits of ICM to emerge, and for the costs and benefits to be effectively reported at appropriately scheduled milestones and in language that was both comprehensible and unequivocal (Atkins Project Team 2004). As well, setting an appropriate time frame for ICM implementation would contribute to the flexibility needed to positively address new information and to adapt to changing conditions.

3.4 Plumbing the Depths

As Olsen (2000, p 335) put it, "if anthropogenic change to the world‟s coastlines continues over the next five decades at a similar pace to the one we have seen during the 20th century, measurable progress towards sustainable development will continue to lie off in the future". Even if the pace of coastal change slows, ICM will have a long path to climb from its current scattering of isolated efforts to initiatives of sufficient scope to significantly impact the well entrenched patterns of change that produce reductions in the qualities of the coastal regions." Despite its visionary goals and well defined principles, the ultimate test of the values of an integrated approach to coastal management is whether it can live up to its promises to improve our understanding of coastal processes and coastal change, to enable the resolution of conflict amongst users, and to ensure the sustainability of coastal environments and communities.

It is clear from this assessment that while there are a range of constraints to effective ICM implementation, there are ongoing and significant issues with the emphasis ICM places on the need for vertical and horizontal integration within government, as well as with the reliance on overarching command and control governance instruments. Integration as a concept for improved harmonization in governance has been appealing, but early support for integrated approaches to environmental management in many forms has now been challenged by researchers in other areas claiming that it is proving neither effective nor efficient (Bellamy et al. 1999). It is not surprising, as Friedheim (1999) noted, that despite our efforts to date, many of the decisions most critical to the future sustainability of coasts continue to be made outside the sphere of influence of ICM programs, lodged firmly within the economic development sectors of governments. The emphasis that was placed on environmental sustainability in many integrated environmental management documents may have been seen as a threat to the interests and autonomy of sectors of government most concerned with economic sustainability.

And while, in some coastal management circles, this emphasis on integration has been replaced with other paradigms such as ecosystem-based management, we appear to have learned little as the attention paid to economic issues continues to be both superficial and ambiguous (Vallega 2000).

To be positive, in much of the world, real gains have been made and can still be made by coastal management efforts that focus on developing goals shared by both environmental and economic interests, adapting existing legislation, regulations, standards and codes of practice to promote more sustainable decision-making, improving and supporting science to management linkages, engaging voluntary industry compliance, empowering the local community to actually take on management of coastal resources, educating and training the planning and design professions, requiring that all decision-makers be held accountable for their contribution to improving coastal conditions, and finally, improving respect and support for volunteer advocacy, monitoring and reporting activities. As others have done to exert positive changes in areas such as sustainable fisheries, water supply protection, and solid waste management, through educating our youth and training our professionals we can in a very cost effective manner advance the principles for sustainable use, protect coastal resources and ensure the stability of our growing coastal communities. But, and it is a large but, if as Klinger (2004) concluded, ICM is still our best approach to coastal management, there is an immediate need to apply our collective wisdom to the identification and resolution of the constraints to management at the speed that is necessary to outpace the challenges imposed upon coastal areas by this rapidly changing world. Renewing public and political interest and gaining long term support for coastal management initiatives will now become even more difficult, as the world faces economic downturns unheard of and unanticipated by this generation, and the emphasis moves strongly to restoring the financial well being of governments, industries, communities and individuals. As the UNEP Yearbook (2009, p 6) reported, management approaches that do not respond to, and adapt faster than, changing economic and environmental conditions will invariably fail, taking with them the societies that have been complaisant. For many in our generation, it is beyond our comprehension how, so quickly, we have lost the luxury of time.

3.5 The Next Steps

While the constraints identified and discussed in this chapter may not be new to experienced coastal managers, it is important that their contribution to the process of ICM implementation is respected and addressed as proactively as possible, so as to reduce their potential to negatively impact effectiveness of the coastal management initiative. Complaisance in the face of unchanging and significant constraints is unlikely to assist efforts to prove the benefits of an ICM approach, and has the potential to derail implementation entirely, to ensure that it poses no ongoing threat to the *status quo* of coastal development, or to ensure that additional funding support will not be forthcoming. Although not intended to replace comprehensive evaluation of progress in ICM, there may be considerable value, as a first step, in using a coarse constraint analysis to identify and assess problem issues using the following simple but important questions to which a yes or no answer may provide surprising insight.

- Are there within governments and the community shared goals for coastal area management?
- Are there commitments to change current practice?
- Is there adequate political and financial support to implement these changes?
- Can sufficient change be achieved within an acceptable time frame?

The next step would be a realistic and pragmatic assessment of the constraints, and the capacity of an ICM process to resolve them using available resources and in an appropriate time frame (i.e., can we fix that which is not working?). And if there are no clear and achievable alternatives to the problems identified in the constraint analysis, the final question would be whether to discard what cannot be fixed and move on.

With the longest coastline in the world, Canada already faces a complex array of spatial, environmental, cultural and temporal challenges in its efforts to sustainably manage the marine, aquatic and terrestrial resources that rely on coastal ecosystems for their survival. Efforts to date to implement integrated forms of management have been unsuccessful, with little documented effort to understand the causative factors for failure. Have Canada‟s efforts to implement integrated coastal management been plagued by similar constraints to those identified in other nations? Or are the failures in our initiatives the result of other factors unique to the Canadian experience?

CHAPTER 4:
INTEGRATED COASTAL MANAGEMENT IN CANADA:
AN ANALYSIS OF THE CONSTRAINTS TO PROGRESS

4.1 Introduction

While internationally recognized as a strong supporter of the need for a more holistic and integrated approach to management, Canada has yet to make substantive progress towards a national program for the planning and management of its own coastal areas (Ricketts and Harrison 2007). With the longest coastline in the world, and a relatively small population, in addition to science-based opinions (CEC 2008, Eaton et al. 1986, GOC/EC 1996, Stewart and White 2001, Wells et al. 1987, Wells and Rolston 1991, Wilson and Addison 1984), a simple search of the Internet will reveal that it is still commonly accepted that, as compared with other nations, Canadian coastal waters have remained relatively pristine. This complacency has effectively dispelled most compelling reasons for concern over the management of coastal issues. Faced with dramatically deteriorating conditions in coastal areas elsewhere in the world, within the scientific community there is a growing uneasiness that Canada may be equally vulnerable to growing, but unmeasured impacts from coastal development, resource extraction, land-based activities and climate change (Mercer Clarke and Bard 2007, Mercer Clarke et al. 2008). Canadians are rightfully looking to their governments to substantiate claims that the coasts remain relatively un-impacted, and to advance plans for managing coastal risks. Progress towards a national program of coastal management remains glacially slow (Ricketts and Harrison 2007), potentially threatened by the same constraints to implementation that have afflicted ICM efforts throughout the world (Shipman and Stojanovic 2007).

This Chapter examines efforts towards implementation of ICM in Canada, questioning whether the cycles of enthusiasm and apathy are the result of shared constraints to effective practice, or whether efforts to improve coastal management have been impaired by uniquely Canadian issues. This analysis of past and current experience within Canada also questions whether the impediments to integrated management are solvable within the time frame needed for change, and if not, what alternatives exist for achieving positive change in existing governance as well as societal practice.

4.2 Systematic Review and Meta-Synthesis of Canadian Experience

> *As a community of professionals, we need to critically evaluate our actions and continuously seek to increase our effectiveness. If we have done a lot of good things we should have the evidence to demonstrate it. But credibility is also about being self critical and identifying the bad as well as the good. (Pullin and Knight 2009, p 933).*

Within some fields of research, there has been a growing recognition that considerable knowledge lies buried within the experience-based reporting of both researchers and governments. Recognition of the need to consolidate the knowledge in this relatively untapped resource has led to the development of new deductive approaches to research that are intent on mining primary studies for important information that can be used to draw new conclusions on overarching issues (Petticrew 2001, 2003, Sutherland et al. 2004, Zhao 1991). From its earliest beginnings in medical disciplines, meta-research methodologies have rapidly evolved in scope and application to an expanding range of disciplines. Meta-research is especially appropriate to areas of research such as environmental management and ecosystem science, that are both blessed and cursed with an ever-expanding complex body of published and grey literature (unpublished but distributed reports by governments and environmental non-government organizations (ENGOs)), challenging the best efforts of both scientists and practitioners to remain current in their fields (Pullin and Knight 2009, Pullin and Stewart 2006).

This research applied qualitative meta-research techniques including a systematic review and meta-synthesis of coastal management experience in Canada as reported in the published and grey (unpublished) literature. The meta-synthesis of the findings of primary studies in the field contributed to a better understanding of the state of ICM experience in Canada, enabling the formulation of new conclusions and the development of alternative solutions, as well as providing insights into policy, practice and the need for additional research (Alavi and Carlson 1992, NAS 2004, Tranfield et al. 2003, Weed 2005, Zhao 1991). The research was grounded in established methodological rigour (Atkins and Louw 2000, Moody 2003, Petticrew 2001, 2003, Petticrew and Roberts 2006) intended to provide focus, ensure comprehensiveness of coverage, provide for insightful analysis of the relevant information, and where possible, reduce the potential for bias in synthesis and interpretation. During the Canadian assessment over 400 documents were collated and screened against criteria that included relevance to the research questions, trustworthiness of the reporting, and timeliness. Studies that met these criteria were examined in detail, and useful information was consolidated, integrated and re-interpreted within the context of the research questions. As determined for the international review, reporting on individual case studies at a local level was generally not included in this research due to the potential for a significant array of confounding factors unique to the local setting.

4.3 Progress towards Integration

For more than thirty years, efforts towards the development of a national framework for coastal management in Canada have ebbed and flowed like the tides. Integrated approaches to coastal management were first reported in Canada in the seventies (Johnston et al. 1975) when a number of collaborative symposia focused attention on the development of a national framework for coastal management (CCREM 1978, GOC/EC 1972, Hare 1978). The early development of the Victoria Principles and other publications of the time recognized the importance of shore areas and the need for a cooperative approach to management that involved (CCREM 1978, Day and Ricketts 1984, Harrison and Parkes 1983, Parkes and Manning 1998):

- coordination of government policies and programs;
- recognition of the role of local governments and the contribution of industry;
- protection of public access;
- conservation of sensitive and significant areas;
- development of dedicated information support systems; and
- a renewed effort to enhance public awareness of coastal assets and coastal issues.

Publication of the Victoria Principles was followed in 1980 by the establishment of the federal Shore Zone Directorate, a short-lived agency that was the first in a series of similar coastal initiatives that would promise great change but all too quickly would succumb to diminished political interest and budget cuts. In the same year that the Directorate was closed, Hanson (1983, p 9) concluded that interest in coastal management in Canada "had died a gentle almost painless death".

It is somewhat ironic that as the sun was setting on coastal management along Canada"s home shores, the federal government was moving to provide global support for ICM practice in other countries. Responding to the extension of national marine jurisdictions to 200 nautical miles, Canada established the short-lived International Centre for Oceans Development (ICOD) to enable Canadian expertise to provide assistance to developing countries and through training, to improve local capacity in the integrated management of their coasts and oceans (GOC/CIDA 1998). Yet while there has since been an array of initiatives and publications that have supported the implementation of an integrated approach to coastal management in Canada (Table 4.1), there is still as yet no national policy or framework (Chircop and Hildebrand 2006, GOV/EC 1996, Hildebrand 1989, Hildebrand 1995, Hildebrand and Norrena 1992, Hildebrand et al. 2002, NRTEE 1998, Parkes and Manning 1998, PWM 1992, Ricketts and Harrison 2007).

Table 4.1: Some of the Steps towards Coastal Management in Canada

Approx Date	Event or Publication
1978	Publication of the Victoria Principles at the Shore Zone Management Symposium (Victoria, BC), (CCREM 1978)
1980-83	Creation of the Federal Shore Zone Program (FSZP)
1980	Creation of the Associate Committee for Research on Shoreline Erosion and Sedimentation (ACROSES), National Research Council
1985	Workshop on strategic planning for the coastal and marine environment (DPA 1985)
1985-93	Establishment of ICOD (GOC/CIDA 1998)
1987	DFO Policy on Oceans
1989	Gulf of Maine Agreement and Action Plan
1992-1995	Framework for the Management of Marine Environmental Quality within the Federal Govenment
1993	Establishment of the Atlantic Coastal Action Program (ACAP)
1994	Establishment of the Coastal Zone Canada Association
1994	Coastal 2000 Policy in Nova Scotia (GOV/NS 1994)
1995	Signing of the UNEP GPA for the Protection of the Marine Environment from Land-based Activities (GOC/DFAIT 2007)
	Establishment of the Frazer River Estuary Management Program (FREMP)
1996-04	Creation of the Bi-national Global Programme of Action Coalition for the Gulf of Maine (GPAC) (Mercer Clarke 2001a)
1996	Canada Oceans Act (GOC 1996a)
1998	Government of British Columbia Coastal Position Paper
1999	Policy and National Framework for Marine Protected Areas (GOC/DFO 1999)
2000-05	Minister of Fisheries and Oceans Advisory Council on Oceans
2001-09	Oceans Management Research Network (OMRN)
2001	The Intergovernmental Montreal Declaration on the GPA on Land-Based Activities
2002	Canada"s Oceans Strategy (GOC 2002)
2002	Canada"s National Programme of Action for the GPA on Land-Based Activities (GOC/EC

Approx Date	Event or Publication
	2000, 2001a)
2003	Ratification of the UN Convention on the Law of the Sea (UNCLOS III)
2004	Canada-British Columbia MOU to Implement the Canada"s Oceans Strategy
2004 -	Deputy Minister"s Interdepartmental Committee on Oceans (DMICO)
2005	Policy and National Framework for Marine Protected Areas (GOC/DFO 2005a)
2005	Oceans Action Plan: Phase I (GOC/DFO 2005b)
2005	New England Governor"s and Atlantic Premier"s Oceans Working Committee
2005	A Coastal Areas Protection Policy (GOV/NB 2005)
1996	Implementation of the DFO Large Ocean Management Area (LOMA) pilot projects
2007	Ministerial approval of the Eastern Scotian Shelf Integrated Management Plan (GOC/DFO 2006b)
2008	Development of a Coastal zone management framework for Nova Scotia (GOV/NS 2008)
2008	Symposium for a Canada"s Ocean Commission. Suzuki Foundation. Ottawa

In a recent survey of over 100 individuals from across Canada, many of whom are actively involved in oceans science and management, most respondents felt that Canada"s oceans were under tremendous stress and rated current conditions in both oceans environments and in coastal communities at only fair to poor (DSF 2008). Over 75% felt that, despite the high calibre of Canadian ocean and coastal scientists, there were significant gaps in the data on current conditions, and dwindling government support for monitoring and research. Respondents were also concerned over the seeming inability to link existing knowledge to government policy and priority setting. Though practitioners remain positive, it is clear that progress towards ICM remains glacially slow (Ricketts and Harrison 2007), marked by periods of high interest and activity followed by steady declines by governments to make needed changes to policy or to continue support for local efforts. This pattern of raised expectations and diminished hopes has been repeated in some form in every decade since the seventies, and continues to plague current efforts towards ICM in Canada.

4.4 Constraints to ICM Progress

When Johnston et al. (1975) first examined the opportunities for a new framework for coastal management in Atlantic Canada, they concluded that the following three legal and administrative elements were individually and collectively constraining intergovernmental collaboration:

- a lack of consensus on spatial or functional definitions for coastal areas;

- a corresponding overlap in jurisdictions, roles and responsibilities among governments and departments; and
- a lack of support from key individuals within governments for coordinated policy or management.

In his 1995 review of coastal management in Canada, Hildebrand (1995) found that these same issues continued to impede progress towards the development of ICM initiatives throughout the country. Hildebrand also identified other confounding issues such as:

- the perception of coastal resources as common property;
- a lack of both public awareness and political interest in coastal issues or impacts;
- continuing federal-provincial conflicts over jurisdictions and continuing management by sector; and
- no clear motivation for implementation of a more integrated form of coastal management.

Yet despite these impediments, Hildebrand was able to report on positive changes in social attitudes, policies and practices that had occurred during the 1980s and early 1990s, including:

- recognition of the need to define the coastal zone by local issues and physical, ecological, cultural, economic and political considerations;
- use of watershed and natural boundaries to establish emerging ICM programs;
- recognition of the need to balance multiple uses and to manage at the local level;
- enhanced public, government and political awareness as a result of both state of the environment reporting and dramatic environmental crises such as marine transport oil spills and fishery collapses;
- the inadequacy of existing management systems to address the obligations tied to Canada‟s participation in international accords and treaties;
- dramatic social, economic and environmental declines and the increased public desire to take a more active role in decision-making;
- recognition of shared versus divided responsibilities for planning and implementation;
- rationalization of government responsibilities at the federal level and harmonization with the provinces;

- emphasis on integrated policy and coordinated efforts; and
- new legislation that directly and indirectly affected efforts in sustainable coastal management and protection.

There is little doubt that in addition to the positive changes reported by Hildebrand, there have been successful efforts to control the deposition of persistent pollutants, to move towards sustainable fisheries, and to curtail the destruction of habitats. But as was evidenced by the findings of the recent Canada-Nova Scotia Joint Review Panel on a proposed quarry and marine terminal, the gaps that still exist in governance processes within coastal areas can allow for both resource use and development activities that are likely to cause significant adverse environmental effect and are not in the best interest of sustaining coastal environments or communities (JRP, 2007). In this instance, the Panel voiced similar and growing concerns of other decision-makers throughout the country, that a lack of coastal policy and planning instruments at both the federal and provincial levels of government were contributing to conflicting goals and practices on coastal resource and development management.

It has been over 35 years since the review by Johnston et al. and over a decade since the review by Hildebrand Given the declining state of coastal conditions in other countries, and the questions arising over ICM effectiveness throughout the world, this is a good time to reassess Canada"s commitment to the need for integration in coastal governance. To better understand the impediments to coastal management in Canada, and drawing from the work of Johnston et al. (1975), Hildebrand (1989, 1995), current ICM practice in Canada was examined in the context of the challenges faced by this and other nations including:

- confusion over coastal boundaries;
- limitations in spatial and temporal data;
- differing perspectives and conflicting goals;
- lack of political will and long-term support;
- lack of vertical and horizontal integration in government;
- failures to identify the economic benefits;
- limitations to participatory management and implementation;
- lack of capacity; and the
- lack of interdisciplinary science and science to government collaboration.

4.4.1 What is a Coast in Canada?

Within Canada, only two provinces are without a marine shoreline (Alberta and Saskatchewan) yet after more than 30 years of discussion and debate, there is still no consensus on the spatial, jurisdictional or ecological boundaries of coastal areas (Fanning 2008, Hildebrand 1989, Hildebrand 1995, Ricketts and Harrison 2007). Coasts remain a no-man‟s land where “everyone claims a piece of the action but no one has yet been prepared to accept responsibility for holistic management” (Hanson 1983).

International guidance on successful ICM implementation has continued to emphasize that formal designation of coastal boundaries is an important initial step in ICM (Belfiore et al. 2006). For many countries, boundary-setting relied on marine law to prescribe precise limits for federal and provincial jurisdictions, national ownership and international freedom of use (Tanaka 2004). Canada‟s Oceans Act (GOC 1996a) has relied almost exclusively on this tradition of international marine law and provides only a definition for coastal waters*,* which are defined as marine and estuarine waters that extend seaward from the low water line (baseline) for twelve nautical miles. Landward of the low water mark, the Act provides only for the management of activities and measures that might affect coastal waters. As a consequence, the Act has done little to alleviate ongoing confusion among all levels and sectors of government over coastal responsibilities for land-based activities, and has further complicated the hope for a more holistic approach to coastal management (one that would include land-based activities) by designating the Department of Fisheries and Oceans as the federal agency responsible for leadership in ICM.

Debate also continues over the real or perceived rejection of the Great Lakes as the fourth coast of Canada, a discussion that began as early as the 1970s (CCREM 1978, Hanson 1983). Unlike the United States, which includes the Great Lakes (the sweetwater ocean) in its national and state coastal management strategies, the federal government of Canada has made it clear that all waters to the landward side of the oceanic low water baseline, including the Great Lakes and the St. Lawrence River, are defined as the internal waters of Canada. As such, they are not coastal waters and are not included in national integrated management initiatives as proposed under the Oceans Act.

Since the earliest days of ICM efforts in Canada, practitioners have been convinced that consensus on spatial definition of the coast was not achievable (Johnston et al. 1975). Since that time, as Hildebrand reported it (1995, p 65), proponents of coastal management have consistently fallen into an “unfortunate and debilitating black hole”, dug deeper by their convictions that coastal definition was a necessary first step towards ICM. Whether boundaries are based on political divisions, sectoral responsibilities, ecosystem requirements or watershed areas, spatial and temporal mismatches of scale and function will occur. Both Chircop (2000), as well as Parkes and Manning (1998) have cautioned that the time and resources wasted arguing about what constitutes the coastal zone would be better spent deciding what needs to be done, how it can be achieved and getting on with it in the context of the resources we have at hand.

4.4.2 Are Canada’s Coasts in Peril?

For the past twenty years, state of environment reporting for coastal waters in Canada has depended on data that are spatially and temporally limited and predominantly focused on marine water chemistry, point source pollutants, and commercial species management (Mercer Clarke and Bard 2007, Mercer Clarke et al. 2008). In recent years there has been a growing unease within the scientific community that conclusions on coastal well being continue to be based on outdated information and reliant upon the available data as opposed to needed data; that for vast areas of the coast there is no information; and that monitoring efforts to supply new data continue to be constrained by resource limitations (GOC/DFO 2006a, Mercer Clarke and Bard 2007, Vandermeulen and Cobb 2004, Wells 1996). Following a national review of information on nutrification of Canadian coastal waters, Brylinsky et al. (2005) reported that, where data did exist, they were fragmented and difficult to apply to assessments of regional conditions. Furthermore, with the exception of Prince Edward Island, there had been few attempts to link land-based activities with coastal water quality. When reviews of marine water quality (Breeze et al. 2002, Breeze and Horsman 2005, Stewart and White 2001, Zaloum 2003) were examined more closely, it became apparent that most of the information had been collected from sites in excess of three kilometres offshore. Data on nearshore conditions were limited, and where they did exist were most often focused on point source effluent sites (Brylinsky et al. 2005, GOC/DFO 2006a, GOC/EC 2001b). Yet even recognizing these limitations, there appears to be a continuing complacency that while there are some areas of significant contamination (e.g., major ports and industrial centres), the majority of the coast remains relatively pristine and un-impacted by human activities (Eaton et al. 1986, GOC/EC 1996, Stewart and White 2001, Wells et al. 1987, Wells and Rolston 1991, Wilson and Addison 1984). Perhaps as a consequence, neither the national indicator programs for state of the environment nor those intended to track progress towards sustainable development have to date included indicators reflective of coastal environmental conditions (Bond et al. 2005a, 2005b, GOC/EC 2003, 2005, 2008, NRTEE 2003, UNEP 2006a).

Almost thirty years ago, Harrison and Parkes (1983) concluded that while most of the coast in Canada is in the far North, remote from the majority of the population and essentially undeveloped, Canada"s southern coastal areas are intensively settled and subject to development pressures similar to those experienced by urban and industrial coasts throughout the world. In his work on shifting coastal populations, Manson (2005) concluded that 38% of Canadians now live within 20 km of a marine coast or a Great Lakes shoreline, and by 2015 that number could grow to over 50%, many of them residing with 5 kilometres of the shore. Yet as a result of the continuing and pervasive lack of current information and cutbacks to both science and monitoring budgets, knowledge on coastal conditions in Canada could at best be described as inconclusive, with little growth in understanding the linkages between development on the land and the effects on nearshore coastal waters. When increasing pressures from resource exploitation and changes in land cover are coupled with growing concerns over the effects of sea level rise and severe storm events, Canadian scientists and managers are struggling to better define existing conditions in our coastal areas, at a time when there is little doubt that significant change has already taken place.

4.4.3 Change and Conflict in Perspectives and Goals

As a result of either declining or growing populations, modern technologies, new economies and associated cultural shifts, coastal communities and environments within Canada are undergoing a level of dramatic and pervasive change that is not unlike the dislocation and distress that occurred at the end of the 18th century as a result of the industrial revolution (Coffen-Smout 1996, McNiven et al. 1997. Ommer 2007. Sinclair and Ommer 2006). While change can be detrimental to current conditions, it can also form the basis for invigorated strength and growth in both human communities and ecosystems. As Brown (DSF 2008) has noted, within society an environmentally concerned citizenry can associate economic development with biodiversity loss, while economic interests can view environmental protection and conservation efforts as being detrimental to wealth generation and the security of their livelihoods. Throughout Canada there has been a population shift from the predominantly rural-based economies of the 19th century to the urban-based economies of the 21st century (McNiven et al. 1997). In some coastal communities, failures in traditional fisheries have contributed to economic and social decline, while in others broadened awareness of coastal amenities has given rise to increased coastal tourism and enhanced the popularity for non-resident coastal living. The changing demographics may also have contributed to soaring real estate values, prohibitive residential property taxes, increased demands for municipal services, and differing societal perspectives on public access and utilization of formerly shared coastal resources, especially when new residents come from urban cultures or other countries (Fawson 2004, Manson 2005, RCIP 2003). When coupled with the belief that coastal environments within Canada are vast, un-impacted and able to withstand considerably more pressure from human activities, conditions within coastal communities and economies are rife with competing goals, opposing viewpoints, and a growing potential for conflict.

Where conflicting perspectives and goals for land and resource management have resonated horizontally and vertically throughout government policy, the situation has resulted in priorities and programs that work in opposition to each other, and actively resist efforts towards harmonization or integration of public administration. In the absence of either national or local strategies for coastal development, conflicts have arisen when proposed economic development is at odds with coastal community values and goals. Without a level playing ground for the planning and regulation of coastal development at or near the coast, private sector initiatives, whether residential or industrial, face myriad and disparate policies and requirements, administered by different levels and sectors of governments.

4.4.4 Changing Times and Dwindling Political Will

As noted by Belfiore et al. (2006), legislation alone is not sufficient to provide an enabling environment for ICM implementation. There must also be political support for activities and resources that reinforce the legislation and promote its application. In his second review of ICM progress in Canada, Hildebrand (1995) reported that the major stumbling block to the development of national policy and process for ICM had been the lack of political will. In 1996, as part of a comprehensive review of Canadian ocean policy and practice, participants voiced concerns that despite Canada"s adoption of the principles of sustainable development and integrated management of oceans and coasts, national policy continued to be driven by economic issues such as profit motivated resource utilization and government support for unsustainable economic practices (Coffen-Smout 1996). In recent years, a number of national collegia of coastal and oceans managers have voiced their concerns over the lack of government leadership, and the continuing inability to link existing knowledge to government policy and priority setting for oceans and coasts (DSF 2008, GOC/DFO 2006a, OMRN 2007, PNCIMA 2007). But as Parkes and Manning (1998) recognized, coastal management is but one of the competing demands for decreasing public funds. Given that the conditions that contributed to political apathy in the past remain valid in today"s Canada, it is not surprising that political support for coastal management is once again declining, a situation that is not improved when the potential benefits of ICM are not just weighed against the costs for implementation, but must also compete with public concerns arising from the current economic recession.

4.4.5 Who's Got the Helm? Failures to Integrate in Government

It has been said that coastal landscapes, characterized by the complexities created when air, water and land meet, are also the place where government jurisdictions collide, and responsibilities and priorities divide. Historically this has clearly been the case within Canada where there is a complex network of government agencies that directly or indirectly have responsibilities to manage some element or activity that falls within a coastal area (GOC/DFO 2009a, 2009b). It must be noted that in general, coastal management in Canada, in accordance with the definitions provided in the Oceans Act (GOC 1196a), does not include inland waters (e.g., the Great Lakes), and has been restricted to the management of marine and estuarine waters. Lack of vertical and horizontal integration and harmonization of policies and programs has long been cited as a primary obstacle to the development and implementation of effective coastal management in Canada (Beanlands 1983, Chao 1999, Hildebrand 1995, Johnston et al. 1975).

Canada is a federated state, where authority and responsibility for marine waters is vested with the federal government, but the rights and responsibilities for the stewardship and management of coastal resources can be shared among the federal, provincial and municipal levels of government, and with the First Nations and other Aboriginal peoples. In its simplest interpretation, ownership of natural resources and public lands within Canada has been vested with the provinces. Consequently, landward of the high water mark on shorelines, the responsibility for managing land and land-based resource development has fallen primarily under the jurisdictions of provincial and municipal levels of government, and has not historically been considered as a component of coastal management. Provincial and territorial ownership and authorities can also be complicated by the rights of jurisdiction over coastal resources that were vested within their terms of confederation with Canada. In more recent times, new and historic treaties and agreements with the First Nations, Tribal Councils and other Aboriginal peoples have also played important roles in determining rights and responsibilities for the stewardship and management of marine and coastal resources, and for the establishment of coastal and marine protected areas. In a summary of provincial and territorial roles and responsibilities for the oceans sector prepared by the DFO, consideration was given only to those resources and human activities (i.e. aquaculture, oil and gas exploration and production, tourism) that essentially either take place below the high water mark or are related in some way to the maintenance of harbour infrastructure (GOC/DFO 2009b).

While the Department of Fisheries and Oceans has the lead oceans role, twenty-nine other federal departments and agencies also have authorities and responsibilities through oceans-related policies, programs, services, regulations, and or procurement requirements (GOC/DFO 2009a). In most instances the management of inland waters (including the Great Lakes) generally falls under the authority of the provinces, though in some circumstances the federal government shares its responsibilities (e.g., pollution control, fish habitat protection) with a province. Similarly there are situations where fisheries are co-managed with the local community and/or with First Nations, Métis and other Aboriginal groups (Berkes 2001, Vodden and Kennedy 2006). Some overlap of federal and provincial jurisdictions also occurs when the management of large bodies of water is shared through international agreements, such as the work of the International

Joint Commission between Canada and the United States which oversees management of a number of trans-boundary rivers and the Great Lakes (IJC 2009).

To add to the complexity of the current structures of coastal governance in Canada, there is little harmonization among policies, goals, objectives and programs (Mercer Clarke 2005, GOC/DFO 2009a, 2009b). As is the case in many industrialized countries, there appears to be both an ideological and a functional gap between departments responsible for economic development and those responsible for environmental protection and conservation. Further, perhaps because of their focus on land-based management and development, provincial and municipal governments have until recently only rarely considered the potential for impact to coastal receiving environments in their planning and decision-making (Mitchell 2004).

For some time now, Canada has recognized that policies and practices intended to support the implementation of principles of sustainable development throughout government have largely been short-term, piecemeal, and fragmented (Gélinas 2002, 2005). Under the much anticipated Oceans Act (1996), the federal Department of Fisheries and Oceans (DFO) was made responsible for providing leadership in the development of a national strategy and integrated management plan for all activities affecting estuaries, coastal waters and marine waters (GOC 1996a). While the Act was to provide needed leadership towards an integrated approach to coastal and oceans management, by 2005 the Commissioner for Environment and Sustainable Development concluded that the pace of progress had been unacceptably slow (Gélinas 2005). Given the shared and overlapping jurisdictions over water, the lack of federal powers over land management, and the fisheries management mandate of the DFO, concerns were raised early in the process as to how effective integration of coastal management could be achieved with the DFO as the lead agency. By 2000, the DFO had initiated integrated management programs in a number of Large Ocean Management Areas (LOMAs) off both the Pacific and Atlantic coasts (Chircop and Hildebrand 2006, Coffen-Smout 2002, GOC/DFO 2008, Smith 2005). Priority has been given to management of deeper, offshore waters (>50 metres depth) located seaward of the 12 nautical mile limit of the territorial sea, but the DFO has expressed its intent to use the experience gained to promote integrated management approaches in coastal waters. Resources provided through the Oceans Strategy and Phase I of the Oceans Action Plan were largely expended on improvements to fisheries and Coast Guard infrastructure (GOC 2001, 2002). With a change in the political structure of the federal government in 2006, political support has dwindled for the promised Phase 2 of the Oceans Action Plan, which was to have more fully addressed coastal management initiatives. While Provincial Oceans Networks (PONs) comprised of federal and provincial representatives from environment and fisheries departments have been established, progress remains slow, and does not yet include other sectoral departments. As Hare (1978) noted over thirty years ago, there is still no legislation similar to the Coastal Zone Management Act of the United States that would link federal and provincial authorities and jurisdictions in the coastal landscape and provide for collaborative management across the land-water divide.

Responding to its commitments under the Global Programme of Action for the Protection of the Marine Environment from Land-based Activities (UNEP/GPA 1995), Canada‟s National Programme of Action (Arctic Council 1998, GOC/EC 2000, 2001a) recognized the potential for impact to the coastal zone from land-based activities, and the need for more holistic, eco-system-based approaches to management, especially in immediate nearshore environments (O'Boyle and Keizer 2003, O'Boyle et al. 2005). However, with the notable exception of the short lived bi-national GPAC (Global Program of Action Coalition for the Gulf of Maine 1997-2003) initiative (Mercer Clarke 2001a, 2001b), federal efforts to link land use and coastal management have been limited in both area and scope, and largely reliant on established regional, watershed or river basin management programs (BIEAP 2001, BoFEP 2002, 2005a, FBC 1998, FREMP 2003, GBAP 2003, GOC/DFO 2006c, GOMC 2007, UINR 2004).

Given the limited progress in federal leadership on coastal management in the decade since the Oceans Act was passed, provincial and territorial governments have themselves begun work on coastal management initiatives (Binkley et al. 2006, GOV/BC 2006, GOV/BC 2009, GOV/NB 2005, GOV/NL 2007, 2008, GOV/NS 1990, 1994, 2008). International collaboration with the United States continues with the work of the International Joint Commissions (e.g., Great Lakes, St. Croix River, Columbia River) and in marine waters shared with the United States (e.g., British Columbia‟s Georgia Strait and the Gulf of Maine) (AGL 2007, GOMC 2007, IJC 2009, Hildebrand et al. 2002), but there is no established national framework that links any of these initiatives, or provides easy access for the sharing of knowledge, insight or resources At recent gatherings of highly respected scientists and government managers (DSF 2008, OMRN 2007), participants have summed up their frustrations on the current state of oceans and coastal management by stating their fears that environmental conditions continued to deteriorate, overfishing was continuing, funding for science was insufficient, and that the Oceans Act, by then over ten years old, had simply not lived up to its potential.

4.4.6 Tallying the Costs: Economic Benefits Versus the Price of Inaction

> *Current marine resource management and allocation policy, in Canada and many other national jurisdictions generally subscribe to three objectives. These are: (1) ecological sustainability (i.e., protecting ecosystem health and diversity); (2) economic goals (e.g., maximum efficiency, generating and maintaining income and employment); and (3) social outcomes (e.g., reducing conflicts, promoting equity and fairness, maintaining social and cultural qualities of the communities). Operationally, these objectives are frequently found to be in tension, if not in outright conflict. For instance, while many ecological and bio-economic models and market-based mechanisms have been developed to assist managers with attaining ecological and economic goals, very little effort has been devoted towards achievement of social objectives. In fact, the interests and agents of economic development, masked in policies promoting rational economic utilization and efficiency, typically supersede concerns about both ecosystem and community sustainability. (Davis and Wagner 2006, p 491)*

Within Canada and elsewhere, efforts to identify and document the economic benefits provided by the coastal and oceans sector have generally focused on marine resources, marine industry and marine transportation (IC/NRC 2005, MERA 1998, OSTP 2007). Activities that are largely land-based, such as coastal tourism and urbanization, have been imperfectly captured in either local or national statistics (Charles et al. 2005). As a consequence, accurate assessment of the economic contribution of coastal ecosystem goods and services continues to be a complex and elusive task, confounded not only by the lack of data, but also by the difficulties encountered when ascribing economic values to intangible assets (Charles et al. 2005, Charles et al. 2007, Gill et al. 2003, Sikaneta and Evans 2006). As Parkes and Manning (1998) noted, only rarely have industrial sectors been active partners in the planning or management of coastal areas. Given the continuing societal emphasis on economic versus environmental goals, it is not unexpected that the linkages between environmental degradation, socioeconomic well-being and human health remain poorly understood. It is also worthwhile to note that some economic benefits that accrue to industries located in close proximity to a coast (i.e., the intake of cooling waters, and the discharge of wastewaters) are seldom calculated, while the associated costs of impacts to nearshore ecosystems are considered an acceptable trade-off for economic prosperity. While recent studies in the Great Lakes and Atlantic Canada have confirmed that under-investment in ecosystem protection and conservation will result in considerable short and long-term economic impacts to ecosystem goods and services, estimating and communicating the direct and indirect costs of damage to habitats, species and amenities continues to be a challenge (Austin et al. 2007, Charles et al. 2005, Emerton and Bos 2004, Gardner et al. 2005, Gardner et al. 2009, Pendleton 2008).

To further emphasize the need for improved economic accounting of coastal resources, and the impact of the do-nothing responses, there is growing awareness throughout the country that coastal communities and ecosystems are extremely vulnerable to climate change impacts such as sea level rise and severe storm events (C-CIARN 2004a, 2004b, EAC 2007, Holland 2002). Predictive models have been used to project the impacts to coastal infrastructure, categorizing not only the disruption to services, but also calculating the financial impact if buildings, roads, and utilities are damaged, or have to be relocated (GOC 2003a, GOC/EC 2006, McCulloch et al. 2002). Concerns are growing over the resilience of aging small craft harbour infrastructure such as wharves and breakwaters, which already need costly repair and replacement but which are the mainstay of coastal fisheries and tourism (CCN 2004), as well as over the direct and indirect costs of disruption or loss of habitats and species, and damage to coastal beaches (EAC/CCN/CCNS 2007). And perhaps even more disturbingly, a recent report to the Senate of Canada concluded that the current state of emergency response measures in this country leave Canadians ill prepared to adequately respond to the increased frequency and severity of storm events and the potential for associated environmental disasters (GOC 2008b).

4.4.7 Dashed Hopes: The Constraints to Participatory Management

Some of Canada"s greatest successes towards ICM have undeniably been achieved at the local level where community-based organizations have become strong advocates for improved science, integrated decision-making, and change in planning and development policy and practice (Bastien-Daigle et al. 2008, Berkes et al. 2007, Berkes et al. 2001, McCleave et al. 2003, McNeil et al. 2006, Omner 2007, Parkes and Manning 1998). When Canada speaks on the world stage of its advances towards coastal management, inevitably there are references to successful participatory management initiatives, networks and partnerships such as the Atlantic Coastal Action Program (ACAP) (Chircop and Hildebrand 2006, Ellsworth et al. 1997), the Fraser River Environmental Management Plan (FREMP 2003), the Georgia Basin Action Plan (GBAP 2003), the Global Programme of Action Coalition for the Gulf of Maine (GPAC) (Mercer Clarke 2001a), the Southern Gulf of Saint Lawrence Coalition (SGSLC) (Bastien-Daigle et al. 2008), the Great Lakes Coalition (Sproule-Jones 1999). Yet for many of these universally underfunded and largely volunteer organizations, government respect and financial support has been hard to get and difficult to keep (Hildebrand et al. 2002, Kearney et al. 2007, LEPS 2003, Reid 2004). As a consequence, collaborative organizations and networks, such as the Atlantic coast"s Bay of Fundy Ecosystem Project (BOFEP), the Clean Annapolis River Project (CARP), and the GPAC, have continued to struggle, barely surviving on uncertain financial resources and the volunteer actions of participants drawn not only from local citizenry, but also from government staff, academia, private sector, and First Nations. Government policy not to provide financial assistance for core services such as planning and administration has resulted in an over-reliance on short-term project funding, placing considerable additional burden on the backs of already over-extended volunteers and staff.

Community-based management initiatives in Canada began in earnest in the 1990s to respond to local interest in participating in resource management, to address environmental issues, and to fill a governance vacuum caused by continuing cutbacks to staff and budgets. Devolution of management responsibilities to locally trained and active community organizations was intended to provide a sense of shared vision and purpose, improve public knowledge, assist with monitoring and reporting and contribute directly to the sustainable management of communities and environments (Berkes et al. 2007, Chircop and Hildebrand 2006, Ellsworth et al. 1997, Kearney et al. 2007, Monette

2000, Sable et al. 2007). However, the hopes of many community participants that local watershed or coastal management organizations would assume responsibility for co-management of resources and development have been consistently dashed (Davis and Wagner 2006, Hildebrand et al. 2002, Reid 2004). As Vodden and Kennedy (2006) and Rothwell and VanderZwaag (2006) have cautioned, expectations that the First Nations are moving steadily along a continuum from colonialism to actual self-government does not reflect the complex realities of their relationships with governments on any of Canada"s coasts. And as Huggett (1998) reported in his review of federal interventions in coastal planning, the Atlantic Coastal Action Program (ACAP) was intended as a vehicle for the development of comprehensive environmental management plans for 13 harbours and estuaries. In reality, few levels or sectors of government have assigned actual planning or decision-making responsibility or authority to these or any other CBM organizations (Davis and Wagner 2006, Kearney et al. 2007, McCleave et al. 2003). Without an actual management role, CBMs have continued to improve community awareness but have had limited success in achieving needed change to societal activities (Bastien-Daigle et al. 2008).

CBMs in Canada have proven their ability to establish expert and stable platforms for monitoring and restoration programs, to provide employment opportunities and to mentor young coastal managers and scientists, and to develop successful partnerships across academic, governments, the private sector and the First Nations (Berkes et al. 2001, Chircop and Hildebrand 2006, Kearney et al. 2007, Pearce 2009). Despite the ongoing policy and framework vacuum for local coastal governance, there is a growing need to recognize the important contribution that collaborative efforts among volunteer organizations and municipal governments can make. There is demonstrated experience that CBMs can contribute to improved coastal planning and decision-making, the development of trusted communications on environmental conditions, the creation of peer to peer networks that assist with voluntary enforcement, and the augmentation of declining government resources with trained volunteers and staff. Yet without the continuity that results from stable funding programs, it is difficult to develop and maintain requisite staff expertise and experience or to provide needed quality assurance within monitoring and data analysis programs. While important, the collection of data, without analysis or needed follow-through to management decision-making and policy formation, can render important local volunteer efforts ineffectual (Bard 2006).

4.4.8 Failures to Pass the Torch: The Dawn of Limited Capacity in Coastal Science and Management

Since the earliest days of ICM, Canada has been an international leader in the training and education of coastal and oceans managers. Coastal and marine governance programs such as those offered by the International Oceans Institute (Canada) (IOI-C) at Dalhousie University, have graduated over 1000 alumni who now work in marine management throughout the world (Coffen-Smout 1996). However, for many years the IOI curricula remained focused on marine rather than coastal management. As well, most of the graduates of the Halifax program have been international students as opposed to Canadians. Several universities throughout the country, including Dalhousie"s School of Planning and Marine Affairs Program, now offer some training in coastal planning and management, yet within the applied science disciplines (architecture, landscape architecture, planning and engineering), with the exception of directed graduate research programs, there has been limited integration of coastal management within the curricula of professional degrees.

Government departments have also faced years of budget restraint and cutbacks, resulting not only in reductions in the numbers of marine scientists in government and academia, but also in failures to provide opportunities for new graduates, many of whom have moved on to other fields of endeavour or to other countries. As a result, much of the knowledge base on the coasts is now vested within an aging cadre of individuals, many of whom work in relative isolation and without supporting frameworks on coastal policy or management. Progress to date can be attributed to their ad hoc personal networks and to the commitment and willing cooperation of their colleagues in other departments and sectors. But given the absence of concerted efforts to recruit and train new coastal scientists and managers, fears are growing that these highly valued collaborative relationships will retire with them (Coffen-Smout 1996, Mercer Clarke and Bard 2007).

Throughout Canada, community-based organizations, though dependent on volunteered services and constrained by limited budgets, have continued to educate and train the public, to mentor young graduates, and to sustain complex knowledge sharing networks (Kearney et al. 2007, Vodden et al. 2003). In the nineties, the retiring Canadian workforce was seen to be an opportunity to bolster local volunteer expertise, while ensuring their availability to mentor young professionals. In addition, within governments and universities new recruitment, or the filling of retirement positions, continues to be minimal. Consequently growing retirement figures appear to be marching in step with attrition programs.

4.4.9 Science and Governance: Transforming Data into Practical Wisdom

Within Canada, coastal decision-makers at all levels of government have continued to express their need for improved access to expert and timely knowledge on coastal conditions. Yet science to management collaboration continues to be challenged by persistent barriers that include (Canessa et al. 2007, Ernst 2004, GOC/DFO 2006a, Guenette and Alder 2007, McCleave et al. 2003, Mercer Clarke and Bard 2007, OSTP 2007, Walmsley 2006a):

- failure to communicate existing knowledge to management in language that is comprehensible and relevant to management issues;
- failure to communicate management needs to scientists,
- ongoing reductions in funding support, especially for basic ecosystem and socio-economic research;
- continued reductions in both academic and government research budgets and staff;
- limited academic or government support for interdisciplinary team building and research;
- lack of sufficient data to permit cumulative assessment of cause and effect relationships;
- differing opinions over public access to data and information; and
- unrealistic expectations by managers for certainty in ecosystem predictive modelling.

Scientists continue to raise concerns that federal funding does not encourage coastal ecosystem research, but more often rewards proposals for empirical laboratory studies. The Government of Canada has persistently reduced its internal capacity for research, relying on federal funding of academic research, and contracts to consultants to fill the gaps creating by retiring federal scientists. Within the universities, interest in interdisciplinary approaches to research and problem-solving continues to be challenged by disciplinary barriers related to methodological rigour, by the lack of administration support for participation in non-academic fora and initiatives, and by limitations to available resources caused by increasing job responsibilities, decreasing staff and limited fiscal resources.

While it is true that other disciplines are increasingly becoming involved, too much of the research in coastal planning and management in Canada remains vested within the disciplines of marine biology, marine management, and marine law. While it is now a common assumption that management of land-based activities will be a critical aspect of coastal sustainability, it is still difficult to find within any level of government coastal decision-making positions that are staffed with individuals whose training in the applied sciences included a focus on coastal issues. Even within the universities, as Parkes and Manning (1998) noted, there continues to be a legendary lack of dialogue on coastal issues among disciplines such as engineering, science, economics, and planning. Seldom do the curricula in the applied professions address the impacts of developments, or challenge students to both understand their contribution to the ongoing dilemma and their responsibilities to enact positive change.

4.4.10 Uniquely Canadian Challenges– Eh?

Canada‟s coastline, the longest in the world, snakes along the shores of three oceans and four of the Great Lakes, linking a diverse array of landscapes and cultures. In addition to the constraints to integration that are shared with other nations, efforts to promote a consistent and integrated national coastal management system in Canada continues to be challenged by:

- a range of coastal terrestrial ecosystems that transition from Arctic to Temperate;
- a population that is predominantly located in a relatively small area of land in the south;
- a national governance system based on a confederation of powerful provinces and territories;
- a bi-lingual (French, English) national government;
- the recognition and inclusion of the Aboriginal peoples of Canada;
- provincial and territorial governance systems that are derived from the British, French or Aboriginal cultures;
- a lack of consensus on the role of the Great Lakes in coastal management; and
- with the melting of Arctic ice, challenges to Canada‟s sovereignty over its marine waters and resources.

4.5. The Bottom Line on Coastal Management in Canada

There is no doubt that after thirty years of concerted effort by scientists, governments, the private sector and the community, Canada has made important gains in the protection and conservation of coastal environments and coastal communities. Levels of contaminants are down in coastal waters, the numbers of marine protected areas are growing, and communities have built and sustained a culture of volunteerism that is the envy of many nations. However, most efforts towards coastal management are best characterized as environmental protection and conservation efforts, operating as they do in an arena separate from mainstream political and governance activities such as economic management, infrastructure development, and social planning. Concepts such as integration, holism, and even sustainability have resulted in only marginal or temporary changes to resource management and development practice, and are still treated as lofty ideals for which there is no effective mechanism to guide society‟s transition from vision to realization.

The spectre of a new national system of integrated coastal management, accompanied by expectations of increased government regulation and decreased access to land and water-based resources, has yet to be perceived as offering positive incentives to economic interests. Failures to outline both the short and long term benefits to the economy, as well as the potentially catastrophic costs of doing nothing, may have disenfranchised the most powerful voices for change. And as Parkes and Manning (1998) noted, policy makers have not been convinced that the establishment of an umbrella coastal management system or agencies would effectively and efficiently resolve the conflicts between development and conservation interests, or outweigh competing demands for decreasing public funds. Perhaps as a consequence, there is little evidence that integration on the scale suggested by ICM guidance documents will either evolve on its own or be imposed as a national system of governance.

While proponents of change in coastal management recognize the complexity and risk that characterizes many coastal issues, they must curtail their ambition to control all the interactions that result from these factors, or risk being seen as attempting to over-manage (French 2004, Jentoft and Buanes 2005). Integration, as defined by Kenchington and Crawford (1993), does not rely on the developing of overarching legislation and agencies, but speaks to a unity of purpose, supported by consensus on overall principles, and collaboration and coordination between established agencies and legislation in the execution of their day to day activities. Canada, like Australia, is a large and diverse country with much to gain from a national leadership that fosters shared principles and cultivates a unity of purpose. While a key element of success in coastal management in other countries has been the creation of an enabling environment that proactively encourages and supports action by all levels of governments (Burbridge and Humphrey 2003), within some nations successful societal change has only been achieved through regionally relevant initiatives implemented at the local scale.

The ongoing dialogue on defining the coast in Canada has yet to contribute positively towards improving management, and has instead deflected attention and resources away from effective action. As Chircop (2000) and French (1997) have suggested, we need to see the coast in the context of functional units, not as myriad legal or jurisdictional areas, recognizing that overlap in government will occur, and working within each administration according to its mandate.

Despite the recognized need within Canada to deliver coastal management at the local level, for too long too much of the effort has been left to volunteer community-based management organizations, and too little has been done to support these organizations or to engage provincial and municipal levels of government. As a consequence, and despite the continued enthusiasm and commitment of local volunteers, Canada may soon face disillusionment and frustrations similar to those which developed in England and Wales where community organizations have lost faith in government promises, and distrust for the motives and commitment behind the creation of new coastal government programs is growing (Milligan and O'Riordan 2007).

For long sought after and effective change to occur, it is necessary to face up to the constraints that have impeded progress in the past and to find new solutions for persistent but key issues (Friedheim 1999, Hildebrand 1989, Hildebrand and Norrena 1992, Jentoft and Buanes 2005, Johnston et al. 1975). The lessons that can be learned from both Canadian and international experience in coastal management are somewhat simple, and would not be difficult or costly to resolve through shared purpose and a willingness to collaborate. While it is disheartening that most of these challenges have remained essentially unchanged from those identified by other reviewers in the past, it is to be hoped that for Canada to achieve progress in coastal management it will not require, as Johnson and VanderZwaag (2000) concluded, the prospect of catastrophe before fundamental changes will occur within society. The good news is that Canadian society is better informed and more concerned over issues of coastal health and sustainability than it has been at any time in history. The economic crisis that has struck the world in 2008 created serious doubts in previously unassailable beliefs that our free market approaches would solve all societal problems, given enough rein and opportunity. While the world today is characterized by limited resources and more than a little fear of the future, there is also an unprecedented openness to new ideas and to change. There has been no better time in Canada for a new vision of the coast to emerge, strengthened by the skills gained at home and from the experience of other nations.

So what is really holding us back? Is it the continuing popular belief in Canada that there is no driving need to improve on our systems for managing coasts? In such a massive young country, the perception of extensive wilderness areas unspoiled by human activities continues hand in hand with the equally pervasive expectation that dilution with the clear cold waters of the northern oceans will solve any residual concerns over ecosystem sustainability. We may be drowning in data, but the question remains as to whether much of it is useful to improving either our knowledge on the current state of our coasts, or our understanding of the impending challenges posed by human development and climate change. What is the true state of our knowledge on coastal conditions?

PART III: SUSTAINING THE COASTS OF CANADA: TOWARDS IMPROVED SCIENCE AND MANAGEMENT

CHAPTER 5: ARE CANADA'S COASTS IN PERIL? AN ANALYSIS OF CURRENT COASTAL INFORMATION AND ITS RELEVANCE TO DECISION-MAKING

It ain't what you don't know that gets you into trouble.
It's what you know for sure that just ain't so.
Mark Twain (as quoted in Gore, Al, 2006. An inconvenient truth. Rodale, New York)

Some of the content of this Chapter appeared first in Mercer Clarke et al. (2008) which has been included in its entirety as Appendix A.

5.1 Measuring Change in Coastal Conditions

For over 100 years, governments, academia and community-based organizations have monitored conditions within marine and coastal environments by collecting and recording data on an array of biological, chemical and physical parameters, all intended to contribute towards a better understanding of the functioning of the associated ecosystems (Hameedi 2005). Despite the advances that have been made in fisheries management, pollution abatement technologies, and the creation of marine protected areas, the health of the world's oceans and coasts continues to decline (EEA 2006a, 2006b, GESAMP 2001b, Lotze 2004, MEA 2005a, 2005b, Steffen et al. 2004). GESAMP (2001a) estimated that 80% of the pollution load of the oceans, including municipal, industrial and agricultural wastes and non-point source run-off, emanates from land-based activities. Land cover and land use changes have already degraded over 23% of the world"s usable land, and the expectation is that with rising populations, this downward trend will continue (UNEP 2002c, 2006b). As human populations continue to grow in coastal areas, increased conflicts over rights of access and development are coupled with rising expectations for sustainable resources, beautiful landscapes, and healthy environments that support a high quality of life for coastal residents and visitors (UNEP 2006b). While there is growing recognition that the drivers of change in coastal environments are largely derived from anthropogenic activities on the land, much of the effort to assess change in coastal ecosystems has remained focused on the monitoring of marine environmental conditions. Insufficient attention has been paid to advancing understanding of the causal relationships between human activities and the health of nearshore environments (2WEC 1999, Aubrey and Elliott 2005, Shipman and Stojanovic 2007). And while society has long been aware of the dangers of consumption of contaminated seafoods, knowledge of other linkages between human health and coastal and oceans health, such as water-borne transmission of disease, remains poorly understood (Boesch and Paul 2001, Flemming and Laws 2006, Ocean.US 2006).

Given the escalating deterioration in global coastal environments, and the increasing threats of impact from climate change, considerable effort has been expended to identify a more holistic suite of indicators that would accurately identify and report on deteriorating trends in coastal conditions (Aubrey and Elliott 2005, Barton 2003, Belfiore 2003, Belfiore et al. 2003, Belfiore et al. 2006, Bortone 2005, Cordah Ltd. 2001, Cox et al. 2004, ETC/TE 2004, Fry and Jones 2000, Gallagher 1999, Hameedi 2005, ICES 2004, IGOS 2006, Knap et al. 2002, Mageau and Barbiere 2003, Niemi et al. 2004, Rees et al. 2008, Talaue-McManus et al. 2003, Toth 2005, US/EPA 2008). However, science remains challenged not only by the costs of expanded monitoring programs, but also by the need to communicate with clarity the findings to those government organizations capable of understanding the implications, and sufficiently empowered to make needed changes to societal policy and practice.

Although a supporter of more holistic, ecosystem based approaches to coastal management, Canada has yet to make substantive progress towards improved planning and management of its coastal areas (Ricketts and Harrison 2007). As has been reported for Norway (Jentoft and Buanes 2005), a country that also possesses long stretches of relatively unpopulated coasts, public interests and political will in Canada may too often be guided by populist myths about coastal sustainability that may not be supported by science. As discussed in Chapter 3, in Canada, there are expectations that much of the coast remains relatively pristine. Such expectations fuel public complacency on coastal conditions, and provide few compelling reasons for governments to implement additional measures for coastal planning and management. As information on the global decline of coastal environments continues to accrue, and the potential for impacts from climate change become more credible, there is a growing concern that Canadian coasts may be more vulnerable than was anticipated, and that the consequences of human activities may have been accumulating while societal attention was distracted elsewhere (Fraser 2007). Scientists are now questioning whether there are sufficient data on current conditions to support the country"s complacency on coastal health, recognizing that governments have for too long relied on the data they had, rather than the data they needed (Mercer Clarke and Bard 2007, Mercer Clarke et al. 2008).

This chapter examines the state of current knowledge of coastal conditions in Canada, questioning the adequacy of the science to support suppositions that Canadian coasts remain relatively pristine, and challenging governments to look again at the need to improve efforts towards improved coastal governance.

5.2 Assessing the State of Coastal Information in Canada

While recognizing that the preponderance of information available on the state of the coast in Canada was likely to be marine-based, the research relied on an interdisciplinary approach common to investigations in landscape ecology (Visser 2004). Within this context, coastal landscapes were recognized as being comprised of a mixture of terrestrial, aquatic, marine and human ecosystems, in which human populations play integral roles, and cause and effect mechanisms transcend traditional watershed, marine and political boundaries. As a consequence, attention was paid not only to information generated through marine science and management but also to sources of data from the broader range of disciplines, sectors and departments of government that play a role in providing information on land-based activities.

To effectively focus the analysis, recent national and regional efforts to develop more holistic approaches to the measurement of coastal well being were compared with international efforts and used to develop a shortened list of coastal parameters or indicators that could provide core information on changes in coastal well being, intended to improve both scientific knowledge of emerging trends and clarity in communicating important issues to decision-makers. These indicators were used as a baseline to assess past and current coastal monitoring efforts and the state of knowledge on the state of coastal environments in Canada.

An intensive review was conducted on available national resources for state of the environment reporting for the Pacific, Atlantic and Arctic coasts. Regional, provincial and local sources of information were examined in more detail for the Atlantic coast, with a special emphasis on those programs that provided information on conditions along the Atlantic shore of Nova Scotia. Existing and available data and information were identified, collated and reviewed, including but not limited to sources in the published literature, the grey literature and data publicly available from government departments, Internet clearing houses and information nodes. Where appropriate, content of the databases was confirmed with database managers. Conclusions were drawn on the adequacy of this information to improve understanding of the state of health of Canadian coasts, to identify important trends, to assist predictions of future conditions, or to aid current policy and decision-making especially as relates to land-based activities.

While the information assembled during this review should not be considered as representing all the data available in Canada, it does represent a comprehensive synopsis of data and information that would be readily available to government staff, the scientific community and to the public. It is recognized that additional data on specific topics or spatially restrictive areas may reside within closed networks and individual researchers working within governments and academia.

5.3 Pressures in the Nearshore: Are Canadians a Coastal People?

Before moving to assess the state of knowledge on coastal conditions, it was important to ascertain whether Canadian coasts might be facing pressures and threats similar to those now impacting other populated coasts throughout the developed world. Interestingly, there were no ready answers to questions on coastal population densities and distribution, or on trends and changes in land cover and land use in coastal areas. Census data that could link Canadian population distribution with proximity to a coast have been difficult to find and to assemble. Population data published by Statistics Canada has in the past attributed residency against national postal codes, which have not been geographically referenced. As a consequence national census information does not readily inform an accurate understanding of coastal area populations, or of the patterns of population and demographic changes that have resulted from economic downturns in coastal fisheries and increased interest in coastal living. While efforts are now being made within governments and by researchers to relate postal codes to spatial locations, the task is complex and time consuming and has yet to achieve national coverage.

However, given that Canada‟s coastline is the longest in the world, and the country‟s total population is just under 34 million (GOC/STATSCAN 2009), it was a simple matter to determine that more than 70% of the Canadian coastline winds its course through distant northern landscapes, where it is home to a mere 0.4% of the population (GOC/NRCAN 2007, GOC/STATSCAN 2009). Though relatively unpopulated by humans, these northern coastal landscapes, as well as other coastal areas distant from population centers, have already been affected by forestry, mining and other resource extraction activities (SCL 2005). Disturbing levels of contamination from sources outside these regions have been carried into the area via air and water currents, and as the ice melts and the permafrost thaws, there are growing threats from climate change, and sea level rise (C-CIARN 2004a, CEC 2008, GOC/DIAND 2003, GOC/EC 2006b, SCL 2005, Stewart and Lockhart 2004).

But if Canadians do not live on these northern coasts, where do they live? Surprisingly to many, Manson (2005) reported that in 2001, over 38% of the Canadian population lived within a mere 20 km of a coast, clustered along small portions of the southern shorelines of the Pacific and Atlantic marine coasts and the southern Great Lakes (Huron, Erie, Ontario) and St. Lawrence Seaway, on less than 3% of the country‟s land mass. Given the continuing shift in population from a rural to urban base, and the attractiveness of coastal living, Manson estimated that by 2015 more than 50% of Canadians would reside within 60 km of a shoreline, clearly establishing Canadians as a coastal people. As population densities and development pressures in these southern coastal areas are anticipated to be similar to those experienced in the United States and Europe, it is quite likely that these coastal landscapes have for many years been subject to impacts from land-based development, habitat damage and over-harvesting practices that have not been identified by traditional monitoring methods.

Until recently, information on large scale land use and land cover change within Canada has been limited to national scale assessments focussed on the suitability of lands for agricultural, forestry and wildlife. With a few exceptions, land cover mapping, where available, has not been linked to changing conditions within either aquatic or coastal environments, unless the system was a provider of potable water, or vulnerable to climate change impacts such as sea level rise and severe storms. Throughout Canada there has been considerable variation in the status of digitally available geo-referenced data on land cover and land use. Within the boundaries of large municipalities, geographic information systems (GIS) are generally employed to collate, analyse and assess data relevant to planning and development decision-making and to the maintenance of municipal utilities such as potable water supply, stormwater and waste water collection and treatment, roads and corridors, and energy and communications systems. However, there is still considerable distance between management of land-based resources and utilities and impacts to nearshore coastal environments. Many smaller municipalities do not have GIS capabilities, and land cover mapping has not been universally available in digital formats. Until recently, the best digital land cover mapping for the province of Nova Scotia was provided by the Department of Natural Resources, and was based on forest cover inventories using data from the early 1990s. In June of 2009, as a result of collaborative work between Agriculture and Agri-Food Canada (AAFC), Natural Resources Canada (NRCan), the Canadian Space Agency and Canadian provinces and territories, the GeoBase Secretariat, an intergovernmental initiative overseen by the Canadian Council of Geomatics, released downloadable land cover data for the entire country.

Recent reviews of coastal and estuarine conditions in the United States have reported that in the northeast coasts just to the south of some of Canada"s more populated coastal areas, 27% of embayments and estuaries have been impaired for aquatic life, an additional 49% is threatened, and 31% has been impaired for human use (US/EPA 2005). Nutrient enrichment of coastal waters is widespread, and there are increasing concerns that nutrients sequestered within nearshore sediments will continue to degrade these environments far into the future (GOV/PEI 2005). American scientists, struggling with their own challenges to reverse coastal deterioration brought on by land-based impacts such as nutrification, have voiced concerns that Canadian complacency on coastal conditions could be the result of our failures to measure the right parameters, leaving undetected potentially accelerating deterioration in critical components of coastal ecosystems.

5.4 Indicators of Coastal Conditions

Canadian scientists from academia and government have continued to participate in international and national fora and publications intended to examine current state of the coast information, to advance ecosystem based management practices, and to improve on the scope and content of monitoring programs that provide data and information on more holistic suites of indicators of coastal well being and sustainability (Belfiore et al. 2006, ICES 2004, 2006, Jamieson and Zhang 2005, O'Boyle and Keizer 2003, O'Boyle et al. 2005, Rees et al. 2008, Rice 2003, 2007, Rice and Rochet 2005, Walmsley 2005, Walmsley et al. 2007). While ecosystem-based management and co-management initiatives represent a growing trend in Canada, they have largely been the focus of departments and agencies responsible for environmental protection and stewardship, rather than with those whose mandate is in managing land use or fostering economic development.

Even where federal departments have committed in policy to the principles of sustainable development, program changes have been constrained by insufficient resources to adequately address complex relationships between development and conservation, inadequate monitoring, and decision-making that too often placed economic considerations over the needs of the environment (GOC/OAG 2006, Peterson et al. 2005, Strain and Macdonald 2002). Information on environmental change has only rarely been linked with information on economic progress, and can be lost in the barrage of issues presented to decision-makers and to the public. Parameters that report on changes in coastal conditions are still missing from the national indicators of environmental health and sustainable development (Bond et al. 2005a, GOC 2003b, 2007, 2008a, GOC/EC 2001b, 2001c, 2005b, 2006a, 2007, GOV/CAN/US 2003, NRTEE 2003, UNEP 2006a, UNEP/CEC/IISD/WRI 2002).

There is as yet no nationally accepted suite of indicators for assessing coastal health and sustainability (Buckland 2007). National working groups, comprised of staff from several federal departments and programs, have been collaborating with other levels of government, with science and with community-based environmental non-government organizations (ENGOs) to identify coastal indicators, but the work is still in its early stages (Buckland 2007, GOMC 2004, GOMC/ESIP 2004, Mills 2006, Walmsley 2005, Walmsley et al. 2007). A sample of recent initiatives in the development of indicators of the state of the coastal environment are summarized below. Work to develop regionally valid indicators of aquatic and marine ecosystem health has also been completed in the Great Lakes, in the Georgia Basin on the Pacific Coast and in the Arctic.

5.4.1 Fisheries and Oceans Canada Eastern Scotian Shelf Integrated Management (ESSIM)

In its Oceans Act (GOC 1996a) and its Oceans Strategy (GOC 2002) Canada recognized the need for more holistic, ecosystem-based approaches to management of coastal and estuarine waters. However, the Department of Fisheries and Oceans (DFO), which is charged with providing leadership in this area, has continued to focus its local efforts on advancing science and co-management in a number of new large open ocean management areas (LOMAs). Activities along the shores of the Great Lakes are excluded from DFO‟s coastal management efforts as the Lakes are considered inland waters, not coastal waters. Off Nova Scotia, the boundaries for the Eastern Scotian Shelf Integrated Management (ESSIM) LOMA, were specifically established to fall outside of federally defined coastal waters, encompassing open oceanic areas where conflicts of human use occur predominantly among major sectors such as fisheries, oil and gas, and transportation (Rutherford et al. 2005).

To date, the thin band of nearshore coastal waters (<20 m depth), which is the initial receptor for land-based impacts, has received less attention from the DFO, either in monitoring efforts or in attempts at integrated management (Breeze and Horsman 2005, Jamieson and Zhang 2005). As the DFO has stated its intention to move LOMA boundaries further inshore to include coastal areas, efforts to identify ecosystem health indicators have included land-based issues and socio-economic conditions (Breeze 2004, Strain and Macdonald 2002, Walmsley 2005, Walmsley et al. 2007, Walmsley 2006b). However, it has been noted that as linkages between land use and marine environmental quality have in the past predominantly focused on impacts to fisheries, there is a need for additional data to address broad information gaps on ecosystem relationships (Jamieson and Zhang 2005, Strain and Macdonald 2002).

5.4.2 Gulf of Maine Council on the Marine Environment (GOMC)

The Gulf of Maine Council is a bi-national government organization committed to the sustainable management of the Gulf of Maine, a coastal area shared by the United States and Canada. The GOMC is unique in that it is led by the governments of the states and provinces whose watersheds empty into the Gulf of Maine and not by the federal governments of the two conjoined countries. Federal governments in both countries remain fiscally supportive of the GOMC, and participate in its programs and initiatives. In 2002 the Gulf of Maine Council on the Marine Environment (GOMC) embarked on an initiative to develop an indicator based State of the Gulf report. In support of this project, the GOMC developed a potential list of indicators for assessing environmental health that focused on fisheries, coastal development (including land-based development) and contaminants (GOMC 2004, Pidot 2003, Wake et al. 2006).

5.4.3 Ecosystem Indicators Partnership (ESIP)

Building on the work of the GOMC, Canada, together with other partner organizations from the provinces and the states and federal agencies of the United States, is actively involved in the Gulf of Maine Ecosystem Indicators Partnership (ESIP). ESIP has been working towards the development of a set of regional indicators for the geographic area of the Northeastern coastline of the United States and Canada that extends from the Bay of Fundy to Long Island Sound (GOMC/ESIP 2004, Mills 2006). ESIP"s efforts to identify appropriate indicators are guided by the following considerations:

- relevance of the indicator to the target audience;
- relevance of the indicator to management questions of interest and management responsibilities in the region; and
- presence of a scientific rationale behind an indicator and its interpretation.

To advance this process, ESIP has formed six working groups, each challenged with identifying and developing indicators relevant to one of the six leading management topics; aquatic habitats, coastal development, contaminants and pathogens, eutrophication, fisheries and aquaculture, and climate change (Table 5.1). The ESIP approach, while not necessarily unique to indicator development, demonstrates through a readily comprehensible logic the relationships between coastal management issues and concerns and the science needed to assist policy development and decision-making.

Table 5.1: Selected Indicators (adapted from GOMC/ESIP 2004)

Management Issues	Proposed Indicators
Aquatic Habitat	
How are aquatic habitats changing over time	Extent and distribution of habitat
	Changes to community structure, species and habitats of concern
	Percentage of area designated as protected
What are the causes of habitat change	Changes in scope and intensity of human use
	Number of boat registrations
	Habitat area altered by hydraulic restrictions, erosion and sedimentation
	Vulnerability of algae to pollutants
Coastal Development	
What is the type, pattern and rate of land use change	Percentage of types of land use and land cover
	Trends in land cover & land use change over time and area
	Changes in demographics
How are governments responding to changes in coastal ecosystems	Increased protected areas, habitat restoration & land conservation
	Changes in land management instruments
Contaminants	
How is the input of contaminants changing over time and space by province and year	Annual chemical load to water bodies
	Area of contaminated sediments
	Level of contaminants in non-migratory organisms
	Area and numbers of shellfish bed and recreational beach closures
	Days of beach closure due to contamination
	Number of bacterial source investigations and sources eliminated
How does management change the extent of human health effects	Incidences of human disease from sea food & recreational contact
	Level of contamination in fish/shellfish and at-risk humans
How well are contaminant management actions protecting ecosystem integrity	Quality of habitats and sediments affected by contaminants
	Incidence of disease
	Reproductive success
Eutrophication	
What are the extent, severity and trends of eutrophication impacts	Levels of dissolved oxygen, chlorophyll A, water clarity
	Submerged aquatic vegetation
What are the sources of nutrients, how are they changing	Measured and modelled loads
	Loading from land us and land cover, and population changes
Fisheries	
What are the trends and status of exploited fish stocks	Proportion of stocks at/above targeted abundance/biomass
	Age/size structure of species from surveys or landings statistics
	Spatial distribution of fisheries species
What are the effects of fishing on non-targeted species and their associated communities	Characteristics of by-catch and discards
	Population levels for selected species
	Species diversity
What are the effects of fishing and non-fishing activities on marine habitat and fisheries	Areas closed to fishing
	Benthic diversity
	Spatial distribution of bottom fishing
What are trends in the socioeconomic characteristics of fishing	Fleet composition and days at sea
	Commercial and recreational fishing value
	Natural capital value
Climate Change	
What are the impacts of climate changes to weather, atmospheric &	Changes in patterns of precipitation and temperature
	Storm frequency and intensity

Management Issues	Proposed Indicators
ocean circulation, ecosystems & society	Changes in surface and water column water temperatures
	Sea level rise
What are the impacts of climate change on biotic systems	Shifts in warm and cold water species diversity
	Shifts in plankton diversity, quantity, distribution and seasonality
	Changes to wetland extent, distribution and composition
	Increase in the incidence of marine diseases

ESIP is refining the list of issues of concern to coastal managers and is providing a web-based platform for the interactive presentation of monitoring data collected by an array of organizations at work throughout the Gulf. Recently ESIP posted an on-line fact sheet containing the priority issues and indicators derived to date (Table 5.2) (ESIP 2009):

Table 5.2: ESIP Priority Issues and Indicators

Aquatic Habitats	Coastal Development
• Extent of eelgrass • Extent of salt marsh • Locations of tidal restrictions	• Point sources • Population density • Employment density • Impervious surface coverage
Contaminants	**Eutrophication**
• Sediment triad data • Shellfish sanitation data • Gulfwatch/Mussel Watch data	• Nitrogen loading • Secchi depth • Dissolved oxygen • Chlorophyll A
Fisheries and Aquaculture	**Climate Change**
• Production/area for aquaculture • Economic value of aquaculture • Mean length of all sampled fish • Economic value of fisheries • Proportions of stock at or above targeted biomass	• Sea level change • Precipitation trends and anomalies • Air temperature trends and anomalies

5.4.4 Ecological Monitoring and Assessment Network (EMAN)

The EMAN program of Environment Canada, which has developed the Canadian Environmental Sustainability Indicators for terrestrial environments, has begun development of a suite of coastal and marine indicators. Though charged with national responsibility to coordinate the collection and reporting of data on environmental sustainability, EMAN has limited staff and fiscal resources. Much of its mandate in terrestrial environments has been accomplished through partnerships with other agencies, academia and non-governmental organizations. To advance its work in the coastal and marine environment, EMAN has co-ordinated efforts to standardize the methodologies being employed by largely volunteer community-based management organizations such as the Atlantic Coastal Action Program (ACAP) in the collection and reporting of information on marine and coastal environments in Atlantic Canada. But as there are few additional resources ascribed to EMAN to conduct these coordination activities, there has been limited progress.

5.4.5 Community-based Environmental Organizations

Relying heavily on a Canadian heritage of volunteer action, governments across the country have encouraged and provided (limited) support for community-based environmental organizations. While often touted as community-based management (CBMs) initiatives, very few have actually had the opportunity, or authority, to participate in decision-making on coastal management. Canadian CBMs have however contributed significantly to local monitoring of environmental conditions, and can be the first to report disturbing trends. CBMs are often respected partners with governments, academic, the private sector and First Nations in local, regional, and bi-national collaborative efforts to manage estuarine and marine environments (Georgia Bay-Puget Sound, Gulf of Maine Council Ecosystem Indicators Partnership (ESIP); International Joint Commission on the Great Lakes) and have contributed significantly to progress in identification of more holistic, ecosystem based programs of indicators of coastal change (2WEC 1999, Bertram and Stadler-Salt 2000, FBC 1998, GBPS 2002, GMS 2004, GOMC 2004, GOMC/ESIP 2004, GOV/CAN/US 2003, Mills 2003, Mills 2006, Monette 2001, O'Brien 1998, SGSLCS 1999, Sikaneta and Evans 2006, Wells 2004, Wells 2005).

Although the focus for indicator development within CBMs appears to have remained on measuring the health of marine ecosystems, there has been recognition of the need for a broader perspective and movement towards the inclusion of socio-economic parameters and indices of land cover and land use change. While CBMs may often be severely constrained by uncertain and limited financial resources, they have worked cooperatively to standardize monitoring programs, to establish sampling, analysis and reporting protocols, and to share information and data freely with academia, government and the private sector. Such partnering at the local level not only produces benefits towards sustainable development, but also creates an ever-widening sphere of influence and engagement that may produce positive results at a landscape or ecosystem scale (McNeil et al. 2006).

5.4.6 Summary of Existing and Proposed State of the Coast Indicators

It becomes readily apparent when reviewing the literature and practice on coastal indicators in Canada that there is no single perfect indicator, or suite of indicators that can be applied in all conditions, or at all times. All indicators must be chosen to reflect the unique context, goals and objectives of each coastal environment and its corresponding management initiative. And as Toth (2005) concluded, the level of integration of natural and social parameters achieved during planning and design of monitoring, assessment and management initiatives continues to be highly dependent on the individual and collective backgrounds, skills and perspectives of participants in the process. Despite growing concerns that the patterns and trends in changing conditions within coastal ecosystems are not being accurately reported, most coastal indicator programs are still selected by marine scientists working from the perspective of marine environmental quality (MEQ). Departments and agencies with responsibilities for land-based development and resource management in general, are seldom significant partners in either the development of coastal initiatives, or in the collection and dissemination of information (Mercer Clarke 2005). Although MEQ programs can arguably rely on existing data sets that can go back decades, the suite of indicators can be limited, and generally do not encompass nearshore coastal conditions. As a result, the bias towards marine science, and to monitoring conditions in deeper and well mixed coastal waters rather than in protected nearshore embayments has continued, leaving fewer resources for the collection of data on other aspects of coastal system stability and change, and making it less likely that sufficient attention will be paid to broader indicators of socio-economic change within the near future (Vandermeulen and Cobb 2004).

Bottom-up approaches to indicator identification and application may also perpetuate the difficulties encountered in translating data on ecosystem change into information that is readily comprehensible and usable by decision-makers in other disciplines such as planning, engineering, resource management, and policy development. Conversely, top-down, policy driven processes for the selection of indicators can be hampered by the lack of specific governing policy on coastal management at all levels of government, limitations of staff and fiscal resources needed to collect new data, and the lack of participation by key disciplines (planning, engineering, land-based resource management) in the planning and design of monitoring programs (Mercer Clarke 2005).

Following from this review, it was determined that effective coastal indicators should provide information not only on existing conditions, but also on the relevance of observed changes to coastal management issues such as:

- population demographics and distribution (stressors);
- economic conditions and the pursuit of economic growth (stressors);
- cultural and aesthetic values (stressors);
- land cover and land use patterns and changes (pressures);
- climate change (pressures);
- environmental conditions (state);
- sentinel phenomena indicative of broader changes (state);
- deteriorating ecosystem conditions (impacts);
- loss of built infrastructure, resources, livelihoods (impacts);
- government program investments (responses);
- planning, administrative and regulatory instruments (responses);and
- policy change and adaptation (responses).

As noted by other authors (Belfiore et al. 2003, 2006, ETC-TE 2004) criteria for the selection of indicators should include:

- applicability: appropriateness of use across a broad array of coastal conditions;
- reliability: supported by scientific methodologies, replicable and verifiable,
- practicality: costs of monitoring not to exceed value and benefits to decision-making;
- capability: useful in the detection of trends, linkages and patterns and applicable to the assessment of past change and to the prediction of future scenarios; and
- relevance: usefulness to a range of decision-makers within all levels of government, the private sector and the community.

The suite of indicators proposed in Table 5.3 are representative of the kind needed to assist managers in understanding the full array of changing conditions within coastal areas, with special reference to the inter-relationships between anthropogenic changes and ecosystem changes.

Table 5.3: Proposed Core Indicators of Coastal Conditions

Ecological Indicators	Socio-Economic Indicators
• water column temperature & salinity • **oceanographic processes** • sedimentation • **sea level change** • wave climate • beach and shoreline erosion • landscape & bottom integrity • **aquatic and marine contaminants** • **point-source discharges** • **non-point source nutrient loading** • **point-source nutrients** • **quantity and quality of pathogens** • sediment quality • air borne deposition of contaminants • **marine biodiversity** • **estuarine biodiversity** • **terrestrial biodiversity** • **migratory species** • **habitat area and alteration** • **buffered riparian and shoreline habitat** • **aquatic and saltwater wetland area** • species density and distribution • **species at risk** • **invasive species** • food web structures and complexity • reproductive capacity • spawning survival rates • shifts in life-stage of sentinel species • mean time between generations • predator-prey relationships • diseases & abnormalities • anthropogenic mortality (by-catch, etc.) • natural mortality due to predation • natural mortality due to severe weather • quantity & quality of primary productivity • bio-accumulation of toxics	• **population density and change** • **resident and total (seasonal) population** • **land use / land cover patterns and trends** • **deforestation** • **urbanization** • **intensive agriculture** • **extent of hard surface areas and change** • construction in the backshore • non-resident ownership of the coastline • percent of public owned land • public access to the shoreline • **population with wastewater treatment** • **volume of ballast and bilge discharge** • **dumped and dredged material** • **litter and debris** • **exploitation of living resources** • **exploitation of non-living resources** • **aquaculture expansion and production** • **high impact gear fishing practices** • non-consumptive uses • commercial marine traffic • recreational boat use • resident coastal tourism • non-resident coastal tourism • non-boating recreational use • economic value-added to resource use • employment payroll value • local economic value • economic value of exports • total economic value • **seafood and water-vectored illnesses** • **shellfish closures /openings** • **seafood contamination** • deterioration of sea food quality • **days of beach closure and change** • economic loss due to severe weather • lives lost due to weather and disasters • **loss of scenic vistas** • **impacts to cultural values** • local economic losses • loss of exports • total socio-economic losses

* indicators in bold could be used as meta-indicators of both direct and trickle-down changes in socio-ecological conditions.

Despite the growing support for ecosystem-based approaches to management and recognition of the need for more holistic suites of indicators to assess coastal health, there are few circumstances where existing monitoring efforts will supply the needed information, or where sufficient funds and staff are available to initiate new programs (Mills 2006). Governments, academia and communities continue to be constrained by limited human and financial resources, and by the sheer magnitude of the task before them.

5.5 Assessing the State of Coastal Knowledge

In the 2002 UNEP review of the state of the North American environment, discussion on coastal conditions within Canada relied heavily on information on fisheries and point source pollutant inventories and management (UNEP/CEC/IISD/WRI 2002). Canada"s last comprehensive state of environment reporting to address coastal conditions was published over a decade ago, and was based on data acquired much earlier (GOC 1996b). Since that time, while there have been numerous government, private sector, scientific and community-based reports on environmental conditions, there have been no new national reviews of the state of coastal or marine environments. Despite government, academia and local efforts to research change in the Arctic and to capture traditional knowledge, data on coastal environmental conditions throughout Hudson Bay and the Arctic is patchy and limited (Brylinsky et al. 2005, SCL 2005, Stewart and Lockhart 2004, Zaloum 2003). On the Pacific coast, the Government of British Columbia had for several years produced reports on the state of their environment (GOV/BC 1993, 1998, 2000, 2002, 2006). Reporting on coastal conditions has primarily focussed on the marine environment, with limited reference to the linkages to land cover or land use changes. Nova Scotia (GOV/NS 2009) and Newfoundland and Labrador (GOV/NL 2008) have recently produced reports on coastal conditions and coastal issues that are also either limited to the marine environment, or compromised by gaps in important data and information.

While there is considerable information on environmental conditions on the Great Lakes available through work of the International Canada-United States Joint Commission (IJC-GL), for the past decade the emphasis has been on conditions within deeper waters, with little reference to land cover and land use changes in the basin (GOV/CAN/US 2007, 2009a). Recognizing that earlier research on nearshore conditions throughout the Lakes was now dated, in 2008 the IJC-GL focused resources on improving its understanding of a wide range of issues affecting nearshore waters, and on becoming better informed on the relationships between land cover and land use and impacts to environmental and human health (GOV/CAN/US 2009b).

Despite growing global concerns over declining coastal health, there has been little movement towards the development of a national assessment of coastal health similar to that conducted regularly in the United States (JOCI 2007, US/EPA 2005, US/NOAA 2006). The focus for federal monitoring and state of environment reporting has remained on assessment of oceanic conditions and offshore fisheries stocks (Boyd and Charles 2006, Caddy 2004, Curran et al. 2006). As noted in Chapter 4, reporting on the economic value of coastal resources has predominantly focused on the contributions of the industrial marine sector (i.e., fisheries, transportation, oil and gas) and on coastal (marine-based) tourism. Data on other tangible and intangible contributions of coastal resources remains non-existent or elusive, as does information on the benefits of improved coastal management, or more importantly, the costs of in-action (Bowen and Riley 2003).

Disjointed yet important information on changing local and regional coastal conditions can be found in scientific and technical papers and reports contained within both the primary literature and the grey or unpublished literature, or scattered throughout government departments, universities, the private sector and community organizations (Brylinsky et al. 2005, Lotze 2004, Pauly et al. 2001, Zaloum 2003). In addition to the national clearing house sites, there is a wide array of Internet sites that attempt to identify, collate and provide linkages to information on a range of topics of interest to coastal scientists, managers and society. Appendices B and C provide lists of additional information on state of the environment compiled during the research, as well as related web-sites. Much of this body of information is technical in nature, not easily communicated to the public and relatively in-accessible without expending considerable effort. The federal and provincial departmental Internet sites that provide either access to data or current government reports on marine conditions are not easy to find, and sometimes require access permission to view contents. During the course of this research, some of the information previously available on Government of Canada web-sites had been removed or the web-sites have been discontinued.

The last federal inventory of databases for environmental analysis was published in 1998 (GOC/STATSCAN 1998). Since that time, considerable effort has been made by national and provincial levels of government to provide access to data, and to collate linkages to data and information on environmental conditions through the development of open Internet resources as well as several comprehensive Internet information portals (GOC/PRI 2006). Ironically, the progress made by these initiatives to identify and link a wide array of both public and restricted information sites has produced an immense body of complex data on a broad array of subjects that can easily overwhelm the casual user. As well, even where links are provided, access to data and information may be restricted to specific user groups, or available only through purchase. Outside of the sources identified below, no other significant sources of coastal environmental data were identified. Although conditions affecting data sharing appear to be improving, attempts to identify, access and collate these often disparate bodies of information have met constraints from issues such as information silos, ownership, lack of common protocols for collection and reporting, poor data management within organizations, lack of funds to collect and transfer information, and mistrust of downstream applications and users (Lemmen et al. 2008).

Fisheries and Oceans Canada and Environment Canada operate the primary national databases for the collation and disbursement of information on marine and coastal environmental conditions. The following sections provide summaries of the most comprehensive and relevant sources of data and information available from these and other national and regional sources. Table 5.4 provides an overview of the focus and content of the most readily accessible national, regional and local datasets. As an example of the scale of data available provincially and locally, the focus for the research was on the Atlantic coast of Nova Scotia.

Table 5.4: Overview of Accessible Data for Key Classes of Coastal Indicators at the National Scale and for Nova Scotia

(Empty cells in the table indicate that data for those classes were not part of organization"s resources)

	National	NS Atlantic	Physical Processes	Plankton	Biodiversity	Ecosystem Structure	Contaminants	Nutrients	Non-Point Contaminants	Habitat Change	Pathogens & toxins
DFO MEDS	✖	✖	✖	✖	✖	✖	✖	✖		✖	
DFO NCIS (disc)	✖	✖					✖	✖			
DFO BIOCHEM		O		✖			✖	✖			
DFO Coastal Oceanography		O	O								
CSSP	O	O		✓	O			✓			✓
EC-CWS	O	O			O			✓		O	
EC- Point Sources	✓	✓		O	O		✓	✓		O	O
EC-EEM	O	O	O	O	O		✓	✓		O	O
NS Aquaculture		O		O	O		O	O		O	O
ACAP		O		O			O	O		O	O
HRM		O		O			O	O	O		O
FSRS		O		O			O	O			

Program	**Coverage**		**Socio-Economic Indicators**								
	National	NS Atlantic	Population	Land Cover	Land Use	Land Ownership	Economic Assets	Economic Losses	Climate Change Vulnerability	Cultural Assets	Cultural Losses
Statistics Canada	✖	✖	✖		O	O	O	O		O	
GeoBase	✓	✓		✓							
DFO Fish Landings	O	O					O				
NS Aquaculture		O					O				
NS Municipal Affairs		O	O		O	✓					
HRM		O	✓	✓	✓	✓	✓			✓	

✖ Poor coastal coverage   O Fractured data   ✓ Good coastal data

5.5.1 Internet Clearing Houses

Within Canada in the past decade, considerable effort has been expended to develop comprehensive Internet-based clearing houses for the collation of the vast array of information that is resident in the public, private and research sectors throughout the country, as well as with international organizations. Of particular value to those seeking information on coastal conditions in Canada are Natural Resource Canada"s GeoConnections and the Canadian Council of Geomatics" GeoBase, which together provide information and access to a massive array of data. Most Internet clearing house sites provide only metadata, or information about the data contained within each of the referenced collections, as well as linkages to the sites where the data can be accessed. Most offer search tools which can identify data based on location, subject, or data manager. Provincial governments offer a range of similar services through the Internet, such as the GEONOVA site of the Nova Scotia Government. Data can be accessed directly from these sites, or from other linked resources within related government departments. While considerable progress has been made in the development of metadata Internet-based clearing houses, there is as yet no single national clearing house for either coastal information or coastal data, making it difficult to separate coastal information from that on deeper oceanic conditions, or to assume that all sources of data and/or information have been identified. For some time the Atlantic Coastal Zone Information Steering Committee (ACZISC) has worked to improve identification and sharing of data and information on coastal conditions in the Atlantic area and nationally across the country amongst government departments and the private and research sectors (ACZISC 1992). Participants to the ACZISC have also played pivotal roles in advancing GIS based data networks and most recently in the establishment of the COINATLANTIC geobrowser, which is a searchable database of data specific to coastal management and science in Atlantic Canada.

5.5.2 Fisheries and Oceans Integrated Science Data Management (ISDM)

The mandate of the ISDM is to manage and to archive ocean data collected by the Fisheries and Oceans Canada, or acquired through national or international programs in waters that are adjacent to Canada. The ISDM provides access to these data and other data products to a broader community of government staff, researchers and the public. In addition to information on physical, chemical and biological oceanography, ISDM oversees the Marine Environmental Database (MEDS), which contains biological and chemical oceanographic data dating back over 80 years. The DFO has been working to ensure that the MEDS becomes the national repository for all departmental data, including data and information that have previously been contained within the records of individual scientists or contained within specialized programs and/or regional databases such as the National Contaminants Information System (NCIS) and the East coast BIOCHEM database. Integration of data into the MEDS has been time consuming work, as each of the datasets was subjected to quality control review prior to being harmonized with the MEDS protocols and framework. While the MEDS contains millions of data points, there are relatively few data from the Arctic coast. The majority of data collected on the Pacific coast was sampled from sites located in the south western region of the province (Straits of Georgia and waters off Vancouver Island) in deep, well-mixed waters. Data from the Atlantic Coast is also predominantly representative of conditions within deep offshore waters. Even where coastal stations exist, most sites were located within larger, well-mixed bays and very few samples were collected within a kilometre of shoreline.

National Contaminants Information System (NCIS)

The NCIS was a computerized warehouse of information collected by the DFO on toxic chemicals in fish, other aquatic species and their habitats. The NCIS was created in the late nineties to improve access to data, including historical data, and to facilitate its use in impact assessment studies and in the identification of trends. The program operated from six locations across the country, each of which was responsible for specific national programs of data, such as the National Dioxin Database, the DFO Pulp and Paper Monitoring Program, the Arctic and Atlantic monitoring programs, and data on contaminants in the Great Lakes. Before its funding was cut in 2001, the NCIS had archived over 1.5 million data points. Recognizing that the database contained important data on aquatic and marine concentrations of metals, PCBs, dioxins and furans, pesticides, nutrients, hydrocarbons, alkanes and aromatic compounds, heavy metals, organochlorines, and PAHs, it was recently acquired by MEDS staff, and if resources remain available, the NCIS data should be integrated within MEDS by 2010.

Atlantic Canada BIOCHEM Database

Initiated by the Atlantic Region office of Fisheries and Oceans Canada, BIOCHEM is a national archive of marine biological and chemical data largely collected from stations located within the North Atlantic. Staff from the Department searched out hard copy and electronic sources of information dating as far back in some cases as 1921 (Gregory and Narayanan 2009). While the majority of the data originated with DFO staff, additional information was obtained from the archives of the World Ocean Database (WOD), as well as from the Sir Alister Hardy Foundation for Ocean Science (SAHFOS). BIOCHEM collated the data provided from more than 1575 research missions, and included in excess of 2.2 million discrete observations and over 500,000 plankton measurements. For the past few years, DFO scientists and data managers have also conducted a rigorous program of data acquisition intended to identify all DFO resources of both historic and current chemical and biological data, including attempts to recover non-digital data from historic programs and from the files of retiring staff. On the East coast, data obtained in Quebec by DFO scientists at the St Lawrence Observatory, Maurice Lamontagne Institute, data from the Bedford Institute of Oceanography, as well as the Moncton and St. John"s offices of the DFO, have been loaded into BIOCHEM and subsequently are being loaded into MEDS.

Access to MEDS/BIOCHEM from the Internet requires a password from the DFO. Queries to the dataset can be a difficult task for users unfamiliar with the DFO sampling programs and departmental language. Queries for nearshore data are especially complex as there are no reference maps available to identify sampling station locations. While over 30,000 data points on marine environmental quality are available from MEDS for Nova Scotian waters, the vast majority of these parameters report on the analyses of water chemistry and plankton samples that were collected from ships in deep waters. Given the highly mixed conditions of the water column at these sites, it is unlikely that the information can credibly assist in the advancement of knowledge of conditions within nearshore protected embayments and estuaries. Almost none of the MEDS/BIOCHEM data were obtained from sample sites located in depths <25 m or within one kilometre of a shoreline. In a few localized areas (bays and fiords), highly relevant coastal data sets have been acquired by a number of scientists at the DFO, but only a portion of those data have been ratified and loaded into departmental databases.

5.5.3 Fisheries and Oceans Geographic, Oceanographic and Hydrological Parameters for Scotian Shelf, Bay of Fundy and Southern Gulf of St. Lawrence Inlets

The Fisheries and Oceans and Ecosystem Science (OES) initiative is a compendium of scientific information and data in oceanographic, environmental, ecological and fish conservation issues for the eastern coasts of Canada. Contained within the publicly available data are interactive web sites that provide valuable information on the coastal geomorphology and hydrodynamics (including flushing rates) of Nova Scotian bays and inlets, including coastal shallow water (<12m) temperature climatology.

5.5.4 Fisheries and Oceans Statistics Services

Statistics Services at the Fisheries and Oceans Canada provides information on the landings and economic values of aquaculture, commercial and recreational fisheries as well as economic summaries of related ocean sector and trade activities. Information available to the public through this DFO website covers the period from 1990 to one year before the current fishing season. Fish landings are compiled annually by species and by province. Offshore and nearshore landing data are generally combined making it difficult to assess trends within coastal fisheries.

5.5.5 Environment Canada Atlantic ENVIRODAT Water Quality Database

Data stored in the ENVIRODAT database in Atlantic Canada can be retrieved by the public from the Internet website. Data on ENVIRODAT includes information collected not only by Environment Canada, but also through federal-provincial agreements, and by environmental non-government organizations. Sampling stations include sites on lakes and rivers, harbours, estuaries and marine environments. While the information contained within ENVIRODAT represents a significant collation of environmental studies in Atlantic Canada, sampling stations are site specific to each project, and there may be considerable variation in the parameters measured, seasonality of sampling programs, and in sampling, analysis and reporting methodologies.

5.5.6 Environment Canada National Environmental Effects Monitoring (EEM)

The National Environmental Effects Monitoring (EEM) program at Environment Canada (EC) promotes environmental monitoring as an assessment and decision-making tool to protect aquatic and marine environments from the impacts of industry operations such as pulp and paper manufacturing and metal mining, and more recently aquaculture.

Monitoring studies are conducted primarily by the private sector and the data are provided to Environment Canada. EEM monitoring programs are conducted in three to six year cycles, depending on the requirements for each industrial facility, and the results of the most recent cycle of sampling. EEM data are not publically available through the Internet. While EEM programs provide valuable site specific information, the variations in parameters measured, sampling times and protocols, and analysis methodologies complicate comparisons across sites, and can render suspect broader conclusions drawn on the state of coastal environments. Efforts have been made to standardize the sampling methodologies and reporting protocols of more recent EEM studies.

5.5.7 Environment Canada Shellfish Monitoring Program

As lead agencies in the Canadian Shellfish Sanitation Program (CSSP), Environment Canada, Fisheries and Oceans Canada and the Canadian Food Inspection Agency (CFIA) together monitor conditions in shellfish growing and harvest areas throughout the country, and control the harvesting and marketing of shellfish to ensure that they are safe for human consumption. Closures to commercial harvest are the responsibility of the DFO, on the recommendations of either EC or the CFIA. Environment Canada"s shellfish growing area (sanitary) surveys are the major component of the Marine Water Quality Monitoring Program and include activities such as identification of pollution sources, meteorological and hydrographic studies and bacteriological studies. While information on the findings of the surveys and on areas closed to shellfish harvesting were once available through departmental Internet sites, currently neither the DFO nor EC provide easy access to on-line information on shellfish restrictions for sites in Nova Scotia, or on trends or changes in this area. However, information on the Gulf and Pacific region closures remains available from the Internet. Information obtained from the Environment Canada Internet site in 2006 (Figures 5.1 and 5.2) are no longer available as they are not considered to represent current conditions. However, they do demonstrate that up to that date, a significant proportion of shellfish habitats were closed to commercial harvest, and that the areas affected by closures had been increasing. Figure 5.3 was obtained from the Halifax Regional Municipality website at the same time, and demonstrates not only the scope of areas closed to shellfish harvesting, but the proximity to coastal areas regularly used by the public for other fisheries, and for recreational boating and swimming. Outside of Halifax Harbour, there is no regularly scheduled monitoring program for recreational water quality.

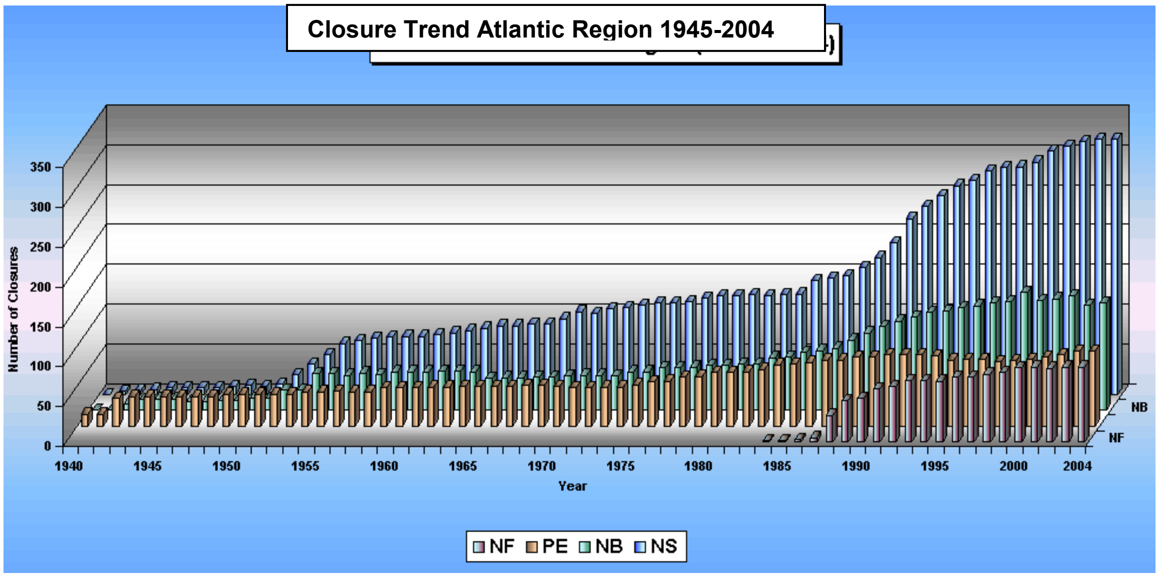


Figure 5.1: Closures in Atlantic Region Shellfish Areas 1945-1995 (Downloaded from the Environment Canada Website, 2006)

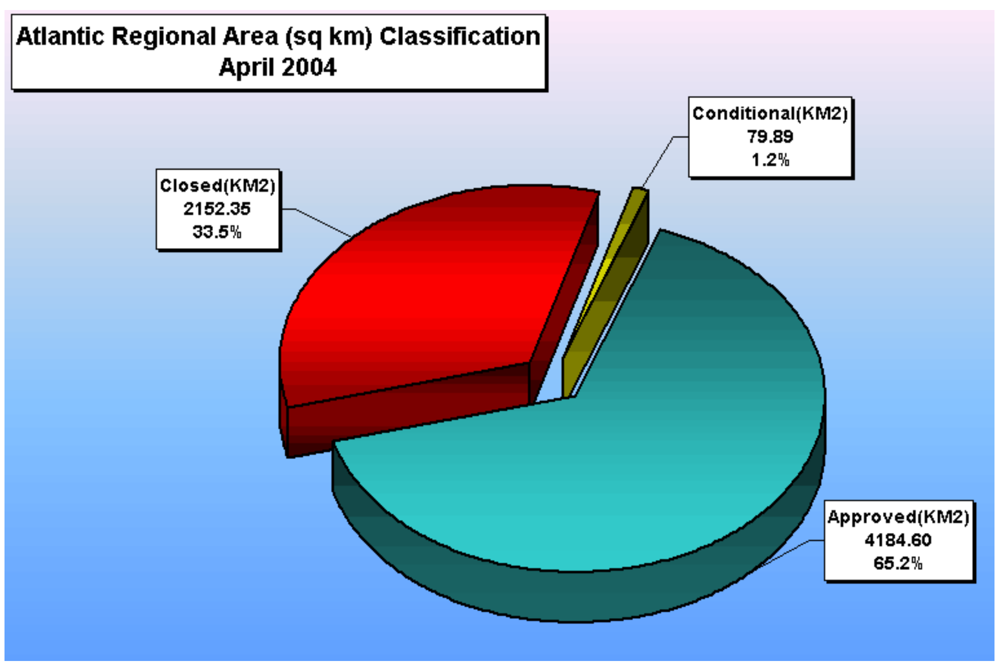


Figure 5.2: 2004 Shellfish Closure Areas in the Atlantic Provinces (Downloaded from the Environment Canada Website, 2006)

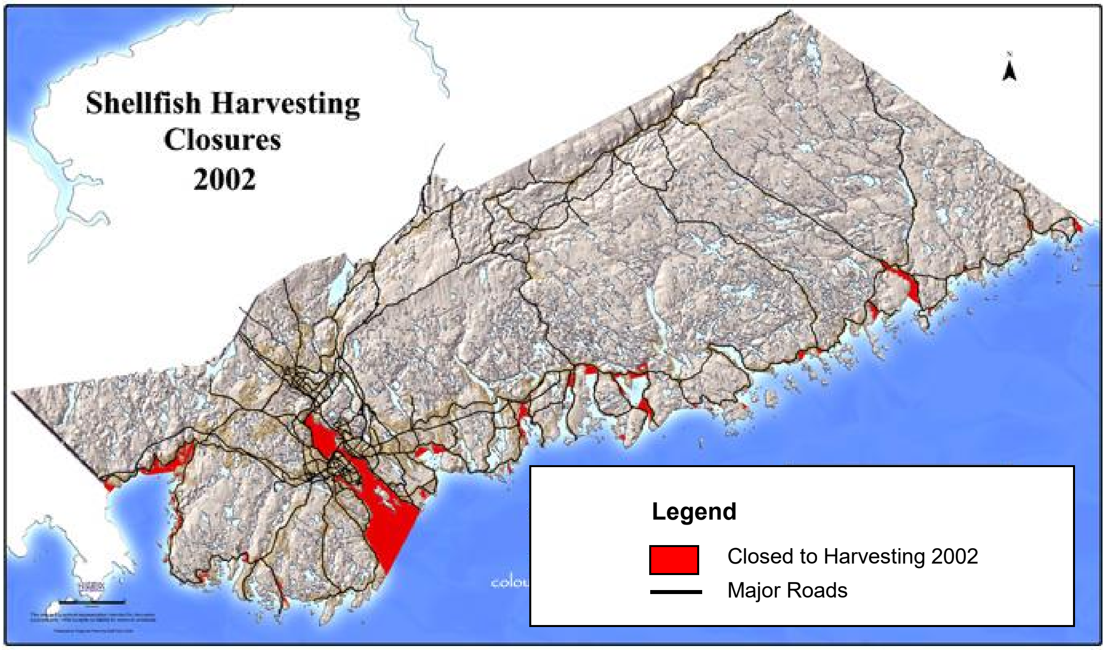


Figure 5.3: Shellfish Closure Areas in the Halifax Regional Municipality 2002 (Downloaded and adapted from the HRM Website 2006)

5.5.8 Provincial and Municipal Monitoring Programs

Throughout Canada provincial and territorial governments, as well as some municipal governments, regularly conduct water quality monitoring programs intended to satisfy specific information needs. Coastal and estuarine water quality is monitored by a number of municipalities (e.g., the Greater Vancouver Region, City of Victoria, Halifax Regional Municipality) intent on tracking conditions that may relate to their municipal wastewater treatment programs and outfalls. On the East coast, the private operators of marine aquaculture sites provide the Government of Nova Scotia with reports on water quality and other parameters within their immediate vicinity. Interestingly, recent studies on nutrification in the nearshore concluded that Prince Edward Island, whose nearshore waters face considerable challenges from agricultural stressors, has the most comprehensive program of monitoring for nutrient concentrations in the country (Bryklinsky et al. 2005). However, most of the information remains focussed on water quality or fisheries, little data exists to relate land cover or land use changes to nearshore conditions, and the data is not generally publicly available.

5.5.9 Environmental Non-government Organizations (ENGOs)

With continuing reductions in staff and financial resources, most federal, provincial and municipal governments have been hard pressed to maintain monitoring, data analyses and reporting programs on environmental conditions. Complacency on the relative health of Canadian coastal environments has not helped funding for these initiatives, a situation which has been further exacerbated by federal government policies that have seen reductions in the in-house science capabilities of departments such as Environment Canada and Fisheries and Oceans Canada. Since the early nineties there has been a proliferation of environmental non-government organizations across the country. Building on the nation"s culture of individual volunteerism, and with some fiscal support from governments, a number of these organizations have become substantial stakeholders in both the generation of new knowledge on coastal conditions and on advocacy for change in the policies that often drive government decision-making on coastal land use and resource extraction.

On the Pacific Coast, there is a wide array of ENGOs representing advocacy, stewardship, resource management and conservation interests. In addition to the internationally known work of the David Suzuki Foundation, a number of other environmental and community-based organizations are either individually or collectively at work monitoring and advocating for the sustainability of the coastal environment. Many of these communities and NGOs, including multi-participant organizations such as the Shorekeepers, the Burrard Inlet, Georgian Bay and Fraser River initiatives (GBAP 2003, GBPS 2002, FREMP 2003) work with the on-line Community Mapping Network to build local capacity to collect and manage resource information. The Community Mapping Network is a unique website that not only provides information on sample protocols, but links community-based monitoring and mapping data with government databases, providing a usable interactive geospatial tool freely accessible on the Internet (CMN 2005).

On the Atlantic Coast, in addition to the work of local volunteer networks associated with the Gulf of Maine Council, ENGOs like the Ecology Action Centre, and the organizations participating in the Atlantic Coastal Action Program (ACAP), as well as *ad hoc* networks of scientists, government staff and the interested and skilled community such as the Fishermen and Scientists Research Society (FRCS0), the Bay of Fundy Ecosystem Partnership (BoFEP), the Global Programme of Action Coalition for the Gulf of Maine (GPAC) and the Coalition for the Southern Gulf of St. Lawrence, have grown to play major roles in improving knowledge of coastal conditions (Bundy et al. 2007, den Heyer et al. 2006, GBPS 2002, GMS 2004, Harvey et al. 1998, Milewski et al. 2001, Percy 1997, SGSLCS 1999, Turcotte-Lanteigne and Ferguson 2008).

In the Great Lakes, in addition to local community-based organizations, Great Lakes United (a bi-national coalition of ENGOs) provides strong advocacy on a range of conservation issues, and is working towards integrating river and lake conservation in the curricula of a range of educational programs. Working with the International Joint Commission, researchers from governments, universities and the private sector meet regularly at the bi-annual State of the Lakes conferences, and collaborate on the production of focus reports on topics of interest.

Along the shores of Hudson Bay and the Arctic, there are long-established networks of academic and government scientists, yet public identification of and access to information on the state of the coasts can be difficult. While there are successful examples of local community-based monitoring and reporting (e.g., the Arctic Borderlands Ecological Knowledge Co-op (Gordon et al. 2007) and the Ashkui Project of the Innu Nation of Labrador (INNU/EC/GRI/NRCAN 2002, Sable et al. 2007)), integration of traditional and western scientific knowledge is a complex process, and can be challenged by revolving membership and leadership in community organizations, cultural differences, poor historical research community-researcher relations, financial limitations, time constraints, and difficulties in communicating methods and results to stakeholders (Manseau and Parlee 2003, Pearce et al. 2009).

Government organizations, such as EMAN, had been helping ENGOs to standardize their protocols for sampling and reporting, but continued resource and funding cuts have curtailed the progress made to date. National conferences of organizations such as Coastal Zone Canada and the Oceans Management Research Network, as well as regional and local symposia sponsored by science, community and government networks, government departments and/or environmental non-government organizations, have continued to provide important venues for the sharing of data and information among government and academic scientists, the private sector and community-based volunteer organizations (BoFEP 2005a, 2005b, den Heyer et al. 2006, Gallaugher et al. 2005, Hinch et al. 2002, Monette 2001, SRSF 2001). Publications from these organizations can represent the best synopsis available of the current state of knowledge of coastal health, but even here the language can be highly technical and the focus remains on the health of marine and aquatic environments (Bliven 1998, Lotze and Milewski 2002, Milewski et al. 2001, Percy 1997, Percy and Harvey 2000, Tank 2004, Werring 2005, 2007).

5.5.10 Conclusions on the State of the Coast Information

Following from this review of state of the coast environment information in Canada, it was concluded that there was insufficient information to either support convictions that Canadian coasts remain relatively unaffected by human activities, or to provide credible evidence of the sustainability, or lack thereof, of any or all of the physical, biological, chemical, or socio-economic components that make up coastal landscapes. The review did reveal the following disturbing realities about the state of coastal knowledge.

- National indicators for sustainability do not include coastal indicators.
- There is no current state of the coast reporting for Canada.
- Considerable analysis is required before available coastal data and information can be translated into knowledge of past or current coastal conditions.
- Existing databases may contain thousands of data points but few have relevance to conditions in nearshore waters, or to the relationships between land cover and land use change and impacts to coastal environments.
- Where coastal data exist, they are spatially isolated, temporally inconsistent, measure a disparate array of parameters and are subject to significant variation in collection, analysis and reporting protocols, any of which can render data ineligible for integration into regional or national databases.
- There is as yet no national consensus on a suite of indicators of coastal well being.
- Existing government programs for monitoring coastal conditions continue to face severe financial and professional resource challenges.
- As a result, opportunities to expand monitoring programs to encompass more holistic indicators of coastal conditions are few.
- While it has not been substantiated, some scientists feel that federal granting agencies have a preference for laboratory studies over field ecological research.
- Much of the current effort in monitoring coastal conditions is accomplished only through the efforts of ENGOs and local volunteers.

- Funding for existing community - scientific networks (BoFEP, ACAP, OMRN, GPAC) etc. is ephemeral, and despite their demonstrated successes, organizations such as BoFEP and OMRN no longer have even the minimal funds necessary to continue.
- Reporting on coastal science is disjointed and seldom do either the facts about current conditions or concerns over disturbing emerging trends reach the appropriate audience for action.
- Given the demands placed on scientists for rigour in their work, reporting outside of academic journals and collegia is rare, is somewhat unintelligible to the average decision-maker, and generally is not placed in a context that provides guidance for action.
- Too much of the essential knowledge required for understanding coastal change remains in a format or storage condition that renders it publicly inaccessible.

Much of Canada‟s understanding on the state of coastal health continues to be derived from data on traditional chemical and biological parameters of marine and freshwater environmental quality and stock assessments for commercial fisheries (Caddy 2004, Harding 2001, Vandermeulen 1998, Vandermeulen and Cobb 2004). For vast areas of the Canadian coasts, even this level of information is rare. Where information does exist, much of the data was either collected from research vessels operating at distance (>3 km) from shores, was focused on the regulation of point sources of pollution (e.g., aquaculture, pulp and paper, fish processing, offshore energy), and/or was geographically localized to discrete sites (Breeze and Horsman 2005, Brylinsky et al. 2005, Curran et al. 2006). Only a few marine data sets address closer nearshore conditions, or provide time series information (Brylinsky et al. 2005, Li et al. 1998, Parker et al. 2007, Strain et al. 2001). Where such data sets do exist, they are seldom regional in scope, and have relied on differing methodologies for collection, analysis and reporting, making integration difficult and generalized conclusions suspect. With the exception of Prince Edward Island, which may have the most useful data on coastal health in the country (Bates and Strain 2006, Brylinsky et al. 2005, Sommers et al. 1999), few efforts have been made to link changes in land use to nutrification and other impacts in nearshore receiving waters. Trends such as the dramatic and extensive diebacks of eelgrass (*Zostera marina)* observed in southern and eastern Nova Scotia over the past 15 years are of concern as no reason has yet to be discovered. But still there is no regular monitoring program (Bundy et al. 2007).

While it is increasingly being accepted that the levels of persistent contaminants in marine waters in Canada have been declining, there are concerns on the scope, quality, quantity and timeliness of the data on which these findings continue to rely (Mercer Clarke and Bard 2007). When Stewart and White (2001) reported that, with the exception of localized pollution from point sources or harbour contamination, coastal embayments along Nova Scotia‟s Atlantic shores have low to negligible baseline concentrations of contaminants, they accepted that for many areas of the coast information was either dated, or that no data were available. Given that conclusions on coastal health continue to rely on assimilative water quality assessments in active mixing areas, and on commercial fisheries parameters, it is a simple step to assume that the current body of knowledge on coastal health may not adequately represent accumulating effects of land-based activities and other pressures and impacts on estuaries and embayments. These concerns are bolstered by recent research into changes in biodiversity and physiological well being of nearshore marine species exposed to outfalls of treated and untreated industrial and municipal wastewater effluents which have demonstrated disturbing trends in the declining fecundity of key species and in reductions in biodiversity in the intertidal and littoral zones (Coray and Bard 2007a, 2007b)

Equally disturbing is the enduring gap between land management activities and efforts to protect and conserve marine and estuarine environments. As information on changing conditions is seldom shared across the land-sea divide, there are few circumstances where there are harmonized goals and policies to guide development and resource use. The pervasive lack of critical information may have also contributed to questionable assumptions on ecosystem stability and community well being, and reinforced public indifference to the state of the coasts. Without pressures from the public or a valid science voice, there has been insufficient political will to close the gaps in coastal management policy, priorities and action that are experienced by all levels of government.

Canada has also done little to link changing conditions in coastal areas with human health endangerment. While programs exist to oversee the safety of consumption of marine food species such as shellfish, there have been fewer attempts to monitor or to understand other aspects of exposure to pathogens and contaminants in the marine environment. Outside of major municipalities who sometimes monitor recreational water quality, there are few initiatives providing timely information on the risks posed by human contact with coastal waters. In areas where pathogenic concentrations in the water column have resulted in regulatory bans on commercial shellfish harvesting, nearby public recreation areas and beaches can remain untested and open for public use. By example, most areas of the Atlantic coast of Nova Scotia are not regularly monitored for threats to human health unless public complaints are made. Despite research that demonstrates the persistence of other bacteria, and viruses in salt water past the time frame in which faecal coliform can survive, coliform counts remain one of the most used parameters to determine risks to human health.

Data on socio-economic conditions that link coastal ecosystem health to the health and well being of coastal residents is even more difficult to obtain. Attempts to value coastal ecosystem services have met obstacles caused by continued dependence on traditional economic parameters, a lack of data on sectors such as coastal tourism and recreation, and by difficulties in attaching fiscal values to tangible as well as intangible costs and benefits (Gardner et al. 2005, Gardner et al. 2009, GOV/NL 2002, Ledoux and Turner 2002, Mandale et al. 1998). There is a growing body of information on change in coastal communities being developed by collegia comprised of academic researchers and members of the informed community; however, seldom are the results of these initiatives circulated widely (Catmur et al. 2003, Gallaugher et al. 2005). In much of the country, departments and agencies with responsibilities for land-based development and resource management in general, continue to operate outside of the dialogue on coastal management. As a result, there are significant gaps in the collection of new data, the prioritization of issues, the transfer of knowledge on causality, and on the education of decision-makers as to their responsibilities to sustain coastal ecosystem health. Within the scientific community, while there are escalating concerns on the potential impacts climate change will have on coastal communities, infrastructure and sensitive coastal ecosystems effects, governments have as yet paid only limited attention to understanding and planning for coastal adaptation. Successful initiatives such as the Canadian Climate Impacts and Adaptation Research Network (C-CIARN) initiative have been discontinued, and the current focus of federal efforts on managing for climate change appears to have shifted towards the reduction of contributing air emissions. New reports on the potential for impacts from severe weather events, sea level rise and storm surge have not only identified significant costs to coastal infrastructure and economies, but have raised questions of Canada‟s preparedness for emergency response to coastal disasters (GOC 2003a, 2008b, Heap 2007, Lemmen et al. 2008)

Finally, the realities posed by the aging Canadian population may be having their own impact on coastal information and data. Retirements of academics and government staff are contributing not only to the loss of considerable intellectual capital and gained experience, but may also be resulting in losses of data and information that currently reside within individual libraries and collections (Isenor et al. 2001, Lemmen et al. 2008). Whether it is the loss of the only remaining hard copy of valued reports or the deterioration of data stored on now-defunct electronic media, there are growing concerns amongst the technical librarians that a staggering loss of knowledge may be going undetected as offices are vacated and materials discarded.

So what are Canadians to do? Gunton (2007, 2008) has already reported that Canada had one of the worst environmental record of any developed country, ranking 28^{tth} out of 30 of the nations of the OECD (Organization for Economic Co-operation and Development). But given the current economic crisis, reduced fiscal and human resources will likely be with us for the foreseeable future, hampering the ability to maintain, let alone expand, current monitoring programs. If we are to adequately understand existing conditions and the patterns of change that may shape the future, there is a compelling need to measure the right things, and to communicate the findings with clarity to the appropriate audience. We have been using indicators to determine if conditions are getting worse. We should also be using indicators to assist in planning for and adapting to coastal change.

5.6 Linking Coastal Science: A Proactive Approach to Management

Within today‟s world there is no such thing as a stable climax ecosystem. The entire planet is in a state of deep flux, as are the human institutions that seek to mange it. But stability within ecosystems is not only a poorly understood concept, it is not an advantageous condition. Concrete is stable, but the living world is dynamic and relies for its survival on its ability to adapt to changing conditions. Recognizing the nature of current and future changes in the coastal landscape is a necessary first step towards understanding the need for progressive and continuous transformation of coastal policy and decision-making. Most coastal indicators report on the state of current conditions, but provide little insight into the patterns or pace of change, nor have they been framed so as to spur needed action by decision-makers (Rogers and Greenaway 2005). Insufficient attention has been paid to setting standards, targets, guidelines or limits by which change in measured parameters can be communicated as being beneficial, detrimental or maintaining of the status quo. As a result, too little of our knowledge of change in coastal systems has been used to inform or to improve upon resource and land development decision-making. With a widening gap between science and management, changes to government policy and programs are more often responsive to economic conditions than to the need to sustain environments. There is a pressing need for coastal science that provides insight into the risks to our future, and offers advice on our options for planning, adaptation and management (Wells 2003, Wieler 2007). Coastal managers need indicators that can report with clarity, relevance and usefulness information on all of the following:

- reference conditions in terrestrial, aquatic, marine and human systems;
- cause and effect relationships that operate within and across coastal ecosystems;
- immediate and emerging trends and issues of concern;
- existing and potential impacts to ecosystem health and community well being; and
- the pace and scope of change.

To date in Canada, too much emphasis has continued to be placed on management approaches that mirror the DPSIR (drivers-pressures-stressors-impacts-responses) model for coastal governance (Hameedi 2005). Theoretically DPSIR approaches offer decision-makers opportunities to proactively effect change through the reduction of drivers, pressures and stressors. Pragmatically, much of the response of governments to coastal issues has remained reactive, requiring proof of impact to coastal systems before responses or actions are triggered. By the time impacts to coastal systems have become measurable, either the damage has already been done or the opportunities to reverse or mitigate the causative factors (land use, land cover change, loss of natural forests and wetlands, hydraulic shifts, nutrification) are limited or financially impractical (Austin et al. 2007). What is needed is a DPSIR system in which knowledge of the linkages between drivers, pressures, stressors and ecosystem impacts, triggers proactive policies and programs within government intended more to avoid damage to coastal systems and communities than to remediate its impacts (Figure 5.4).

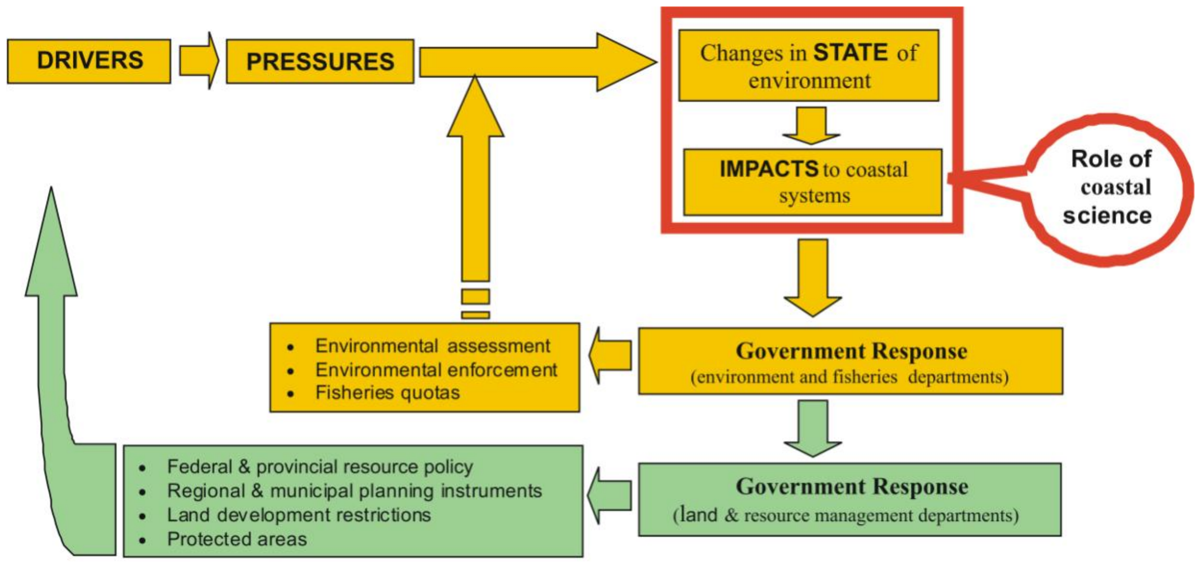


Figure 5.4: Proposed Shift in the DPSIR Model

By linking nearshore information on coastal conditions with terrestrial data such as population distribution, land cover, the quantity and quality of freshwaters, our understanding of the forces that impact coastal receiving environments could be improved (e.g., stormwater runoff, seasonal stream flows, nutrient and sediment inputs, temperature and salinity changes, and buffering capacity). While some difficulties may be encountered when attempting to integrate data sets based on arrays of indicators collected at different temporal and spatial scales (and for entirely different purposes), critical issues may be overcome through the use of readily available and relatively inexpensive geospatial technologies (Bartlett and Smith 2005), and through the development of meta-indicators.

A meta-indicator is a parameter in which evidence of change points to suspected changes in other conditions. Meta-indicators have long been applied as useful tools in human-health diagnostics, where simple changes in body temperature or blood chemistry are used daily as meta-indicators of potential illness. In coastal management, meta-indicators such as increases in nutrient loadings could be used to provide a coarse assessment of the overall state of the system (Degnbol 2005), to set thresholds for management action, or to point to the need for more intensive observation of the recorded phenomena. Changes in the loadings of nutrients into coastal waters could warn of the potential for oxygen depletion, eutrophication, and/or other knock-on impacts such as shifts in the species composition and timing of plankton assemblages and declining biodiversity and abundance in nearshore habitats.

Meta-indicators could also be used in an adaptive learning approach to build ecosystem knowledge, and as a pragmatic tool to aid decision-making, refocusing at least some of the effort currently expended to develop detailed understanding of ecosystem functioning towards information that assists in regulating major human derived pressures on ecosystems. If as Degnbol (2002) proposes, the best gains in improving the quality of marine ecosystems can be achieved through improved fisheries management, then a similar benefit to coastal ecosystem health could be achieved through improved management of land-based activities.

Meta-indicators of land cover change applied as benchmarks or thresholds could be used by land planners to set limits that would reduce or eliminate activities capable of causing detrimental effects throughout the coastal landscape. Such an approach is currently being employed by the State of Oregon (2000) where land use has been found to be an effective meta-indicator not only for assessing current conditions in the landscape (e.g., urbanization, deforestation), but also to assist in complex development decisions. Changing land cover ratios within the watershed has also been proposed as one of several meta-indicators to guide planners in sustaining biodiversity within watershed areas of southern Ontario (GOC/EC 2004).

Pragmatically it is important to accept that in most instances society and the politicians that serve it are motivated to action first by concerns for the protection of human health and safety, then by ensuring economic well being, and only after these have been addressed, by concerns for the protection of ecological integrity and cultural assets. To be relevant to these decision-makers, indicators must be tied to social issues and concerns; contribute to prevention, enforcement and/or remedial actions; be categorized according to significance of impact; and identified as either a short- or long-term priority for action.

Moving away from traditional circumstances where science has selected indicators, to one in which both science and management have equal voices, critical indicators for coastal management in Canada could be assembled into the following categories of meta-indicators for further un-packing and development.

- population demographics
- land cover and land use
- adaptation to climate change
- human health
- economics
- coastal geomorphologic and riverine hydraulic changes
- contaminants
- nutrification
- biodiversity
- critical habitats
- sentinel species
- protected areas

5.7 Through the glass, clearly

A more interdisciplinary approach to understanding and managing coastal areas is needed, in which greater respect is paid to attributes such as cooperation, collaboration, contingency, and adaptability, and the primary goal is a progressive transformation of society (Aberley 1994, Burbridge 2004, Milligan and O'Riordan 2007, Stojanovic et al. 2004). There will always be a need to monitor marine and coastal ecosystems, in order to provide information on reference conditions and to better understand the complex causative factors of change. However, society also needs science to ensure that this knowledge is used beyond the identification of priority issues in coastal marine management, to address land-based as well as resource-based management, and ultimately to affect policy development and to provide guidance useful to coastal and terrestrial decision-makers in their everyday actions. The new challenge is to identify indicators that promote understanding of the complex relationships between human activities and ecosystem change and that contribute to the development of analytical, communication and management tools that improve our capacity to:

- detect and understand relationships and patterns of change;
- identify issues of concern that require management response;
- set priorities and define an appropriate time frame for response; and
- plan for a range of probable but uncertain alternative future scenarios.

The situation along the coast is similar to a house constructed entirely of glass walls. We can see through these walls to what we need, to whom we need to talk, to what we want to change. But the walls can restrict the movement of people, impair communication and sharing of information, and contribute to the tunnel vision of many scientists. Access to seemingly un-related sources of data may be constrained by ownership, as well as by collection, analysis and reporting methods. Collaborative efforts may be hampered by outdated academic and disciplinary boundaries. Scientists may step back from participating as stakeholders in the setting of coastal policy and goals, deterred by their own, perhaps misguided, perceptions that their participation would be neither welcomed nor appropriate.

As coastal areas begin to deteriorate under the unremitting impacts of land-based activities, unapologetic science and scientists must leave the security of their laboratories to provide needed information to society. Collaboration among governments, the private sector and the professional community should inform the development of pragmatic and effective alternatives to current practice in both science and management, so as to shape the sustainable future of our coasts. Our objective should be to develop, define and enshrine the tangible inter-disciplinary meta-indicators of coastal sustainability, rather than to continue the struggle with the individual and intractable intra-disciplinary objectives of coastal management. It is unlikely that we will be able to identify or to plan for all of the potential permutations that will affect coasts in the future. But we must move quickly to make the best of what we know and what we can do, while science plays catch up in an unequal race with time and change.

CHAPTER 6:
MANAGING THE RELATIONSHIPS BETWEEN LAND COVER CHANGE AND NUTRIFICATION IN THE NEARSHORE: A NOVA SCOTIA CASE STUDY

They paved paradise, and put up a parking lot
They took all the trees, put em in a tree museum
Don't it always seem to go, that you don't know what you've got
Till its gone
(BIG YELLOW TAXI Words and Music by Joni Mitchell © 1970 (Renewed) Crazy Crow Music. All Rights Administered by SONY/ATY Music Publishing All Rights Reserved)

It is not too early to speculate that the next thirty years will bring the most significant changes to the ocean and coastal economies since the arrival of industrialization and rapid urbanization in the late 19th century. Tracking, understanding, and shaping those changes will shape the next generation of competition over the coasts, oceans, and Great Lakes. (Kildow et al. 2009)

6.1 The Changing Face of the Planet

Pushed by a range of socio-economic drivers, changes in land cover (the biophysical characteristics of the surface of the earth) and in land use (the activities undertaken by humans that can alter or change land cover) have been accelerating, transforming the face of the planet, affecting climate, and raising concerns for the stability of global ecosystems (MEA 2005a, 2005b, Turner et al. 1990, UNEP 2007a, 2009). Changing land cover and land use alters not only local ecosystem functions and biodiversity but can contribute to broader impacts throughout the watershed and in coastal receiving environments (GESAMP 2001a, 2001b, Kennish 2002, Malone et al. 1999, Waycott et al. 2009). Land cover and land use change can alter downstream hydrodynamic conditions through erosion and sedimentation, increased water temperatures, and changes to the periodicity and intensity of seasonal and peak flow conditions (Jones et al. 2001, NRC 2004). Industrialization, urbanization, deforestation and agriculture load significant amounts of contaminants, silts, and nutrients into the air and water through a combination of point- (industrial, commercial and municipal piped effluents) and non-point (overland, water and air borne transport and deposition) sources (Boesch 2002, Boyer et al. 2006, Carpenter et al. 1998, EEA 2002, 2003, 2006a, Green et al. 2004, MEA 2005d, NRC 2004, Salomons 2004, UNEP 2002d, 2006b). Accepting that over 80% of coastal pollutants originate from land-based activities (GESAMP 2001b, UNEP/GPA 1995), much of the developed world focussed its attention on the management and reduction of contaminants from point sources. Only recently has science determined that non-point sources can significantly outpace industrial and municipal point sources, especially in the loading of nutrients (nitrogen, phosphorus and silica) into coastal waters (Gao et al. 2007, HELCOM 2005, Kroeze and Seitzinger 1998, UNEP 2002d, 2006b, Vermaat et al. 2005).

6.1.1 Land Cover Change and Nutrification

Concerns over phosphorus and nitrogen enrichment and eutrophication of fresh water environments became prominent in the last half of the twentieth century, leading to significant reductions in the allowable concentrations of nutrients in detergents and other substances that regularly found their way into aquatic environments (NRC 2004). However, nitrogen and silica, long believed to be the limiting nutrients in marine waters, did not raise similar concerns, buoyed by expectations that marine ecosystems, especially cold water environments, were nutrient impoverished, and that anthropogenic sources of nitrogen would be outpaced by naturally occurring upwelling of nitrogen from deeper oceanic waters. Measurable evidence of deteriorating conditions (i.e., algal blooms and die-offs, anoxic zones, fish kills) that have occurred in coastal and marine environments throughout the world, has caused scientists to look again at potential causative factors (Diaz and Rosenberg 2008, Kennish and Townsend 2007). Increased loadings of nutrients to coastal waters is now believed to have long-term detrimental impacts to both the structures and functioning of estuarine and marine ecosystems (Crain et al. 2009, Crossland et al. 2005). Throughout the world, nutrification of coastal waters is widespread and potentially inter-generational, with few cost-effective or practical opportunities to mitigate existing damage, or to prevent continuing impacts from established land use practices, or from nutrients that have been already been deposited in nearshore sediments (CBP 2005, EEA 2001, 2006, Kennish 2002, Lotze et al. 2006, MEA 2005c, NRC 2004, Randall 2004, Selman et al. 2008, UNEP 2007a, 2009, USEPA 2005, 2007).

Anthropogenic changes to land cover are the result of the complex needs of growing human populations for food, water and commercial resources. Deforestation, agriculture, urbanization, resource extraction and transportation driven by complex local and non-local social and economic forces that may not contribute positively to the well being of local populations (Lambin et al. 2001). Yet the patterns of change in land cover and land use continue to be under-reported, and are only rarely linked to direct or indirect impacts to local or downstream environments or to socio-economic conditions within dependent human communities. Despite the growing body of knowledge linking changes in land cover and land use to pervasive impacts to ecosystem stability and growing threats to human health, coupling those changes to deteriorating conditions in the nearshore continues to be challenged by the lack of data on current and historic conditions, and by the complexity of coastal ecosystems.

6.1.2 Modelling the Contribution of Non-point Sources

In recent years, significant resources have been applied to the development of modelling technology for point and non-point loadings of nutrients into aquatic, estuarine and coastal waters, especially in areas where local data were lacking (Borja et al. 2008, Siewicki 2006). In North America and in Europe, research into the nutrification of coastal waters has focussed on advancing knowledge in key areas that include:

- loadings from non-point sources (Basnyat 1999, Boesch and Brinsfield 2000, Boyer et al. 2002, Caraco and Cole 1999, Cole et al. 2006, Correll et al. 1992, Driscoll et al. 2003, Holland et al. 2004, Kleppel et al. 2006, Portman et al. 2009, Rodriguez et al. 2007, Van Drecht et al. 2005);
- modelling nutrient loadings to coastal waters based on land cover and land use in watersheds (Beusen et al. 2005, Cardosa da Silva and Carmona Rodrigues 2004, Cloern 2001, Dumont et al. 2002, EEA 2001, Evans et al. 2002, Harrison et al. 2005a, Harrison et al. 2005b, Haygarth et al. 2003, Kérouel and Aminot 1997, Painting et al. 2007, Seitzinger and Harrison 2005, Seitzinger et al. 2002a, Seitzinger et al. 2002b, US/EPA 2001, Valiela et al. 2000, Voinov et al. 1999, Zitello et al. 2008);
- nutrient cycles in coastal waters (Le Tissier et al. 2006, Tobias et al. 2001);
- groundwater sources (Slomp and Van Cappellen 2004);
- denitrification mechanisms (Seitzinger et al. 2006, Tobias et al. 2003, Valiela and Cole 2002); and

- impacts of nutrient enrichment on coastal ecosystems (Bokn et al. 2003, Bowen and Valiela 2001, Cloern 2001, Diaz and Rosenberg 2008, Ferreira et al. 2006, Fletcher et al. 1999, HELCOM 2006, McClelland and Valiela 1998, Portman et al. 2009, Tor et al. 2003, Worm et al. 2000).

Given the complexities of coastal environments, and their constant state of flux, there have also been efforts to develop integrated environmental models of coastal processes, or meta-models. Meta-models are capable of assembling and analyzing a complex array of data and information loaded either as primary data or derived from the outputs of established software simulation products capable of modelling environmental processes such as land cover and land use change, hydrology, fluid dynamics, and biogeochemistry (Barton et al. 2008, Van Drecht et al, 2005). Biogeochemical or ecological models can address both biotic (species, functional groupings) and abiotic (nutrients, contaminants, suspended matter) parameters, providing considerable insight into processes such as watershed nutrient loadings, denitrification processes, and/or ecosystem responses. With the increased resources provided by rapidly evolving computer technology, meta-models are able to harmonize data inputs and to coordinate outputs so as to provide a broader assessment of existing conditions, and to provide for more complex prediction of future scenarios. Similar gains in remote sensing of changes in coastal land cover, sediment transport, sea level rise and population densities, have transformed the ability to work on regional, national, and global scales. In addition to these resources, the Internet continues to facilitate access to data and sharing of information, including the provision of public access to modelling applications either through interactive streaming or download to desktop computer stations.

Examples of meta-models that focus on the impacts of land cover and land use change on conditions within riverine and nearshore coastal environments include:

- the DITTY Project of the European Commission (European Commission 2005a, 2005b);
- the LOICZ project (Herman et al. 2005, Huntley et al. 2001, Kremer et al. 2005, Pernetta and Milliman 1995, Talaue-McManus et al. 2003);
- the GTOS (Global Oceanographic Terrestrial Observing System) (Christian 2003, Christian et al. 2005);
- the NLOAD project (Bowen et al. 2007, Bowen and Valiela 2004);

- NOAA"s N-SPECT and the USGS SPARROW (Hoos and McMahon 2009), and the
- international SCOPE projects (Howarth et al. 2002, NRC 2004).

Despite all these efforts, the science on cause and effect of nutrification in nearshore coastal environments continues to be challenged not only by the complex nature of coastal ecosystems, but also by the broad array of stressors from anthropogenic activities (NRC 2004). Estimates of nutrification derived by empirically calculating loadings from non-point sources are complicated by variables related to local hydrology, vegetation, soils, climatology, topography and seasonality. Watershed modelling can be a difficult and tedious task, requiring large amounts of data and covering broad temporal and spatial scales (Evans et al. 2002). While current modelling efforts may work on regional scale (i.e., Western North Atlantic), there can be difficulties in accurate application at the local embayment level (EEA 2001, Howarth et al. 2002, NRC 2004). Yet it is these sheltered nearshore coastal embayments such as fiords and estuaries that are believed to be the most susceptible to impact from land derived pressures (NRC 2004). Too many of the meta-models have been developed with a natural science bias and are more focused on improving knowledge than on providing support for needed changes to regional or local land use planning policy and decision-making processes (Mcintosh et al. 2005). As a result, their useful application to practical decision-making remains as challenged by their complex nature and the need for unavailable data, as by failures to adequately communicate their usefulness to politicians and managers.

6.1.3 Failing to Connect the Dots

Perhaps it is not surprising then, that as knowledge of the relationships between land use and deteriorating environmental conditions has grown, human activities that contribute to the loading of nutrients and pathogens to marine and coastal ecosystems of North America have also inexplicably continued to increase - sometimes dramatically (Burkholder 2001, Dixit and Brylinsky 2008). Increased population densities in coastal areas have contributed to urbanization and increased sewage loads. Intensive agricultural has led to increased fertilizer use and higher volumes of animal waste. And in general, throughout North America and Europe, there have been increases in the combustion of fossil fuels (Chambers et al. 2001, GOC/EC 2001b, UNEP 2002d). Gains have been made in reducing loadings of nutrients (especially phosphorus) from point sources such as sewage treatment plants, but most treatment facilities throughout the

United States and Canada still allow the overflow of untreated sewage during even moderate storm events. And despite the growing science on the environmental impacts of nutrients, inputs from non-point sources, such as agriculture and urbanization, have continued relatively unchecked, and have in some areas continued to increase. In North America, fertilizer production alone has grown by 30%. Throughout the United States, nutrient contributions to coastal waters have continued to rise, resulting in eutrophic conditions in over 65% of coastal rivers, estuaries and bays (NRC 2004, UNEP 2002d). Coastal managers continue to be challenged by the mismatches in spatial and temporal scales between the science on ecosystem structures, functions and relationships and the knowledge needed to support management (Sherman 2000). As a result, the attention of policy and decision-makers is often diverted into relatively small scale efforts to protect habitats and species, without a clear understanding of the broader ramifications of human land-based activities on biodiversity loss and ecosystem change. By example, as reported by Stegeman and Solow (2002), while sewage plants discharged twice as much oil into US waters, the focus of public and government attention was on catastrophic yet episodic tanker spills.

While there is still much debate over what constitutes coastal ecosystem health, practical definitions have assumed ecosystems to be healthy when they are not measurably impacted by negative influences but are sustainable and resilient to stress (Boesch and Paul 2001, Coates et al. 2002, Costanza 1992, Jorgensen and Richardson 1996, Nielsen 1999, Sherman 2000, VanLeeuwen et al. 1999, Wells 2005, Windhorst 2005). Comparisons drawn between human health and ecosystem health, while successful in capturing public interest and comprehension, may have contributed to assumptions that ecosystems are healthy unless and until science can prove they are not. But unlike the human body, ecosystems are large, complex assemblages of species and habitats, for which the knowledge base continues to be very limited. And to further confound our understanding of stability and health, ecosystems seldom achieve equilibrium, but are constantly evolving to adapt to new conditions, bringing into question how to assess when change is good and when change is bad. While seeking pragmatic and cost effective indicators of coastal health, both science and management have come to rely on indicators that provide measurable evidence of negative change (i.e., increased levels of nutrients in water and sediments, plankton blooms, reductions in fish landings, loss of biodiversity, and increased incidences of illness in humans), most of which only appear once the system has passed its assimilative capacity and is no longer resilient to impact (Bricker et al. 1999). Environmental management systems (i.e., the DPSIR frameworks) that focus monitoring programs on indicators that report on current state of the environment conditions, seldom link impacts to the underlying stressors in the watershed that force detrimental change (Hakanson and Blenckner 2008, Hardman-Mountford et al. 2005, Robinson 2004). By continuing the focus on defining acceptable levels of contaminants in coastal waters, we are monitoring for evidence of impacts to coastal health that will have already occurred, and that may, by the time they are detected and reported, be beyond our technical abilities or fiscal resources to effectively mitigate. (Gray and Wiedemann 1997, Kremer et al. 2005, Niemi et al. 2004). This may be especially true of impacts that result from nutrification of coastal waters.

In Canada, as early as the 1980s, it was anticipated that areas of populated and developed coastlines faced developmental pressures similar to those experienced in Europe and the United States (Beanlands 1983). Yet concerns that Canadian coasts may also be threatened though nutrification or pathogenic contamination of coastal waters are relatively recent (CCME 2007a, Chambers et al. 2001, Chambers et al. 1997, Dixit and Brylinsky 2008, GOC/EC 2001b, US/NOAA/GOMC 2001, US/NOAA/UNH 2001, Werne and Connor 2001). For many years, it was believed that the sea could absorb these wastes, and that nutrient contributions to coastal waters were sufficiently well-mixed with oceanic waters to dilute concentrations to acceptable levels and to kill harmful pathogens (Hinch et al. 2002, Howarth et al. 2000, Howarth et al. 1996, Howarth et al. 2002, Strain 2000, Strain et al. 2001). Relying on this science, the disposal of untreated municipal sewage into coastal waters was considered to be potentially beneficial, contributing to increased productivity in impoverished marine environments through the addition of needed nutrients. However, in the past decade, a strong consensus has developed among scientists that loading of nutrients, especially nitrogen, into protected coastal and estuarine waters contributes to nearshore eutrophication (Burkholder 2001, Howarth and Marino 2006). And while dilution through mixing may ameliorate nutrification along exposed coastlines, there are few data to support assumptions that more protected coves and estuaries along the Canadian coasts remain as yet un-impacted by pathogen and nutrient inputs (Brylinsky et al. 2005). Indeed, where data exist, there are a growing number of disconcerting reports of deteriorating conditions in estuarine and coastal embayments throughout the country (Chambers et al. 2001, Chambers et al. 1997, Dixit and Brylinsky 2008).

In the Atlantic region, over half of the shellfish production areas of the Canadian shores of the Gulf of Maine have been closed to harvest as a result of bacteriological contamination (largely the result of contact with human sewage) (Hinch et al. 2002). There is an unexplained and significant decline in eel grass (*Zostera marina)* throughout the Maritimes (Hanson 2004). Protected estuaries and coastal embayments in New Brunswick are reporting eutrophic conditions (Lotze and Milewski 2003). In Prince Edward Island, which is coping with escalating eutrophic conditions in its estuaries, provincial and federal authorities have been cooperating on monitoring efforts in nearshore waters, developing what is believed to be the most comprehensive program at work in the country at this time (Bates and Strain 2006, Brylinsky et al. 2005, GOV/PEI 2005, Sommers et al. 1999). Considerable effort is also being made to improve understanding of the relationships between the province‟s highly valued agricultural industry and the health of its equally important coastal tourism areas (CCME 2007a, GOV/PEI 2008, Martec Limited 2002). As local concerns for the state of the coast grow, provincial governments throughout the country have begun work on their own initiatives in coastal monitoring and management, yet few of these efforts have as yet focused on linkages between land cover and land use change and coastal conditions. And even where it exists, there are still insufficient spatial and temporal data on nearshore water quality and coastal ecosystems to support complex modelling of ecosystem loadings and impacts.

Throughout the world, proactive management of watershed land cover and land use change continues to be a challenge (Boesch 2002, Crossland et al. 2005, NRC 2004, UNEP 2002d). In reality it may matter little whether the problems are the direct result of continuing complacency on the ability of coastal mixing to dilute contaminants, the lack of data on past, current and projected future conditions, conflicts over jurisdictions, or the inherent complexities of coastal environments. Much of the science needed to support and to inform decision-making is still either not available, is poorly communicated, or cannot be directly applied to policy development or needed changes to practice (DeVoe and Kleppel 2006). Then too, land-based activities are managed by government staff who may have had little training or knowledge of coastal systems and processes, and few opportunities to become better informed on the linkages between their decisions and coastal impacts (US/NOAA/UNH 2001). Recent initiatives in Canada and the United States to develop guidance frameworks for nearshore marine eutrophication have relied on a science-based approach to set specific guidelines for nutrient concentrations in coastal waters (CCME 2007a, Dixit and Brylinsky 2008, US/EPA 2001). While the work is excellent, and provides needed insight into the issues around ongoing nutrient loading from agricultural and other land uses, these are primarily reactive tools that do not by themselves translate well for application by planners and policy makers concerned with land-based decision-making. Establishing baseline conditions and setting limits for nutrient levels in coastal waters provides needed answers to questions on the existing status of Canadian coastal inlets, but is only one piece of the puzzle that is nutrient management (Costa et al. 1999). A broader view of coastal management would see this dynamic landscape as a range of elements, each of which provides for sustainability of societal as well as environmental needs, and relies on achieving a balance between ecological and economic capital. As the impacts to coastal systems mount, there is a pressing need for planning and management tools that are supported by science, increase understanding of the pressures and opportunities for prevention and recovery, are relevant to the salient issues at the local level, and support policy and decision-making in all levels of society (Borja et al. 2008, Mcintosh et al. 2005).

This interdisciplinary research utilized a multi-method approach derived from landscape ecology, planning and natural science to demonstrate the potential influence of land cover on the loading of nutrients into the nearshore waters of the Atlantic coast of Nova Scotia, and to develop pragmatic tools that would aid understanding and negotiated management of land cover change as a proactive instrument for the reduction of environmental stressors.

6.2 Methodologies

Beginning in 2005, a team of graduate students and researchers from the Interdisciplinary PhD Program, Environmental Studies Program and the Biology Department at Dalhousie University in Halifax, NS and the Atlantic Centre for Global Change and Ecosystem Research (ACGCER) at Acadia University in Wolfville, NS conducted collaborative, multidisciplinary research on aspects of the coastal environment of the Atlantic shore of Nova Scotia. The scope of research undertaken included studies on nearshore marine biodiversity, water chemistry, geomorphology, land cover, and toxicology in an attempt to improve knowledge of current and potential future conditions throughout this coastal landscape (Farina 2006, Greenlaw 2009, O'Connor 2008, Ryan et al. 2008). Building on the findings of these primary studies, the research described in this dissertation bridged the disciplines of landscape ecology, marine ecology and regional and land use planning and sought to:

- demonstrate the link between land cover ratios in coastal watersheds and nutrient loading in coastal receiving waters; and to
- develop and apply a simple diagnostic tool that linked the sensitivity of local coastal receiving environments to changes in land cover in the watershed, and that aided negotiated decision-making by land-based planners and resource managers.

Three locally actuated factors affect the nutrification of coastal marine environments: human activities, nitrogen inputs and estuarine susceptibility to impact (Bricker et al. 1999). Human influence was expressed as land cover and land use in large watersheds draining to coasts, nitrogen inputs were assessed through monitoring riverine contributions and conditions in nearshore surface marine waters, and estuarine susceptibility was estimated based on a combination of hydrodynamic and productivity factors and land cover ratios in the watershed.

6.2.1 Application of Landscape Ecology to Coastal Management

While widely respected in terrestrial ecology, and usefully applied within regional and land use planning, the discipline of landscape ecology has had limited visibility within coastal management (Allmendinger 2002, Bekkby et al. 2001). Landscape ecology is a problem-solving science that seeks to improve our understanding of the distribution patterns of communities and ecosystems, the ecological processes that affect those patterns, and the changes in pattern and process over time (Farina 2006, Forman 1995b, Forman and Godron 1986, Opdam et al. 2001). As a science, landscape ecology recognizes the complexities inherent in working across ecosystems and adjusts its need for certainty in conclusions accordingly, working well with terms like probable, appear to and should. Spatial planning and landscape design and management are the applied disciplines by which the knowledge generated is applied within the community. Because landscape ecology approaches to research cross traditional boundaries between the natural, social and applied sciences, it is an appropriate discipline upon which to base an ecosystem-based approach to coastal management (Bekkby et al. 2001). By improving our knowledge of the driving forces that affect changes in the scale and spatial extent of land cover, we may become better equipped not only to predict change, but to proactively shape the future of our landscapes. It is unfortunate that coastal scientists and managers, perhaps put off by the term *landscape*, have been slow to participate in this field of study whose basic principles (Farina 2006, Forman 1995b, Forman and Godron 1986, Opdam et al. 2001) support:

- effective study of the inter-relationships between terrestrial, aquatic and marine ecosystems;
- integration of human communities as the dominant ecosystem in many landscapes;
- an improved capability for identifying important causal relationships between anthropogenic stressors and ecosystem change; and
- an approach to management that is vested in proactive planning rather than reactive remediation of impacts.

6.2.2 Defining the Coastal Landscape and the Coastal Fringe

Within landscape ecology and land use planning, a landscape is a cluster of interacting ecosystems characterized by the structures, functions and developmental trends of its natural and social environments that make it distinctly different from adjacent landscapes (Forman 1995a, 1995b, Jakes et al. 1990). Landscapes are an integral part of ecological organization, falling below biomes and regions, and above ecosystems (Bailey 2002). Where the rigours of disciplinary science require precision in application and certainty in conclusions, landscape views of our environment employ a coarser-grained perspective that facilitates a more insightful balance between human needs and environmental sustainability (Antrop 1998, Farina 2006, Jones et al. 2001, Lee et al. 1992, Naveh 2001, O'Neill et al. 1999). Working at a landscape scale is also appropriate when attempting a broader, ecosystem based approach to the planning and management of complex environments (Stewart and Neily 2008). The need for a broader view of the coast was first voiced by Ray (1991), who saw the need for an approach that would transcend jurisdictional and disciplinary boundaries, while recognizing the inter-connectivity of the land with the sea (Ray and McCormick-Ray 2003). A coastal landscape can be defined as a collection of linked, or nested, terrestrial and marine ecosystems that exists at differing scales, ranges geographically from the headwaters of watersheds to the outer limits of the coastal or continental shelf, and includes unique ecotones, or transition systems between the land and the sea (Farina 2006, Vallega 1999, Vallega 2001a, Vallega 2001b, Visser 2004).

Viewing the coast as a landscape rather than a zone more accurately addresses current understanding that coasts are comprised of a complex array of intertwined components (Figure 6.1) that include:

- terrestrial, aquatic and marine ecosystems linked through shared spatial, temporal and functional attributes;
- transition areas or ecotones (Attrill and Rundle 2002, Naiman and Decamps 1990, Ray and Hayden 1992) that bridge these ecosystems; and
- co-dependent human communities responsible for both the exploitation and protection of coastal resources and ecosystems.

In southeastern Canada, the Atlantic shore coastal landscape of Nova Scotia is characterised by its shared soils, vegetation, drainage patterns, coastal hydrodynamics, flora and fauna, exposure to the Atlantic Ocean and patterns of human settlement, and is distinctly different from the coastal landscapes of the adjacent Bay of Fundy shore and the Northumberland Straits. The Atlantic shore coastal landscape of Nova Scotia is comprised of:

- the terrestrial ecosystems that are linked to marine ecosystems by their hydrology, species, or habitats;
- the human communities that are supported by these ecosystems;
- the nearshore terrestrial and marine ecosystems of the coastal fringe of Nova Scotia (see below); and the deeper coastal waters of the continental shelf of Canada, as defined by the Oceans Act of Canada and extending to not more than 12 nautical miles offshore.

Just as traditional definitions of the coast have too often excluded the conjoined terrestrial ecoystems, too little attention has been given to nearshore shallow water marine environments. These shallow water marine ecosystems are the first point of human contact with the ocean and are also the first to register impacts from land-based activities. Within tropical seas, nearshore marine environments typically harbour a coral reef that grows along the edge of the shoreline and is generally referred to as the *fringing* reef (Fox 1992).

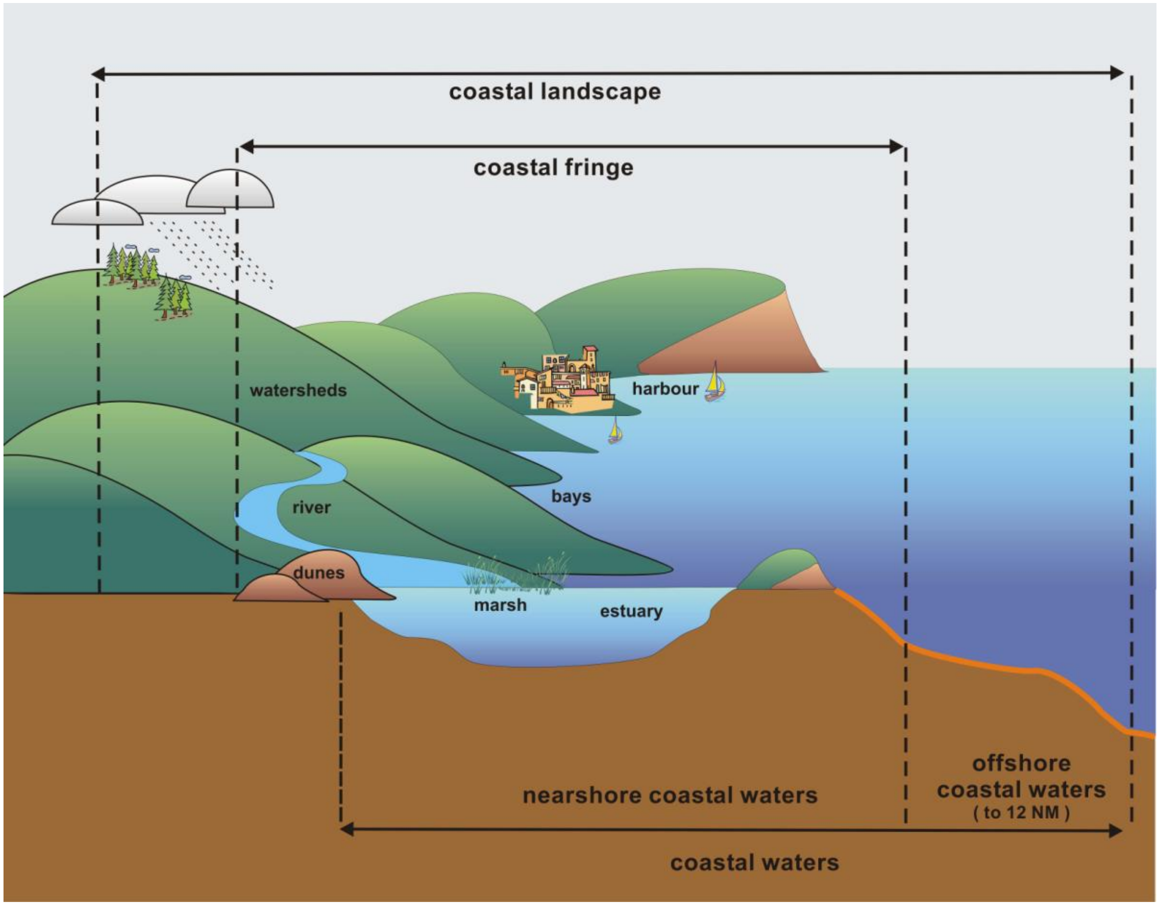


Figure 6.1: The Coastal Landscape

Fringing reefs are known to be areas of high biodiversity, contributing significantly to the productivity of the shallow coastal waters. Fringing reefs are also susceptible to damage as a result of direct human activities such as fishing, boating and tourism, and from indirect sources of contaminants and sediments contributed by land-based activities. In tropical seas fringing reefs have been the subject of targeted protection and management initiatives. Along Canada"s coasts, only limited research or management focus has been attached specifically to the nearshore fringe environments of the coasts. Nearshore terrestrial and littoral habitats characterized by one or more species of interest (e.g., shellfish, rockweed and eelgrass beds, migratory waterfowl habitat) can receive special attention in development decision-making and in conservation efforts, but as a whole the immediate nearshore environments have not been singled out as a specific area worthy of closer scrutiny. To address this deficiency and to ensure that the focus of this research remains on conditions within these nearshore waters, the coastal fringe of Nova Scotia (Figure 6.1) has been defined as follows.

- **Spatially**, the coastal fringe environment includes, at a minimum, all the area from the backshore (e.g., 100 year storm surge mark, backshore dune complexes, salt marshes) extending seawards to include waters less than 20 m in depth.
- **Functionally**, the coastal fringe consists of that area of the shoreline where the marine environment is significantly affected by land activities, and the terrestrial environment is significantly affected by marine conditions.
- **Temporally**, the coastal fringe encompasses past, present and future change in the delineation of the shoreline, as well as seasonal use by species such as migratory waterfowl, marine mammals, etc.

6.2.3 The Research Study Area

The research study area lies entirely within the Atlantic shore coastal landscape of the Canadian province of Nova Scotia, and is comprised of the terrestrial and marine ecosystems that fall between 43 and 47 degrees N in the realm of the Cold Temperate Northern Atlantic (Figure 6.2). While within its broadest limits the terrestrial portion of the study area extends from St. Mary"s Bay to Chedabucto Bay, the research focus is primarily on those watersheds which drain to the Atlantic shore in the area of the coast that falls between Barrington Bay and Whitehead Harbour.

The Atlantic Shore Coastal Landscape falls within the Atlantic Coast (Table 6.1) and Atlantic Interiors Theme Regions as described in the Natural History of Nova Scotia (Davis and Brown 2005). Over the past 15,000 years, the resistant bedrocks that characterize these areas were carved by glacier action and sea level rise, creating a highly crenulated shoreline with many inlets; the majority of which are submerged river valleys. In the past century alone, as a result of crustal subsidence, the Atlantic shoreline has risen 35 cm (Gehrels et al. 2004). Within the next hundred years, sea levels are predicted to rise another metre as a result of climate change, making much of Nova Scotia highly vulnerable to impact (GOC/NRCAN 2009). Local rivers are also sensitive to climate change impacts through increased precipitation and storm events with the potential to increase flows and cause flooding and erosion. Wind, waves, tides and ice have continuously shaped the Atlantic coastline, but throughout much of the area, wave action has been the predominant agent of change.

Table 6.1: Coastal Environments of the Atlantic Coast of Nova Scotia

	Subdivision	Geological Character	Backshore Relief	Beach Character	Fetch and Wave Exposure	Mean Tidal Range	Sediment Availability
Atlantic Coast	Eastern shore (Barrington Bay to New Harbour)	Resistant sedimentary and granitic rocks; variable thickness tills and drumlins	Indented low rocky coast, some eroded drumlins (30 m)	Absent or barriers or pocket beaches in re-entrants, coarse	Exposed open coast, embayments sheltered: ice in sheltered areas 2-3 months	1-2 m	Very scarce
	Western shore (Barrington Bay to St. Mary"s Bay)	Resistant sedimentary and metamorphic rocks; thin till deposits	Till or rock cliffs (3-30 m)	Narrow or coarse-sediment barriers	Variable, locally very exposed; local ice up to 2 months	4 m	Scarce but locally abundant

Inland from the coast, the Atlantic Interior is a large, contiguous landscape with an almost even skyline, interspersed with rounded hills that rise gently from the terrain reaching elevations that generally do not exceed more than 150 m above sea level. Drumlins (loose materials transported and deposited by glacial action) dot the landscape and the coastline, forming a distinctive topography of irregular hills and coastal islands. Soils are typically thin, and comprised of humo-ferric podzols, interspersed with areas of gleysol, Rockland and peat. Soils are permeable and often acidic, a condition that has been exacerbated for many years by airborne acid precipitation from the eastern United States.

The area falls within the Acadian Forest ecoregion which is characterized by a mixed forest consisting predominantly of conifers (red spruce, hemlock, balsam fir and pine) interspersed with hardwoods (red and sugar maple, aspen, white and yellow birch) (Neily et al. 2003). Bogs and barrens are common, and large salt-marsh habitats can be found in protected, shallow inlets all along the coast. River valleys that cut through this landscape follow complex drainage patterns, but the predominant southeastern slope is towards the Atlantic coastline. Flow rates are highest in the spring and lowest during July and August. Where estuaries exist, they seldom have distinct salt water wedges

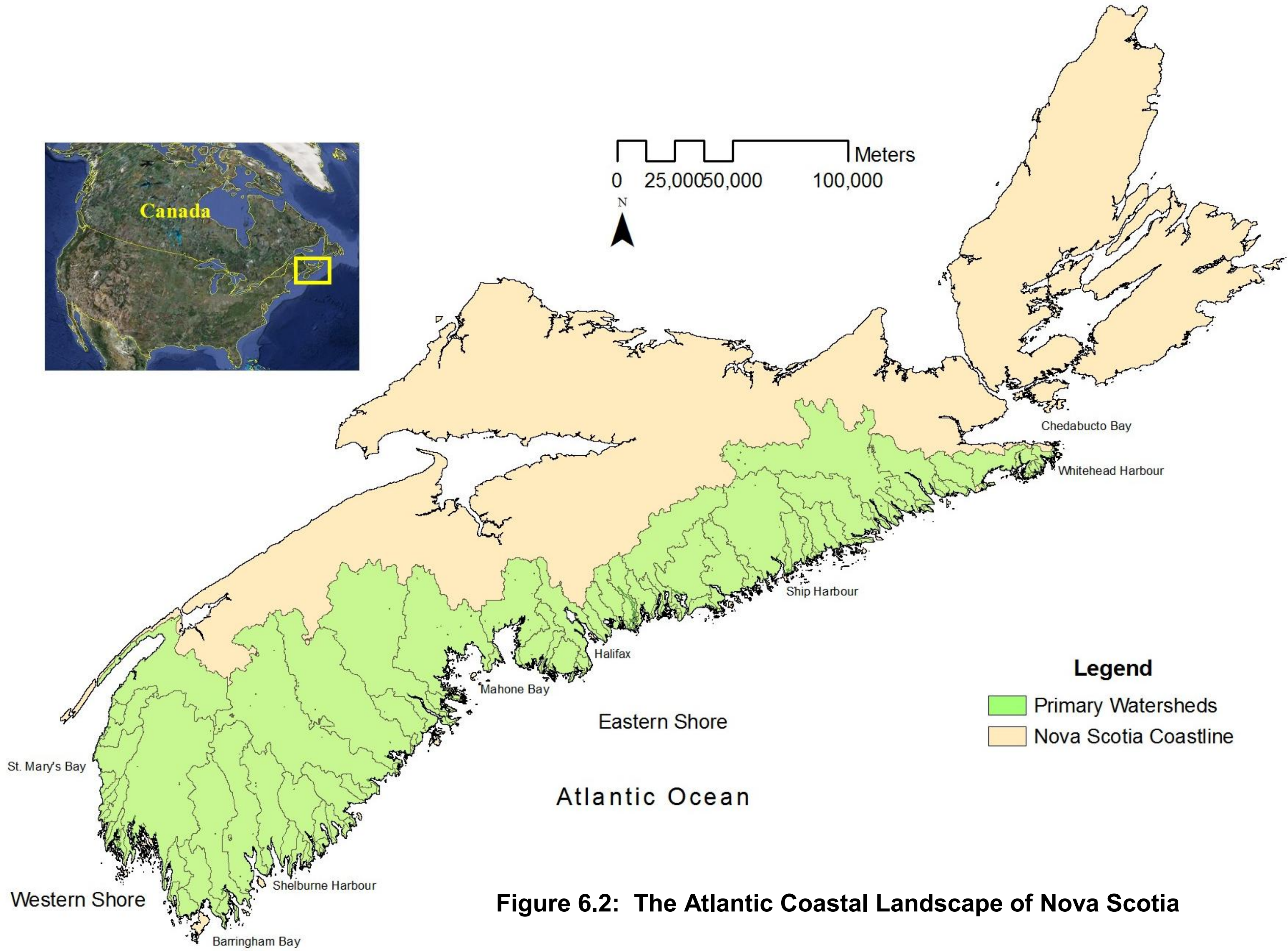


Figure 6.2: The Atlantic Coastal Landscape of Nova Scotia

and are well mixed by wind and tide (GOC/EC 1987, Gregory et al. 1993). Large bays such as Mahone Bay, St. Margaret‟s Bay and the outer reaches of Halifax Harbour, Liverpool Bay and Country Harbour are more exposed and exhibit conditions similar to the open ocean.

Winds are primarily from the southwest in summer and from the west/northwest in winter. Annual peak water temperatures occur in the fall, but remain relatively consistent throughout the year. The exposed nature of much of the coast, tidal action, prevailing winds, and deeper circulation of water caused by the Nova Scotia current and by upwellings from the continental shelf all contribute to conditions within the well-mixed, deeper coastal waters. Because the predominant focus for research and monitoring programs has been on these deeper coastal waters, little is known about spatial and temporal conditions in shallower, nearshore waters and protected embayments, unless they have been the subject of specific research programs or environmental impact assessment.

The Atlantic Coastal Landscape is the homeland of the M‟ikmaq First Nation of Canada, and has been settled by Europeans perhaps as early as the 1500s. While most of the population lives in relatively small coastal communities, the large urban complex of the Halifax Regional Municipality supports a population in excess of 350,000 and encompasses a significant proportion of the geographic area of the Atlantic Coastal Landscape. In addition to urban and sub-urban development, land cover in the primary watersheds has been transformed as a result of agriculture, transportation, mining, energy and other human uses.

6.2.4 Building the Coastal Geospatial Framework

The application of geographical information systems (GIS) technology is gaining acceptance as a means to collate, store, analyze, model and present the findings of complex research on geospatial and ecological relationships. Originally developed as a tool for geographers and cartographers, planners, economists and engineers quickly grasped the potential for application of GIS technology to community planning and management. Within the natural sciences, spatial analysis has been growing in recognition as an effective tool to improve understanding of the scope and pace of change within landscapes, and the related impacts to ecological functioning (Fortin et al.

2005, Green and King 2003). Marine and coastal GIS applications began to emerge in the late nineties, in response to the growing need to improve management of complex, multidisciplinary data and to advance understanding of the land-sea linkages (Klemas et al. 2000, PlanCoast 2008, UNESCO/IOC 2009). Faced with impending impacts from climate change, and the need to embrace cultural assets and values as well as bio-physical parameters, the value of coastal GIS as an integrating tool capable of working at the coastal landscape scale, had become more accepted (Bartlett and Smith 2005, Canessa et al. 2007, Mayer et al. 2004, Vallega 2005).

In Canada, while GIS is widely used within municipal governments to aid in planning and management, the tool is less evident within research in the natural sciences or in marine management in departments such as Environment Canada and Fisheries and Oceans Canada, or in their provincial counterparts. Then too, while accessibility to GIS software has improved, and the tool is simpler to use out of the box, arguments against the acquisition and application of this technology still revolve around the cost of the software and licenses, and the perceived complexity of its application by previously untrained professionals. Many of the available land cover and nutrification modelling applications are expensive to acquire, technologically challenging to apply, and operate at a level of detail that while amazingly proficient, does little to aid land cover and land use decision-making. Development of a coastal GIS that that can include both land and marine data has been delayed by issues as simple as reconciliation of the shoreline and free access to available data (Canessa et al. 2007, Strain 2004). This research challenges these views by applying off the shelf GIS software to the development of a tool intended to support negotiated decision-making on land cover and land use capable of responding to an array of conflicting needs and values. Though familiar with GIS capabilities, I had no previous hands-on training, and obtained my skills from two weeks of on-line training and completion of the ESRI Virtual Campus modules in ArcGIS and Spatial Analyst, and from the kind assistance of more capable friends and colleagues.

ArcView GIS (Version 9.2) software was used to develop a framework and to compile and analyze data on land cover, land use and environmental conditions in the Atlantic Shore Coastal Landscape of Nova Scotia. Existing and available geographically referenced data sets on forest cover, watersheds and topography were obtained from the Dalhousie University GIS Centre and Map Library at the Killam Memorial Library, as provided under licence by the Government of Nova Scotia. All databases were converted to formats readable by ArcView GIS (9.2). The shoreline of Nova Scotia was rationalized to current topographic mapping at a scale of 1:25000. Watersheds were derived from primary and secondary watersheds identified in the Nova Scotia Watershed Series compiled and drawn by the Maritime Resource Management Service, Amherst NS in 1980. Only those watersheds falling within the mainland Nova Scotia component of the Atlantic shore coastal landscape were included within the study area.

Until the publication in 2009 of the GeoBase national land cover data, digital land cover data for the province of Nova Scotia were limited to forest cover data developed by the province and the industry. As the national GeoBase land cover data had not yet been made public, land cover in Nova Scotia was derived from the best data set available, which was a 1993 interpretation of forest cover conducted by the Nova Scotia Department of Natural Resources (NSDNR). In the NSDNR dataset, land cover type was represented as polygons, including water, forest, and non-forest areas, with a primary focus on identifying the attributes of forested land. The NSDNR source data were obtained by interpretation of 1:10,000 aerial photography and updated by applying change detection algorithms to satellite imagery, and treatment information obtained from various ground sources (GPS, compass and stringbox). New imagery was obtained by NSDNR for approximately 10% of the province each year. Given that this information was compiled as a forest management tool, there was the potential for bias in interpretation. However, the data set also provided considerable detail in separation of forest characteristics into relevant categories of land use and land cover.

Data from a number of federal, provincial and non-governmental monitoring programs were examined and determined inappropriate for application to this research. Coastal monitoring programs in Atlantic Canada continue to be seriously affected by limited fiscal and human resources and by a lack of standardization in the parameters measured, as well as the methods of sampling, reporting and analysis of data. Where information and data exist they are fragmented spatially and temporally (Barrington et al. 2003, Clement et al. 2007, Coray and Bard 2007a, Doherty and Horseman 2007, Ducharme et al. 2001, Hargrave 2003, Hart 1994, Li et al. 1998, McCulloch et al. 2005, McNeil 1994, Menon 2005, NSCAD 1976, Owens 1971, Parker et al. 2007, Peach 1991, Ryan et al. 2008, SRSF 2001, Stewart and White 2001, Strain 2000, Yeats et al. 1998).

Data on aquaculture sites in Nova Scotia were provided by the Province of Nova Scotia. Data on the Canadian Shellfish Sanitation Program were obtained under license from the Marine Quality Monitoring Unit at the Atlantic Region offices of Environment Canada in Dartmouth Nova Scotia. Data used in the EMAP program of Environment Canada were also obtained from the departmental website, and provided by staff of the Dartmouth office. Data on marine water quality in Nova Scotia were downloaded with permission from the BIOMEDS/ MEDS website of Fisheries and Oceans Canada. Within BIOMEDS there are few data sampling stations that fall within the parameters of the study area. Other data on nearshore coastal water quality, were found to be fragmented spatially and temporally, compromised by differing standards for data collection, analysis and reporting and inappropriate for application to this research.

Recognizing the limitations of existing data and information, a water sampling program was initiated to provide relevant data on nutrient concentrations in the study area.

6.2.5 2006-2008 Aquatic and Nearshore Water Quality Program

When coupled with naturally occurring changes in ecosystem functions, habitats and species, it is difficult if not impossible for the current state of coastal science in Nova Scotia to establish defensible baselines for coastal ecosystem stability. This situation is especially critical in nearshore waters where watershed characteristics such as soil and bedrock, hydrology, and land use are compounded by coastal hydrodynamics such as longshore currents, exposure to wind and wave action and the mixing dynamics of the water column. Given the economic climate, it was important to accept that within municipalities, other levels of government and the research sector, there were few fiscal or human resources available to support new or expanding environmental monitoring programs. Consequently, this research focussed on the development of an effective yet inexpensive water quality sampling and analysis program, which could be implemented by even the smallest town or village. Water quality parameters (nitrogen, phosphorus), and sampling locations (riverine, nearshore marine) were selected to provide information on nutrient loadings from the primary watersheds of the Atlantic Coastal Landscape. Emphasis was placed on obtaining results of specific interest to land-based decision-makers and to coastal impact assessment scientists.

Water quality sampling field programs were conducted during July of 2007 and May and June of 2008 (Figure 6.3, see Appendix D, Table D1 for a list of sampling sites by year). With the permission of the primary researcher, data from a related study of nutrification within coastal embayments conducted during March and August of 2006 was also incorporated (Ryan et al. 2008). All water samples used in this research were collected by hand or with a Wildco 2.21 Horizontal Alpha Water Sampler from the null point in major rivers emptying to Study Area embayments, and by hand from boat in the nearshore waters of the same bays. The null point of the rivers was determined as being the furthest downstream area of the river that was not subject to tidal influences. Nearshore marine samples were collected from sheltered inner coves, and from more fully mixed waters of large bays. All fresh water samples were collected mid-stream in running water from 10 cm below the surface of the stream. All estuarine and marine samples were collected from 10 cm below the surface of the water.

All water samples were filtered through a 25 mm Millipore APFC glassfibre filter and stored in 30 mm wide-mouth Nalgene bottles, which had previously been soaked in 10% ACS grade hydrogen chloride for 2 hours and rinsed with de-ionized water (Milli-Q Gradient). Samples were placed in a 9-V portable cooler, and transported within 48 hours to the laboratory where they were frozen at -20 ºC, until they could be analysed. Nutrient analyses were performed using a Tecnicon AutoAnalyzer II system. The methodologies for analyzing nitrate + nitrite can be found in Strain and Clement (1996) and those for ammonia in Kérouel and Aminot (1997). Total phosphorus (TP) analysis involved digestion following ESS Method 310.2 (US/EPA 1992) except that an Accu-Test C.O.D. Heater Block (Bioscience 163-466) was used instead of an autoclave and analysis used the phosphate manifold. Duplicates of each sample were analyzed in runs of 42 with blanks placed every six samples. Total nitrogen (TN) was calculated by adding ammonia (NH_4) and nitrate (NO_3) concentrations.

Using embedded ArcGIS and Excel data analysis tools, a series of correlations were run to examine the relative and statistical relationships between nutrients and land cover. Nutrient concentrations were first presented graphically to illustrate the range of conditions, and to establish locally relevant thresholds for potentially non-impactive concentrations. Sample sites were arrayed along the x-axis according to their location from the south to the north along Nova Scotia"s Atlantic shore. Using geospatial

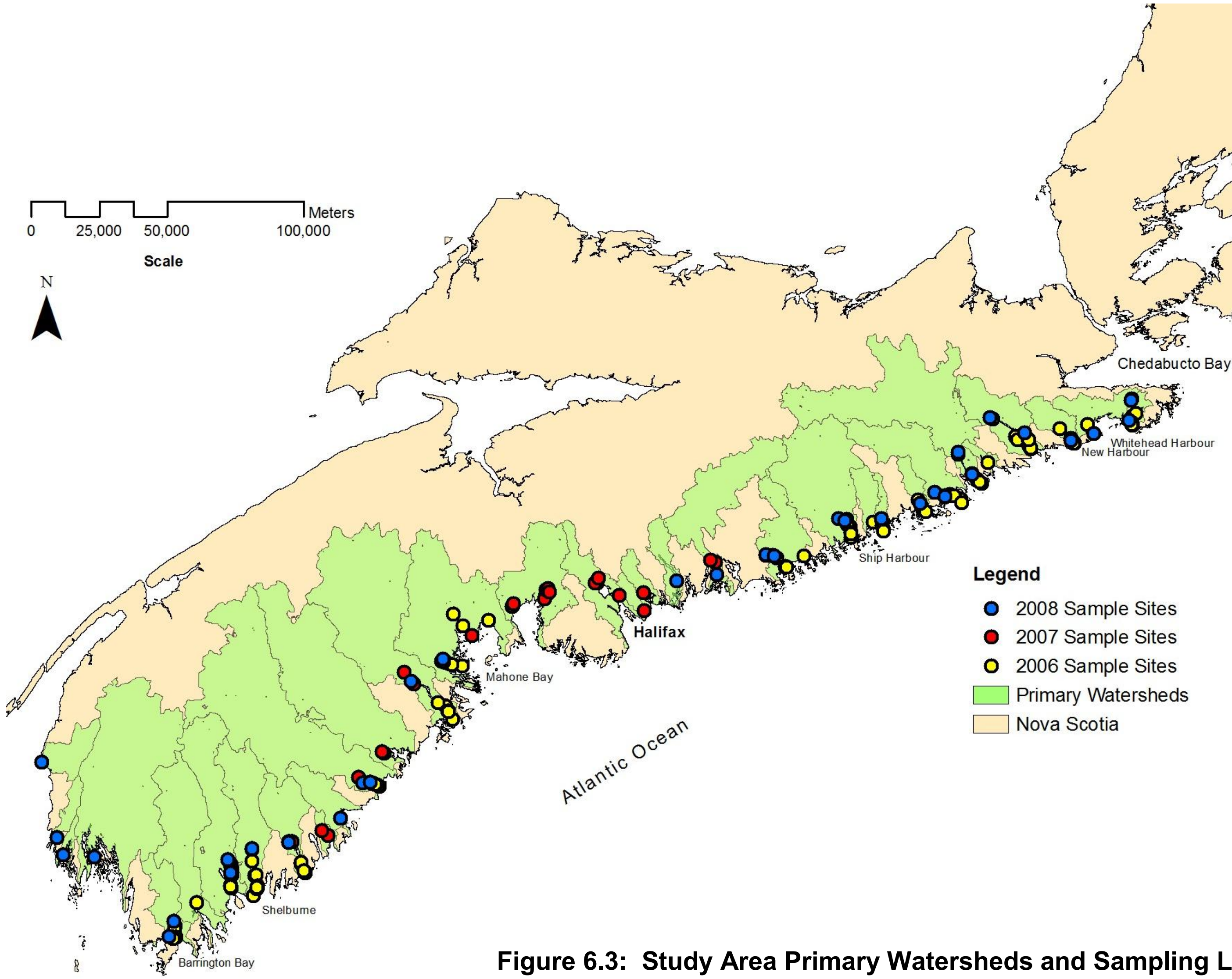


Figure 6.3: Study Area Primary Watersheds and Sampling Locations

analytical techniques, these data were then presented in plan view to illustrate perceived linkages between land cover ratios and nearshore nutrient levels. Finally, using Excel, simple linear regressions were run comparing nutrient concentrations with the relative geographic distance from the null point in the rivers.

6.2.6 Establishing Threshold Levels for Nutrient Comparisons

Guidance on thresholds for acceptable concentrations of nutrients in estuarine and marine coastal waters is complicated, fragmented, and uses a range of conflicting terms and units of measure. Even the term „total nitrogen" can have different meanings and methods of measurement, and in reporting concentrations, science is moving towards the use of micromoles per litre (μM/L) while regulatory agencies commonly use milligrams per litre (mg/L). These different protocols exacerbate the complexity of an already difficult literature. In Canada, as in other countries, guidance documents that set thresholds for nutrients such as nitrate, nitrite and ammonia within freshwaters have for some time focussed on concentrations which can result in toxic conditions to fish and wildlife (CCME 2007a). Until recently less attention has been paid to nutrient levels that contribute to deleterious but generally sublethal changes in ecosystem functioning such as changes in trophic status (including but not limited to eutrophication), shifting in food chain relationships, oxygen depletion and biodiversity loss.

Because the factors that contribute to eutrophication in coastal ecosystems are complex and often site specific, it has been difficult to define acceptable levels for nitrogen and phosphorus within nearshore waters, and even more difficult to prove cause and effect relationships between land cover changes in the watershed and deleterious changes in biodiversity and production in nearshore waters (NRC 2004). In eastern Canada, where coastal waters often enjoy significant flushing, there is continuing expectation that anthropogenic inputs of nutrients to coastal waters fall within the assimilative capacity of the receiving environments. As a result, scientists and regulators have paid only limited attention to the assessment of nutrient conditions. In recent attempts to establish thresholds for nutrient enrichment of coastal waters in Prince Edward Island, mean concentrations measured across a range of estuarine and embayment conditions fell into three categories, often representative of the influences of agricultural land cover in the watershed (Table 6.2) (Dixit and Brylinsky 2008).

Table 6.2: Nutrient Levels in Prince Edward Island Embayments) (Dixit and Brylinsky 2008).

Nutrient Concentration	Low	Medium	High
Total Nitrogen (TN) (mg/L)	0.206	0.250	0.377
Total Phosphorus (TP) (μg/L)	50.1	55.2	62.8
Chlorophyll A (μg/L)	5.1	8.5	12.3

Building on local research and studies in the United States and Europe (Bricker et al. 1999, Bricker et al. 2003, CCME 2007a, Dixit and Brylinsky 2008, EEA 2002, 2003, Glenen and Sharpe 2009, GOC/EC 2001b, NRC 2004, Ryan et al. 2008, Strain and Clement 1996, Strain 2000, US/EPA 1992, 2000, 2001), this research based its examination of nutrient concentrations in riverine and nearshore coastal waters on the following key assumptions.

- Once nutrients have been deposited in a waterbody, they can be taken up by benthic or pelagic algae, macrophytes and micro-organisms, may become attached or sorbed to organic or inorganic particles in the water column and in bottom sediments, or transformed and released as a gas. As a consequence, measures of nutrients in the water column are a product of locally contributing factors such as nutrient supply, primary production and denitrification.
- Both nitrogen and phosphorus play important and linked roles in nutrient enrichment in freshwater, estuarine and marine environments.
- Dissolved inorganic forms of nutrients are the most biologically available.
- Within recent studies on nutrification in Canadian marine waters, NO3 (nitrate) has been used as a measure of TN (total nitrogen), as it was concluded that concentrations of ammonia (NH_4) and nitrate (NO_3) were likely to be significant only in oxygen depleted waters (Dixit and Brylinsky 2008). While this may be an acceptable logic for well-mixed coastal waters, in riverine and nearshore areas, anthropogenic sources of ammonia may play a more significant role in nutrient chemistry. As a result, in this study, where data on ammonia were available, TIN (total inorganic nitrogen) was calculated by adding NH_4 and NO_3, and used as a measure of TN.
- Total phosphorus (TP) has been held to be synonymous with dissolved inorganic phosphate (PO_4).

- Existing regulatory guidance on acceptable concentrations of nitrogen and phosphorus in both fresh water and salt water remains focused on direct toxicity to aquatic and marine organisms (CCME 2007b).
- More stringent standards for nitrogen and phosphorus are needed to avoid adverse effects such as eutrophication within affected ecosystems (Dodds and Welch 2000)

Responding to these assumptions I proposed the following thresholds for non-impactive nutrient concentrations in riverine and coastal waters of Nova Scotia‟s Atlantic shores (Table 6.3):

- In coastal rivers, total nitrogen (TN) (as NO_3, or where data were available, NO_3 and NH_4) should be less than 0.30 mg/L (~ 4.00 μM).
- In coastal rivers, total phosphorus (TP) (as PO_4) should be less than 0.030 mg/L (~ 0.30 μM).
- In coastal marine waters, total nitrogen (TN) (as NO_3, or where data were available NO_3 and NH_4) should be less than 0.30 mg/L (~ 4.00 μM) in well-mixed bays and less than 0.1 mg/L (~ 2.00 μM) in more sheltered embayments.
- In coastal marine waters, total phosphorus (TP) (as PO_4) in relatively aerated nearshore waters during the late summer should not exceed 50 μg/L (~ 0.50 μM).
- In coastal marine waters, planktonic chlorophyll A should fall below 10 μg/L in relatively aerated embayments, and below 3 μg/L in protected nearshore areas.

Table 6.3: Proposed Non-Impactive Thresholds for Nutrients in Rivers and Bays

Parameter	River Threshold	Sheltered Bay Threshold	Exposed Bay Threshold
TIN (μM)	4.00	2.00	4.00
NO_3 (μM)	4.00	2.00	4.00
PO_4 (μM)	0.30		0.50
Chlorophyll A (μg/L)		3	10

6.2.7 The GreenField Ratio: Setting Thresholds for Land Cover

With improved understanding of the stresses generated on coastal ecosystems by many land-based activities, there is an increased need to monitor and to manage change in the patterns and distribution of large scale elements of the coastal landscape such as land cover. Just as body temperature in humans is used as an indication of a decline in health, measures of change in top order parameters such as land cover could be used to point to the potential for occurrence of other detrimental changes throughout the coastal landscape (Jantz et al. 2005, Patil et al. 2001, Wells 2005). Research has clearly demonstrated that changes to land cover within a watershed can be linked to increased nutrient loading and deterioration in biodiversity and productivity, conditions that are likely to be exacerbated by climate change (Gergel et al. 2002, Hale et al. 2004, Shahidul Islam and Tanaka 2004, Williams 1996). As knowledge on the linkages between land cover and coastal health continues to grow, land cover ratios are increasingly seen as an important landscape scale indicator of environmental well being. Research has also suggested that this may be especially true of land cover types in primary watersheds (high order rivers) (Johnson and Patil 2006). Guidance on threshold levels of land cover within watersheds that pose unacceptable threats to coastal nearshore waters is badly needed as a basis for proactive policy and land use decision-making.

In a review of habitat requirements to sustain biodiversity in the watersheds of Southern Ontario, a collaboration of scientists, land planners and managers produced a set of guidelines that seeks to answer the question: "How much habitat is enough?" (GOC/EC 2004, 2005a). They concluded that within Ontario watersheds, the landscape should include at least 30% natural forest cover and 10% productive wetlands, and that at least 70% of the banks of streams and rivers (designated for this research as 30 m either side of the streambank) should be vegetated with natural forest or wetland cover. When applied in an adaptive management approach, these and other thresholds for land cover could be an effective landscape scale tool for regulating the overall pressures on ecosystems (Degnbol 2002, Mercer Clarke et al. 2008). Such an approach has been used by the State of Oregon (2000) where land-cover has been an effective meta-indicator of current conditions in the landscape (e.g., urbanization, deforestation), and has also been used to assist in complex development decisions. Other research into land-water linkages has demonstrated similarly interesting correlations between water quality and the ratio of land cover in the watershed (Carpenter et al. 1998).

Where rivers flow through naturally vegetated areas, overland flows can be significantly moderated, and concentrations of non-point source contaminants and nutrients reduced (Cappiella et al. 2005, Gergel et al. 2002, NRC 2008, Schou et al. 2006). Wetlands, both freshwater and salt marsh, also contribute to denitrification and to the uptake of harmful pollutants. And in watershed areas where human activities have transformed the landscape, conversion of as little as 10% of a watershed land area from natural cover to impervious cover (i.e., buildings, pavements) can detrimentally affect ecosystem functioning (Arnold and Gibbons 1996, Beach 2002, DeVoe and Kleppel 2006). Where impervious surfaces cover 20-35% of the watershed, the loading of chemical and other contaminants, including silts, can cause widespread impacts in water quality and biodiversity (Holland et al. 2004, Scott et al. 2006). When dealing with land cover as a non-point source for nutrient loading, the rates of nitrogen loss can be more than twice as much from agricultural lands and urban lands as from naturally vegetated lands (US/EPA 2002). For high intensity livestock farming, the level of nutrient loading increases considerably.

Based on the supporting science behind each of these approaches, I developed the GreenField Ratio (30:10:70:10) (Table 6.4) as a compilation of recommended thresholds for each major land cover type, expressed as a percentage of the total area of the watershed. It was hypothesized that where these selected land cover types fell below the GreenField Ratio thresholds, the contribution of non-point sources of nutrients to surface waters would increase, and there would be measurable impacts to nutrient levels within nearshore receiving waters. The threshold levels proposed in my GreenField Ratio were not intended to cumulatively represent 100% of the area of any watershed, but are targets below which each land cover type should not be expected to fall. The intent was to identify the minimum requirements for protection of biodiversity and reduction of contaminant and nutrient loading to the watershed and eventually to nearshore coastal environments. Given the limitations with the land cover database used in my research, urban land cover was used as being indicative of the extent of impervious cover, which can affect both storm water quality and quantity.

Table 6.4: The Mercer Clarke GreenField Ratio

Land Cover Type	Description	Recommended Percentage of Watershed Land Cover (0-100)
Forest Cover	all types of natural forest and vegetative cover (old fields, barrens and heaths), but not recently clear-cut areas	> 30
Wetlands	all types of wetlands (bogs, fens, swamps, salt marshes, drowned forests)	> 10
Buffered Watercourses	a buffer of forested or wetland cover calculated as a distance of 30 m from the edges of lakeshores, rivers and streams	> 70
Urban Cover	urban and suburban development as well as land cover which presents barriers to the movement of water from the surface to the soil	< 10

Using ARCVIEW and these thresholds as meta-indicators of minimally acceptable conditions for land cover, I conducted a land cover assessment on the primary watersheds that fell within the Atlantic coastal landscape study area.

6.2.8 Classification of Coastal Fringe Estuarine and Marine Environments

In the past several decades, there have been several attempts to classify coastal embayments, based on geomorphic, hydrodynamic, and biological parameters, or a combination of all three (Bricker et al. 2003, Devlin et al. 2007, Fairbridge 2004, Ferreira 2000, Finkl 2004, NRC 2004, Roff et al. 2003, Taylor and Atkinson 2008, US/EPA 2001, Zacharias and Roff 2001). Even without the complications inherent in taking a broader view of the coastal landscape, classification of estuarine and marine coastal systems can be difficult because of the myriad combinations made possible by the range of physical and biological conditions, and by the dynamic nature of environments that spatially and temporally are in a constant state of change. To be useful in advancing proactive management of coastal ecosystems, classification schemes must be capable of application across a broad array of local coastal landscapes, employ readily available information, integrate an array of structural and functional factors, and communicate with clarity to resource managers and decision-makers (Brylinsky 2006, Ferreira 2000, Greenlaw 2009, Hume et al. 2007, NRC 2004, Wilkinson et al. 2007).

When attempting to improve our understanding of the sensitivity of a coastal system to increased nutrification from point and non-point sources, it is important to address not only the local physiographic factors that contribute to flushing rates (i.e., tidal range, currents, wind and wave exposure) (NRC 2004). Other factors such as substrate type, denitrification processes, water clarity, and species and habitat types are also important in determining critical loading and assimilative capacity (CCME 2007a, Dixit and Brylinsky 2008). Both the diversity and dominance of species and habitats within the system dictate the primary production base (i.e., salt mashes, littoral, benthic or pelagic macroalgae and phytoplankton) and the grazing potential of other species in the food chain.

The following system for classifying coastal embayments within the study area was based largely on Greenlaw (2009), with contributions from Dixit and Brylinsky (2008), the Canadian Council of Ministers of the Environment Guidance Document (2007a), and from Hume et al. (2007). While all of these methodologies are science based approaches for rating the sensitivity of coastal embayments to anthropomorphic stressors such as nutrification, their application requires considerable expertise of a sort that may not often be found in planning offices throughout Atlantic Canada. The Greenlaw classification system required interpretation to translate the classification system into a simpler tool that could be used to advance proactive policy and decision-making on changes to coastal land cover. Relying on a coarse assessment of coastal geomorphology, derived from the topography of the land/sea interface, the relative input of freshwater from a riverine source, and the influence of wind, wave, tide and river flows, the following four physical categories of coastal inlets were derived.

- **Bays** are the larger inlets along the coast, offering a range of shelter from oceanic conditions (semi-exposed to exposed), and subject to a relatively low input of freshwater from riverine sources, as compared to their overall volume (e.g., St. Margaret‟s Bay, outer Halifax Harbour, Mahone Bay).
- **Exposed Coves** are the smaller embayments found between the headlands of major bays along the exposed coastline, with a low proportion of shelter from oceanic conditions and a low to moderate input of freshwater from rivers (e.g., Cow Bay, Quoddy Harbour).
- **Sheltered Coves** are most often inlets off major bays, have a moderate to high degree of shelter from oceanic conditions, and a midrange contribution of freshwater from rivers as compared to their total volume (e.g., Sackville Cove, Hubbards Cove, Mahone Bay Harbour).
- **Estuaries** provide the highest degree of shelter from the ocean and experience major inputs of freshwater from riverine sources. In this research, the definition of an

estuary aligns closely with that of Hume et al. (2007, p 908) as "a partially enclosed coastal body of water that is either permanently or periodically open to the sea in which the aquatic ecosystem is affected by the physical and chemical characteristics of both runoff from the land and inflow from the sea". When applied to the inlets of the Atlantic coast of Nova Scotia, fjords, tidal river mouths, and barachois ponds would also fall into the estuary classification (e.g., La Have River Estuary, Sable River Estuary, Ship Harbour).

6.2.9 The Coastal Sensitivity Rating: A Tool to Aid Negotiated Management of Changes in Land Cover Within the Coastal Landscape

To ensure that the findings of this research are relevant for use by planners and managers, a Coastal Sensitivity Rating (CSR) tool was developed to link the stressors within a watershed to the capacity of local coastal receiving waters to withstand impacts (Table 6.5). Using a logic flow similar to that developed by Cox et al. (2004) and Lee et al. (1992), the CSR can be used to assess the risk posed by historic and continuing land cover change to the well being of nearshore environments, without waiting for observable impacts to ecosystem health to become apparent and measureable. While admittedly coarse in scale and execution, and subject to some uncertainty, this form of risk-based analysis is not new to societal policy and decision-making. As recent times have demonstrated, our grasp of the driving forces behind economic stability is tenuous at best, and rife with the same degrees of uncertainty that have in the past plagued scientists challenged to predict with accuracy the effects that human action and inaction would have on the natural world.

The results obtained from this research, as well as the findings of other modelling efforts specific to the Atlantic coastal landscape can be used to provide a better understanding of the direct and indirect relationships between land cover and coastal nutrification (Dixit and Brylinsky 2008). The CSR tool is intended to assist decision-makers in the prevention of adverse effects within the watershed and to downstream nearshore receiving waters. Users of the tool can vary any of the factors, developing alternative scenarios for current and future decision-making, and using the alternatives as a tool in

Table 6.5: A Matrix for Rating Coastal Sensitivity to Land Cover Change

Land Cover Type	Mercer Clarke GreenField Ratio		Land Cover Rating	Coastal Condition Contributing Factors					COASTAL SENSITIVITY TO LAND COVER CHANGES
	Threshold Watershed Coverage	Actual Land Cover Watershed Coverage		Point Source Inputs	Airborne Vulnerability	Tidal Range	Coastal Exposure	Riverine Inputs	
	(0-100 %)	(0-100 %)	(0 - 40)	(1 - 3)	(1 - 3)	(1 - 3)	(1 -3)	(1 - 3)	(5 - 55)
Forest Cover	>30								
Wetlands	>10								
Buffered Watercourses	>70								
Urban Cover	<10								
Watershed Coastal Sensitivity Ranking			0 - 160						20 - 220

Forest Cover	all types of natural forest and vegetative cover (e.g., old growth, plantations, old fields, barrens and heaths, but not clear-cut areas)
Wetlands	all types of wetlands (e.g., bogs, fens, swamps, salt marshes, drowned forests)
Buffered Watercourses	a buffer of forest or wetland cover (see above) calculated as a distance of 30 m from the edges of lakeshores, rivers and streams
Urban Cover	urban and suburban development as well as other impermeable land cover that restricts the movement of water from the surface to the soil
Land Cover Rating	each land cover type was scored by comparing the total area of that land cover that occurs within the watershed with the recommended threshold. Ratings were calculated as follows: 0 is very good (at or above the threshold), 10 is deteriorating (0-10% below the threshold), 20 is fair (11-20% below), 30 is poor (21-30%) and 40 (>30%) represents a significant reduction in land cover.
Point Source Inputs	the number of major point source effluents in the watershed (e.g., sewage treatment plants, food processing plants (especially fish plants), industrial waste streams) where a rating of 1 = 1 -5 effluents; 2 = 6-10, 3 = 11 or more
Airborne Vulnerability	the likelihood of deposition of contaminants over land mass and nearshore waters where a rating of 1= low; 2= moderate; 3 = high
Tidal Range	mean tidal amplitudes along the coast, where a rating of 1 is >1.7 m; 2 is 1.5 to 1.7 m, 3 is < 1.5 m
Coastal Exposure	the potential for mixing of nearshore waters with deeper oceanic waters through wind, wave and current action, where 1 is an exposed cove or bay, 2 is a sheltered cove; and 3 is an estuary
Riverine Inputs	the relative volume of fresh water to salt water within the embayment; where a rating of 1 is very little (1:>50), 2 is moderate (1: 50-150), and 3 is large (1:<150)

negotiating consensus among competing values for land protection and land development. As well, such an entry level tool could help to de-mystify the supporting science for land use planners and development managers, opening minds to the value of committing resources towards support for the collection of badly needed data on current conditions and for more complex modelling efforts.

6.3 Riverine and Coastal Nutrient Conditions

The results of the riverine and embayment water quality sampling program are provided in Table D-2, Appendix D. All nitrogen and phosphorus concentrations reported fell below the thresholds proposed in the CCME guidelines for the Protection of Aquatic and Marine Life (which are primarily based on toxicity, not on eutrophication) (CCME 2007b). Riverine concentrations of nitrogen, reported as nitrate (NO_3), ranged from 0.00 to 10.78 μM, and phosphorus reported as phosphate (PO_4) from 0.0 to 0.58 μM (Table 6.6). When riverine nutrient conditions were compared to Study thresholds that sought to avoid adverse effects to ecosystem functioning, the results were even more disconcerting. Nutrient concentrations in nearly 85% of the river samples were below the conservative thresholds proposed by this research for N and P, indicating that ambient levels of nitrogen in most of these rivers remains quite low.

Data that exceeded Study thresholds were collected from rivers that could be expected to have experienced impacts from land-based activities (Table 6.6) (Figures 6.4, and 6.5). Riverine concentrations of nitrogen were highest in rivers draining urban, clear-cut, and agricultural areas, or where there was a potential for nutrient contributions from point sources such as sewage treatment plants, aquaculture sites, or industrial or commercial effluents.

The range of concentrations reported in this research are comparable to those reported in recent studies on nutrient conditions in the Annapolis River of Nova Scotia (a watershed with considerable agricultural, commercial and municipal development) where nitrogen (NO_3) ranged from 1.13 to 11.94 μM, and phosphorus (PO_4) ranged from 0.19 to 0.92 μM.

Table 6.6: Results of 2006-2008 Nutrient Sampling Programs

Parameter	Rivers				Bays			
	Study Freshwater Thresholds	Min	Max	Percentage Samples Below Threshold conditions	Study Salt Water Thresholds	Min	Max	Percentage Samples Below Threshold conditions
TIN (μM)	**4.00**	0.03	11.11	85	**4.00**	0.53	11.44	92
NH_4 (μM)		0.00	2.63			0.00	6.66	
NO_3 (μM)	**4.00**	0.00	10.78	83	**2.00**	0.53	4.79	87
TP (μM)					**0.50**	0.28	1.59	17
PO_4 (μM)	**0.30**	0.0	0.58	76	**0.50**	0.06	1.00	63
Chlorophyll A (μg/L)					**10**	0.317	55.312	98

Within the nearshore coastal marine waters, concentrations of total nitrogen (NO_3 +NH_4) (which ranged from 0.53 to 11.44 μM) (Table 6.6, Figures 6.6 a, b, c and Figure 6.7 a, b, c) largely fell below the upper threshold proposed by Dixit and Brylinksky (2008) for well-aerated bays in Prince Edward Island, where concentrations of total nitrogen ranged from 3.32 to 6.08 μM. Even when compared with the lower recommended threshold of 2.00 μM, concentrations of nitrogen (NO_3) were generally within the suggested limits. Phosphorus levels were more diverse, with only 63% falling below threshold levels. Concentrations reported as PO_4, ranged from 0.0 to 0.58 μM throughout the study area, and were comparable with ranges experienced in Prince Edward Island (0.53-0.66 μM) and in earlier studies on the Atlantic coast of Nova Scotia (0.120.-3.75 μM). Chlorophyll A results were below threshold in all but one of the sites sampled, and were not considered further in the research.

Concentrations of ammonia (NH_4) were highest in samples taken in rivers, immediate nearshore areas and near the headlands of the bays. In some embayments, concentrations of nitrogen (NO_3) demonstrated an anticipated trend towards dilution with distance from the null point in the river. While it is expected that nitrogen may also enter nearshore waters from other non-point and point sources not captured by the river sampling, the trend in the data supports the premise that rivers draining primary watersheds are a significant source for nitrogen in nearshore coastal waters. Perhaps more importantly, the data challenges assumptions that deeper oceanic waters would be the primary supplier of nutrients to the nearshore.

Concentrations of phosphorus (PO_4) demonstrated a different trend, often increasing in marine waters, with distance from the input of major rivers, possibly as a result of nearshore productivity, and/or mixing with deeper oceanic waters (Figure 6.8).

Without more monitoring and/or improved understanding of the functioning of these nearshore marine ecosystems, it is not possible to conclude that the effects of increased nutrients are detrimental to the rivers or embayments in which they were reported. However, the data clearly demonstrate that nutrient levels in both freshwater and in marine waters throughout the study area currently occur at levels well below established regulatory guidelines for the protection of aquatic and marine life. While this could be construed as being an indicator of relatively pristine conditions, it may communicate a false sense of complacency over the state of both aquatic and nearshore marine environments. When ambient nutrient conditions are compared against Environment Canada thresholds intended to prevent nutrient loading in excess of ecological assimilative capacities (Dixit and Brylinsky 2008, CCME 2007a), the data from Nova Scotia would indicate that the aquatic and nearshore systems of the Atlantic shore may already be close to the recommended maximum concentrations. Nutrient concentrations that exceed the thresholds proposed by this research were generally reported from rivers and embayments in which anthropogenic impacts could be anticipated as having already taken place. While the research does not provide substantive evidence of adverse nutrification, it does question whether these cold water aquatic and marine environments can assimilate (without impact) higher nutrient loads, challenging expectations that current and emerging guidelines for nutrient levels are low enough to prevent the development of adverse ecosystem effects.

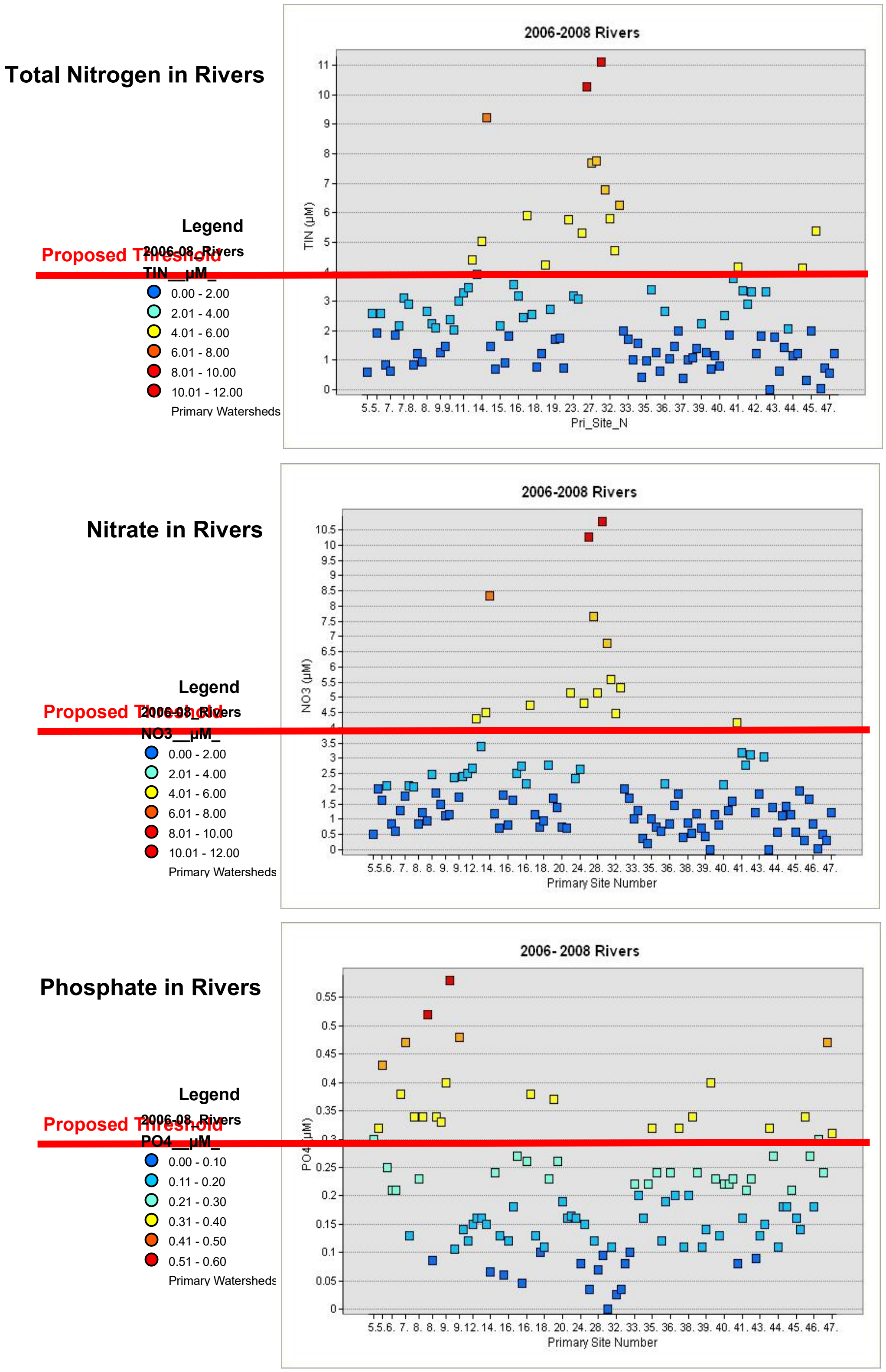


Figure 6.4: 2006-2008 Nutrient Concentrations in Study Area Rivers as Compared to the Proposed Thresholds (Yellow to red fall above the thresholds)

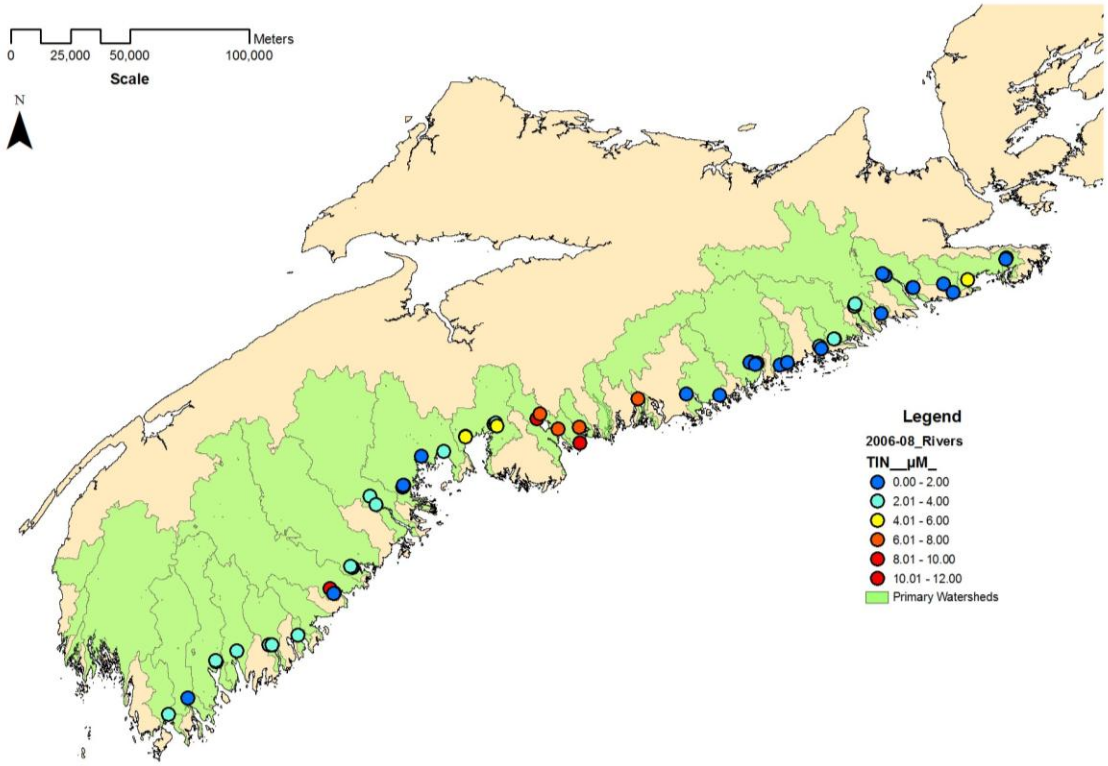


Figure 6.5a: Spatial Distribution of Total Nitrogen (TIN) Concentrations Sampled at the Null Point in Study Area Rivers and Compared to Proposed Thresholds

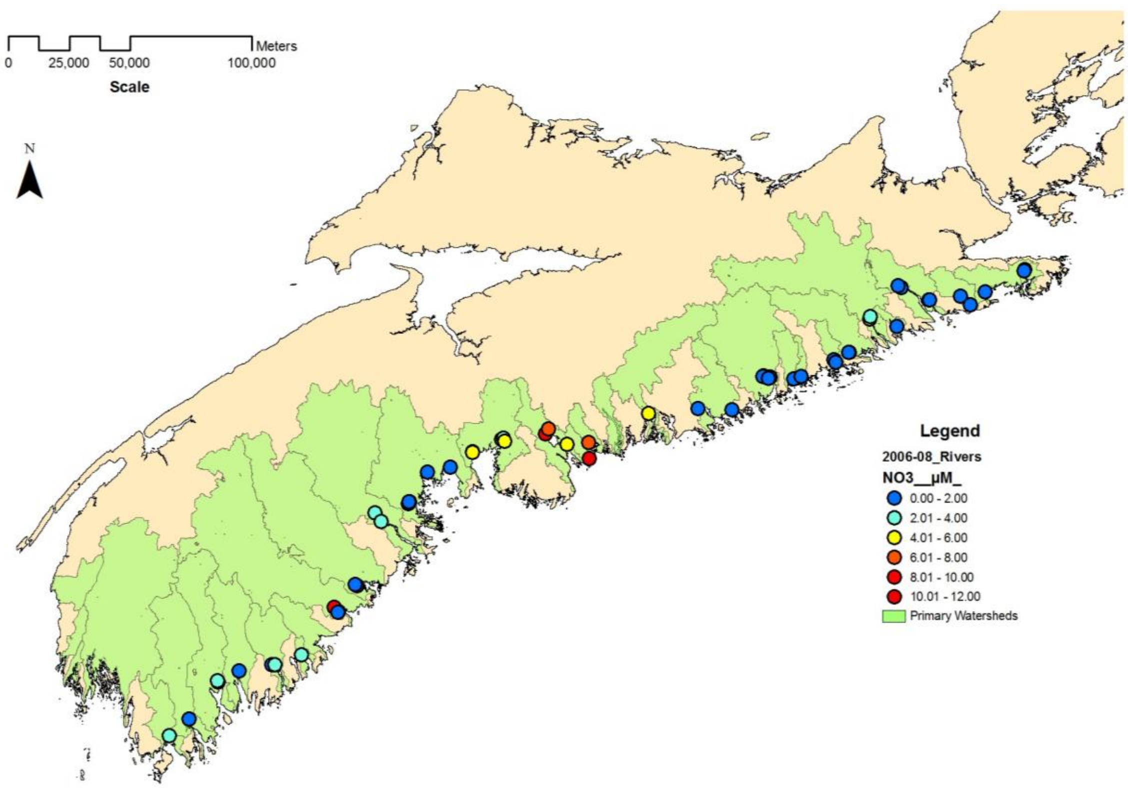


Figure 6.5b: Spatial Distribution of Nitrate (NO3) Concentrations Sampled at the Null Point in Study Area Rivers and Compared to Proposed Thresholds

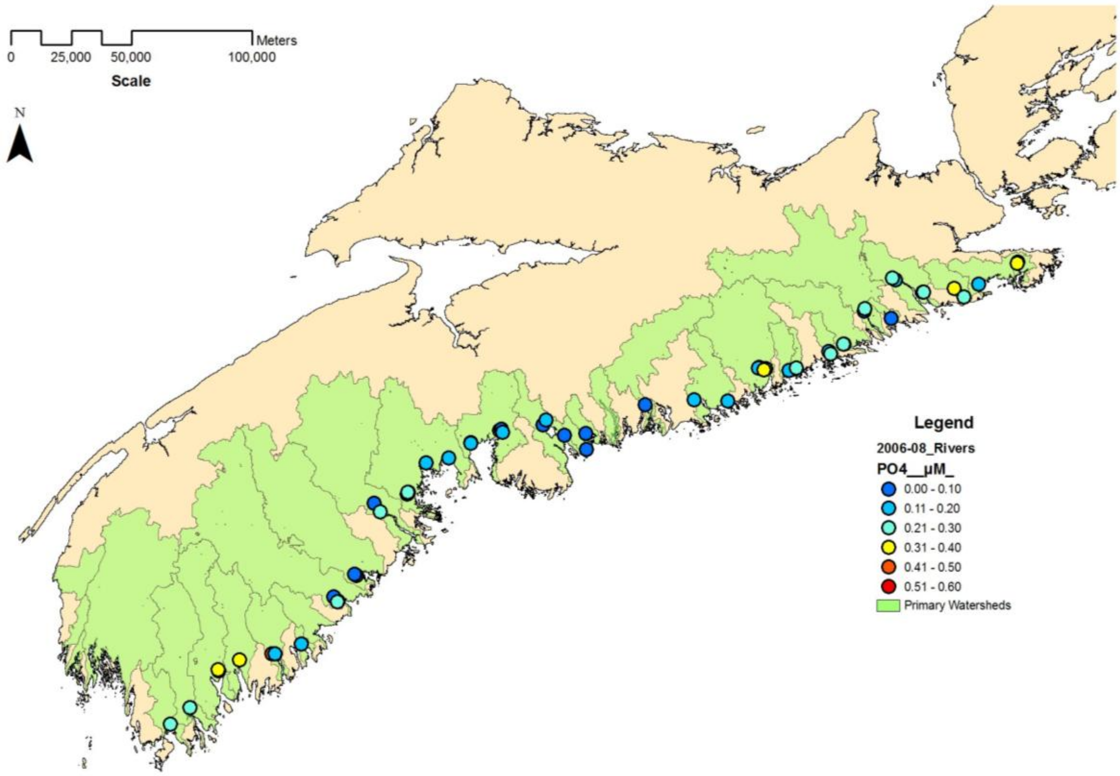


Figure 6.5c: Spatial Distribution of Phosphorus (PO4) Concentrations Sampled at the Null Point in Study Area Rivers and Compared to Proposed Thresholds

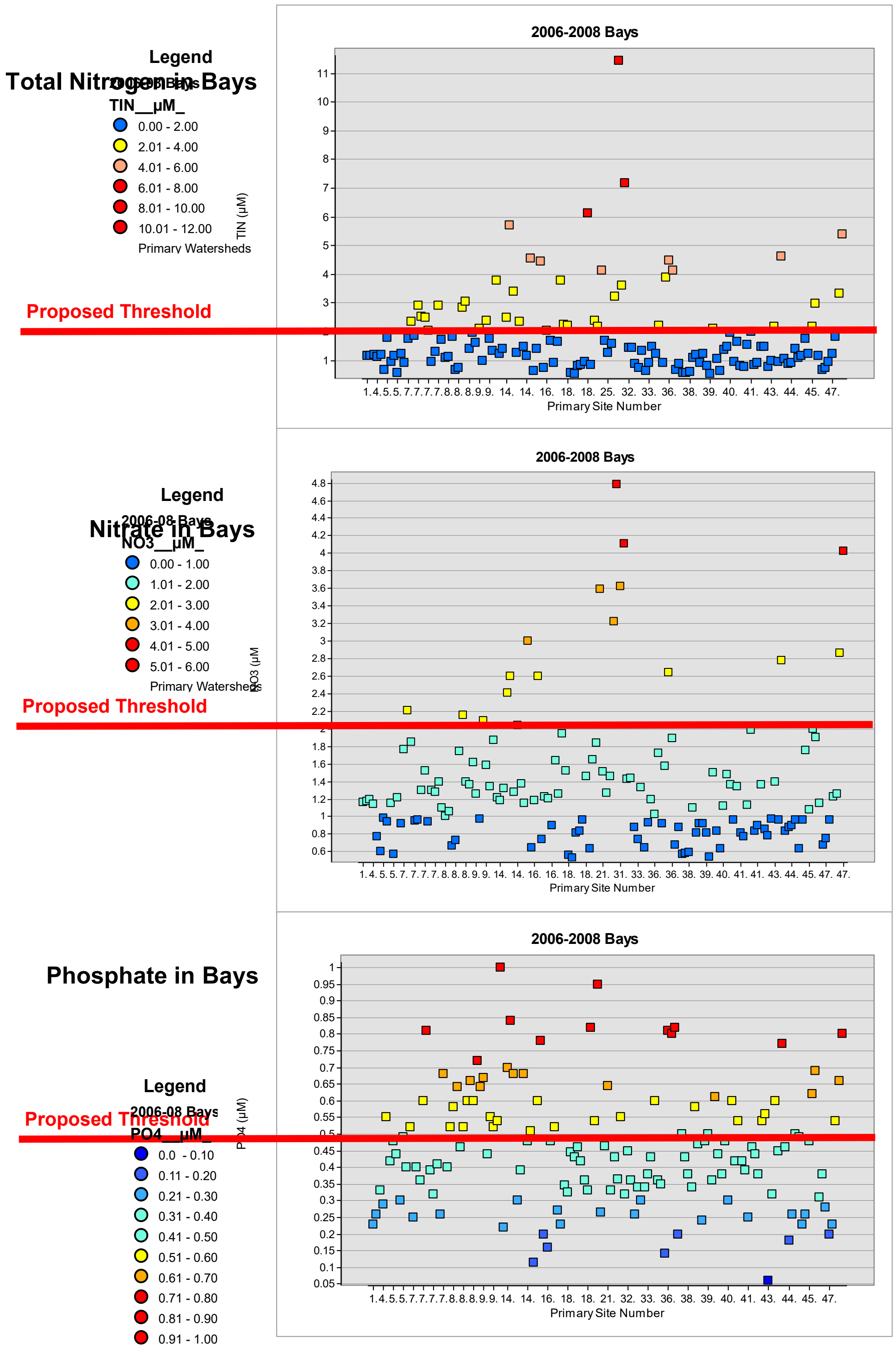


Figure 6.6: 2006-2008 Nutrient Concentrations in Study Area Bays as Compared to the Proposed Thresholds for Sheltered Bays (Yellow to red fall above the thresholds)

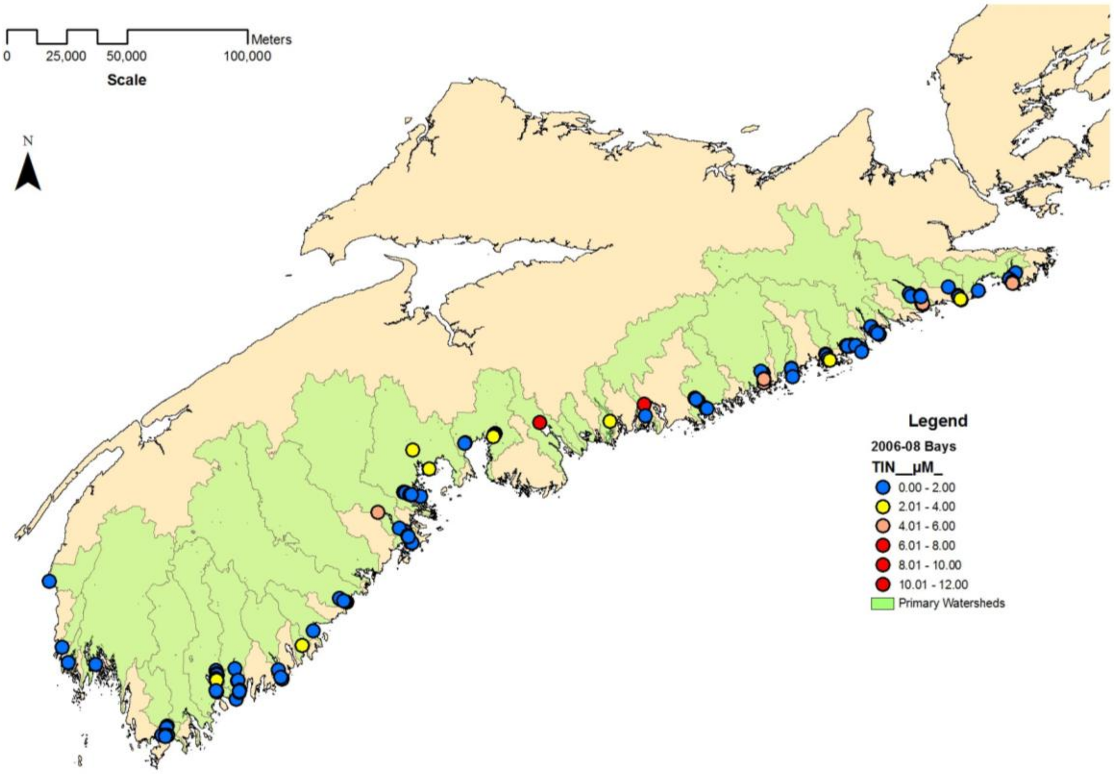


Figure 6.7a: Spatial Distribution of Total Nitrogen (TIN) Concentrations Sampled in Study Area Bays and Compared to Proposed Thresholds

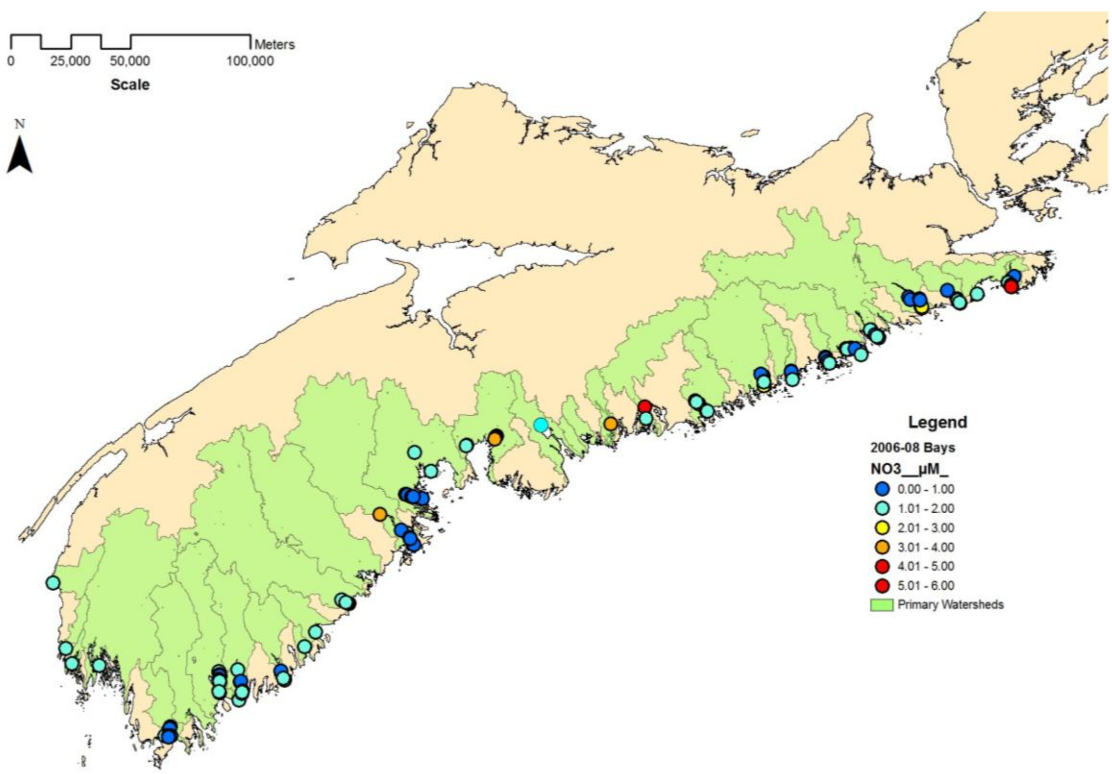


Figure 6.7b: Spatial Distribution of Nitrate (NO3) Concentrations Sampled in Study Area Bays and Compared to Proposed Thresholds

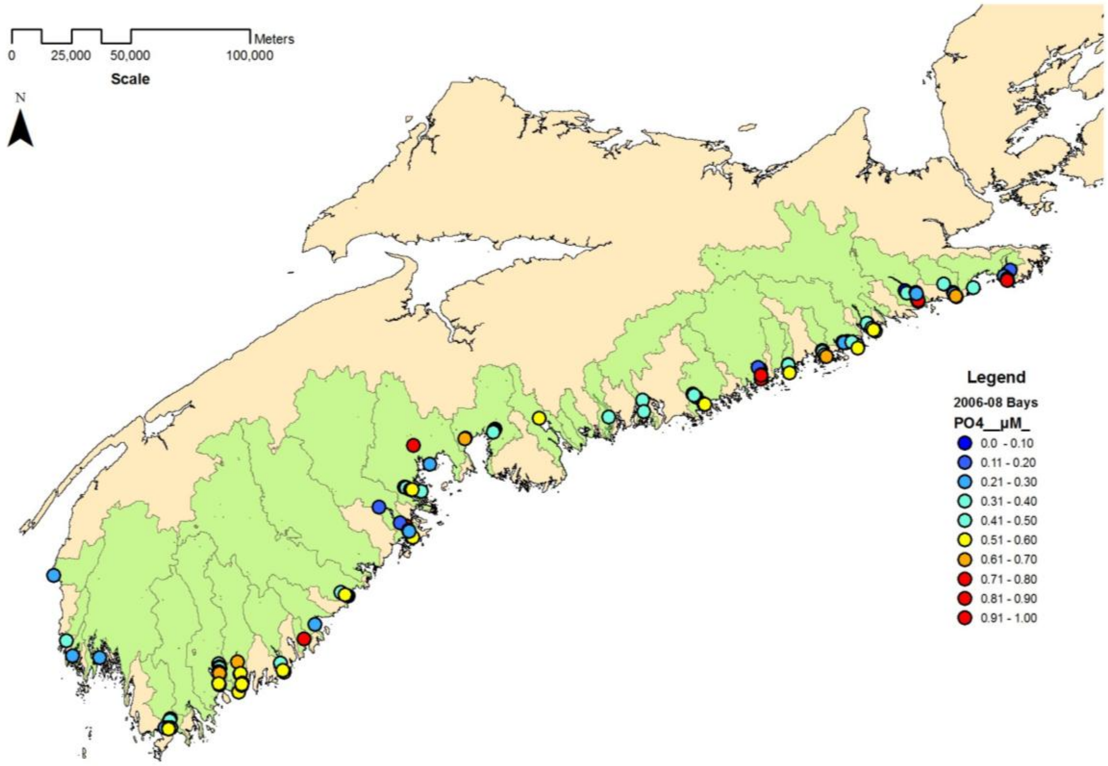
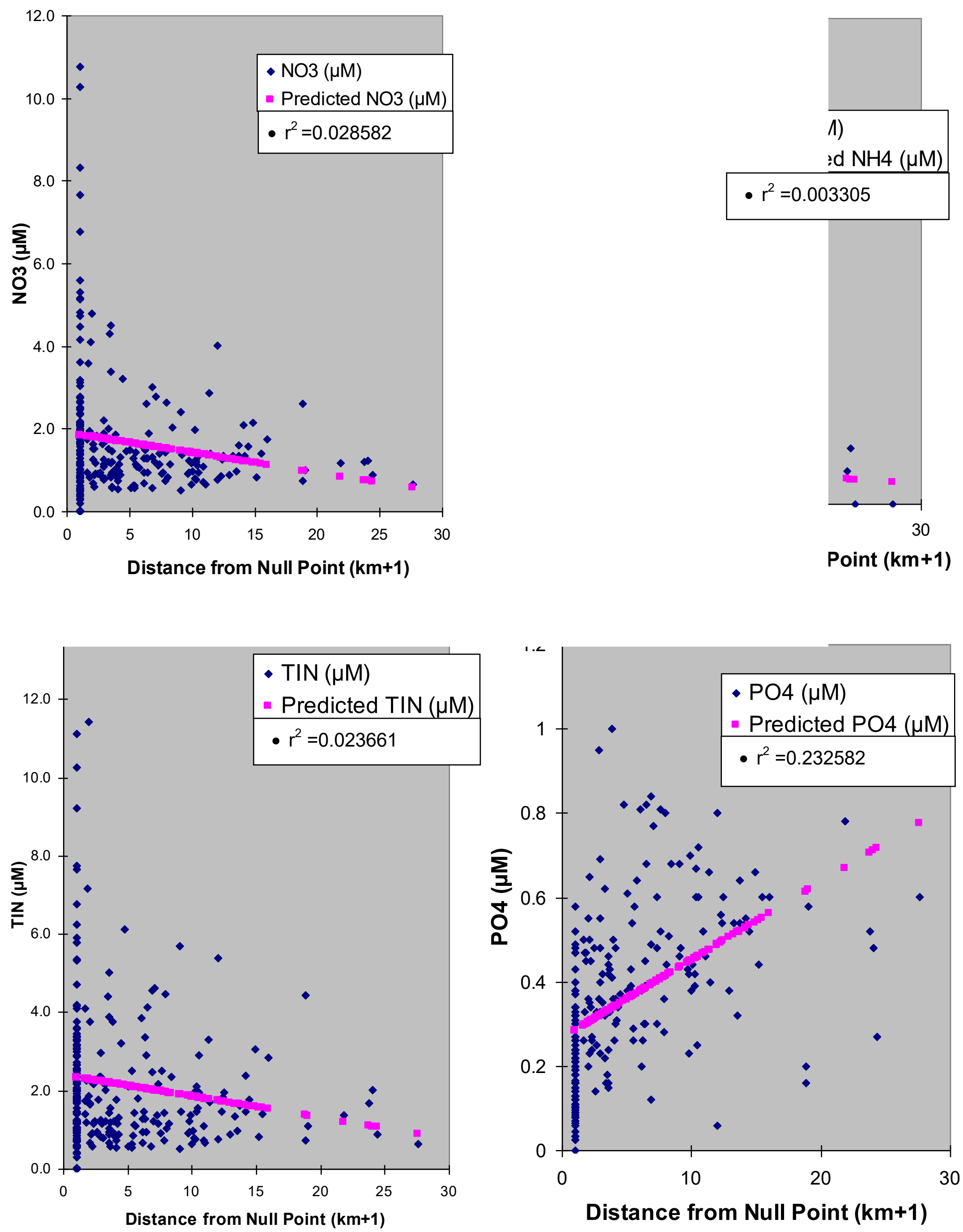


Figure 6.7c: Spatial Distribution of Phosphate (PO4) Concentrations Sampled in Study Area Bays and Compared to Proposed Thresholds



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6.4 Land Cover in the Atlantic Coastal Landscape

Working with land cover in Nova Scotia has until recently been complicated by the lack of accurate and timely data. While this research relied on land cover maps produced by the Nova Scotia Department of Natural Resources as part of a forest inventory program, it has been recognized that the data may have been affected by the primary objectives of that initiative. It is also not a simple matter to establish what would constitute a base condition (pre-European settlement) for forest cover ratios in this landscape, especially as new information on the land management practices of First Nations and Founding Tribes continues to emerge from historic records (Duke 2006). Since European settlement in the last half of the 1700s, the forest cover of Nova Scotia may have experienced a number of significant changes in spatial coverage as well as in speciation, as a result of both natural forces such as forest fires, and from clearing operations for defence, agriculture, fuel, construction, and pulp and paper manufacturing. It is important to note that since 1993, which is the presumed date of the forest inventory land cover data, land cover in Nova Scotia may have been significantly altered by ongoing forestry operations, urban development, invasive insects, and the impacts of Hurricane Juan in 2003. As reported by the Ecology Action Centre (EAC 2009), between 1981 and 1995, forest harvest in Nova Scotia increased by over 40%. Since that timeframe, clear-cut operations have continued, on increasingly younger stock, harvesting an average of 500 km^2 a year.

As reported by the Government of Nova Scotia (GOV/NS 2008), forest cover represents on average approximately 77% of the land cover, so it is not surprising that in the Atlantic coastal landscape few of the primary watersheds reported forest cover ratios of less than 30% (Figure 6.9). Recognizing that the 30% forest cover ratio was developed for agricultural landscapes in Southwestern Ontario, a threshold of 60% forest cover was considered to be more reflective of post-European conditions within the forested watersheds of Atlantic Nova Scotia. When applied against this threshold, forest cover ratios in study area watersheds became more interesting, highlighting largely unpopulated areas of the landscape in which forest harvest activities were likely to be responsible for the reduction of forested area (Figure 6.10). Recognizing that the Atlantic coastal landscape is not a densely populated region, and most of the soils are not conducive to agriculture, it was not surprising when the inventory demonstrated that for both urban cover and agricultural land cover the area of coverage was less than 10% of the watersheds (Figure 6.11). What was surprising was that in most watersheds wetlands (as recorded in the forest inventory mapping) also represented less than 10% of the total watershed area (Figure 6.12). The results obtained in this research raises questions as to whether all wetlands were captured in the original NSDNR forest cover inventory. But if the 1993 data holds up when compared against non-sectoral analyses of land cover, the spatial extent of wetlands in Nova Scotia would appear to be considerably less than anticipated, placing renewed emphasis on the need to protect and maintain wetlands of all types. An analysis of buffered watercourses (lake shorelines, rivers and streams) found that in most of the watersheds at least 70% of these important elements fell within forest cover or wetland areas (Figure 6.13).

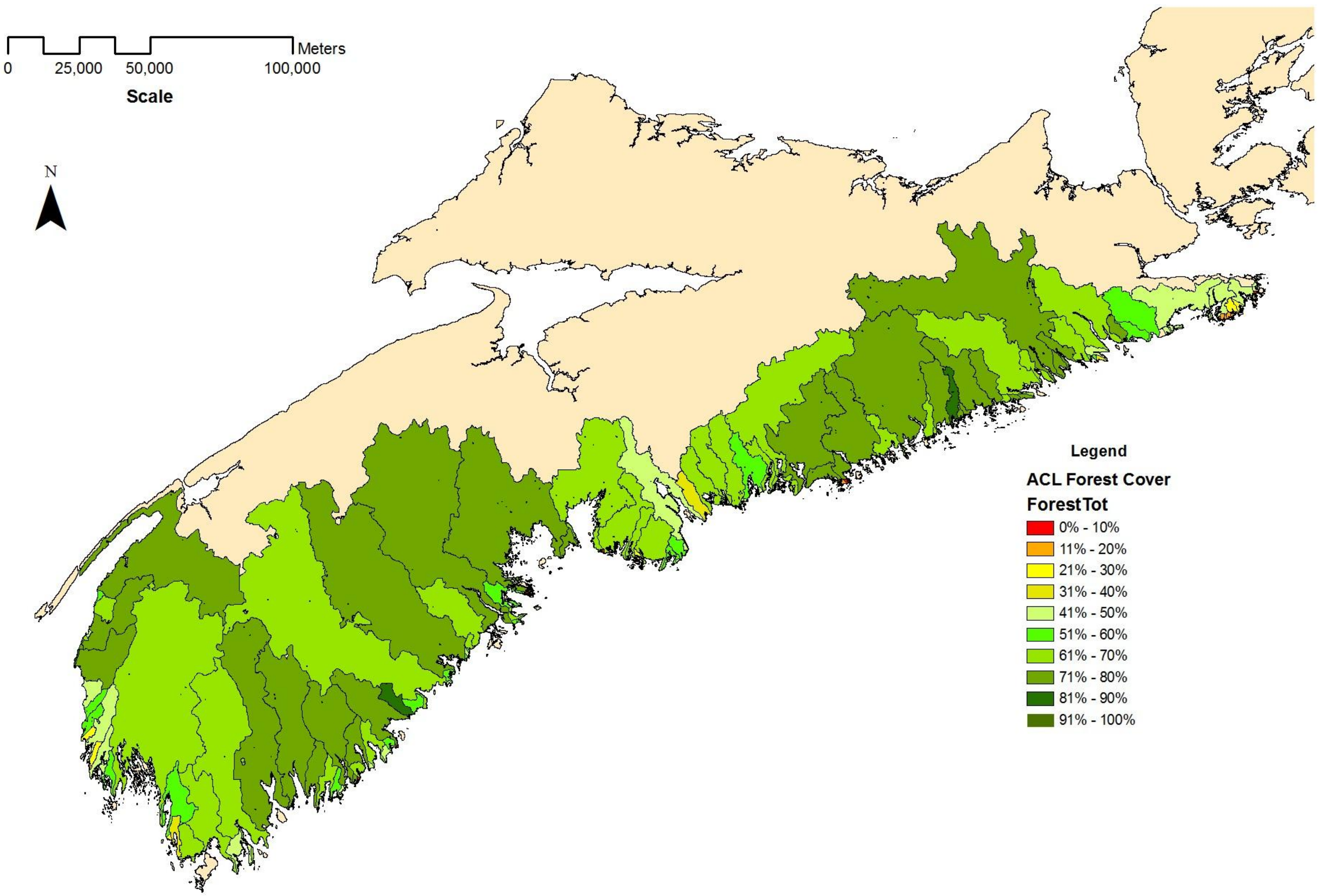

Figure 6.9: Forest Cover as a Percentage of Total Land Cover in Atlantic Coastal Landscape Primary Watersheds as Compared to a Proposed 30% Minimum Threshold

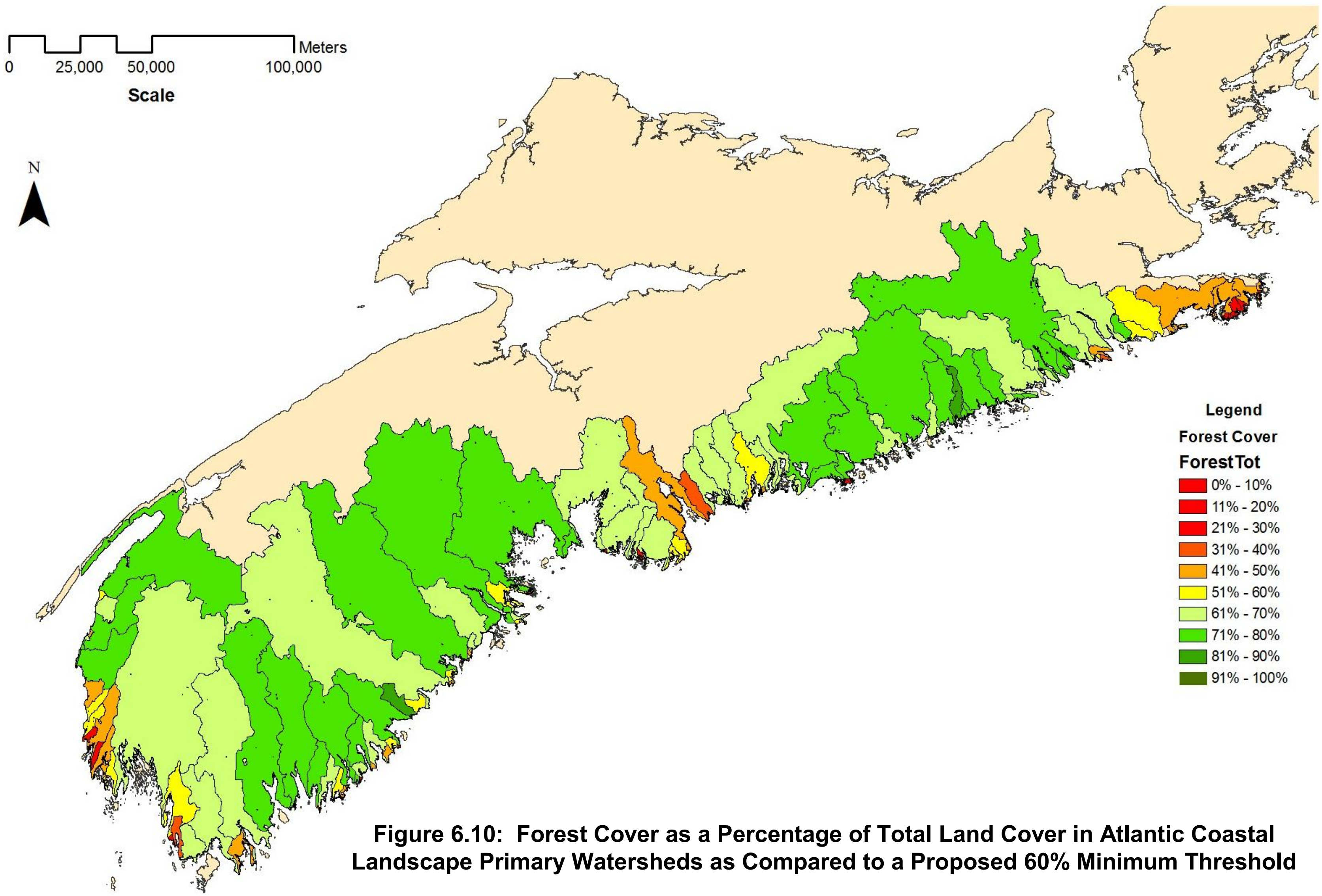

Figure 6.10: Forest Cover as a Percentage of Total Land Cover in Atlantic Coastal Landscape Primary Watersheds as Compared to a Proposed 60% Minimum Threshold

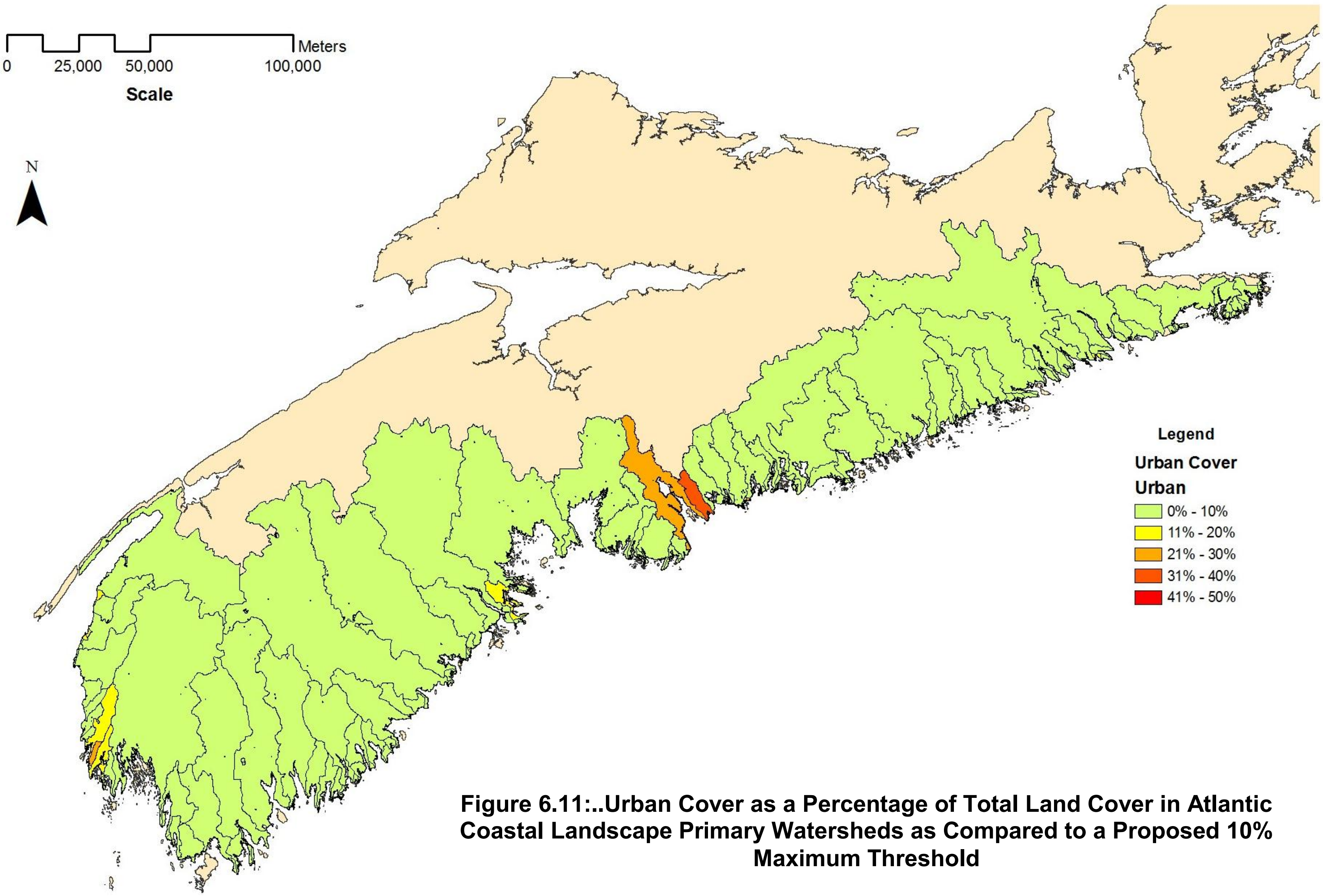

Figure 6.11:..Urban Cover as a Percentage of Total Land Cover in Atlantic Coastal Landscape Primary Watersheds as Compared to a Proposed 10% Maximum Threshold

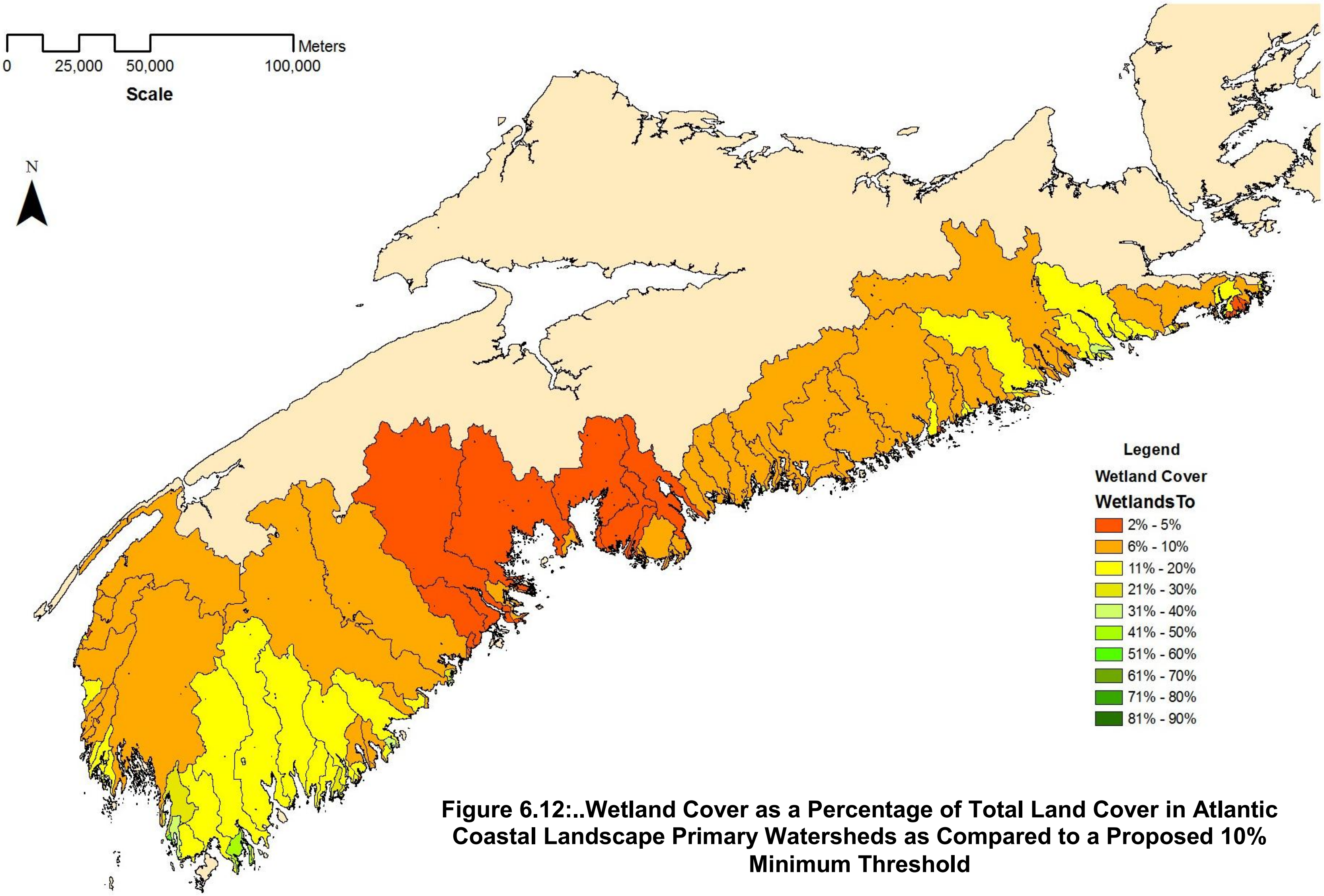

Figure 6.12:..Wetland Cover as a Percentage of Total Land Cover in Atlantic Coastal Landscape Primary Watersheds as Compared to a Proposed 10% Minimum Threshold

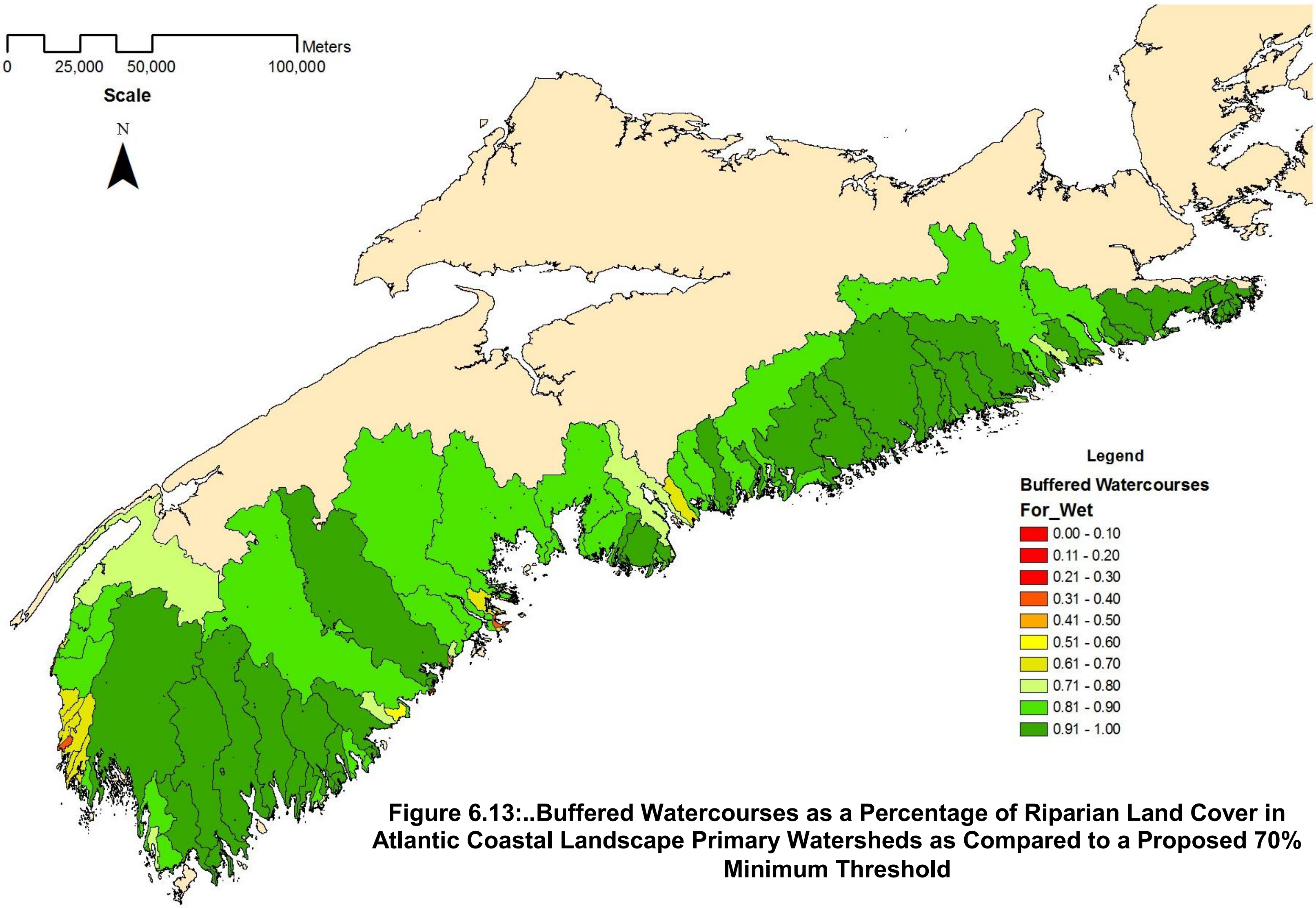

Figure 6.13:..Buffered Watercourses as a Percentage of Riparian Land Cover in Atlantic Coastal Landscape Primary Watersheds as Compared to a Proposed 70% Minimum Threshold

6.5 Land Cover and Nutrification

Given the changes in Nova Scotia‟s land cover over the past decade as a result of forestry, urbanization, and natural events, it was not surprising to see a possible trend between changes to forest cover in the watershed and increased nitrogen concentrations in the rivers and bays of the Study Area (Figures 6.14-6.17). While the data were insufficient to support a statistically valid conclusion, the highest concentrations for nitrogen compounds were reported from rivers and bays associated with watersheds in which forest cover had been substantially (10-20%) reduced from study thresholds. The relationships between phosphorus and land cover appear to be more complex, and may be affected by point sources effluents from sewage or food production facilities. While urban and agricultural land cover did not comprise a significant proportion of most Study Area watersheds, in settled, sheltered coves, such as Sackville Cove in Halifax Harbour, Cole Harbour, and Musquodoboit Harbour, nutrient levels in both the rivers and the bays are above the norms reported for other, less developed areas (Figures 6.18, and 6.21). Sackville Cove and Cole Harbour receive storm water drainage from extensive suburban residential and commercial development areas, and in the case of Sackville Cove, the effluent from a secondary sewage treatment plant. Agriculture in the Musquodoboit River, one of the more heavily farmed watersheds of the Atlantic coastal landscape, occurs mainly in the upland sections of the watershed, so nutrient loading may already be considerably reduced by inflows from forest cover areas in the lower reaches of the watercourse. The LaHave and Mersey Rivers drain extensive watersheds that have been subject to forest harvesting for generations. Both rivers also receive stormwater drainage and sewage treatment effluent from the towns of Bridgewater and Liverpool, and in Liverpool Bay, additional nutrients are added from the waste stream of a pulp and paper plant.

The landscape scale trends that have become more visible through this analysis would support concerns that current land use practices may be having a detrimental effect on nutrient loading into rivers and nearshore coastal areas. But the data from this research is insufficient to provide conclusive evidence of cause and effect relationships, or to provide insight as to the assimilative capacity of either the freshwater or marine environment to absorb these loadings without experiencing adverse impacts. When compared to other areas of eastern North America, there is some evidence to support contentions that the patterns of post-European settlement land cover change in Nova Scotia may have been similar to historic changes wrought in coastal embayments in the eastern United States. In Chesapeake Bay, where nutrification is now considered to be widespread, European settlement was at one time responsible for the removal of over 80% of the natural forest cover, the effects of which may still be affecting coastal systems (Malone et al. 1999). Malone reported that, like parts of the Atlantic coastal landscape, forest cover ratios in the Chesapeake currently accounted for nearly 60% of the area, with urban land cover at only 11% and agricultural lands making up most of the difference, ratios not radically dissimilar to those reported for Nova Scotia.

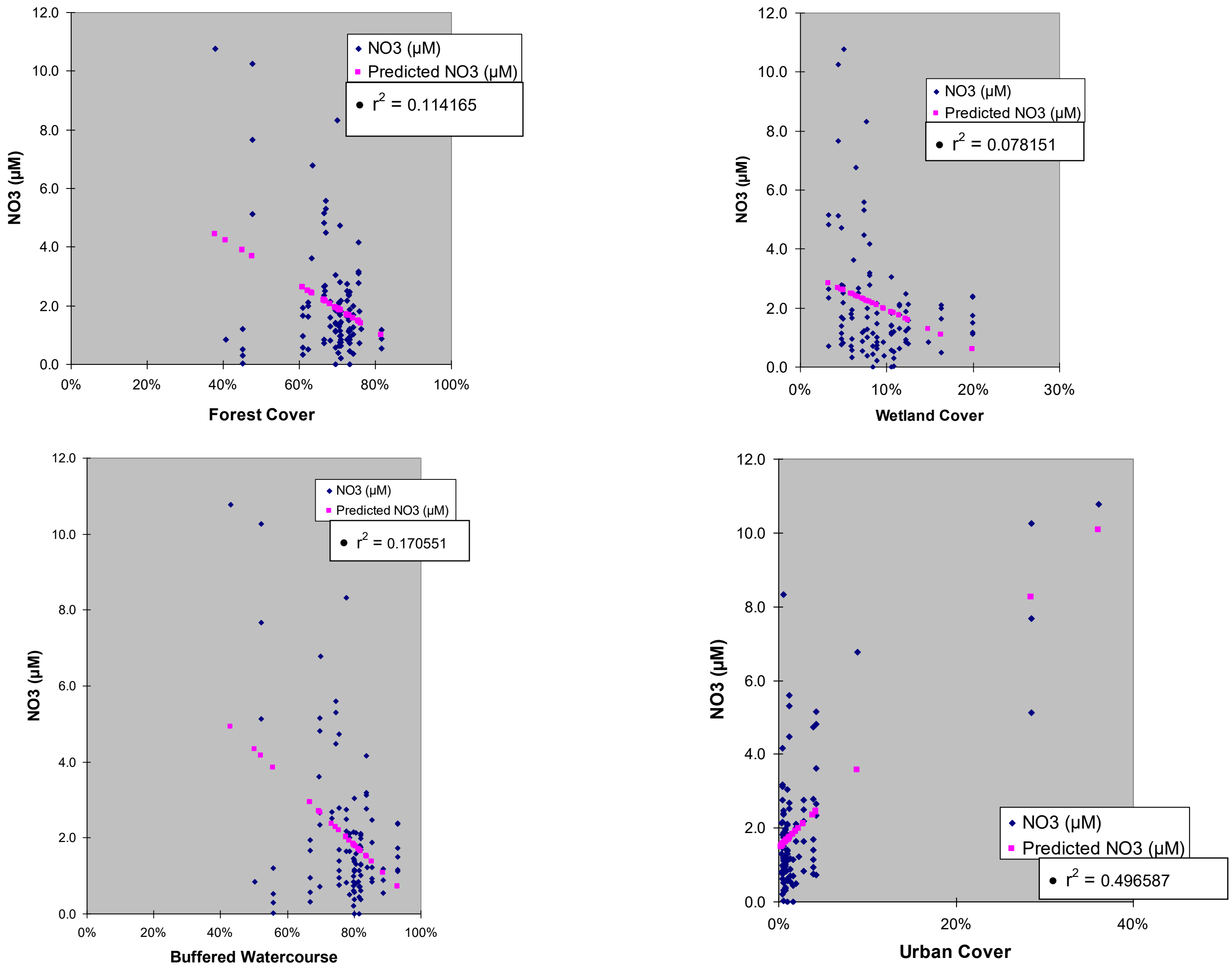

Figure 6.14: A Comparison of Land Cover in Watersheds and Nitrate Concentrations in Study Area Rivers. (The Predicted Relationship is a Calculated Regression Line).

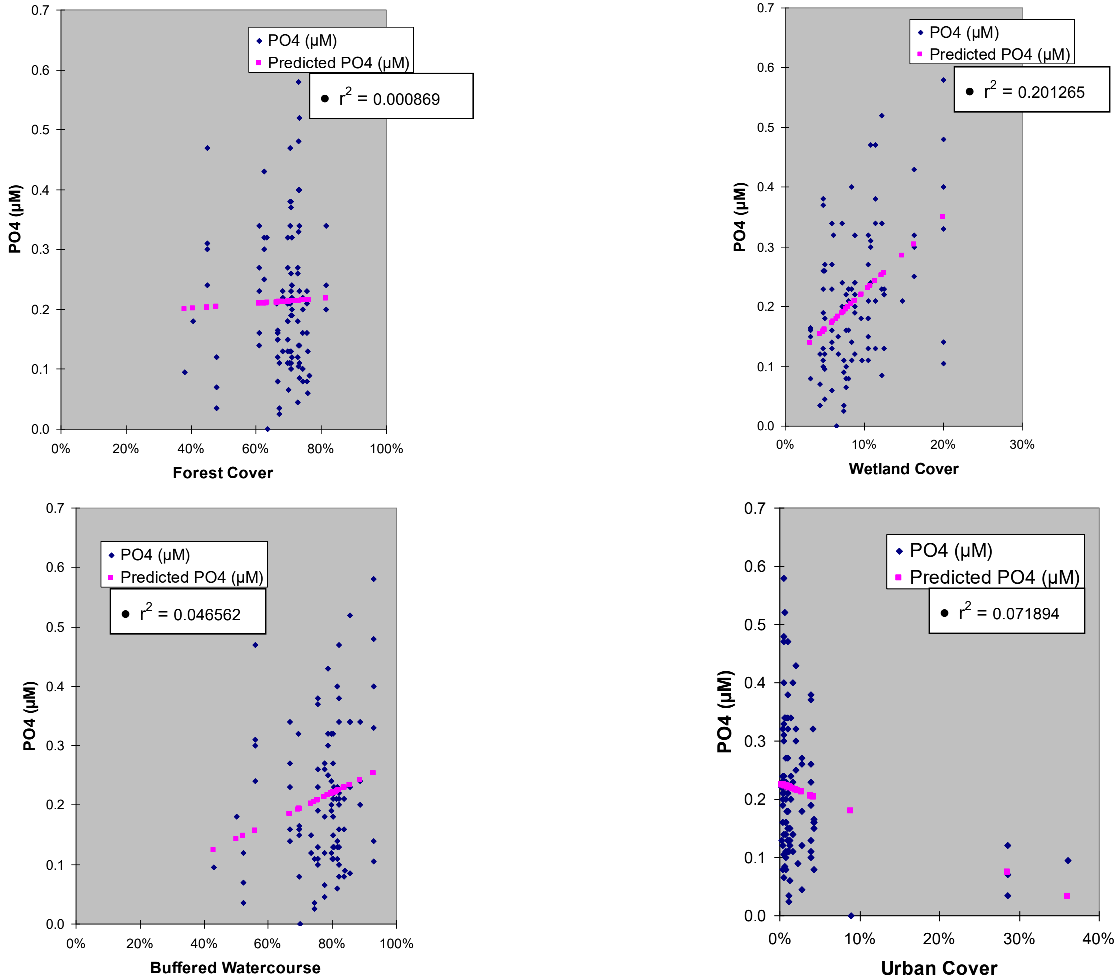

Figure 6.15: A Comparison of Land Cover in Watersheds and Phosphate Concentrations in Study Area Rivers. (The Predicted Relationship is a Calculated Regression Line).

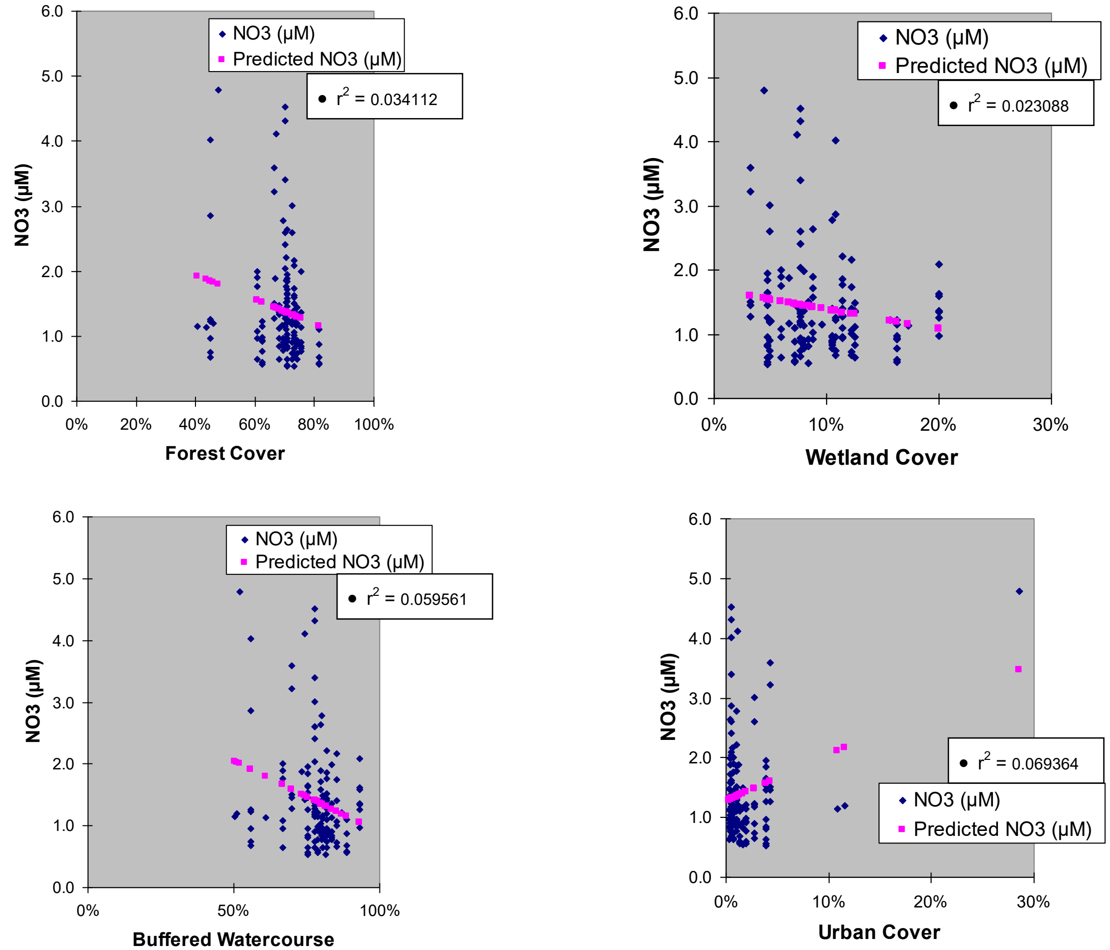

Figure 6.16: A Comparison of Land Cover in Watersheds and Nitrate Concentrations in Study Area Bays. (The Predicted Relationship is a Calculated Regression Line).

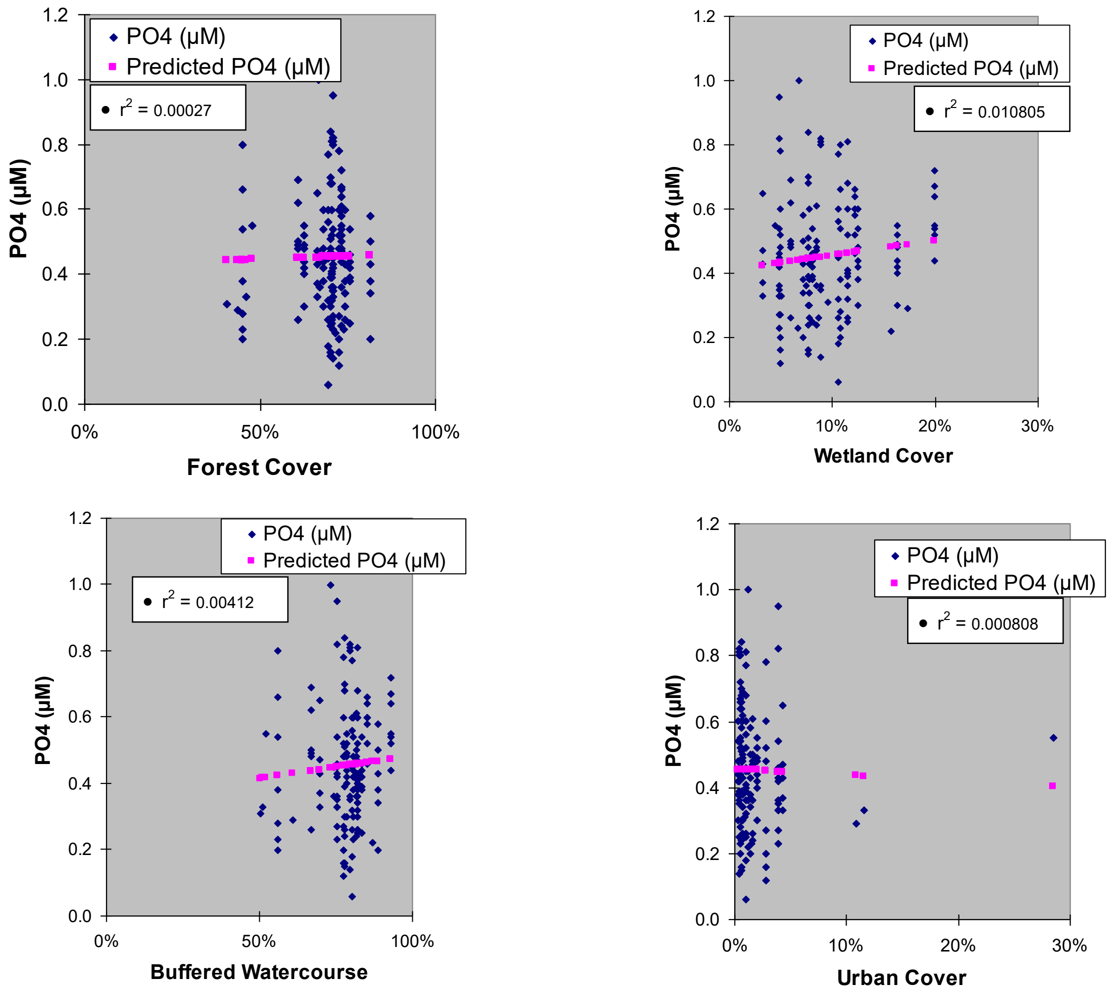

Figure 6.17: A Comparison of Land Cover in Watersheds and Phosphate Concentrations in Study Area Bays. (The Predicted Relationship is a Calculated Regression Line).

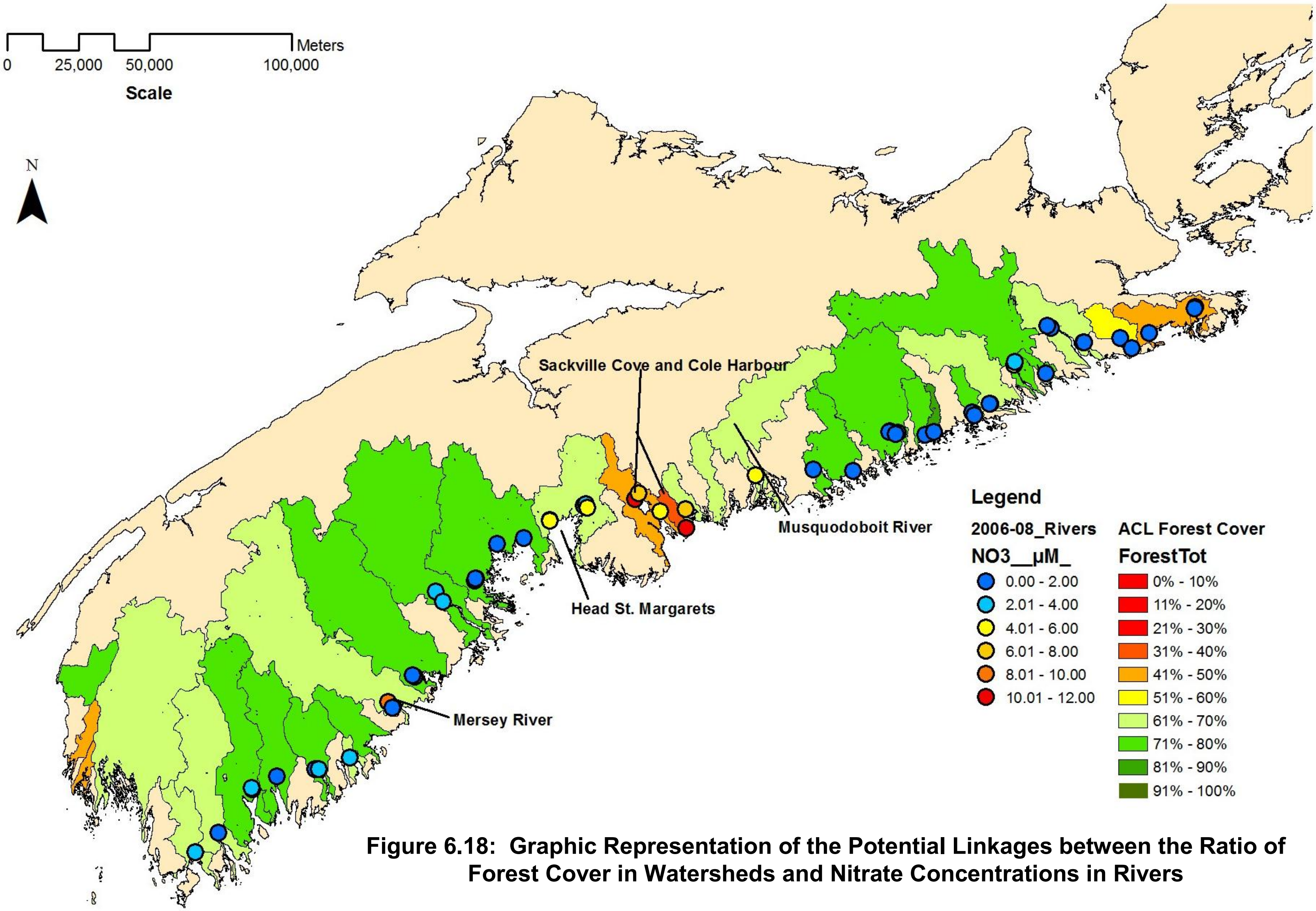

Figure 6.18: Graphic Representation of the Potential Linkages between the Ratio of Forest Cover in Watersheds and Nitrate Concentrations in Rivers

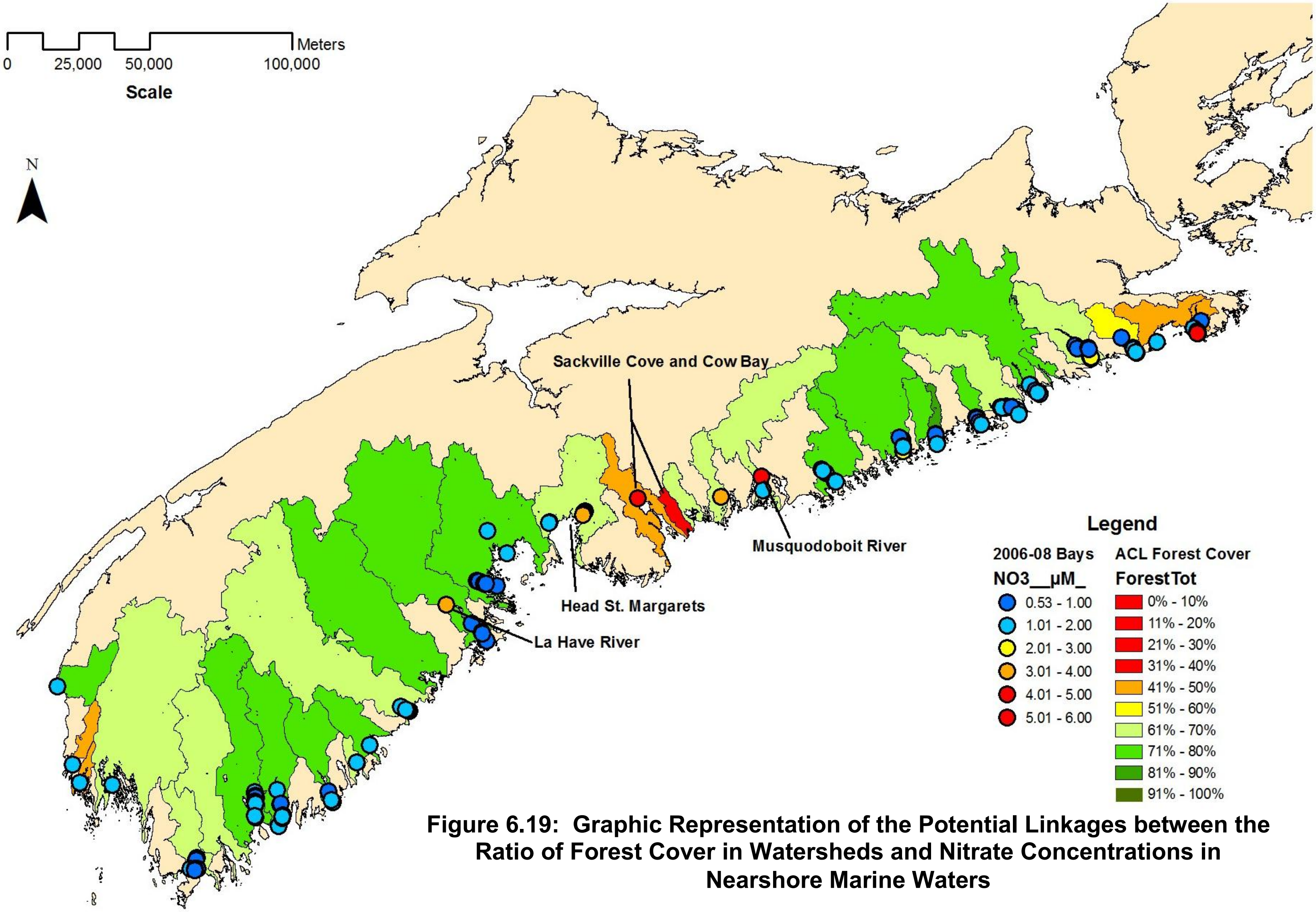

Figure 6.19: Graphic Representation of the Potential Linkages between the Ratio of Forest Cover in Watersheds and Nitrate Concentrations in Nearshore Marine Waters

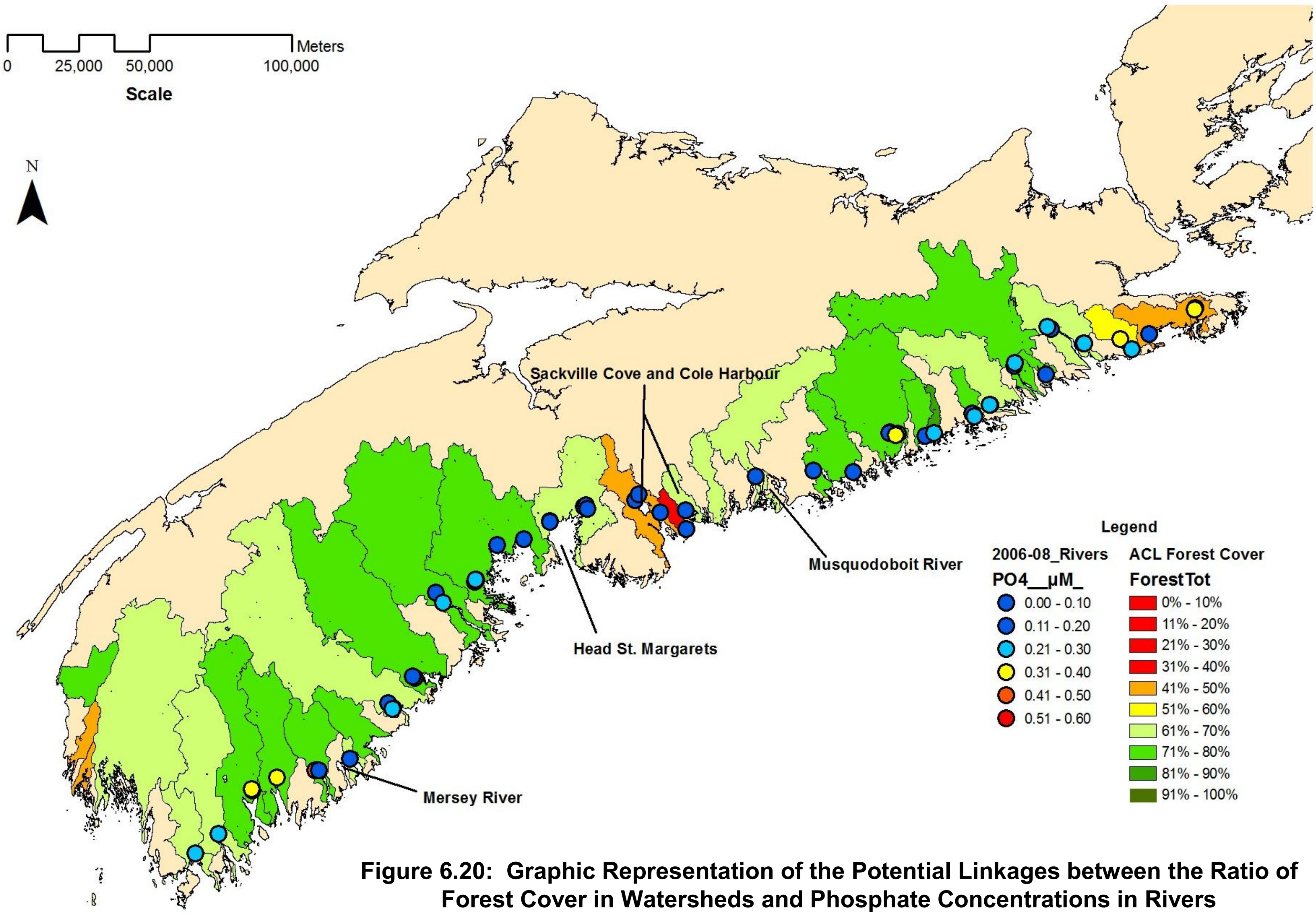

Figure 6.20: Graphic Representation of the Potential Linkages between the Ratio of Forest Cover in Watersheds and Phosphate Concentrations in Rivers

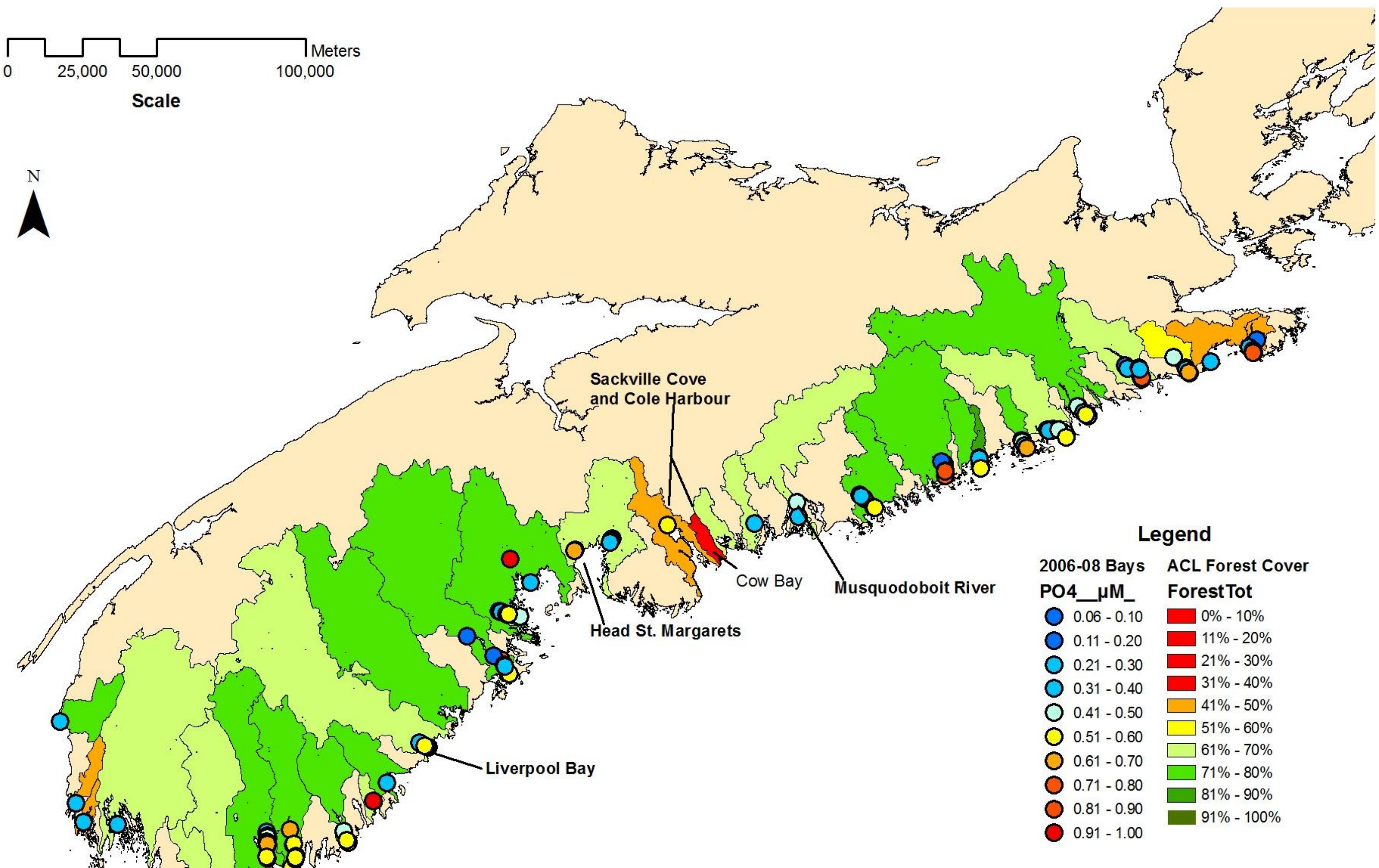

Figure 6.21: Graphic Representation of the Potential Linkages between the Ratio of Forest Cover in Watersheds and Phosphate Concentrations in Nearshore Marine Waters

6.6 Application of the Coastal Sensitivity Rating Tool

The Coastal Sensitivity Rating Tool was applied to an array of primary watersheds selected from the Atlantic coastal landscape to represent the range of conditions found in both land cover and nutrient concentrations. Where available, the ranking of physical characteristics of embayments was based on available data. Where there were insufficient supporting data, such as in the vulnerability of both watersheds and coastal waters to airborne deposition of nutrients, a series of deductive judgements were made to assign numeric rankings of potential risk to coastal well being. Information on physical and hydrodynamic conditions within the selected coastal embayments was largely drawn from Gregory et al. (1993) (Table D-3, Appendix D), or extrapolated from comparison with conditions in similar inlets.

Based on findings of the land cover assessment and the water quality analysis program, the criteria for the Coastal Sensitivity Rating Tool were adjusted as reported in Table 6.7. The threshold for forest cover was increased to 60% to more accurately reflect changes from natural cover conditions. When assessing wetland cover ratios, the rankings were adjusted to reflect the smaller ratios of wetlands to total watershed area. The potential for piped disposal of stormwater drainage was included within the ranking of point-source inputs. Ranking of river inputs was revised based on the assumption that higher volumes of freshwater drained larger areas of the watershed and could contain increased loadings of nutrients and other contaminants. Mixing, dilution and flushing potential for the inlets was accommodated through tidal range and coastal exposure rankings.

When the adjusted criteria were applied to Study Area embayments, a range of coastal sensitivities was developed (Table 6.8), reflecting both the stresses currently placed upon these environments by human activities, as well as the potential capacity for assimilation of impacts. Perhaps not surprisingly, Sackville Cove and Cow Bay which are an integral part of the urban landscape of the Halifax Regional Municipality, scored significantly higher than the other coastal areas. For less settled areas, further work is needed to refine the thresholds for land cover to more accurately reflect pre-settlement and current conditions in the watersheds, and to permit the development of locally appropriate standards.

However, the CSR Tool does provide a simple method for estimating current conditions, and their potential effect on coastal receiving waters, especially as they relate to other areas of the Atlantic shore of Nova Scotia. This landscape scale analysis provided a coarse assessment of land cover and nutrient conditions within the primary watersheds and nearshore coastal waters of Nova Scotia, as well as a perspective on change that could be useful in regional planning and management of land and land-based resources. Where there are data, the trends identified by the regional analysis could be more fully examined through an examination of land cover change at the watershed scale, or within the management boundaries of counties or towns.

Table 6.7: Adjusted Coastal Sensitivity Rating Matrix

Land Cover Type	Mercer Clarke GreenField Ratio		Land Cover Rating	Coastal Condition Contributing Factors					COASTAL SENSITIVITY RATING
	Threshold Watershed Coverage	Actual Land Cover Watershed Coverage		Point Source Inputs	Airborne Vulnerability	Tidal Range	Coastal Exposure	Riverine Inputs	
	(0-100 %)	(0-100 %)	(0 - 40)	(1 - 3)	(1 - 3)	(1 - 3)	(1 -3)	(1 - 3)	(5 - 55)
Forest Cover	>60								
Wetlands	>10								
Buffered Watercourses	>70								
Urban Cover	<10								
Watershed Coastal Sensitivity Ranking			**0 - 160**						**20 - 220**

Forest Cover	all types of natural forest and vegetative cover (e.g., old growth, plantations, old fields, barrens and heaths, but not clear-cut areas)
Wetlands	all types of wetlands (e.g., bogs, fens, swamps, salt marshes, drowned forests)
Buffered Watercourses	a buffer of forest or wetland cover (see above) calculated as a distance of 30 m from the edges of lakeshores, rivers and streams
Urban Cover	urban and suburban development as well as other impermeable land cover that restricts the movement of water from the surface to the soil
Land Cover Rating	each land cover type was scored by comparison of the total area of that land cover that occurs within the watershed with the recommended threshold. Ratings were scored as follows: 0 is very good (at or above the threshold), 10 is deteriorating (0-10% below the threshold), 20 is fair (11-20% below), 30 is poor (21-30%) and 40 (>30%) represents a significant reduction in land cover area below the recommended threshold.
Point Source Inputs	the number of major point source effluents in the watershed (e.g., sewage treatment plants, food processing plants (especially fish plants), industrial waste streams, piped stormwater) where a rating of 1 = 1 -5 effluents; 2 = 6-10, 3 = 11 or more
Airborne Vulnerability	the likelihood of deposition of contaminants over land mass and nearshore waters where 1= low; 2= moderate; 3 = high
Tidal Range	mean tidal amplitudes along the coast, where a rating of 1 is >1.7 m; 2 is 1.5 to 1.7 m, 3 is < 1.5 m
Coastal Exposure	the vulnerability of the nearshore to mixing with deeper oceanic waters through wind, wave and current action, where 1 is an exposed cove or bay, 2 is a sheltered cove; and 3 is an estuary
Riverine Inputs	the maximum monthly river discharge of freshwater to the embayment; where 1 is relatively little (20 m^3/s), 2 is moderate (80m^3/s) , and 3 is large (over 80 m^3/s)

Table 6.8: Assessment of Coastal Sensitivity to Land Cover Change

Coastal Embayment	Inlet Type	Forest Rank	Wetland Rank	Buffered Watercourses Rank	Urban Rank	TOTAL LAND COVER RANKS	Point Sources	Airborne Vulnerability	Tidal Range	Coastal Exposure	River Input	TOTAL PHYSICAL FACTORS	Coastal Sensitivity to Change Rating
Shelburne Harbour	Estuary	0	0	0	0	**0**	1	3	1	3	2	**10**	**10**
Sable River Estuary	Estuary	0	0	0	0	**0**	1	3	1	3	1	**9**	**9**
Port Jolie	Bay	0	10	0	0	**10**	1	3	1	2	1	**8**	**18**
Liverpool Bay	Estuary	0	10	0	0	**10**	2	3	2	3	2	**12**	**22**
LaHave Estuary	Estuary	0	10	0	0	**10**	2	3	2	3	3	**13**	**23**
Mahone Bay Harbour	S- Cove	0	10	0	0	**10**	1	3	2	2	1	**9**	**19**
Hubbards Cove	S- Cove	0	10	0	0	**10**	1	3	2	2	1	**9**	**19**
Head St. Margaret's Bay	S- Cove	0	10	0	0	**10**	1	2	2	2	1	**8**	**18**
Sackville Cove	S- Cove	20	10	20	20	**70**	2	2	2	2	1	**9**	**79**
Cow Bay	E-Cove	30	10	30	30	**100**	1	2	2	1	1	**7**	**107**
Cole Harbour	S- Cove	0	10	0	0	**10**	1	2	2	2	1	**8**	**18**
Musquodoboit Harbour	Estuary	0	10	0	0	**10**	1	2	3	3	2	**11**	**21**
Ship Harbour	Estuary	0	10	0	0	**10**	2	1	3	3	2	**11**	**21**
Quoddy Harbour	E-Cove	0	10	0	0	**10**	1	1	3	1	1	**7**	**17**
Ecum Secum	E-Cove	0	10	0	0	**10**	1	1	3	1	1	**7**	**17**
Liscomb Harbour	Estuary	0	0	0	0	**0**	1	1	3	3	2	**10**	**10**

6.7 Discussion and Conclusions

In the past decade, faced with continuing deterioration of coastal environments, support for stronger linkages between land and river management and coastal management has grown rapidly (Olsen et al. 2006a, Pickaver and Sadacharan 2007, SCOR/GESAMP 2008, UN/CSD 2009). Yet in Canada, initial efforts towards a more integrated approach to coastal management do not adequately address the effects of land cover and land use changes on nearshore environments (Hardy and Cormier 2008). Up to now, Canadian management of land cover and nutrification in coastal waters has largely been based on an assimilative capacity approach which assumes that contamination of marine environments is acceptable up to the point of serious or irreversible harm (Williams 1996) . In this paradigm, action is required only if there has been proof of damage to the environment, and thresholds for contaminants such as nutrients are set accordingly. Proactive management of land cover change would require a more precautionary approach based on avoiding environmental contamination. Proactive management would accept the limitations of science to accurately predict the effects of increased loadings of nutrients on coastal ecosystems. Precautionary approaches are gaining in application within the Canadian regulatory field, as is evidenced by recent initiatives of the federal government to develop management instruments for municipal wastewater based largely on required levels of treatment rather than on assimilative capacity of receiving freshwater and marine environments.

While we continue to be challenged by the limitations of existing data and information on the state of change within coastal environments in Canada, there is a growing need to develop science based tools that can provide insight into the stressors and pressures affecting coastal sustainability, and inform the development and implementation of proactive policy and planning. As evidenced by this research, even relatively simple spatial modelling of coastal land cover change can be used to improve understanding of current conditions, and to evaluate the consequences of alternative future scenarios for land cover change on a range of social and environmental endpoints. It is important that scientists and land use planners collaborate to ensure that the maximum potential is achieved from studies such as this, and that the information generated is applied effectively to the identification of options for land development that have the least potential to impact sensitive coastal landscapes. Why place increased controls on land development now, as opposed to waiting until there is visible evidence that Nova Scotia‟s coastal environments have been impacted? The simple answer is that once we have paved paradise, restoration of the natural forests may be a fiscally as well as an ecologically impractical goal. By example, as reported for the Chesapeake Bay watershed, in the decade between 1985 and 1996 over $3.5 billion were spent on point and non-point sources in an effort to control nutrient loading to the coastal system (Butt 2000).

Even along the relatively unpopulated shoreline of Atlantic Nova Scotia, this research identified some potentially disconcerting linkages between land cover ratios and nutrient concentrations in some of the study area rivers and bays. To better manage these complex relationships, an examination of land cover ratios in the watershed, when coupled with monitoring of nitrogen concentrations at the null point of major rivers, can provide simple, yet effective meta-indicators of changing conditions. When added to an improved understanding of the potential capacity of the nearshore marine environment to assimilate those changes, decision-makers will be better equipped to understand and assess the risks associated with land use and land development. With improved understanding, comes increased support for the additional science needed to improve knowledge of cause and effect mechanisms at the local scale, and to address environmental and social consequences of inaction.

A proactive agenda for land management in Canada is an ambitious goal that would require the participation of all levels of government and all sectors within the community. Leadership is needed from federal and provincial authorities to entrench shared goals and to harmonize policy on coastal management. But the greatest opportunity for change to current practices will only be achieved through a new and vigorous approach to coastal management that engages the active participation of all sectors and especially of local governments, who continue to hold much of the responsibility for decisions on land planning and development. By building on Canada‟s heritage of volunteer participation at the community level, existing constraints to needed monitoring and reporting can be overcome, and new and effective avenues developed to inform the public of the linkages between their activities on the land and the health of the coastal environment on which they have relied economically and culturally for generations.

CHAPTER 7:
WELL MANAGED COASTS: SETTING A NEW COURSE FOR CANADA

Change will not come if we wait for some other person or some other time. We are the ones we've been waiting for. We are the change that we seek. Barack Obama, President Elect of the United States of America, February 05 2008, Chicago, Illinois

7.1 A Sea Change in Coastal Management

Management of humanity"s impacts on large scale landscapes like the coasts remains one of the great challenges of governance in the twenty-first century (Nagendra and Ostrom 2008, Olsen et al. 2009). For almost forty years, international organizations and nations have responded to the crisis in coastal environments through growing commitment to the principles of integrated coastal management (ICM). ICM systems have been proposed as tiered, hierarchical structures of national, provincial/state, and local/municipal policies and programs, which emphasize the need for both vertical and horizontal integration across governments and society, and rely on both enabling national legislation and the establishment of a separate agency to oversee implementation. Yet when faced with the complex task of integrating management of the coast across established bureaucracies, governments have proven resistant to substantive change to their methods of doing business (Billé 2008, Brown 2005, Shipman and Stojanovic 2007). Given the benefits and constraints shared by ICM initiatives (as examined Chapters 2 and 3), and the lack of progress in Canada (Chapter 4), it is perhaps past time to question the appropriateness of a governance model that, while inspirational, may be out of step with the practical realities of life and governance in the twenty-first century.

Integrated coastal management has essentially been proposed as a panacea (i.e., a standardized methodology for a system of governance that could be applied in all circumstances, providing a comprehensive solution to many or all problems) (Ostrom 2005, 2007b, Ostrom et al. 2007). Yet in examining the effectiveness of similar institutional systems throughout the world, Ostrom and her colleagues challenged expectations that scholars could propose governance or institutional models that were capable of providing general solutions to the overuse of resources, or that governments could create, implement or sustain the type of leviathan institution necessary to assume planning and management control of all aspects of a complex socio-ecological system.

Throughout the world, voices are calling for a different, non-hierarchical perspective on coastal management, one that is based more on ecological empathy, precautionary management and shared governance than on the forced integration of planning and decision-making processes (Jentoft 2007, Kay et al. 2003, Rothwell and VanderZwaag. 2006, Sale et al. 2008, Waltner-Toews et al. 2008, Vallega 1999, Vallega 2000, Vallega 2001b, Vince 2008). As Crance and Draper (1996) concluded, finding a new framework for sustainable management of our coasts will likely require an approach based not only on structural institutional solutions but also on behavioural change that enables a more collaborative management of existing and emerging dilemmas.

Examples of this shift in perspective are emerging throughout the world, some more successful than others. In the United Kingdom, despite advocates that wanted to see land planning included in coastal management (Allmendinger 2002, Kremer 2004, Kremer et al. 2004), the recent Marine and Coastal Access Act (GOV/UK 2009) and the new Coastal Change Policy (GOV/UK/DEFRA 2009) still pay only limited attention to the management of inland stresses and pressures on marine environments. However, the Netherlands, deciding that there was little need for a new institutional system, have incorporated coastal sustainability into their National Strategic Planning Strategy, fostering implementation through changes to established government policies and programs (GOV/NETH 2005a, 2005b, Shipman and Stojanovic 2007). In the United States, the shift in coastal management is also towards more stewardship of the land (Boesch and Greer 2003, Environmental Law Institute 2009, US/NOAA 2007, JOCI 2006). At the State level, the long-standing and progressive Coastal Management Program of the State of Oregon (GOV/US/Oregon 2001) and initiatives within the State of New Jersey, have focussed on improved harmonization of established land and water management instruments through the collaborative efforts of all involved agencies (Neuman 1999).

In Australia, where the Oceans Policy (GOV/AUSTR 1997) has been in place for over a decade, the State of Queensland has continued on an innovative path towards improving coastal management across both its land and water through the participation of all levels of government, as well as non-government organizations. Australia has challenged its citizenry as well as its public service to use all instruments available to advance the principles for coastal management, and continues to refine guidance tools and legislative instruments to that end (GOV/AUSTR 2006, 2008, 2009, Harvey and Caton 2003). And in their review of coastal management efforts in Sydney Harbour, Dawkins and Colebatch (2006) added their voice to the growing consensus for more innovative thought, concluding that even where structural tensions existed among governments, there was more than one way to frame either the issue or the governance response.

In Canada, it has been more than a decade since the Oceans Act (GOC 1996a) assigned the Department of Fisheries and Oceans the leadership role for integrated management of estuarine and coastal waters and the activities which impact upon their well-being. Yet there has been little substantive progress towards a national system of coastal management (Juda 2003, Ricketts 2009, Ricketts and Harrison 2007). While continuing complacency over the state of Canada‟s coasts appears to be widespread, it is unlikely that there are many places within Canada‟s vast coastal landscapes that have neither a legacy nor a future of human occupation or human impact. Even in the far North, the continued and pervasive warming trends associated with climate change, and the resulting expectations for increased international marine traffic, will challenge not only Canada‟s sovereignty in the Arctic, but the survival of species, habitats and traditional ways of life (Ommer 2007).

There is still considerable confusion in this country as to (i) what constitutes a coast, (ii) whether the Great Lakes would be part of a national coastal management system, (iii) whether land planning and management is a component of coastal management, (iv) who is leading the long-anticipated integration of government policy, rules and programs, and (v), whether there will be a real role for community-based organizations in policy-setting and decision-making. Some provinces, perhaps frustrated by the lack of national progress, have begun their own processes towards improving management along their coasts (e.g., British Columbia, Nova Scotia, New Brunswick, Newfoundland and Labrador). In Ontario, because the provisions of the Oceans Act do not embrace the sweet water ocean of the Great Lakes, efforts in coastal management have remained isolated from the work being conducted in other provinces.

In this chapter, I draw on innovative approaches and insights in institutional and organizational management, to offer an alternative approach to coastal governance in Canada. Governance, in my interpretation, is comprised not only of the political and administrative authorities (federal, provincial/territorial and municipal) and the sets of rules (law, policy, and other instruments) by which society operates, but also includes the participatory efforts of non-government organizations. Setting a new course for coastal governance in Canada requires an increased respect for the complexity of environments and institutions, a determination to embrace uncertainty and risk, and a reliance on the collaborative will of all sectors of society.

7.2 Getting our Bearings

Given the apparent stagnation of national efforts towards coastal management in Canada, this is a good time to re-examine the challenges posed by an integrated approach (Chapters 3 and 4), in favour of a softer, approach that is more supportive of working within existing governance systems and instruments. To accomplish this change in perspective and application, it is important that coastal practitioners grasp the implication of the following key shifts in management theory and practice.

7.2.1 How Complexity and Uncertainty are Changing Management

In her assessment of the effectiveness of environmental management systems, McMillan (2004) concluded that too many approaches to organizational change and management continue to rely on world views that are no longer consistent with the realities of the twenty-first century. She described current management theory as the product of over-rationalization derived from the mechanistic viewpoints espoused by Newton and Descartes. But the universe is no longer perceived simply as a clockwork machine, which could be understood by reducing its functions to ever smaller components and reassembling them to form a more manageable whole. Socio-ecological systems are better perceived as constantly evolving, complex systems, where few functions can be explained through linear cause and effect relationships, where change is an anticipated phenomenon, and where stability is an unreasonable expectation (Burnes 2005). Understanding how complex systems really operate and how change is perceived, studied and addressed is key to understanding the degree of departure of complex systems from more traditional mechanistic viewpoints. Kay and Regier (2000) argued that society has for too long relied on hard science (which is perceived as providing definitive quantitative answers and explanations, but only to well-defined and relatively simple situations that can be explained by linear cause and effect relationships). Because it can be hard to provide definitive and statistically supported solutions for complex issues, the soft science answers (which contain a degree of uncertainty or risk) have been discredited or disregarded.

Complexity theory, which since the 1990s has been a rapidly evolving field of management science, has been described as “an attempt to demonstrate why the whole universe is greater than the sum of the parts and how all its components come together to produce overarching patterns as the system learns, evolves and adapts” (Dann and Barclay 2006, p 21). Complexity theory accepts that systems can behave in a non-linear fashion and that the outcomes of small changes may be significant and wide-ranging effects on the larger system (i.e., the butterfly effect, where the beating of small wings can affect large weather patterns). Complexity theory also accepts that systems operate somewhere between two states: stability and instability. The conditions that are created when these states overlap is often referred to as chaos, which can create behaviours that are unpredictable (e.g., weather patterns, a bicycle on an icy road) (Dann and Barclay 2006, McMillan 2004). Chaos is also seen as amplifying small changes in the environment, either responding to or causing the instability that is necessary to transform existing structures or behaviours into new and more appropriate ones (Burnes 2005). Science that accepts the validity of chaos theory as an aspect of systems functioning assumes that change is an inevitable condition, that knowledge is always limited, that uncertainty is an expected consequence, and that cause and effect explanations may not be able to lead to adequate predictions for future conditions (Kay and Regier 2000, Waltner-Toews et al. 2008).

Mitchell (2009, p. 13) defined a complex system as one in which “large networks of components with no central control and simple rules of operation give rise to complex collective behaviour, sophisticated information processing, and adaptation via learning or evolution.” Individual organisms, communities, and private sector or government organizations are all forms of complex systems, transforming to meet changing circumstances, and occasionally creating something unexpected, complex, and enriching (Burnes 2005, McMillan 2004). Patterns of behaviour evolve or emerge from the interaction of participants in the system, (e.g., a flock of birds or school of fish), allowing adaptation to local changes in the environment through application of sets of rules which preserve some form of order, even while permitting change. Complex systems may be self-organizing, without an overall blueprint or prescribed model for their development or their functioning (Burnes 2005, McMillan 2004, Stacey et al. 2005). When organizations are viewed as complex systems, they can be seen as not just adapting to their environments, but also as substantively changing the environments in which they function. Success for complex systems can come from contradiction as well as consistency, and goals may be achieved by revolutionary as well as incremental changes in the ways in which the organization functions. Since the nineties, interest has mounted in the application of complexity theory to improving understanding of the linkages among economic, ecological and social systems, challenging traditional perspectives in both science and management (Burnes 2005, Gunderson and Holling 2002, Holling 2001, Kay and Regier 2002, Manson 2001). As noted in Table 7.1, perspectives are shifting, sometimes dramatically, from the views and mores of the last century to a new understanding of how science and society will evolve and interact in the twenty-first century.

Table 7.1: Comparison of Changing Perspectives Affecting Science and Society (adapted from McMillan (2004) and Vallega (2001a))

Traditional Perspectives	Emerging 21st Century Perspectives
Mechanistic view of systems	Complex, dynamic view of systems
Reductionist	Holistic
Linear relationships (cause-effect)	Non-linear relationships (effect-effect-effect)
Uniform	Diverse
Hierarchical and centralized	Non-hierarchical and networked
Closed	Open
Controlling	Self-organizing
Focussed on structures	Focussed on processes and behaviours
Limited connectivity between systems	Highly connected systems
Change is abnormal, episodic	Change is normal, continuous
Change has limited effect on systems	Change has wide spread effects on systems
Change is predictable and controllable	Change is unpredictable and partially controllable
Uncertainty as a failing of process	Uncertainty as a factor of process
Change is disruptive	Change provides opportunity
Conclusions based on empirical evidence	Conclusions drawn from emerging conditions
Reliant on statistically valid correlations	Open to emerging patterns and trends
Evolutionary	Revolutionary, evolutionary and exploratory

When complexity theory is applied to the management of coastal landscapes, there is the potential for emergence of a dynamic network of governance that evolves over time as it responds to new science and to the opinions and actions of a diverse array of participants, some of whom may make only small, detailed decisions (Innes and Booher 2000). One of the greatest challenges to sustaining coastal landscapes is changing what Kahn (1966) termed a „tyranny" of those small decisions, when everyday actions based on commonly accepted rules can cumulatively create wide ranging problems for coastal ecosystems and communities. If, as Innes and Booher (2000) determined, a distributed network of individuals, each of whom had a little knowledge, could produce outcomes that are coordinated, the result might be a product that demonstrates more collective intelligence and insight than could be gained from any one individual. Participants in a coastal management system, when basing their actions on simple rules for coastal sustainability such as those established by policy or guidelines, might not need to know or understand the larger goals to avoid impacts and to achieve outcomes that more effectively deal with a complex and changing environment. As has been demonstrated in efforts to reduce and recycle solid waste, the relatively small actions of many individuals can result in large shifts in societal performance.

As Burnes (2005) concluded from his review of the nature and importance of complexity theories and their implications for managing change in organizations, while complexity may not offer organizations either a clear picture of current experience, or a prescribed course for achieving productive change, it can offer a vision of what an organization might become, and why that might be a better approach to the challenges it faces than continued reliance on outdated expectations of stability and conformity. The application of complexity theory to the development of a new context for multi-level management of coastal landscapes does not require vertical and horizontal integration of a complex array of government agencies and programs. It could provide new opportunities to work within established institutional structures to craft a socio-ecological system for governance that is less constrained by traditional morés and more reliant on the need to:

- embrace change as an integral and not un-welcome element of ecosystems, human societies and governance;
- accept uncertainty as a reality within science;
- encourage a shift to more adaptive and flexible approaches to management;

- strengthen existing linkages and relationships among individuals and organizations and build new ones as needed; and
- provide insight, enthusiasm and guidance for decision-making at all levels through the development of shared values, goals, objectives and tools for implementation.

Within management science the debate continues as to the validity of complexity theories, questioning whether complexity will function as “a pioneering break from a moribund Newtonian world view” or whether it will be used to complement accepted conceptual frameworks and models (Manson 2001, Stacey et al. 2005, p 412). There are arguments to be made for continued reliance on established norms for problem-solving and decision-making (e.g., critical path method, management by objectives) as productive tools for planning and management of much of our ordinary day-to-day activities. But extraordinary approaches to coastal management may be needed to address uncertainty and change, placing less emphasis on the creation of new institutional structures and more on the facilitation of progressive and productive human interactions within existing systems (Crance and Draper 1996, Rosenhead 1998).

Within science and society in the twenty-first century, change will be inevitable and valued, risk and uncertainly will be a factor in most decisions. Perhaps most importantly, there is a growing understanding that the electronic age is creating a new reality in which the individual actions of many people can significantly affect needed and timely shifts in the performance of complex socio-ecological systems.

7.2.2 Why Scale Matters

Within all aspects of coastal governance, early consideration of scale matters, whether it is political, spatial, temporal, ecological, or cultural in context (Ommer 2007). When considering the causes of mismanagement of natural resources, Costanza et al. (2001) suggested that many problems originated from mismatches of scale between management institutions and scientific research, resulting in situations where available and potentially important information was applied inappropriately and ineffectively to policy and decision-making. Steinberg (2009) worried that mismatches in temporal scale between short-term political agendas and the long-term requirements for the conservation of biodiversity could result in pre-emptive cancellation of needed programs. Ostrom (2005) agreed with all these concerns, noting that one of the greatest challenges facing the management of large, complex landscapes was in deciding which issues were of importance and at what scale they should be dealt with. This is not to say that establishing only one scale at which to work was a constructive solution. Wilbanks and Kates (1999) argued that when policy and decision-making was focused on a single geographic scale (e.g., national, provincial/territorial, municipal), it was practical to assume that the priority issues, information requirements, and operating processes, would be focused at that scale. In contrast, when identifying the priority issues for the Gulf of Maine, members of the bi-national, cross-sectoral GPAC (Global Programme of Action Coalition) concluded that if they limited their deliberations to only those issues that occurred regionally, issues of critical local importance would be dropped from future consideration. Not only would this have disappointed and disengaged most communities, but the GPAC felt it would result in a watered-down list of issues whose primary characteristic were not that they were the most important issues, but that they were the most common or the most readily identifiable issues (Mercer Clarke 2001a, 2001b).

Single scale approaches to both research and management (top-down or bottom-up) can not only fail to identify important issues that operate at different scales or in specific locations, they can also rely on information that may be either too detailed or insufficiently complex to inform effective planning or decision-making (Ommer 2007, Stevens et al. 2007, Waltner-Toews et al. 2003). The lack of interdisciplinary research into important relationships among coastal species, habitats and ecosystems has contributed to a devastating tunnel vision for management of myriad aspects of human activities that continue to impact complex nearshore environments (Eriksson et al. 2009, Kaplan 2009). Past failures to adopt ecosystem based fisheries management has arguably resulted in resource extraction based on an ever-dwindling list of potentially commercial species or as Pauly et al. (2001) termed it „fishing down the food web‟. It is not only important that the research sector be better equipped to provide answers to pressing issues affecting the resilience of coastal systems, but that the science generated be framed within an interdisciplinary context and the information be presented at the geographic or functional scale necessary either to affect policy development or to inform local implementation (Rees et al. 2008, Stevens et al. 2007).

Policy setting in government relies on indicators of change in issues of national or regional importance, and may not be responsive to the needs of local communities (IOI 2006, Visser 2004). Government programs and budgets, which are derived from such policy statements, reflect these priorities. As a consequence, in North America and Europe, coastal issues have seldom had the visibility needed for national policy setting (IOI 2006, JOCI 2006, Visser 2004). Even among environmental non-government organizations (ENGOs), failure to recognize the disparities that can occur between national or regional interests and local goals can result in the adoption of conservation policies and practices that are unsustainable without a local commitment (Ommer 2007, Reed 2007). In its efforts to manage external as well as internal pressures, and to accommodate the diversity and complexity experienced across a nation, larger scale governance may authorize local control, help it, hinder it, or override it (Dietz et al. 2003). Yet as Berkes (2006) found, it may be unrealistic to expect that in all circumstances, without some form of outside oversight, local self-regulation would solve all the issues of overuse of common resources.

Setting spatial or functional boundaries for resource management may in some situations be helpful (e.g., defining areas for clear-cut operations, allocating quotas or locations for fisheries), but when imposed by outside agencies, boundaries and rules may not be viewed as legitimate by those who have cared for a resource over a long period of time (Ostrom 2005). In these complex economic times, resource industries, whether land based or marine based, may be comprised of multiple layers of nested or vested enterprises that require the participation of both the private and public sectors at a range of spatial, social and economic scales.

Expectations that one model for coastal management could fit all these existing and emerging circumstances is at best optimistic, and at worst doomed to failure. While national policy can identify shared values and set common goals for the functioning and futures of our coastal landscapes, the success of coastal management initiatives will continue to be dependent on productive partnerships across all scales, that ensure protection from roving bandits who would exploit a resource, while permitting self-organization and management of local issues within local user communities (Berkes et al. 2006). Viewing the coast as a landscape is an important change in perspective, not only because of its pragmatic application to science and management, but because it allows us to visualize how we can make needed changes at a range of scales and for both nationally shared and locally relevant reasons. Taking a landscape view challenges traditional boundaries based on political jurisdictions and disciplinary rigour, allowing both science and management to work across scales and within contexts that best suit the issues and the challenges.

7.2.3 The Two Faces of Resilience

Resilience is a much discussed phenomenon in complex socio-ecological and institutional systems, but there can be quite different applications of the term (Holling 1996, Gunderson and Holling 2002). Within social and ecological systems, resilience can be taken to mean the magnitude of disturbance that can be accommodated before a system moves into a different state and functions under a different set of controls or rules (Berkes et al. 2002). When scientists and managers speak of the resilience of ecological and social systems, they are referring to the capacity of a society, an ecosystem, an individual, species or a habitat to continue to exist while assimilating impacts from exogenous sources (Folke et al. 2005). A resilient system is expected to have some capacity for self-organization to withstand or adapt to shocks, and to rebuild itself as needed.

Resilience can be seen as a beneficial attribute by which social and ecological systems can adapt to and survive impacts, but it can also be used to justify government decisions to allow increased loading of stresses onto systems that have yet to demonstrate measurable or visible deteriorating change. As was discussed in Chapters 5 and 6, too often the thresholds for environmental contaminants have been based on setting precautionary levels below the concentrations known to cause lethal or sub-lethal effects to selected indicator species, and do not address other non-toxic impacts or disruption to species or ecosystems. Without adaptive management instruments to provide ongoing information on cumulative environmental effects, we are in essence depending on the capacity of species and ecosystems to absorb contaminants and to be resilient to measurable deterioration. Given the complexity of coastal landscapes, we should instead be developing instruments based on a policy of avoidance of disruptive change to ecosystems as a whole (Walters 1986).

Resilience within human communities is also seen as the ability to cope with external stresses as a result of social, political, economic and environmental change (Adger 2000, Adger et al. 2005). Resilience within society can be an important asset, enabling innovation and social learning and decreasing social vulnerability in the face of internal and external change. Yet resilience can also mean an unwavering commitment to a way of life, such as fishing, even when it results in over-exploitation of a dwindling resource.

Resilience within complex institutional systems can also be double-edged concept, where a resilient organization is seen to be capable of absorbing shocks (changes to its goals, rules, components and resources) while continuing to function (Steinberg 2009). Characteristics such as stability, efficiency, constancy and predictability may be viewed as assets to institutions, but they can also be the means to resist needed change. As Visser (2004) noted, in their quest to protect coastal waters, ICM approaches to governance may have suffered from too great a focus on the marine environment, resulting in confusion over jurisdictions and responsibilities when mandates were broadened to address land-based activities. When existing governance policy and rules work against sound environmental management, the hope would be that the institution is NOT resilient to change to its policies, rules and practices. It all depends on your perspective, on the immediate and strategic goals of the organization, or on the ability of leadership to deliver.

Whether describing economic conditions, or ecosystem functions, stability is a false concept in the world of today. Few social or ecological systems exist in a stable state – but are constantly changing and adapting (Kay and Schneider 1994). Walker et al. (2002) advocates an adaptive approach to the management of socio-economic systems that is based on learning to live within the systems we have, placing the emphasis not on forecasting how much change a system can assimilate before failing, but on maintaining the capacity of the system to cope with whatever the future brings. And as Berkes et al. (2002) framed it, we need to move towards a context for management that assumes change and struggles to explain stability, as opposed to the current approach of assuming stability and waiting until there is a crisis to measure, comprehend and explain.

7.2.4 The Soft Paths to Progress

Uncertainty in scientific predictions about the causes and effects of environmental degradation and about the severity of future scenarios has become an excuse for inaction by much of society. Ignoring the Rio Declaration of 1992, the precautionary approach to environmental management was regarded by the private sector as tantamount to raising costs, delaying productivity, and reducing the economic benefits to society. Ten years after Rio, Harremoes et al. (2002) concluded that while the application of the precautionary principle could provide a "many splendored" approach to improved socio-economic decision-making, little had changed and the world was still encouraging inaction rather than action, ignoring early warnings of the disquieting change in global environments that had taken (or was taking) place. Precaution, as Harremoes and his colleagues put it, still continued to be a piece of grit within the lubricated machinery of government and business. Yet there is much to be learned from a precautionary approach, especially in its application to systems of governance that seek to share policy development and decision-making across the public, private and volunteer sectors of society. To date, as concluded by VanderZwaag et al. (2006), Canada has continued to wander cautiously in its efforts towards the application of precaution on issues affecting coasts and oceans management, pleading the need for sound science, and placing the emphasis on economic goals and cost-effectiveness.

One of the difficulties in advancing precaution as a positive principle is the ongoing conflict between economic, social and environmental goals. Keeney (1992) suggests that more of the time devoted to planning and decision-making should be spent giving careful consideration to deciding what is important. Understanding and articulating shared values could assist in the recognition of the truly important questions, and in the identification of better alternatives to the ones currently before us. Value-focussed thinking draws on ethics, priorities, traits, characteristics, acceptable conditions for compromise, and attitudes about risk that affect the day-to-day perspectives and decisions of individuals and organizations. Today"s society appears to formulate most of its goals based on making the best of what we have. What would happen if we followed Keeney"s recommendations for value-focussed thinking, and started thinking about what the best option would be, and how could we make that our new reality? Value-focussed thinking puts risk in its proper place, as a manageable trade-off associated with change for the better. It allows a broadening of the precautionary approach so that decision-making doesn"t just avoid the risk of negative outcomes. After all, making smarter choices is as Hammond et al. (1999) put it, just a plan for deciding what you want and figuring out how to get it.

Soft path planning is one of the emerging new perspectives in the management of natural resources that speaks to the need to establish values, to use precaution and to make smart choices on our use of socio-ecological assets (Brandes and Kriwoken 2006, Gleick 2003). Traditional approaches to resource use have generally focussed attention on the identification of new sources of supply, or increased production to meet the ever-expanding needs of growing populations and expanding industries. As an alternative, soft paths for resource use are created when managers abandon the premise that more is better, and seek to reduce the stresses placed on limited resources through reduction of demand and through resource conservation (Brandes and Brooks 2005, Brandes and Brooks 2007, Gleick 2002). Soft path systems have been developed to manage water and energy consumption, and there is growing interest in similar approaches to food consumption (e.g., Slow Food and the 100 mile diet), and to the management of urban sprawl e.g., (New Villages).

Adopting a softer path to improved coastal management could begin with replacement of the term integration (synonymous with unification, assimilation, amalgamation), which may have created some defensiveness and resistance within established bureaucracies, with the potentially less intrusive concept of harmonization (synonymous with accommodation, alliance, compromise). While the goals may be the same, the path towards implementation could be less autocratic and top-down, and more collaborative. Along the Jersey Shore of the United States, a similar approach was used to advance harmonization of policy and programs within government and to encourage cross-acceptance of shared principles for coastal management (Neuman 1999). And in Australia, efforts towards coastal management encouraged all levels and sectors of government to incorporate into their day-to-day functioning the guiding principles established in the national policy on oceans and coasts (GOV/AUSTR 2006).

Taking the soft path could be especially important when planning for changes in land cover and land use. Too often the impacts created by land cover change have not been considered in coastal management initiatives, many of which are still using the DPSIR (driver-pressure-state-impact-response) model of the European Environmental Agency as a basis for government response. The majority of graphic representations of the DPSIR model show government response to be triggered by impacts to the current state of the environment, placing the emphasis on reaction to measurable and potentially devastating changes that have already occurred (Figure 7.1) (von Bodungen and Turner 2001).

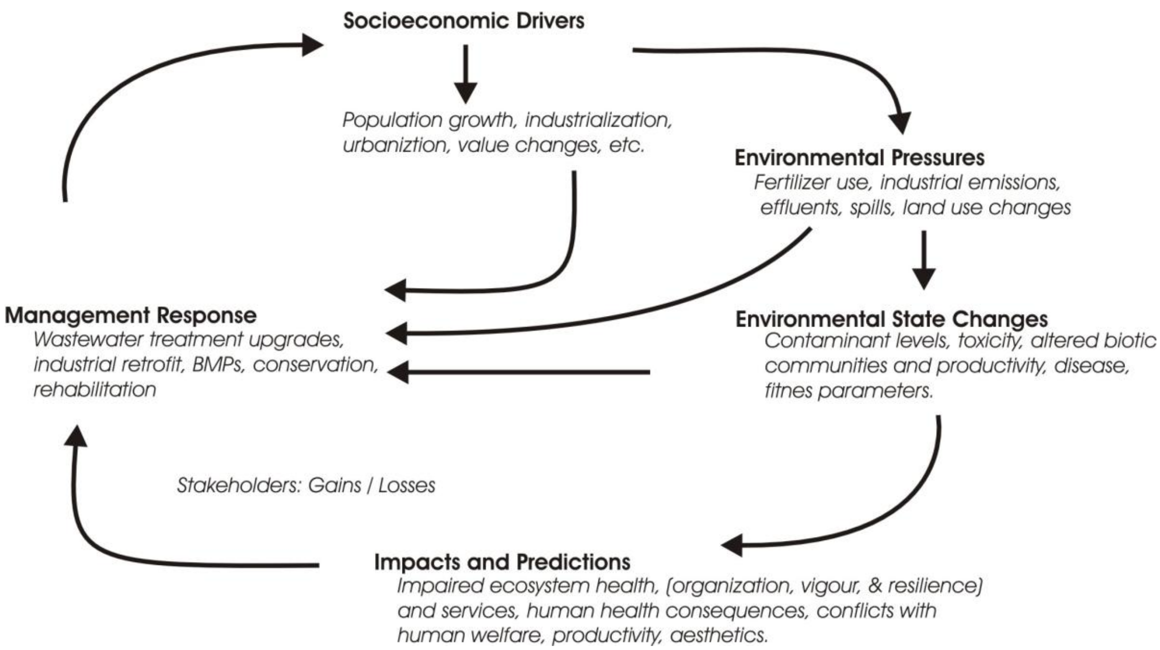

Figure 7.1: The DPSIR Framework: Shifting Response Triggers (adapted from von Bodungen and Turner (2001))

By shifting the emphasis to responding to stresses on the assimilative capacity of the environment rather than on measurable detrimental impacts, government responses could focus on the causes - the socio-economic drivers of change. Using better planning policies and instruments as the tool to reduce human pressures on the ecosystem creates a progressive pro-action stance that protects the environment while reducing economic costs.

7.2.5 Embracing the Electronic Age

Since the early 1980s, the world has been transformed by computers and by the creation of the World Wide Web. As Marche and McNiven (2003, p 74) so aptly put it, "the future isn't what it used to be". Rapid development of Internet technologies has advanced capabilities in the storage and dissemination of existing knowledge, in the creation of new knowledge and technology, and in communication beyond any of the expectations of only a decade ago. The Internet is not only changing the way organizations and individuals do business, it is creating new expectations for services, transparency, and accountability from every level of government (Shane 2004, Allen et al. 2001). The exploding interest in e-government now encompasses everything from electronic voting to buying a dog license (Blackstone et al. 2005). Governments that have embraced the technology are finding value in the provision of high-volume, standardized services through electronic means. While Marche and McNiven (2003, p. 75) make a clear distinction between e-government (i.e., “the provision of routine government information and transactions using electronic means”) and e-governance (i.e., “a technologically mediated relationship between citizens and their governments from the perspective of potential electronic deliberation over civic communication, policy evolution, and in democratic expressions of citizen will”), the result is the same. The Internet is not only having a dramatic and escalating influence on the ways governments think, communicate and act, both internally and in their dealings with society, it is changing our definition of community (Harwood and McIntosh 2004). The rapid expansion of Internet based communication tools such as Facebook, presents more than just another form of social networking. The opportunities to use these tools to create communities of interest is challenging our understanding of how our society is supposed to work, the kind of information on which it will rely, and the speed at which new ideas can be generated, communicated and acted upon by a large number of like-minded individuals.

The usefulness of the Internet and other forms of electronic technology to coastal management has yet to be fully grasped. While Kay and Christie (2001) and Kay and Alder (2005) have examined the Internet as an information management and sharing tool, there has been only limited discussion in the literature of wider applications to the development and implementation of coastal management practice. The Web itself now has a plethora of sites providing access to the most recent information, and increasingly individuals use e-mail, newsletters and other forms of electronic communication to stay in touch with colleagues and to keep up with developments across the globe. By example, the Atlantic Coastal Update e-newsletter, which began as an information source for a small group of Canadians interested in sharing data on coastal conditions, has expanded its service and now reaches over 5400 people worldwide. While this is a seemingly amazing accomplishment, it pales by comparison with the 250 million global users that Facebook now claims.

What is missing from the electronic age dialogue on coastal management is a clear understanding of the opportunities to use the Internet as a platform to effectively deliver action on coastal sustainability. While there are an increasing number of open access sites providing not only technical guidance, data, and modelling and assessment technologies, the e-business of coastal management remains closely focused on marine activities and environments and continues to draw too few participants from land-based science and management. Too little attention has yet been paid to the potential for cross-sectoral, cross-disciplinary, and cross-nation sharing of values, goals and resources in pragmatic ways that empower progressive action by individuals and organizations not previously engaged in sustaining coastal resources and environments.

7.2.6 Managing Common-Pool Resources in a Coastal Landscape

Where coastal areas are limited to marine waters and a limited adjacent shoreline, the area can be viewed predominantly as a marine commons, in which rights of access are universal, resources are mostly under public ownership, and conflicts, though complex and challenging, involve a limited number of sectors of society (Barnabé and Barnabé-Quet 2000, GESAMP 2001b, The World Bank 1993). Within some coastal societies, resources such as fish and wildlife populations, access to shorelines, and use of the water surface and sea bottom, can be viewed as *jure communia* - or common property - for which the government acts as trustee, but to which all citizens have access.

Expansion of our concept of coast to include activities and resources on the land immediately shifts the perceptions and realities of ownership, rights of access, and governance. In managing the coasts, it is important to remember that "People don"t fish from boats. They fish from communities." (Ralph Matthews 2009, Personal Communication). When seen as a diverse socio-ecological landscape ranging from forests to fiords, the coast requires governance systems that must expand their traditional roles in the management of commons resources (typically marine fisheries and non-renewable resources) to address management of what may largely be privately-held resources (typically land and property).

Ostrom (1999) disagreed with Hardin"s (1968) pessimistic view that a tragedy of the commons would occur in situations where users, if not controlled by some outside force, would inevitably destroy the very resource upon which they depended. There has been little doubt that where access is unrestricted, such as is the case with open access fisheries, the resource has been more vulnerable to overharvest and depletion (Berkes et al. 2006, Myers and Worm 2003, Ostrom 2007b). However Ostrom and others have continued to argue that while situations of overuse can and do occur, humans have been productively self-organizing to manage their common-pool resources for thousands of years (Ostrom 2008a). Seeing the issue as one of management as opposed to one of property rights, Ostrom uses the term common-pool resource rather than commons (or common property). A common-pool resource is finite and has two characteristics (Nagendra and Ostrom 2008, Ostrom 2007b):

- it is costly to exclude potential beneficiaries from accessing or harvesting the resource; and
- exploitation of the resource by one user reduces its availability to others.

Because property rights and ownership of the resource are not the defining principle, common-pool resources can include natural and man-made systems such as ground water and surface water basins, forests, grazing lands, and fisheries that provide products and services such as water, timber, and food. The concept can easily be expanded to include both private and publicly owned land, as land is in and of itself a finite resource. While the use of land by one owner reduces its availability to serve the needs of others (e.g., conversion of agricultural land to urban sprawl), land use can also detrimentally affect the well-being of other conjoined and publicly owned resources (e.g., impacts to fisheries as a result of non-point source nutrient contamination of aquatic and marine waters).

Keeping these principles in mind, management of common-pool resources generally falls into one of three categories (Nagendra and Ostrom 2008):

- government ownership: where a level of government owns the resource (i.e., manages the resource on behalf of the public) and has the right to determine who has access and under what circumstances;
- private ownership: where an individual or an organization has full rights to the resource and to limit access; and

- community ownership: where a group of individuals share the ownership and rights to access.

Relying on Hardin"s logic, the expectation has been that to protect resources, governments, who are acting in the interest of the public, must impose rules that command socially (and ecologically) responsible behaviour. The concept of community run management (i.e., based on rules developed by the users themselves) has too seldom been considered as a serious option. Yet government and private sector management of resources has resulted in fisheries collapses, deforestation, loss of prime agricultural lands to urbanization, and pollution of water supplies. Looking for alternative systems that would improve performance and increase local participation in management, Ostrom (2005, 2008a) and others (Dietz et al. 2003, Dolsak and Ostrom 2003, Folke et al. 2005) have recommended that adaptive, self-organizing systems for common-pool resource management could be established at the local level if they were based on the following principles:

- rules should be devised, adapted and managed by the resource users;
- rules should be locally enforceable making compliance easier to monitor;
- sanctions for breaking the rules should be flexible and graduated;
- conflict resolution must be available and at a low cost;
- knowledge should be gained from a combination of sources;
- monitoring programs should be accountable to the resource users;
- all players must learn to live with change and uncertainty; and
- procedures should be established for revising rules and changing the institutional frameworks.

Soundly convinced that local self government of common-pool resources was achievable, Ostrom and her colleagues also saw the need for strong institutional support nested within the levels of government (Dietz et al. 2003, Ostrom 2005). While governments would have less involvement in the way resources were managed, they would provide leadership on what things needed to be done, and why they were important. Government could also provide needed support for monitoring and reporting, as well as for aspects of enforcement that may be required to ensure a level playing field amongst users. Nested, collaborative approaches to governance could provide services at appropriate scales, especially in large complex landscapes such as the coast. Faced with multiple agencies, a range of expectations on the rights of access, a complex array of sets of rules for resource use and development, establishment of strong institutional leadership could provide needed assistance to ensure that the costs and benefits of resource use would spread appropriately in ever-widening ripples across ecosystems and communities (Olsen et al. 2009).

Too often in discussions on coastal management, insufficient attention has been paid to the institutional structures and tools that were already available, or to the ways in which they could have been combined and effectively and collaboratively applied. Ostrom (2005, p 3) viewed institutions in a broad context as:

> *the prescriptions that humans use to organize all forms of repetitive and structured interactions including those within families, neighbourhoods, markets, firms, sports leagues, churches, private associations, and governments at all scales.*

No matter what form the institution took or the role it played in society, all were challenged daily by a wide diversity of complex situations, and all operated by some form of rules. Rules can be imposed upon us either by internal or external forces, or they may be crafted by an individual in an attempt to improve the outcomes they seek to achieve. But in general, most people are expected to learn, reason with, and apply the rules to the situations in which they find themselves. Institutional support would overcome challenges commonly faced by resource users such as communication and coordination of general policy goals and principles related to resource use and conservation, knowledge collection and dissemination, especially over the long-term, and could provide ready access to badly needed professional assistance.

In Canada, top-down models of governance have failed coastal communities and need to be replaced with something that can operate across a range of spatial, political, and temporal scales, beyond the silos of sectoral departments, and in harmony with the needs of the socio-ecological system (Chapter 4) (Olsson et al. 2004, Ommer 2007). Ommer and her colleagues also warned that fragmented and isolated local management initiatives cannot be the only answer to coastal governance. While the provision of insightful, precautionary and effective governance of coastal areas appears to be an appallingly difficult task, it remains primarily the mandate of government. As Agranoff and McGuire (2003) concluded, government still matters. Even within a system of effective non-governmental self management at the local level, there would still be a need for an institutional framework that promoted shared values and goals, collected, coordinated and disseminated knowledge, provided access to expert assistance, enforced the rules against non-conforming players, and reported on progress towards sustainability of resources. Ommer (2007, p 433) said it well:

> *Governments have a fundamental role to play in ecosystem management, which cannot be handed over to any other part of the system (the current buzz word would be 'stakeholder'), because all other players are neither disinterested nor capable of seeing and managing the whole for the better good of all, nature included. Government has an ethical as well as a democratic obligation to govern and to protect all the components of the nation state, even the smallest coastal community, the smallest functioning part of the national social-ecological system.*

7.2.7 Setting a New Course for Coastal Management

As noted above, there has been increasing recognition that the management of our coasts might require a shift from the philosophies and models based on integration, towards some new, more appropriate perspective and context. Sustainable coastal governance will only be achieved through shared principles that facilitate the progressive transformation of existing policy and action towards improved and sustainable management practices. Institutions, like ecological, social, economic, and political systems, are in a constant state of flux, responding in some way to both internal and external factors at a range of spatial and temporal scales. There are few management situations in which the same system or set of rules applied both nationally and locally will produce the same distribution of costs and benefits when applied over time (Ostrom 2007a, 2007b, 2008b).

Polycentric, nested forms of government collaboration may be our best option, allowing us to work with what we have to craft systems that fit a range of scales and interests in the issues at hand (Rubenstein 2006). The attributes of such a system, when combined with strong support for local self-organization, could provide the means by which many of the current barriers to improved coastal management can be overcome. Collaborative approaches to management are an increasingly appropriate alternative to complement or even displace previously established bureaucratic processes (Agranoff and McGuire 2004). As Rubenstein (2006) noted, once the challenges to traditional jurisdictions and authorities are removed, expanding mandates and responsibilities can become less threatening, and an increase in the number of players can be seen more as a positive than a negative force for action. Collaborative, nested and shared governance of coastal landscapes would provide distinct advantages over current practices, some of which include (Beatley 2009, Berkes 2006, Holling 2004, Jentoft 2007, Kay et al. 2003, Olsen et al. 2009, Ostrom 2007b, Rubenstein 2006, Vallega 1999, 2001b):

- a shift in the culture of government that supports the development of adaptive organizations in which groups and individuals can become more engaged in proposing and executing activities according to shared values and goals;
- opportunities for productive collaboration with other colleagues;
- promotion of a broad discourse on coastal issues amongst multiple participants who understand, and have an opinion on, where we are going and what we should be doing;
- harmonization of policy, programs and resources horizontally and vertically across governments to promote cross-acceptance of shared roles and responsibilities for planning, management and conservation of coastal landscapes;
- improved respect for local knowledge of existing conditions, and of change in socio-ecological conditions;
- generation, communication and application of the body of interdisciplinary knowledge and experience needed to identify, understand and manage change;
- the creation of rules that are specific to the management of a resource and the needs of local users, as opposed to rules imposed by disengaged outside interests,
- lowered compliance costs based on local monitoring, reporting and self-enforcement; and
- coordination and standardization for the collection, storage and access to coastal data.

Relying on these and other principles that can contribute towards more sustainable management practices, the following sections outline an alternative approach to coastal management in Canada.

7.3 CoastWORKS: Framing a New System for Canada

Make not little plans; they have no magic to stir men's blood and probably themselves will not be realized. Make big plans; aim high in hope and work. Daniel H. Burnham, American architect and planner (1846-1912).

A shared governance process, among diverse and respected traditions, provides an accessible and equitable basis for responsible action and accountability among all people and their institutions (GLC 1994)

CoastWORKS is my proposed framework for the collaborative stewardship of the coastal landscapes of the Atlantic, Arctic, Pacific and Great Lakes shores of Canada. CoastWORKS is founded on a collaborative, poly-centric approach to governance that:

- accepts the need for a strong institutional presence;
- promotes the cross-sector participation of governments at all levels;
- encourages local self-organization and participation in issue identification, policy development and management;
- affirms the substantive role of science;
- enjoins participation of the private sector; and
- relies on the individual and collective work of a diverse array of communities of practice to get the word out and the job done.

CoastWORKS represents a departure from current thinking and practice in Canada, and/or from integrated approaches to coastal management in that:

- it does not require enabling national legislation or changes to current legislative authorities or mandates;
- it does not rely on leadership from or initiation by a federal department or agency;
- it does not require the creation of new institutional structures;
- it proposes a change in focus from marine-based management to a more holistic understanding of the coast as a landscape, and
- while good science is an essential component, a lack of knowledge on current coastal conditions is not an impediment to precautionary planning and action.

As it is proposed, while the leadership and support of a federal department or agency would be an asset, any organization or individual can use the CoastWORKS framework to advance their initiatives in coastal stewardship and management.

The CoastWORKS framework is comprised of the elements listed below and described more fully in Table 7.2:

- The Canadian Coastal Accord: an inclusive definition of the coastal landscapes of Canada, together with a shared Vision for today and for the future, and a set of Principles to guide and support coastal policy and action;
- Structure: designation of a lead federal department, responsible for coordination and support; monitoring and reporting, and auditing of progress;
- Collaboration: an adaptive governance system based on new and established networks that are capable of working across multiple scales;
- Planning: a shift in the stance of policy and programs from reaction to pro-action;
- Conflict Resolution: enhanced local self governance and authority for decision-making;
- Monitoring/Enforcement: use of meta-indicators to assess change and to manage human stresses;
- Capacity: defined roles for the creation and dissemination of knowledge through an array of government, science, and professional communities of practice, and the creation, development and sharing of instruments and tools that promote and aid change; and
- Auditing: regular reporting of monitoring, enforcement and progress towards sustainability through improved governance of the coasts.

The CoastWORKS framework, while addressing the need for strong institutional leadership at the federal level, does not specifically define the roles and responsibilities for coastal management in the levels and sectors of governments or society. Rather it focuses on the need for a shared vision, common goals, and a willingness to use established authorities and resources to proactively address activities that place stress on the socio-ecological systems that comprise coastal landscapes. CoastWORKS supports action through self-organization and the collaborative mobilization and sharing of knowledge and tools. While institutions and individuals may remain resilient to change that is thrust upon them, it is to be hoped that the creation of new understanding, shared values, and new rules for behaviour will go a long way to achieving the shifts needed in society"s relationships with its coastal resources.

7.3.1 The Canadian Coastal Accord

The Canadian Coastal Accord consists of:

- the definition of a coastal landscapes,
- a shared Vision for the future of our coasts, and
- a set of Guiding Principles by which coastal sustainability may be achieved.

The Accord sets the course for a sea-change in the philosophy, structure and implementation of coastal management in Canada. As a rallying call for action, the Accord seeks the understanding, commitment and participation of all Canadians, whether as individuals or organizations, from all walks of life and from all sectors of society.

Inspired by established and emerging management theory that embraces the realties of working within complex, multi-participant environments, the principles and goals of CoastWORKS have been derived from the vision, experience and insight provided by Canadian and international efforts to promote sustainable management of coastal areas (Cicin-Sain and Knecht 2000, Copp 1995, Costanza 2008, Costanza et al. 2001, Duxbury and Dickinson 2007, Environmental Law Institute 2009, European Commission 1999, GOC 2002, GOC/DFO 2002, GOC/EC 2000, GOV/AUSTR 1998, 2009, GOV/BC 1998, 2006, GOV/NS 1994, 2008, GOV/UK/DEFRA 2009, US/NOAA 2007, Harremoes et al. 2002, Kay and Alder 2005, Ommer 2007, UNEP 2008b, Vallega 2001a).

Defining the Coastal Landscape

In keeping with the need for a broader, more realistic view of the coast that transcends jurisdictional and disciplinary boundaries while recognizing the inter-connectivity of the land with the sea, the Canadian coast is described as a collection of landscapes, each of which is uniquely discernable based on its socio-ecological characteristics.

Table 7.2: A Comparison of Current Practice with the Proposed Elements of a CoastWORKS Framework

Element	Current Conditions	Proposed Change
Vision	• National definitions of the coast are based on dated understanding of coastal processes, limited to coastal marine waters and exclude the Great Lakes. Conservation strategies are largely marine-based	• Provide a more functional definition of coastal landscapes that includes the Great Lakes • Express a shared vision for the future of Canada's coastal landscapes
Principles	• Few established principles for use, stewardship or sustainability of resources or communities within the coastal landscape	• Define principles for coastal sustainability in keeping with Canada's national and international commitments and accords • Establishes goals for coastal use and stewardship
Structure	• No national framework for coastal governance • Jurisdictional confusion, overlap and conflicts • Sector-based policy and management of resources • Limited real or perceived local authority to plan or manage	• Designate EC as national supporting and monitoring department • Encourage nested networks of collaborative governance • Support local implementation through self-organizing governance • Support implementation of principles through communities of practice
Collaboration	• Limited integration or harmonization across government • Limited engagement of municipal government • Limited engagement of professions or the private sector • Restricted participation by NGOs in planning and management	• Harmonize existing governance policy and instruments • Engage municipal government in planning and decision-making • Engage voluntary compliance of the private and professional sectors
Planning	• Over-reliance on punitive vs. enabling instruments to manage land cover change and to protect socio-ecological systems. • Limited professional capacity within governments to address planning and development aspects of coastal management	• Develop proactive, precautionary planning capacity at all levels of government that enable change in current policies, programs and legal instruments • Engage more planners and landscape architects in coastal management
Conflict Resolution	• Increased focus on public consultation on marine resource use • Limited participation in policy development and decision-making. • Limited capacity for negotiated decision-making as relates to land cover and land-use	• Improve capacity for local self governance including participation in planning and decision-making on coastal development • Improve local instruments and authority for negotiated decision-making and conflict resolution
Monitoring and Enforcement	• Significant capacity on pollution control and contaminant management • Limited capacity and instruments for marine habitat protection • Limited capacity for proactive planning and management of land cover change	• Set up a multi-scale framework to assist with monitoring, analysis and reporting on coastal conditions • Improve locally enforced planning and regulatory instruments to deter development in environmentally sensitive or hazard areas (beaches, wetlands, flood zones), and to prevent habitat disruption and/or destruction
Capacity	• Limited training of public service or professions	• Include coastal issues within curricula in public schools, professional degree programs and continuing education for bureaucrats, professionals, and community managers
Audit	• No current mechanism to assess coastal governance efforts	• Establish a framework for reporting on coastal change that is directly relatable to governance efforts towards coastal sustainability

As such a Canadian coastal landscape (Figure 7.2):

- is a distinctive cluster of linked, or nested, terrestrial, aquatic and/or marine ecosystems, that
- ranges geographically from the headwaters of watersheds to the outer limits of the offshore coastal waters of Canada, and includes the Great Lakes;
- includes unique ecotones, or transition systems between the land and the water; and
- supports co-dependent human communities who are responsible for both the exploitation and sustainability of coastal resources and ecosystems.

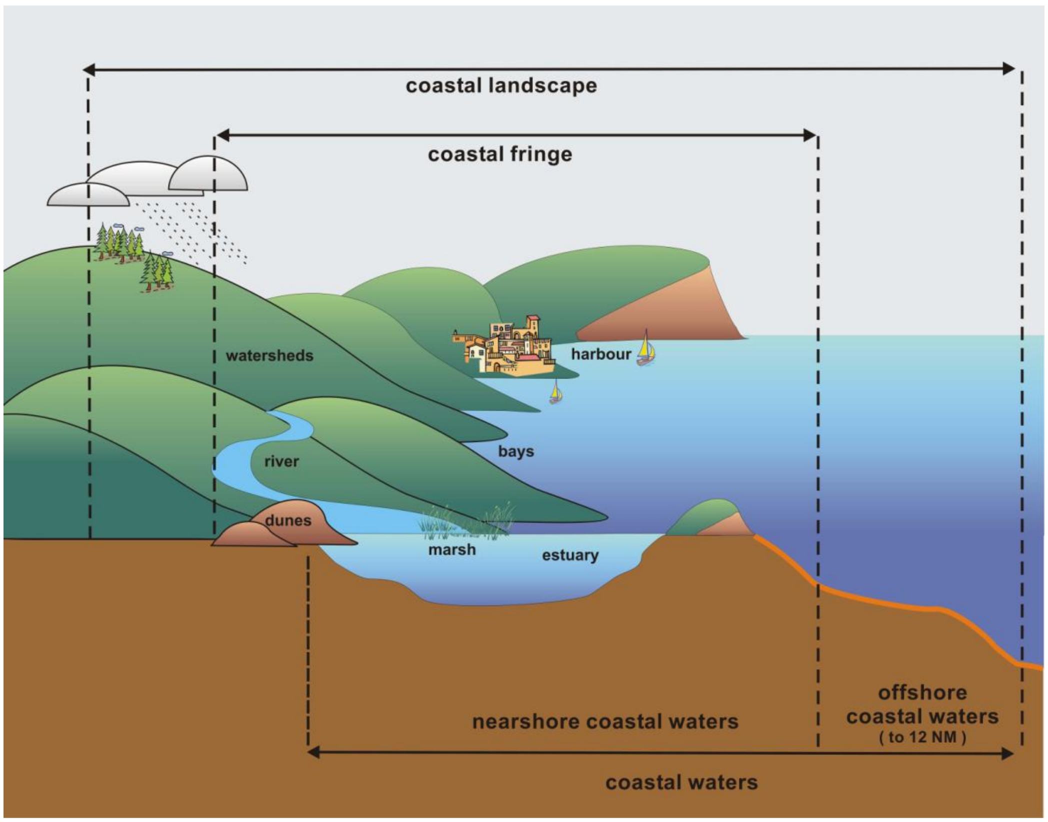

Figure 7.2: Graphic Depiction of a Canadian Coastal Landscape

CoastWORKS recognizes four regional coastal landscapes within Canada: 1) the Pacific Coast, 2) the Arctic Coast, 3) the Atlantic Coast and 4) the Great Lakes Coast, each of which can be subdivided further based on local characteristics. CoastWORKS also welcomes the participation of other Canadian landscapes that face similar challenges to management (e.g., the St. Lawrence River, Lake Winnipeg).

A Shared Vision for the Coasts

Canadians feel strongly that the protection of marine environments is an important priority of increasing national and global importance (GOC 2005). In addition to these convictions, and the growing participation in coastal and marine issues at the local level, Canada as a nation has endorsed international protocols and programmes that support the stewardship and sustainability of coastal landscapes including:

- the Rio Declaration on Environment and Development;
- the United Nations Global Programme of Action for the Protection of the Marine Environment from Land Based Activities, and
- the UN Convention on the Law of the Sea (UNCLOS III).

To support these popular and national expectations of sustainability, a Canadian Vision for the coasts could be stated as:

> Canadians recognize the ecological, economic, cultural and social value of its coastal landscapes, and the vital role they play in ensuring the well-being of the country and of individuals. They aspire to manage these landscapes and their resources so as to ensure their continued sustainably and benefit to current and future generations.

This Vision would reinforce the past, present and future value of coastal landscapes to the Canadian identity and lifestyle, and to the sustainability of biological, economic, social and cultural diversity. The vision would be achievable through the collaborative efforts of all Canadians.

The CoastWorks Principles for Change:
Take Action. Reach Across. Create Legacy:

As noted in Table 7.3, the CoastWORKS Framework proposes a suite of principles intended to challenge, to guide and to support the actions of individuals and organizations seeking opportunities to be a force for change. The Principles promote a new approach to coastal management based on the need to take action, to reach across barriers and time, and to create a lasting legacy for coastal sustainability. CoastWORKS is intended to be the inspiration for action, the pebble in the pond (Figure 7.3). Canada already has the government and societal infrastructure for coastal stewardship, as well as the legal and collaborative instruments by which change can be accomplished. What is needed is purposeful intent, and strategic fiscal support. The following sections provide a summary of how the nested elements of the CoastWORKS framework could function, keeping in mind that no one initiative, while supported by collaboration, is dependent on action taken by another for its inception, or its work.

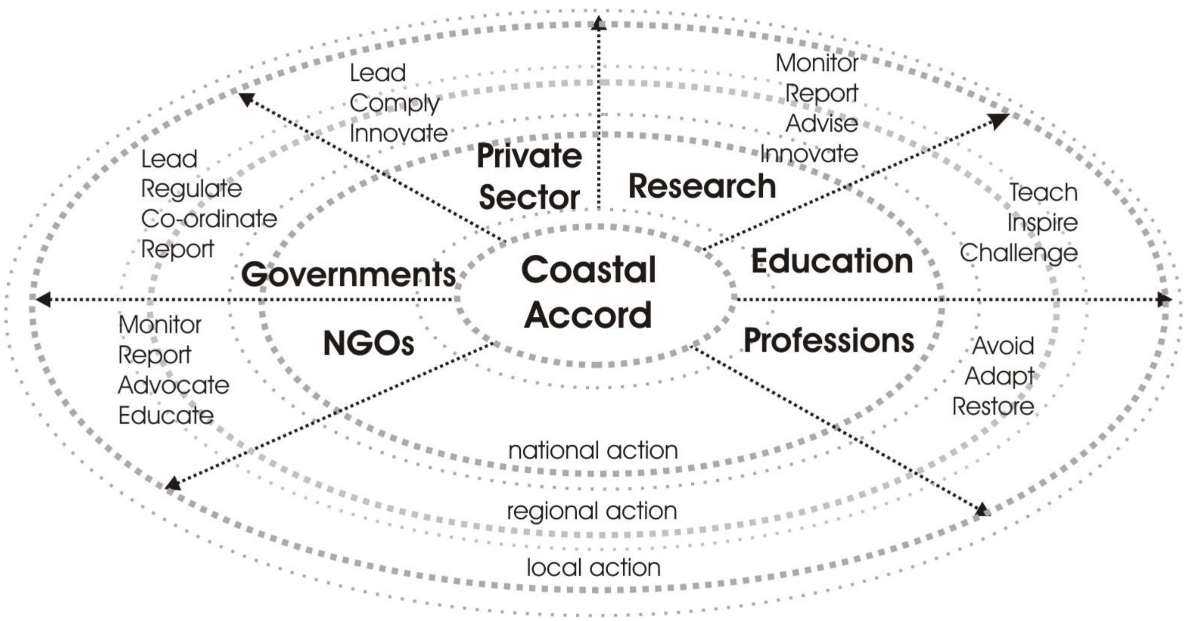

Figure 7.3: Graphic Representation of the CoastWORKS Ripple Effect. (Governments include Municipalities and Aboriginal Communities)

Table 7.3: The CoastWORKS Principles for Change

Principle 1: Sustainability:

Canadians of this and future generations have the right to ecologically sustainable environments that support their health and well-being.

Principle 2: Responsibility:

Users of common-pool resources have individual and collective responsibility and authority to ensure that their activities are economically viable, efficient, socially fair, and ecologically sustainable manner.

Principle 3: Holism and Connectivity:

Planning and management of human activities will address the potential for spatially and temporally wide-ranging and cumulative impacts on the interdependent terrestrial, aquatic and marine ecological systems and on the human communities they support.

Principle 4: Pro-Action:

Planning and management of the human use of coastal common-pool resources (including land) will seek first to avoid, mitigate or remedy impacts to socio-ecological systems through reduction of stresses and pressures.

Principle 5: Resilience:

Environmental regulatory thresholds will be set at levels that seek to avoid adverse effects to ecosystem stability and functioning, rather than at levels near the capacity of the species, habitat or system to absorb change.

Principle 6: Uncertainty and Risk:

Uncertainty in science and management will neither drive planning and decision-making, nor allow non-action to be an alternative to action. Canadians will be prepared to respond to change, risk and surprise in public policy making and in planning and management of coastal resources, and will be better equipped to understand future conditions through on-going research and monitoring that will work towards improving certainty associated with the effect of current activities on the future use and availability of coastal resources.

Principle 7: Precaution:

Where there is uncertainty over potentially irreversible impacts to socio-ecological systems, decisions concerning resource use will err on the side of caution, shifting the burden of proof to those whose activities could alter or damage existing or future conditions.

Principle 8: Preparedness:

Planning for the future will take a long-term strategic view using alternative scenarios to assist with the identification and management of downside risk and the development of policy and budgets, including preparedness for and adaptation to socio-ecological disasters.

Principle 9: Full Cost Accounting:

Costs and benefits to socio-ecological systems will be considered during decision-making on the allocation and use of natural and social capital.

Principle 10: Restitution:

Efforts will be made to improve understanding of the significance of lost or damaged ecological resources and to restore systems so as to maintain ecosystem integrity and sustainability.

Principle 11: Collaborative Governance:

Respecting the nested nature of government and society and the need for productive linkages to address specific coastal management issues, collaborative relationships that promote sharing of information and responsibilities will be promoted within and across all levels and sectors of government, the private sector, and the public.

Principle 12: Leadership Support:

One federal agency will be designated as responsible to Parliament for providing support and needed resources in the management of coastal landscapes.

Principle 13: Cross-Acceptance:

Government policy and programs will be harmonized to promote co-operation, reduce overlap, prevent contradiction, and to ensure cross-acceptance of shared values, principles, goals and responsibilities.

Principle 14 Adaptive Management:

Policy and decision-makers will use existing knowledge and strive to obtain new information through directed coastal research to build understanding of dynamically shifting conditions, to adapt existing goals and processes and to improve the delivery of services.

Principle 15: Participation:

The contribution to coastal governance made by self-organizing groups of representative individuals (within governments, science, industry, and society) will be recognized and supported as shared decision-making. Individuals and organizations will be engaged at appropriate spatial and functional scales to contribute to the formulation and implementation of policy, rules and decisions allocating access to and use of natural and social capital assets, as well as in the conservation and protection of those assets and their supporting systems.

7.3.2 The Role of National Leadership: Carrots and sticks

Given that the powers, duties and functions of the Department of Fisheries and Oceans provide little mandate for the DFO to address the management of land-based human activities, it is not surprising that the Department has been challenged in advancing its role as a federal leader in the integrated management of Canadian coasts as established in the Oceans Act (GOC 1996a, GOC 2010b). While respecting the responsibilities and authorities of the DFO as relates to marine and freshwater ecosystems and fisheries, I suggest that the powers, duties and functions of Environment Canada provide a mandate that is much more appropriate to leadership and coordination in coastal management. Under the Department of Environment Act (GOC 2010a), the powers, duties and functions of Environment Canada include all matters (not specifically assigned to other departments or agencies) that involve:

- the preservation and enhancement of the quality of the natural environment;
- the management of all renewable resources;
- water;
- meteorology; and the
- coordination of all of the policies and programs of the Government of Canada, pertaining to the preservation and enhancement of the natural environment.

The Act goes further to charge Environment Canada with the responsibility for:

- promoting the establishment of objectives and standards relating to environmental quality;
- providing Canadians with environmental information in the public interest; and
- promoting and encouraging practices and conduct that lead to the better preservation and enhancement of environmental quality, including cooperation with provincial governments, organizations and/or individuals with like-minded goals.

Under a CoastWORKS framework, federal leadership in coastal management would have more to do with support for advocacy, research, monitoring and coordination of state of the coasts reporting, than with enforcement. Management of the coastal landscape falls more appropriately within the mandates of Environment Canada, which unlike the DFO is not restricted to the management of fisheries and water ecosystems. Fisheries and Oceans would continue its mandate as the lead agency for coastal waters, but the primary role for support and coordination of the broader context of management of the coastal landscape would fall to Environment Canada.

Under the CoastWORKS framework, Environmental Canada would play a strong institutional role. As the single federal agency ultimately responsible for reporting to Parliament on progress towards sustainable management of our environments and our coasts, the Departmental roles would include.

- **Advocacy** for the sustainable management of coastal landscapes, and promotion of the CoastWORKS initiative within governments, within organizations, and with individuals.
- **Training** and co-ordination of inter- and intra-governmental efforts to harmonize policy, rules and programs so as to reduce overlap and costs of services.
- Support for **Self-Organization** at the local level, such as the internationally respected Atlantic Coastal Action Program process that has assisted and supported the development of self-organized environmental advocacy, monitoring and reporting organizations at the community level for over 15 years. The ACAP experience could be expanded to include communities from other coasts, and to include more pro-action in coastal planning and management. The costs of delivery of coastal monitoring, data management and reporting is significantly lower when delivered by such an arrangement, conducted in accordance with established standards, by well-trained individuals, through collaborative relationships with local scientists.
- Creation and delivery of a system for **Technical Support** that draws on the expertise vested within individuals and organizations from all levels of government, academia and the private sector to provide advice and assistance to local organizations, to mentor students and to report on changing conditions.
- Creation and delivery of a **National Monitoring and Reporting System** through the development and management of standardized instruments for the collection, analysis, reporting, and sharing of data and information on change in socio-ecological systems.
- Bi-annual reporting to Parliament on the **State of the Coasts** and progress made through the conjoined efforts of governments, science, the private sector and society.
- Whether through the Department‟s own resources or via collaborative efforts with other governments, levelling the playing field for industry and citizenry, through

Enforcement of legislative instruments necessary to ensure the compliance of the reluctant and the punishment of the un-cooperative.

- Promotion, evaluation and support for a broad array of **Stewardship** efforts that would include but not be limited to federal and provincial protected areas and species. Training and support for municipalities, organizations, and citizens who by individual or collective means find creative ways to enrich stewardship through private as well as public conservation and protection of resources, species, habitats, ecosystems and cultural and historical assets.

7.3.3 Free for All: Moving towards Collaborative Governance across Scales, Sectors and Jurisdictions

Too often, public service systems can be viewed as disconnected silos or black boxes into which information disappears and outcomes emerge. They are in reality a complex system of intertwined organizations attempting to provide goods and services of value to the majority of the citizenry (Rhodes 2003). Within Canada, integration of all the levels, departments and agencies of government that are actively at work along the coasts has been a daunting prospect that has found few champions, especially within the traditional economic sectors. Yet in reality, much of the work of the governments of Canada already takes place within nested institutional frameworks, which rely on both individual and organizational collaboration.

Collaborative management as described by Agranoff and McGuire (2004) develops when a multi-organizational arrangement is needed to solve problems that cannot be solved within a single agency, sector or level of government. Collaboration can arise spontaneously, or be mandated by a higher authority, offering unique opportunities for society to engage what are sometimes disparate perspectives, and to resolve issues in a positive manner and a practical time frame. Collaborative management within government is not a new concept, but it is becoming more formally recognized as a productive tool for the governance of complex issues. Collaborative management is especially applicable to issues that fall within the jurisdictions of more than one department of government.

CoastWORKS recognizes that to effect needed changes in government, more effort should be spent on inspiring, influencing and supporting the collaborative efforts of individuals and groups, rather than waiting for top-down integration of policy (Crance and Draper 1996). Unlike integrated coastal management systems, CoastWORKS challenges rather than threatens the established jurisdictions and authorities of departments and agencies to do more, and to do it better within the boundaries of the responsibilities, programs and resources they already have.

Recognizing that conflicts can arise among existing policy and practice, especially when moving across the levels, departments and administrative and geographic scales of government, CoastWORKS accepts that harmonization may be needed to remove or negate existing barriers to collaboration. Harmonization and cross-acceptance should be an on-going effort to identify discrepancies and attain compatibility between local, provincial and federal systems (Stead and Meijers 2004). Along the New Jersey shoreline of the United States, cross-acceptance was used as a tool to promote collaboration and to forge new relationships among government levels in ways that did not threaten their existing jurisdictions or authorities. At a time when both human and fiscal resources are increasingly limited, cross-acceptance processes can build understanding, respect, and sharing of objectives, powers, and enforcement procedures (Neuman 1999). By example, in Canada the Department of Fisheries and Oceans would retain its responsibilities for the protection and management of fish and fish habitat, just as the provinces would continue to oversee forestry, and municipalities would continue to plan for and to manage urban development. Using cross-acceptance as a tool to gain an improved appreciation of the opportunities for collaborative effort, both nationally significant and locally appropriate instruments could be coordinated to enact, coordinate and enforce land use plans, reduce point and non-point sources of pollutants, and to develop a suite of private and public mechanisms for the protection of special places (Kennish 2002). Coastal management would become no-one"s fiefdom, but would be a collaboration in which all would be free to participate.

7.3.4 Networks: Putting Knowledge and Influence to Work

When governments are viewed not as entrenched silos but as creative functional networks, there can not only be changes in values, but also in rules, functions, and outputs. Mitchell (2009) described networks as a collection of nodes (individuals or groups of individuals) connected by links (shared interests, conferences, workshops, other communication technologies). While a network is a concrete enough concept for participants to visualize the potential contribution of their sector or level of government, it is vague enough to avoid threatening established roles and responsibilities (Dawkins and Colebatch 2006). Network thinking is generally hive-minded, focusing on shared values, common interests and the development of a culture of joint learning and problem solving (Agranoff 2007, Agranoff and McGuire 2001, Armano 2009). Networks can be based on formal, mandated structures of government or ad hoc relationships, resulting in hierarchical structured assemblages such as scientific centres of expertise, or scale-free collaborative structures such as the World Wide Web. The power created within a network can be a significant force in building trust internally and externally, and in fostering change through the influence wielded by each of the participants. These collective spheres of influence that comprise networks work like ripples in a body of water, building, reflecting, and changing with interactions with other ripples or elements in the landscape (Armano 2009, Olsen et al. 2009).

Working as they often do at the boundaries of government, intergovernmental networks could play significant roles in identifying problems, sharing responsibilities and advancing coastal programs, especially at the local level where there is necessary overlap among a wide array of government levels and departments (Agranoff 2007, Agranoff and McGuire 2003, McGuire 2006). Jurisdictional boundaries and responsibilities, rules, processes or even formal structures of the government are not necessarily lost in the formation of either formal or informal networks. Each party to the process continues to work within its own constructs and responsibilities ensuring continued effective performance and transparency (Agranoff 2007, Dawkins and Colebatch 2006). Within Canada, intergovernmental networks with interests in coastal issues have too often relied more on individual commitment and carefully crafted personal relationship, than on institutionalized mandate or support. Within the government, and indeed within society, a significant proportion of the networks that have been the cornerstone of ad hoc collaboration across sectors and governments has been vested with individuals who will be lost to the system as a result of the daunting number of retirements from the work force that will take place over the next five years. Capturing the essential elements of this resource will require renewed and on-going hiring and mentoring of a new generation, as well as the fostering of existing and new networks so we can continue in the Canadian tradition to do more with less.

In Canada, perhaps the more visible networks are those established to link scientists active in specific areas of research (Canadian Healthy Oceans Network (CHONe), Oceans Management Research Network (OMRN)) and community based management initiatives (Bay of Fundy Ecosystem Project (BoFEP); Coastal Communities Network (CCN), Atlantic Coastal Action Program (ACAP). Purely scientific networks, while impressive in their ability to coalesce intelligence and research towards shared goals, have had less impact in the communication and application of their individual and collective wisdom to needed change in policy and management (Stojanovic et al. 2009). Scientists need to work more closely with professional educators and communicators to effectively reach the public and to mobilize political will to act in a timely fashion on issues of concern (Duarte et al. 2008). Dietz et al. (2003, p 1908) put it very well.

> *Effective governance requires not only factual information about the state of the environment and human actions but also information about uncertainty and values. Scientific understanding of coupled human-biophysical systems will always be uncertain because of inherent unpredictability in the systems and because the science is never complete. Decision-makers need information that characterizes the type and magnitude of uncertainty, as well as the nature and extent of scientific ignorance and disagreement. Also, because every environmental decision requires tradeoffs, knowledge is needed about individual and social values and about the effects of decisions on various valued outcomes.*

Despite issues related to disciplinary rigour, academic requirements for productivity, and scientific uncertainty, research networks must be supported within academia and by funding agencies to improve translation of their outcomes into expert opinions that can be used to inform society of probable and possible scenarios (Donahue 2007, NAS 2008). Research networks are the canary in the coal mine for identifying deterioration in Canadian coastal environments and should once again find their voice, and be respected for it.

Networks also exist within industry, the professions and within community-based organizations. Some generate significant new information on coastal conditions, and provide strong voices for change in coastal management; others represent the challenges and viewpoints facing coastal resource users. For complex management issues that have the potential for conflict, increasingly value is being seen in cross-sectoral networks that provide the opportunity and the time required for diverse perspectives to be aired, for improved respect and trust among participants, and for the development of rules that are more acceptable to users, and more likely to be self-enforced. In some cases, networks that began as communication and knowledge sharing initiatives, have spun-off more tightly focused organizations intent on the creation of new knowledge and the development of specific outputs, and could more appropriately be termed communities of practice.

7.3.5 Communities of Practice (COPs): Knowing What to do and How to do it

"Communities of practice are groups of people who share a concern, a set of problems, or a passion about a topic, and who deepen their knowledge and expertise in this area by interacting on an ongoing basis." (Wenger et al. 2007, p 4). Communities of practice are neither new nor unusual, having been an aspect of society for as long as people have gathered together in caves. Unlike networks, to which you may belong but with which you may have limited interaction, members in a community of practice (COP) are known to each other, ponder common challenges, have a degree of competence that makes them different from other members of society, freely share their knowledge and experience, explore new ideas, solve problems, and create new tools (Snyder and de Souza Briggs 2003).

There may be no formal structure, and leadership of the community of practice will either evolve on its own, or may require some initial assistance. Over time, individuals develop personal relationships that build respect and trust, and an organization with a shared sense of identity and purpose is created. In a world that struggles daily to assimilate the generation of new knowledge and to manage change, communities of practice offer a simple yet enduring mechanism to create, manage and mobilize knowledge. Communities of practice can offer a unique opportunity to deal productively with the short- and long-term dilemma challenging coastal societies by connecting and building upon isolated pockets of local, professional and scientific expertise. COPs can also provide a neutral domain for the improved understanding and resolution of problems whose root cause, or indeed solution, crosses spatial, temporal and functional boundaries (Snyder and de Souza Briggs 2003, Wenger et al. 2007, Wenger et al. 2002, Wenger and Snyder 2000).

Within the coastal landscapes of Canada, communities of practice are already at work across society (e.g., governments, research, industry, professions, stewardship organizations). To date, the primary benefits towards sustainability appear to have been devolved from the activities of communities of practice found within the marine science research sector (government and academia), and within largely volunteer stewardship organizations, both of which have contributed significantly to improved public understanding of coastal conditions and issues of concern, and to the monitoring and reporting of coastal change.

Since the guilds of medieval times, the contributions made to society by professional communities of practice (e.g., architecture, engineering, planning, landscape architecture, accounting, law) have been amongst the most highly recognized and respected. Yet in his examination of coastal management, Vallega (1999) concluded that the primary barrier to improved coastal management may have lain in the failure of society to exert positive changes in established criteria for the planning and design of resource extraction and development projects. While it has become commonly accepted that integration of environmental criteria can result in both tangible and intangible economic benefits, the benefits of application of professional pro-action to the siting and development of coastal initiatives are also increasingly supported by the insurance industry as a means to avoid or reduce the disruptions, devastation and economic costs of the impacts of climate change (Mills and Lecomte 2006). However, in Canada, as was reported for the United Kingdom, too much of the good practice evident in coastal land and resource development may more justly be attributed to the good will and insight of individual planning and design professionals, than to changes in established standards or guidelines for practice that are an inherent aspect of the work of their profession (Allmendinger 2002).

The CoastWORKS framework encourages professional COPs to educate, train and engage their practitioners in the quest to develop improved standards, guidelines and best practices. Working to achieve change through these professional COPs has the potential to significantly and proactively eliminate or reduce existing anthropogenic pressures on coastal landscapes and societies, to prevent the creation of new pressures, and to lower the costs for pollution management and restoration of damaged ecosystems.

CoastWORKS also recognizes that within Canada, local self-organized communities of practice focused on the stewardship of coastal landscapes have for decades been the primary force for monitoring and reporting on coastal change, for education and for advocacy of sustainable management practice (Chapter 4). While lauded by both provincial and federal governments as community-based *management* organizations (CBMs), in reality these are highly visible and respected community-based *stewardship* organizations (CBSs) because they have seldom have been granted any authority for decision-making, but have nonetheless made significant contributions in education, advocacy, monitoring and the overall stewardship of coastal landscapes (Chapter 4, Section 4.4.7). Local CBSs have already demonstrated the ease by which cross-disciplinary and cross-sectoral participation can be achieved, and the benefits of such collaborative efforts. While there appears to be few limitations to the volunteer resources of Canadian communities, fiscal support for core activities of even highly successful and productive CBSs has continued to be elusive. Secure, legacy support for these indispensable and highly effective examples of the enduring individual and collective commitment of Canadians to their coasts is a core CoastWORKS recommendation.

7.3.6 Finding, Building and Sharing the Tools

CoastWORKS recognizes that even with the best will, little positive change can be accomplished without the necessary tools. Individual and collective efforts towards the harmonization and cross-acceptance of existing policies and programs within government departments and across the levels of government could do much to advance the principles and goals of the Coastal Accord. Needed tools and instruments for coastal science, planning and management can be assembled, adapted and applied in a wide array of circumstances throughout the country. Established coastal management approaches such as those in the State of Oregon (United States of America) and the State of Queensland (Australia) provide insight into the scope and content of tasks needed to advance collaborative planning and management of both marine-based and land-based resource use and development, and give a badly needed head start to coastal management initiatives at a range of spatial and governance scales (GOV/AUSTR 2009, GOV/US/Oregon 2001).

Initiatives such as the Green Shores program in British Columbia (Green Shores 2008) and the Integrated Land Management initiative (CILMC 2005), as well as other efforts across Canada and the United States, are providing new approaches to planning as well as tools such as model guidelines and bylaws to assist communities with sustainable alternatives to current practice (DSF 2007, GOV/US/NH 2008).

The education and training of professionals and managers through additions and changes to university curricula, and the provision of post-graduate professional development courses can do much to improve awareness of coastal issues, and to increase the capacity of society to prevent and to remediate the impacts to coastal systems. Pragmatic re-examination and adaptation of existing geospatial planning and development instruments may offer many non-intrusive and cost-effective measures for improved conservation and stewardship of land and resources (PlanCoast 2008, UNESCO/IOC 2009) (Table 7.4).

Table 7.4: A Selection of Existing Planning Tools Appropriate for Harmonization with Coastal Planning and Management Goals.

Regional Plans	Sectoral Plans	Terrestrial and Marine Protected Area Plans
Provincial Land Use	Harbour	Terrestrial/Marine Reserve
Coastal Landscape	Industrial	Emergency Response
Urban Development	Fisheries	Fire Protection
Protection of Biodiversity	Agriculture	Water Supply
Migration Routes	Forestry	Flood Zones
	Mineral Extraction	Parks and Recreational Areas
	Tourism	Open Space
	Transportation	Wildlife Reserves
	Energy	Scenic Areas
	Utilities	Cultural Assets
	Brownfield Restoration	

To capture the interest and engage the participation of the widest segment of society, electronic tools that have quickly become the sentinel communication mechanism of the current generation, could be effectively utilized to advance the principles and goals of the Coastal Accord. Ready access to information could be provided through an Internet portal, where individuals and organizations would have the opportunity to register their commitment to implementation of the Accord. CoastWORKS could utilize the immensely successful model created by the "1 Million Acts of Green" initiative promoted by the Canadian Broadcasting Corporation in collaboration with an array of environmental organizations (which in only 100 days exceeded more that 1.7 million acts in support of the reduction of greenhouse gases and other pollutants) (http://www.cbc.ca/green/). No activity either personal or corporate would be considered too small, and all would count towards Canada"s progress in improving coastal science and management. The portal could also be used to provide links to related initiatives in shoreline protection; private and public conservation and protection instruments; emergency preparedness, stewardship; non-point source pollutant reduction and management; hazards zoning; development buffers; negotiated land cover change; sustainable agriculture and forestry; and new concepts for the management of urban sprawl such as the New Village initiatives.

7.4 The Challenges

> *It's not so much that we're afraid of change or so in love with the old ways, but it's that place in between that we fear. It's like being between trapezes. It's Linus when his blanket is in the dryer. There's nothing to hold on to. Marilyn Ferguson, Author of the Aquarian Conspiracy*

Given the current threats facing our coastal landscapes, there is little time left for proponents of integrated coastal management to continue to advocate for change that, while inspired, may be impractical in its implementation. Self-organized, collaborative and adaptive systems of government may sound like a great alternative to the doldrums in which we currently find ourselves, but decentralizing governance is not a simple, or a universally accepted concept and will have its own challenges (Paquet 1999). Within communities, despite the collective enthusiasm, commitment and desire to recover the ability to manage their own resources and environments, there are few situations where governments are able or willing to surrender their authority. If a more collaborative and shared form of governance is to be achieved and sustained along the coasts, it cannot be forced but must come from individual and organizational willingness to participate, especially at the local level.

Coastal communities can be hotbeds of competitive entrepreneurialism, honed from generations whose very survival depended on their ability to successfully harvest an elusive resource in some of the most dangerous working environments in the world. Real collaboration will be the result of interpersonal respect created by individuals who are constantly learning and reinterpreting their roles based on evolving changes in policies, goals, resources and environments. Despite the anticipated benefits of shared governance, some people will not self-organize either from a lack of interest, a lack of motivation, or from expectations of failure. Some organizations will fail, whether from a lack of capacity or a lack of core resources. Some will fail as a result of disenchantment with leadership, or unresolved conflicts among the users. Some will fail because they have too little access to the information and expertise they need (Ostrom 2007b, Sabatier et al. 2005). But we cannot allow the prospect of failure to be reason enough to fear and avoid change. Failure is an accepted element of risk taking and a critical component of adaptive learning.

Just as Jentoft (2007) and Ostrom (2007) have concluded, it is unlikely that society can be successful in finding the one panacea for coastal management that would work at all levels of government and across all geographic and functional scales. Along the coast, the stakes are especially high and so are the risks of failure. We must simply begin now with what we have, move forward with both optimism and caution, be ready to toss out the aspects that don‟t work, and embrace with enthusiasm the potential of new ideas and technologies.

Implementation of the CoastWORKS framework must rely on a new appreciation of the common-pool resources of coastal landscapes, and a generous application of the increasingly elusive commodity of common sense. CoastWORKS practitioners must have an insightful appreciation of the following rules of „sensible foolishness" (adapted from concepts developed by Jentoft (2007), Keeney (1992) and March (1976)):

- values are important (because they help us understand the important questions and they guide our decision-making);

- goals are hypotheses (because we do not always know what we want or get what we want);
- intuition is a real tool (because we may not be able to precisely describe or scientifically support what we believe to be happening);
- hypocrisy is a transition (because long-term consistency is not required in either policy or action, as change will require us to move away from principles established on outdated knowledge, perceptions or values);
- memory can be an enemy (especially when it prevents us from trying something again because it failed in some other time or context); and
- experience is a theory (subject to reinterpretation or revision through the application of new knowledge, new values, or new goals).

And finally, like other systems of environmental governance and resource management designed in capital cities or in universities, successful implementation of a decentralized framework must remain relevant to local conditions, have support from resource users, and ensure that gains in process are linked to progress towards sustainability of the coastal landscape.

CHAPTER 8:
CONCLUSION

8.1 Thesis Overview

In the five years since this research was initiated, coastal conditions worldwide have continued to deteriorate, and concerns over the impacts of climate change have escalated (Beatley 2009, Crain et al. 2009, Ommer 2007, UNEP 2007a, 2007b, 2008, 2009). In Canada, interest in coastal management, never a hot topic for political discussion, seems to have waned once again, perhaps overshadowed by unforeseen crises in economic conditions. Coastal issues continue to be debated in scientific and community workshops, but outside these dialogues, real interest or change in the way society uses or manages coastal resources remains hard to find.

This thesis challenged populist views that most of Canada"s coasts were fine, and that limited fiscal and human resources that could be applied to coastal management were better expended on other, more pressing societal and environmental needs. The research questioned whether Canada"s coastal areas needed improved management, whether an integrated approach to management could be effectively implemented in Canada, and if not, what might constitute a workable alternative to management theory and practice. In this concluding chapter, I summarize the results of my research, provide answers to the questions posed, state my final conclusions, and discuss the values and the constraints that were inherent in taking a broad, interdisciplinary approach to such a complex field of study.

8.2 Answering the Research Questions

The research took a forensic approach to the collection, assessment and analysis of existing and new information on the state of the coasts in Canada, and on the state of coastal management abroad and here at home. To find answers to the research questions, the study relied not only on traditional approaches to empirical, quantitative research, but also on emerging, holistic methodologies that mined existing information for shared insights into larger issues. The conclusions of the research are summarized in reference to the original questions posed.

What are the reported constraints to implementation of ICM?

Throughout the world, assessments of progress towards improved coastal management relied first on the evaluation of efforts to implement new political, scientific and administrative processes. Much of the literature appeared to rely on the premise that if you found what worked, and focussed on that, success would follow. But coasts continued to decline, and the promised integration of silo-based government policies and programs that was the core of ICM philosophy did not materialize.

This research sought out the reasons for the lack of progress towards improving coastal management systems and reducing the stresses on coastal environments. By deconstructing the literature and focussing on the reported constraints to implementation, it was hoped the barriers to effective practice could be identified, better understood, and eventually overcome. The following ten categories of constraints were identified:

- ongoing deliberation and confusion over the definition of coastal boundaries;
- a lack of political will and long-term support;
- lack of vertical and horizontal integration in government;
- differing perspectives and conflicting goals;
- failures to identify the economic benefits of improved coastal management;
- a lack of interdisciplinary science and science-to-government collaboration;
- limitations on spatial and temporal data on both historic and current socio-ecological conditions;
- a lack of capacity in science, management and community organizations;
- limitations to the authorities vested in participatory management and implementation at the local or community level; and
- conflicting time scales for policy setting and implementation.

Would similar obstacles impair ICM implementation in Canada?

For more than three decades, interest and activity in the development and implementation of coastal management in Canada has flowed and ebbed like the tides. Progress towards the development of a national policy and practice for coastal management has rarely enjoyed significant political support and has largely been initiated and shepherded by networks of committed individuals, many of whom worked in relative isolation within government, science, and the community. As in other countries, integration is still primarily advocated only by government departments and agencies responsible for the stewardship of the environment and the conservation of natural resources. Little participation or harmonization has been effected within departments responsible for economic development.

When compared to the constraints ICM programs have experienced in other nations, it was clear that in Canada the efforts to develop and implement a national policy and program for coastal management continued to be held back by similar issues that included:

- continued, unfruitful debate over an accepted definition for the coast, which appears to have successfully derailed or at best delayed productive dialogue on the implementation of coastal planning and management measures by any level of government;
- inadequate support for needed science to substantiate whether Canadian coastal waters are in fact threatened by human activities;
- conflict amongst the perspectives and goals of coastal residents, and resource users;
- a lack of federal political will either to advance the coastal management initiatives proposed by the Oceans Act, or to continue support for integrative and basic science in coastal and oceans research;
- ongoing jurisdictional squabbling over authorities and responsibilities amongst the levels and departments of government that has left coastal management in Canada without a clear champion, despite the allocation of leadership responsibility to the department of Fisheries and Oceans;
- little understanding that short-term inaction on coastal issues may well result in burgeoning future costs to remediate impacts to socio-ecological systems;
- failure to entrust local organizations with the authority to implement policy, to make decisions, or even to report on change in local socio-ecological conditions; yet continued promotion of under-funded, and largely volunteer community-based management initiatives as a productive example of Canada"s commitment to bettering coastal management practice;

- failure to address the declining capacity in coastal science and management posed by reductions in government fiscal support, retirements, and lack of education and training options for remaining staff; and
- continuing communication and process gaps between the knowledge generated by science and communities and its effective application to policy and practice.

With the longest coastline in the world, a population largely clustered on a small portion of its shores, and limited resources, Canada is challenged by the spatial, ecological, and cultural diversity of its coastal areas, by a political system which contributes to the gulf between land-based and marine-based management, and by a complacency over the impending impacts of climate change. Within the current federal political structure there appears to be little support for or momentum towards the provision of leadership in coastal management. And as Billé (2008) concluded in his review of international ICM practice, in Canada most of the ongoing consultations on coastal management appear to be based on illusions that roundtable discussions could by themselves solve problems, that the authority to govern their own coasts would someday be granted to communities, and that a lack of scientific knowledge continued to justify inaction.

Is the state of knowledge of conditions along Canada's coasts sufficient to support the current expectations that our coastal environments remain relatively un-impacted by human activities?

Following from this review of state of the coast environment information in Canada, it was concluded that there was insufficient information to either support convictions that Canadian coasts remain relatively unaffected by human activities, or to provide credible evidence of sustainability of any or all of the physical, biological, chemical, or socio-economic components that make up coastal landscapes. The last national state of the environment report was released over a decade ago, and based on even older data. For vast areas of the Canadian coast there is essentially no information on current conditions or on patterns of change. Where data and information exist, there are some excellent examples of local research and monitoring, but for the most part, the information is fragmented, and not readily comparable.

Long respected as a leader in marine science and management, Canada has for over a decade permitted the steady erosion of resources and staff that once supported a significant competency in federal marine science. Increased fiscal support intended to transfer this capacity to the university sector has not materialized. The responsibility for monitoring change in coastal conditions has shifted largely to site-specific industry-based monitoring programs, or to local volunteers. Federal funding, necessary to maintain the core activities of community-based volunteer programs, has been steadily evaporating. Funding for some federally established science networks such as the Oceans Management and Research Network has also been discontinued. Modelling programs and research that would link changes in land cover to coastal well-being (increasingly seen by other developed nations as a key to coastal sustainability) have yet to receive significant support from any level of government in Canada.

In developed areas of the Canadian coasts, have human activities on the land contributed to measurable effects in nearshore receiving environments?

Having concluded that from a national perspective there was insufficient information to support conclusions on the state of Canada"s coasts, the research challenged expectations that nearshore waters (excluding admittedly impacted industrial harbours) remained relatively pristine and un-impacted by human activities. Focus shifted to the Atlantic coast of Nova Scotia, where a case study that included ecological field research and geospatial analysis was completed to compare land cover ratios in the watershed with nutrient concentrations in nearshore coastal receiving waters. Even working at a coarse scale of investigation, the research pointed at potential linkages between land cover change in primary watersheds and increased nutrient levels in coastal waters. Not surprisingly, elevated levels of nutrients were detected in areas vulnerable to point sources such as municipal sewage and stormwater effluents, but linkages were also identified between land cover changes (e.g. deforestation) in watersheds and increased nutrient levels in rivers and sheltered embayments.

The research recognized that too often the science on cause and effect relationships can be reported in a manner and at a scale inappropriate to aid policy and decision-making. While excellent complex models of the effects of land cover and land use change have been developed, there was little evidence of their practical application to land use decision-making in Canada. To bridge some of the gaps between scientific knowledge of ecosystem vulnerability and the criteria used by decision-makers, a simple and practical tool was developed to assist with coarse assessment of the potential impacts of land cover changes on local coastal environments. The Mercer Clarke GreenField Ratio and the Coastal Sensitivity Rating Tool can be applied by local planners and managers using relatively inexpensive geospatial analysis software and commonly available data on land use and land cover, supplemented as needed by a simple and cost–effective water quality assessment program. Application of the Tool facilitates a coarse scale examination of alternative scenarios and options for land cover ratios in the watershed, assisting decision-makers in proactive consideration of the potential trickle-down ramifications of decisions taken miles from any shore.

Are there alternative approaches for the management of coastal areas in Canada?

Working through some of the current theory in management science and public administration, the research proposed a new approach to coastal management that relies less on the physical and administrative integration of policy and decision-making within government, and more on education, collaboration, and harmonization to effect needed change to current structures and systems. The CoastWORKS framework proposed a working definition and vision for Canada‟s coastal landscapes, and outlined a set of principles to guide action. While the CoastWORKS framework does not require action by the federal government before it can be initiated at the local or regional scale, the process could benefit from a strong institutional presence providing leadership, support and coordination. But CoastWORKS is based on the assumption that real change will only come from the work of existing and self-organizing networks and communities of practice and from individual effort. To harness the full potential of that individual energy, CoastWORKS was designed to be applied, energized and expanded upon through rapidly evolving and effective Internet and social networking tools.

8.3 The Conclusions

- Integrated approaches to coastal management have not been able to deliver on promised change in the traditional silo-based management systems of government.

- The constraints to ICM implementation reported by other nations bear a striking similarity to conditions that appear to have impeded progress towards a national program for coastal management in Canada.

- Real concerns are growing that the multi-stakeholder consultative processes that have been at the heart of many integrated coastal management initiatives, have not provided real solutions to current or looming coastal problems.

- There is insufficient state of environment information available at a national scale in Canada to substantiate conclusions on the state of our coasts.

- The concept of the coast as a marine environment is no longer valid and should be replaced with a more holistic appreciation of the coast as a landscape comprised of terrestrial, aquatic, marine and human ecosystems.

- The Great Lakes are part of the coastal landscapes of Canada.

- Ecosystem functioning, even in the relatively unpopulated coastal landscapes of Canada, may already have been adversely affected by human activities. Climate change will likely exacerbate this situation.

- It is not acceptable that Canada is without a national framework for coastal management, capable of capturing public attention or of fostering national or local action and stewardship.

- Fisheries and Oceans Canada has demonstrated that it is ill-equipped to provide leadership in integrated management of coastal and estuarine waters. Federal leadership in coastal stewardship and management should more appropriately be vested with Environment Canada.

- Real change towards coastal sustainability will come only from a shared vision of the coasts that motivates and validates the work undertaken at local and regional scales.

- Given the difficulties inherent in devolution of government authority to community-based organizations, the responsibilities and the resources for coastal management should be passed to local governments, ably assisted by formalized relationships with local stewardship organizations so as to engage and ensure their further participation in monitoring, reporting, advocacy and advisory roles.

8.4 The Value of an Interdisciplinary Approach

The interdisciplinary approach adopted by this research program offered new opportunities for a more holistic examination of the issues and challenges facing coasts and coastal science and management in Canada and in the world. Drawing on the disciplines of ecology, planning, landscape architecture, law, and management, while admittedly making for a complex research structure, significantly informed my understanding of the entwined nature of the socio-ecological systems that form coastal landscapes and the human perspectives and institutions that affect their current and future well-being. Perhaps as a true demonstration of the value of the interdisciplinary approach, it is now difficult to identify clear examples in the research that did not draw from or rely upon two or more of these disciplines.

The broad disciplinary, geographic and functional scope contributed significantly to the complexity of both the research questions, and to the methodologies pursued to generate needed answers. Alternatively, a less holistic approach, which has often been the tradition in coastal science, would have limited consideration of coastal issues to ones framed by natural science, by applied science, or by organizational management.

8.5 Strengths and Weaknesses

The strength of the research approach was in its national perspective on both state of the coasts information and on coastal management. While local and regional efforts to improve our understanding of coastal conditions have undeniably made excellent contributions to the knowledge base, too often locally relevant studies have been used to support national-scale conclusions, and to diffuse growing concerns over disturbing, but scientifically unsupported trends. This research acknowledges the old saw that Canada may be drowning in data, while presenting a credible challenge to the conviction that we know enough about our coasts.

It must be noted that there were two significant areas in which readily available information and data on coastal conditions and coastal management in Canada are either missing, difficult to access, or specific to local initiatives: the Canadian Arctic and the on-going work of First Nations, Métis and Aboriginal people.

The Canadian Arctic is an immensely complex socio-ecological system that is currently undergoing great change as a result of the increasing temperatures and loss of ice cover attributed to climate change. Outside of the work of individual scientists, collective information on Arctic coastal environments is limited and fragmented. Considerable value has been gained from inventories of traditional knowledge, and especially now from the ongoing work of communities to report on the changes that they see. But for much of the unpopulated or undeveloped sections of the northern shores that comprise 70% of Canada‟s coastlines, there is little or no information on changing environmental conditions. The First Nations, Métis and Aboriginal people of Canada‟s north continue to provide unique and challenging perspectives on the management of the land, the ocean and the living and non-living resources upon which we all rely. Much excellent work has been accomplished by these first Canadians to foster and sustain coastal landscapes and cultures, but it is still for the most part locally based, and has yet to contribute to a national perspective on coastal conditions or coastal management.

There can be little doubt that the research may have overlooked publications on coastal management, especially from the grey literature. However, it is important to note that access to the extensive body of work that did contribute to the findings of the research was only made possible by emerging electronic tools and by recent developments in the Internet, and by the use of the Internet by the academic and publishing community and by governments and other organizations. I am immensely respectful of the opportunities that the continuing evolution of these tools will present to both research and practice in coastal management in the near future. I believe that the coupling of these tools with an interdisciplinary approach will, as Costanza et al. (2001) put it, slowly (but with determination) push back the edge of uncertainty.

The coarse scale chosen for the land cover and water quality research contributed to both the strengths and weaknesses of the research. Working at such a scale and level of detail leaves the research conclusions open to questions on the validity of the cause and effect mechanisms that appear to link land cover change and nutrient concentrations in the receiving waters. However, working at the landscape scale can also enlighten understanding that these two important elements in the sustainability of coastal landscapes are irrevocably linked, and that messing about with one will probably cause unanticipated and/or unmanageable impacts to the other.

And finally, there is an immediate need to reduce confusion among the scientific and professional communities by adopting commonly accepted protocols and standards for the collection, analysis and reporting of data and information on important indicators of change such as nutrient concentrations in fresh and salt waters.

8.6 Next Steps

The findings, tools and conclusions created by this research challenge the credibility of previously accepted myths and illusions about the state of Canada‟s coasts, and cast new light on our seeming inability to motivate change in the manner in which we utilize and manage coastal resources. While the research provides clarity on Canada‟s efforts to date in coastal management, it is intended to be a rallying call for improved action by all levels of government, rather than a reason for continued inaction.

It is to be hoped that the research will foster further investigations into the relationship between land cover ratios and non-point sources of pollutants, and especially into the contribution of land cover to the potential nutrification of what had seemed to be relatively un-impacted coastal waters. On a local scale, this research relied on available information on land cover in Nova Scotia that was over a decade out of date. With the recent availability of more accurate and current land cover data through GeoBase, it would be interesting to run the analyses again using the newer data.

More study is also needed to develop pragmatic, cost-effective meta-indicators of the changes that are affecting terrestrial, aquatic and marine ecosystems, and the coastal communities which are dependent upon them. This is especially true in considering the potential impacts that climate change may bring to all of Canada‟s coastal landscapes. With adequate fiscal and human resource support, community based stewardship organizations offer a cost effective means to monitor local parameters for change, and to increase understanding and capacity in coastal management.

Presentation of the CoastWORKS framework will offer what are to some coastal practitioner‟s new ideas and opportunities in support of individual and collaborative action. The CoastWORKS framework will be made available to the public through an interactive website and the volunteer efforts of colleagues at work across the country.

Using social networking tools, it is hoped that CoastWORKS could inspire the creativity of others, and take on its own life.

8.7 Not Final Thoughts

The world around us continues to change rapidly. Nowhere will these changes be felt more widely than on the coasts of Canada‟s Great Waters; the Pacific, the Arctic, the Atlantic, and the Great Lakes. In its relatively short existence, Canada has become a nation of such sweeping global identity that our citizens are warmly recognized when overseas by the wearing of a simple maple leaf emblem. We are the stewards of the longest coastline in the world, a breathtaking expanse of richness in both landscape and culture. Yet a blue veil still falls across coastal waters, and most Canadians can neither see nor understand the implications of the changes already wrought by society on the lives and habitats of marine species. It is important that we move past dated perceptions of the seemingly limitless capacity of the ocean to absorb without impact the pressures of human society. While science struggles to catch up, we need to assess the vulnerability of coastal systems in the context of current day decision-making, and planning for future change. It is essential that we progress from the reactive management of impacts to the proactive reduction of stressors and pressures.

Clearly, this thesis draws its perspective from my own conviction that the principles of sustainability are important guidelines for our future. However, conservation and protection values are not the only values that will be used to determine how coastal resources will be managed. Values, criteria and decisions can be derived from adherence to one or more of the cultural models described by Thompson (2007) that may include:

- sovereignty: based on control and ownership, and the rights to exclude other users;
- community: based on social interaction, moral behaviour, and a sense of belonging;
- ecology: based on maintenance of ecosystem function, and ecological connectivity;
- moral order: based on an awe, humility and wonder of nature;
- commodity: based on selling resources now for the highest profit; and/or
- productivity: based on putting resources to use for the betterment of society.

While increasingly respected in Canada, the ecological model may not be the predominant value system used in decision-making by politicians, governments or the citizenry. This can be especially true when there is a lack of understanding of important issues, an absence of readily comprehensible and effective alternatives, and/or major conflicts with one or more of the other value systems. Since we are the ones seeking change to the status quo, it falls upon us to find the ways and means to enjoin the support and participation of these other interests.

The people of our First Nations bid us to follow their example, to look back seven generations at what we have wrought, and to look forward seven generations to what we will leave. Let there be no mistake, tinkering with coastal management over timeframes described as glacial will not meet the expectations of our citizenry, or the needs of the very landscapes that we hold so dear. Whether you are a fisherman working at the edge of the eastern ocean in Brigus, Newfoundland or an accountant spending a Sunday with your kids at the waterfront in Toronto, the waters of Canada‟s four coasts are your Great Waters. The impacts to their well-being must not be disregarded. Our role in their stewardship must not be taken for granted. And everyone, no matter how far from the shore they live or work, must do their part to keep the coasts vibrant, dynamic, and sustainable for all Canadians, but most especially for those who are yet to be.

Back to the future: using landscape ecology to understand changing patterns of land use in Canada, and its effects on the sustainability of coastal ecosystems

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In Canada, concerns are mounting that the coastal environments may be more affected by human activities than is evidenced by current monitoring and assessment of environmental quality. Holistically orientated approaches to coastal management have concluded that indicators of coastal sustainability must include a wider array of factors that go beyond marine ecosystem health to include the health and well-being of coastal terrestrial environments and human communities. Research is needed to bridge the disciplinary and jurisdictional barriers that hamper better understanding of the relationships between terrestrial and marine ecosystems, and to help recognize the role of humans as both a contributing and an affected species in the coastal ecotone. Our examination of past and current knowledge of conditions along the Atlantic shore of Nova Scotia led us to challenge the predominant view that all is well along Canadian coasts. Using an interdisciplinary approach derived from landscape ecology, we examined international, national, and local efforts to assess management indicators against factors that gauge their relevance to marine- and land-development planning and management. We propose a new context for indicators, one that challenges scientists to provide decision-makers with information that can be used to drive social change, avoiding or mitigating human activities and sustaining coastal ecosystems.

Keywords: coastal management, coastal sustainability, indicators, landscape ecology, land use.

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Declining coasts

For more than 100 years, governments, academia, and community-based organizations have monitored conditions in marine and coastal environments by collecting and recording data on an array of biological, chemical, and physical parameters, to increase their understanding of the functioning of the associated ecosystems (Hameedi, 2005). Despite advances in fishery management, pollution-abatement technologies, and the creation of marine protected areas, the health of the world's oceans and coasts continues to decline (GESAMP, 2001a; Lotze, 2004; Steffen *et al.*, 2004; MEA, 2005a, b; EEA, 2006). GESAMP (2001b) estimated that 80% of the pollution load of the oceans, including municipal, industrial, and agricultural wastes and non-point source run-off, emanates from land-based activities. Increasingly, as human populations continue to grow in coastal areas, the rights to access and development are pitted against the rising demand for sustainable resources, beautiful landscapes, and healthy environments that support a high quality of life for coastal residents and visitors.

More than 30 years ago, it was widely recognized that management of the complex issues affecting coastal areas required a new approach based on integrated planning and decision-making. Since then, although there have been >700 initiatives in integrated coastal management (ICM) worldwide (Sorenson, 2002), there is still only limited knowledge of the dynamics of coastal ecosystems. There is even less understanding of the complex relationships between land-based activities and the health of sensitive nearshore environments (GESAMP, 2001b). Perhaps even more disturbing is that we are only beginning to comprehend the linkages between coastal pollution and human health (GESAMP, 2001b; Kennish, 2002).

A basic premise of ICM has always been that the development of shared vision and goals for sustainability and the effective implementation of integrated governance would result in improved coastal health. However, the early emphasis on measuring the success of process implementation, as opposed to success in improving environmental conditions, made the costs and benefits of sustainability difficult to identify or assess. In areas such as the USA, and in Europe, where coastal management initiatives have been in place for decades, concerns are increasing over the ability of ICM to slow or reverse ecosystem degradation (Hershman *et al.*, 1999; JOCI, 2006; Shipman and Stojanovic, 2007).

Despite its long and sometimes chequered history of fishery and marine management, Canada has yet to make substantive progress in the planning and management of its coastal areas. It would appear that there are no compelling reasons for Canadians to be concerned about coastal issues, and with the collapses in offshore fisheries, the limited resources available for monitoring and assessment have been focused on deeper waters. As information about the state of oceans and coasts continues to accrue in other countries, and as climate change impacts become more visible, concern is growing in Canada that the coasts may be more vulnerable to change than was predicted. Have the consequences of human actions over the past 50 years been accumulating while Canadians were otherwise distracted and looking elsewhere (Fraser, 2007)?

Management by myth

As Jentoft and Buanes (2005) reported about Norway, public attitudes and governance decisions on coastal management in Canada may be guided too often by what people believe to be true, rather than by what is supported by science. These myths include the beliefs that Canadians are not a coastal people and consequently do not feel a personal connection to coastal environments and issues; that it is unlikely that the size of the population could irreversibly damage any more than a tiny percentage of the vast coastline; that the coastal environments are relatively pristine; and that there is sufficient science to support all the above. Although Canada has the longest coastline in the world and a population of just more than 30 million (Atlas of Canada, 2007), more than 70% of the coasts lie in northern areas that support a mere 4% of the people. Canadians seem to forget that most of the population lives in cities and towns that are clustered along a relatively small portion of the southern marine and Great Lakes shorelines. In his analysis of population distribution and projected change, Manson (2005) predicted that, by 2015, >50% of Canadians will live within 20 km of a coast.

We have attempted to identify data that support the claim that Canadian coastal areas are relatively pristine, but found that the science can be best described as inconclusive. Data on marine environmental quality are practically non-existent for vast portions of the nearshore waters. Where data do exist, they are largely restricted to water quality, plankton, and commercial fish species. Knowledge of coastal biodiversity, ecosystem function, and patterns of change is limited. Datasets are seldom regional in scope and are based on different methodologies for collection and analysis. Only a few marine datasets address nearshore conditions or provide time-series information (Brylinsky *et al.*, 2005). Information on nearshore land use is available, but few efforts have been made to link changes to related effects in coastal waters. Although much work is needed to improve the state of environmental information about coastal areas, governments, academia, and communities are constrained by available human and financial resources, and by the sheer magnitude of the task before them.

Indicators and management

In its Oceans Act (Government of Canada, 1996) and its Oceans Strategy (Government of Canada, 2002), Canada has recognized the need for holistic, ecosystem-based approaches to management, especially in nearshore environments. Despite this commitment, marine and coastal parameters are still missing from the national indicators of environmental health and sustainable development (Government of Canada, 2003; NRTEE, 2003). National working groups, made up of staff from several federal departments, have been endeavouring to identify coastal indicators, but the work is still in its early stages (Buckland, 2007).

Throughout Atlantic Canada, reporting on coastal health is mostly an exercise in marine environmental quality, based on indicators drawn from traditional biological and physical parameters (Vandermeulen and Cobb, 2004). The continuing bias in monitoring programmes against marine science ensures that, although holistic, ecosystem-based approaches to indicator selection are promoted, they seldom include land-based activities, and the potential for inclusion of socio-economic indicators, such as changes in land use, is unlikely to be realized. This situation is exacerbated by a lack of national and provincial policy on coastal management, and limited participation by key disciplines (i.e. planning, architecture, engineering, landscape architecture) in the development and design of coastal management initiatives (CLC, 2005). Also, largely absent from these collegia are representatives of provincial and federal departments responsible for land-based development and resource management.

The Oceans Act charged the Department of Fisheries and Oceans (DFO) with the responsibility of providing leadership in the development of an integrated ecosystem approach to the management of coastal-zone waters. With regard to Nova Scotia, much of the DFO's attention, and that of other federal and provincial departments, has focused to date on the science and co-management of the Eastern Scotian Shelf (ESSIM), a large ocean management area located entirely in offshore waters and subject to conflicts over use between major sectors, such as fisheries, oil and gas, and transportation. By comparison, the thin band of nearshore waters (<20-m depth), which is the initial receptor for land-based impacts, has received considerably less attention, either in monitoring efforts or in attempts at integrated management. The DFO intends to expand the ESSIM boundary to include coastal lands, and initial efforts have been made to identify a wider range of indicators, including land-based issues and socio-economic conditions (Walmsley, 2005; Walmsley *et al.*, 2007).

Elsewhere in Canada, several regional initiatives are also working on coastal indicators (Georgia Bay–Puget Sound, Gulf of Maine Council Ecosystem Indicators Partnership, Joint Commission on the Great Lakes). Although the focus has remained predominantly on measures of the health of aquatic ecosystems, there is movement towards the inclusion of land-based parameters (GBEI, 2002; GOMC, 2004; Governments of Canada and the United States of America, 2003). In addition, Canada's history of coastal stewardship and volunteerism has supported community-based monitoring across the country for more than 15 years. These organizations, though often severely constrained by uncertain and limited financial resources, have cooperated to identify common indicators, to establish sampling, analysis, and reporting protocols, and to share information and data freely with academia, government, and the private sector. Such partnering at a local level not only benefits sustainable development; it also creates an ever-widening sphere of influence and engagement that may produce positive results at a landscape or ecosystem scale (McNeil *et al.*, 2006).

Despite the progress made in recent years, Canada, like other nations, is struggling to make real progress towards sustainability. In her most recent report, Shelia Fraser, the Auditor General of Canada, concluded that the government was failing—across the board—to live up to its commitments to sustainable development (OAG, 2007). In a review of the performance of DFO in British Columbia, Peterson *et al.* (2005) felt that, constrained by decreasing budgets and insufficient resources to adequately address complex relationships between development and conservation, inadequate monitoring, and decision-making that too often placed economic considerations over the needs of fish, DFO was clearly not supporting its mandate to protect fish and fish habitat. Ecosystem-based management and co-management initiatives represent a growing trend in Canada, but for the most part, they involve departments and agencies responsible for environmental protection and stewardship, rather than those whose focus and mandate is to foster economic development. Consequently, indicators of environmental change are rarely linked to or balanced with indicators of economic progress, and may be lost in the barrage of information presented to the public and decision-makers.

So what are Canadians to do? The reality is that fiscal resources will continue to decrease in the future, hampering the ability even to maintain, let alone expand, current monitoring programmes. If we are to understand adequately the existing conditions and patterns of change that may shape the future, what should be measured, and who is the target audience for the findings? What role should science play in identifying priorities, devising alternative scenarios, and communicating urgency? Are the indicators used to monitor coastal conditions sufficient to answer the important questions: what is happening; why is it happening? why is it important; what can be done about it?

Emerging trends

In the GESAMP (1996) policy cycle, evaluation is one of the five major elements in an ICM governance process. In the 1990s, evaluations were based largely on indicators that measured outputs of the process (e.g. policies, legislation, programmes, plans, permits, meetings, publications) as opposed to indicators that measured outcomes of sustainability (e.g. water quality, species and habitat protection, public access, sustainable fisheries; Burbridge, 1997; Hershman *et al.*, 1999). More recently, there have been several national and international collaborative initiatives to identify holistic suites of indicators of ecosystem health and sustainability (Belfiore *et al.*, 2003, 2006; ETC-TE, 2004). Belfiore *et al.* (2006; p. 11) produced a comprehensive guidance document that redefined indicators as "quantitative/qualitative statements or measured/observed parameters that can be used to describe existing situations and measure changes or trends over time". Indicators were categorized as being either measures of governance or ecological or socio-economic conditions, and were recognized as contributing to the simplification and communication of important information. The target audience identified for these indicators included ICM programme managers and practitioners and their fiscal support agencies, high-level decision-makers, and researchers, but only limited guidance was given on the potential use of indicators as drivers of social change.

Miles (1999) emphasized that ICM initiatives should focus less on process implementation and marine conservation, and more on management of land-based human activities. Despite this early and pragmatic view, initiatives remain focused on the marine environment, information is not networked, and the land–sea divide continues, with limited attention to the integration of spatial planning and management of conjoined marine and terrestrial landscapes (Shipman and Stojanovic, 2007). Coastal issues are rarely at stake during the setting of national government policy and may also be absent from development planning processes. Socio-economic science, though increasingly incorporated in the discussions, is often used more as a backdrop than as a tool that adds reality to the consideration of options. When scientists attempt to communicate more fully, their findings may be considered boring, incomprehensible, inconclusive, controversial, and/or irrelevant to the needs of decision-makers and society (EEA, 2006). Science, which earlier was confined to monitoring the state of the environment, has been further marginalized, reducing opportunities to contribute either to improved understanding of the drivers and pressures of land-based activities and marine-resource use or to the development of response plans (McFadden, 2007).

The communication of information provided by science-based indicators can generate two kinds of response in society: reactive or proactive. For the most part, the response has been reactive, with a tendency to use the precautionary principle as a hind-casting tool. If scientific predictions from models appear inconclusive, governments may respond by ignoring advice, pending the delivery of more precise predictions (EEA, 2006). As a consequence, science has developed a preference for focusing more on describing current conditions and less on predictions. However, to achieve sustainability, we need indicators that provide information not only on current conditions but also on the pace, scale, and nature of change, and the risks to our future posed by such change. We need to rethink the role of indicators, such that they not only report on existing conditions but also act as a prompt and a guide for action. Important opportunities could be created if marine science embraced more fully the scope, scale, and principles of management espoused by landscape ecology, a discipline that recognizes that our coastal landscapes integrate terrestrial, aquatic, and marine ecosystems, in which the human species plays a dominant role. Applying scientific knowledge at appropriate landscape scales will permit the forecasting of scenarios, while using indicators as a tool not only to protect and conserve ecosystems but also to guide development decision-making.

Back to the future: predicting change

Back to the future (BTF) is a model of restoration ecology that aims to create sustainable food and wealth from captive fisheries and aquatic resources (Pitcher, 2005). The purpose of BTF scenarios is to recapture the conditions that might have existed in a "lost-valley" ecosystem relatively unaffected by human activity, and to use this hypothetical system as a template to propose restorative actions that result in a state that approximates predevelopment conditions. BTF starts by constructing descriptive models of unaffected ecosystems, then devises scenarios for sustainable use, based on a range of variables and risk factors. We argue that the approach offers considerable potential for application to coastal management. There is a growing body of knowledge of historical change in landscapes, including change in environmental indicators, such as shoreline hydrodynamics, sea levels, and commercial harvests (Kleppel *et al.*, 2006; Haase *et al.*, 2007). Combining such information with terrestrial data, such as population distribution and land cover, will improve our understanding of the changes that contribute to coastal marine conditions (e.g. storm-water run-off, seasonal-stream flows, nutrient and sediment inputs, temperature and salinity changes, and buffering capacity). Some of the difficulties of integrating datasets that are based on arrays of indicators collected at different temporal and spatial scales (and for entirely different purposes) may be overcome through the use of readily available and relatively inexpensive GIS-based technologies (Bartlett and Smith, 2005), and through the development of meta-indicators that may be used to provide a coarse assessment of the overall state of the system (Degnbol, 2005).

Meta-indicators as regulatory tools

Meta-indicators are a useful tool in human-health diagnostics, where something as simple as changes in body temperature or blood chemistry are used daily as headline indicators of potential illness. Degnbol (2002) goes further and proposes that meta-indicators be used in an adaptive learning approach to build ecosystem knowledge, abandoning the focus on detailed understanding of ecosystem functioning in favour of regulating the overall pressures on ecosystems. Degnbol suggests that, in fishery management, most ecosystem concerns could be resolved by reducing the main pressure on species well-being, the fishing effort. When applied in this context, meta-indicators become benchmarks or thresholds that can be used to determine the limits of resource use and to reduce or eliminate activities that harm the ecosystem. Following Degnbol's logic, changes in land use could be used as a meta-indicator for regulating pressures on terrestrial and aquatic ecosystems, including the downstream impacts on coastal environments and communities. Such an approach is being used by the State of Oregon (2000), where land use is an effective meta-indicator not only to assess current conditions in the landscape (e.g. urbanization, deforestation) but also to assist in reaching complex development decisions.

In a review of habitat requirements necessary to sustain biodiversity in the watersheds of southern Ontario, a collaboration of scientists, land planners, and managers produced a set of guidelines that answers the question, how much habitat is enough? (Environment Canada, 2004). They concluded that, to sustain biodiversity in Ontario watersheds, the landscape should include at least 30% natural forest cover and 10% productive wetlands, in which 75% of the banks of streams and rivers are vegetated. Application of these guidelines as meta-indicators could aid decision-making on both new development planning and habitat restoration priorities and could have ramifications for ecosystem sustainability that is considerably broader in scale and scope than originally envisaged. Using GIS technology and a range of existing datasets, as well as new field information on nutrients in coastal waters, we are in the process of examining the potential application of such guidelines as a meta-indicator for planning and managing coastal watersheds along the Atlantic shore of Nova Scotia, but as yet have no concrete results to report.

Through the glass, clearly

From their examination of the current literature, Stojanovic *et al.* (2004) are convinced that, as ICM continues to evolve, it will be profoundly affected by the philosophical change from modern to post-modern thinking, which broadens society's ability to cope with inconclusive science and a myriad of values and perspectives. Successful coastal management may depend on our success at adapting to these changing paradigms. This requires a more interdisciplinary approach to understanding and managing coastal areas, one that respects cooperation, collaboration, contingency, and adaptability, and that contributes to a progressive transformation of coastal policy (Aberley, 1994; Burbridge, 2004; Stojanovic *et al.*, 2004; Milligan and O'Riordan, 2007). Monitoring of marine and coastal ecosystems will always be needed to provide information on reference conditions and to clarify the complex causative factors of change. However, society also needs science to ensure that this knowledge is used not only for the identification of priority issues in coastal areas, but also to inform and guide both the policy and the everyday decision-making of land-based as well as resource-based government agencies.

The situation along the coast is analogous to a house with glass walls. We can see through the walls to what we need, to whom we need to talk, to what we want to change. But the walls can restrict the movement of people, impair communication and the sharing of information, and increase the tunnel vision of many scientists. Access to seemingly unrelated sources of data can be constrained by ownership, and collection, analysis, and reporting methods. Collaborative effort can be hampered by outdated academic and disciplinary boundaries. Scientists might step back from participating as stakeholders in the setting of coastal policy and goals, deterred by their own, perhaps misguided, perceptions that their participation would be neither welcome nor appropriate.

As faith in ICM wanes, unapologetic science and scientists must once again leave their laboratories to take their rightful place in society. Collaboration among governments, the private sector, and the professional community should inform the development of pragmatic and effective alternatives to current practice in the coastal-zone, so as to shape the sustainable future of our coasts. Our objective should be to develop, define, and enshrine the tangible interdisciplinary meta-indicators of sustainability, rather than continuing the struggle with the individual and intractable intradisciplinary objectives of coastal management.

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APPENDIX B
BIBLIOGRAPHY OF SELECTED STATE OF MARINE ENVIRONMENT REPORTING (ATLANTIC CANADA AND NATIONALLY)

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APPENDIX C
SELECTED STATE OF COASTAL ENVIRONMENT INTERNET RESOURCES

Website Owner	URL Address
AGCAN Agri-Environmental Indicators	http://nlwis-snite1.agr.gc.ca/ind2001/index.phtml?lang=en-CA#
AGCAN Land Resource Viewer	http://nlwis-snite2.agr.gc.ca/nimf/nimf.jsp?site=lrv&lang=en&mode=a
AGCAN National Land & Water Information Service	http://www4.agr.gc.ca/AAFC-AAC/display-afficher.do?id=1226330737632&lang=eng
Atlantic Coastal Action Program (ACAP)	http://atlantic-web1.ns.ec.gc.ca/community/acap/default.asp?lang=En&n=085FF7FC-1
Atlantic Coastal Zone Information Steering Committee	http://aczisc.dal.ca/
BC Burrard Inlet Environmental Action Program BIEAP	http://www.bieapfremp.org/main_bieap.html
BC Coastal Stewardship Series	http://dev.stewardshipcanada.ca/sc_bc/stew_series/NSCbc_stewseries.asp
BC Community Mapping Network	http://cmnbc.ca/
BC Ministry of Environment Oceans and Marine Fisheries Division	http://www.env.gov.bc.ca/omfd/
BC SOE CD ROM	http://www.ecoinfo.org/updates/updates_e.cfm
BC State of Coastal Environment Reports	http://www.env.gov.bc.ca/soe/bcce/index.html
Bay of Fundy Ecosystem Partnership (BoFEP)	http://www.bofep.org/
Bluenose Coastal Action Foundation (ACAP South Shore NS)	http://www.coastalaction.org/index_home.html
Canadian Water Network	http://www.cwn-rce.ca/
Census of Canada	http://www12.statcan.ca/english/census01/home/index.cfm
Coasts Under Stress	http://www.coastsunderstress.ca/home.php
DFO – Canada	http://www.environmentandresources.ca/default.asp?lang=En&n=B1F92BA4-0
DFO Atlantic Integrated Monitoring Program	http://www.meds-sdmm.dfo-mpo.gc.ca/isdm-gdsi/azmp-pmza/index-eng.html
DFO Bedford Basin Plankton Monitoring	http://www.mar.dfo-mpo.gc.ca/science/ocean/BedfordBasin/index.htm
DFO BIO Coastal Embayments Data	http://www.mar.dfo-mpo.gc.ca/science/ocean/ceice/ceice.html
DFO BIO Ocean and Ecosystem Science	http://www.mar.dfo-mpo.gc.ca/science/ocean/sci/sci-e.html
DFO BIO Science Review Reports	http://www.mar.dfo-mpo.gc.ca/science/review/e/Main-e.html
DFO Biochem Database	http://www.meds-sdmm.dfo-mpo.gc.ca/biochem/biochem_e.htm

Website Owner	URL Address
DFO Canadian Science Advisory Secretariat	http://www.meds-sdmm.dfo-mpo.gc.ca/csas/applications/Publications/publicationIndex_e.asp
DFO Canadian Scientific Committee on Oceanic Research Newsletters SCOR	http://www.cmos.ca/scor/newsletters.htm
DFO CHS-Tides, Currents, and Water Levels	http://www.lau.chs-shc.gc.ca/english/Canada.shtml
DFO Coastal Water Temperatures - Atlantic	http://www.mar.dfo-mpo.gc.ca/science/ocean/coastal_temperature/coastal_temperature.html
DFO Fisheries and Economics Information	http://www.dfo-mpo.gc.ca/stats-eng.htm
DFO Geobrowser	http://geoportal.gc.ca/publicGeoBrowser/public/GeoPortalBrowser.jsp?1240598331250
DFO Integrated Science Data Management ISDM	http://www.meds-sdmm.dfo-mpo.gc.ca/isdm-gdsi/index-eng.html
DFO Mapping and Data (Infocentre) | Oceans and Fish Habitat	http://www.dfo-mpo.gc.ca/oceans-habitat/infocentre/mapping-data_e.asp
DFO Marine Environmental Data Services (MEDS)	http://www.meds-sdmm.dfo-mpo.gc.ca/meds/Databases/Data_e.htm
DFO Maritimes Information Climate Change and SLR	http://www.mar.dfo-mpo.gc.ca/lib-bib/mrir/climate_change_and_sea_level_rise-eng.html
DFO Maritimes Ocean and Ecosystem Science Publications	http://www.mar.dfo-mpo.gc.ca/science/ocean/sci/publications-e.html
DFO Maritimes Region Homepage	http://www.mar.dfo-mpo.gc.ca/intro/index-eng.html
DFO Maritimes Region Oceans Management Program Overview	http://www.mar.dfo-mpo.gc.ca/oceans/e/ocmd/ocmd-e.html
DFO Newfoundland	http://www.nfl.dfo-mpo.gc.ca/e0004341
DFO North Pacific Marine Science Organization PICES	http://www.pices.int/publications/special_publications/NPESR/2005/npesr_2005.aspx
DFO Oceanographic Databases	http://www.mar.dfo-mpo.gc.ca/science/ocean/database/data_query.html
DFO Pacific Photos and links to MEHSD sites	http://www.pac.dfo-mpo.gc.ca/science/facilities-installations/index-eng.htm
DFO Pacific Publications	http://www-heb.pac.dfo-mpo.gc.ca/publications/publications_e.htm
DFO Quebec St. Lawrence Observatory	http://www.osl.gc.ca/en/index.html
DFO Reports and Publications	http://www.dfo-mpo.gc.ca/reports-rapports-eng.htm
DFO Statistical Services -Oceans Economy	http://www.dfo-mpo.gc.ca/communic/statistics/oceans/economy/contribution/part037_e.htm
DFO Statistical Services Seafisheries Landings	http://www.dfo-mpo.gc.ca/communic/statistics/commercial/landings/seafisheries/index_e.htm
Eastport Marine Protected Areas	http://www.eastportmpa.com/links.htm
EC Atlantic Envirodat Water Quality Database	http://map.ns.ec.gc.ca/envirodat/root/main/en/main_e.asp
EC Ecological Monitoring and Assessment Network	http://www.on.ec.gc.ca/eman/index.cfm

Website Owner	URL Address
EC E-MAP	http://www.e-map.gc.ca/e-map-program-programme.asp?language=EN
EC Environmental Emergencies Mapping Program	http://www.ns.ec.gc.ca/mapping/index.html
EC Environmental Indicators and SOE Report	http://www.ec.gc.ca/soer-ree/English/resource_network/bg_paper1_e.cfm
EC Freshwater Water Quality	http://www.ec.gc.ca/WATER/en/manage/qual/e_qual.htm
EC Freshwater Website	http://www.ec.gc.ca/WATER/e_main.html
EC Georgia Basin Puget Sound Ecosystem Indicators	http://www.pyr.ec.gc.ca/georgiabasin/reports/EnvInd_Report/summary_e.htm
EC Geospatial Information and Systems	http://www.eman-rese.ca/eman/ecotools/gisarea/intro.html
EC Great Lakes Data and Information	http://www.on.ec.gc.ca/greatlakes/default.asp?lang=En&n=95AF4814-1
EC Municipal Water and Wastewater Survey (MWWS)	http://www.ec.gc.ca/water/MWWS/en/index.cfm
EC National Ecological Framework for Canada	http://www.ec.gc.ca/soer-ree/English/Framework/default.cfm
EC National Environmental Effects Monitoring Office	http://www.ec.gc.ca/esee-eem/default.asp?lang=En&n=4B14FBC1-1
EC National Environmental Indicator Series 2003	http://www.ec.gc.ca/soer-ree/English/Indicator_series/default.cfm
EC Ontario Region Information System for the Environment	http://www.on.ec.gc.ca/ORISE/orise.html?Lang=e
EC Pacific and Yukon Environmental Indicators	http://www.ecoinfo.org/env_ind/indicators_e.cfm
EC State of the Environment Reports	http://www.ec.gc.ca/soer-ree/English/SOER/default.cfm
EC Survey on the Importance of Nature to Canadians	http://www.ec.gc.ca/nature/index_e.htm
EC Tracking key environmental issues	http://www.ec.gc.ca/TKEI/toc/toc_e.cfm
EC Water Survey Canada - Data Products & Services	http://www.wsc.ec.gc.ca/products/main_e.cfm?cname=products_e.cfm
ECOMAP	http://geogratis.cgdi.gc.ca/Ecosystem/ecosystem.html
Fishermen and Scientists Research Society (FSRS)	http://www.fsrs.ns.ca/fsrs/
GeoBase	http://geobase.ca/geobase/en/index.html
GeoBase - GeoBase Orthoimage 2005-2010	http://www.geobase.ca/geobase/en/data/imagery/imr/description.html
GeoBase - National Hydro Network	http://www.geobase.ca/geobase/en/data/nhn/index.html
Geoconnections Discovery Portal	http://geodiscover.cgdi.ca/gdp/index.jsp?language=en
Great Lakes Indicators Program	http://eagle.nrri.umn.edu/pub_documents/EPAreport/Center_rep_fnl_hres.pdf
Great Lakes United - Home page	http://www.glu.org/
Great Lakes Water Quality Agreement Review	http://www.canamglass.org/glwqa/
Gulf of Maine Council on the Marine Environment	http://www.gulfofmaine.org/
Gulf of Maine Summit and Indicators Reports	http://www.gulfofmainesummit.org/report.html

Website Owner	URL Address
NL Government Moving Forward with Coastal & Ocean Management	http://www.releases.gov.nl.ca/releases/2008/fishaq/0219n04.htm
NRCAN Coastweb	http://gsc.nrcan.gc.ca/coast/facts_e.php
NRCAN CoastWeb	http://gsc.nrcan.gc.ca/coast/facts_e.php
NRCAN GeoGratis	http://geogratis.cgdi.gc.ca/geogratis/en/index.html
NRCAN Geoscience Data Repository	http://gdr.nrcan.gc.ca/index_e.php
NRCAN NS Landscape Photographs	http://gsc.nrcan.gc.ca/landscapes/index_e.php
NS Ecological Land Classification	http://gov.ns.ca/GeoNova/outside/?OutSideURL=http%3A%2F%2Fwww.gov.ns.ca%2Fnatr%2Forestry%2Frlul%2Fthemes.htm
NS Forestry Inventory GIS	http://gov.ns.ca/GeoNova/outside/?OutSideURL=http://www.gov.ns.ca/natr/forestry/GIS/
PAME Arctic Portal	http://arcticportal.org/en/pame/
State of the Northern Yukon	http://www.taiga.net/nysoe/
Statistics CAN E-STAT Software	http://www.statcan.gc.ca/estat/licence-eng.htm
Statistics Canada - Nova Scotia	http://www40.statcan.gc.ca/l01/pro01/pro103-eng.htm
The Atlas of Canada	http://www.canadiangeographic.ca/atlas/
The Atlas of Canada - Coastal Sensitivity to Sea-Level Rise	http://atlas.nrcan.gc.ca/site/english/maps/climatechange/potentialimpacts/coastalsensitivitysealevelrise/1
UWaterloo E-Reference for Maps	http://ereference.uwaterloo.ca/display.cfm?categoryID=36&catHeading=Maps%20/%20Atlases#AerialPhotographs&SatelliteImages
Water Balance Model - Canada	http://www.waterbalance.ca/
Water Connections Centre for sustainable watersheds Canada	http://www.waterconnect.ca/
WetKit - Tools for working with wetlands in Canada	http://www.wetkit.net/modules/1/
Yukon State of the Environment Reporting	http://www.environmentyukon.gov.yk.ca/monitoringenvironment/stateenvironment.php

APPENDIX D
SUPPORTING DATA

Table D1: 2006-2008 Water Quality Sampling Sites
(an X denotes an area sampled)

Coastal Receiving Area	River Watershed	Primary Site Number	2007			2006			2008	
			1 River	2 Inner Cove	3 Outer Cove	1 River	4 Mid Bay	5 Outer Bay	1 River	4 Mid Bay
Cape St. Marys		1								X
Lobster Bay		2								X
Yarmouth		3								X
Chebogue		4								X
Barrington Bay	Barrington River	5				X	X	X	X	X
	Clyde River	6				X				
Shelburne Harbour	Roseway River	7	X	X	X	X	X	X	X	X
Jordan Harbour	Jordan River	8	X			X	X	X	X	
Sable River Estuary	Sable River	9	X			X	X	X	X	
	Tidney River	10	X							
Port Jolie Harbour	West Brook	11	X							
	East Brook	12	X	X						
Port Mouton Bay	Broad River	13								X
Liverpool Bay	Mersey River	14	X			X	X	X	X	X
Port Medway Harbour	Medway River	15	X			X				
La Have Estuary	LaHave River	16	X	X		X	X	X	X	
Mahone Bay Harbour	West side town Brook	17	X							
	Mushamush River	18	X	X	X		X	X		
Chester Basin	Chester Harbour	19		X		X				
Mahone Bay East	East River	20				X			?	
Hubbards Cove	Hubbards River (Fitzroy R)	21	X	X	X	X				
Ingram Cove	Ingram River	22	X							

Coastal Receiving Area	River Watershed	Primary Site Number	2007			2006			2008	
			1 River	2 Inner Cove	3 Outer Cove	1 River	4 Mid Bay	5 Outer Bay	1 River	4 Mid Bay
Head St. Margarets Bay	Indian River East fork	23	X							
	Mill Lake Outflow	24	X							
	Hubley Mill Lake outflow	25	X	X	X					
Sackville Cove	Moirs Mill Run	26	X	X						
	Sackville River	27	X	X						
Dartmouth Cove	Shubenacadi e Lakes	28	X							
Cow Bay Outer Shore	Smelt Brook, Morris Lake	29	X							
Cole Harbour Marsh	Little Salmon River	30	X							
	Porter's Lake	31								X
Musquodoboit Harbour	Musquodoboit River	32	X	X		X				X
Ship Harbour	Little River Plus others?	33				X	X	X		X
Tangier Harbour	Tangier River	34				X				
Sheet Harbour	West River	35				X	X	X	X	
	East River	36				X			X	
Port Dufferin		37				X				
Quoddy Harbour	Quoddy River	38				X	X	X	X	
Ecum Secum Harbour	Ecum Secum River	39				X	X	X	X	
Liscombe Harbour	Liscombe River	40				X	X	X	X	X
St. Mary's River Estuary	St. Mary's River	41				X	X	X	X	X
Indian Harbour	Indian River	42				X				
Country Harbour	Country Harbour River	43				X	X	X	X	
Isaacs Harbour	Isaacs Harbour River	44				X	X	X	X	
New Harbour	New Harbour River	45				X	X	X	X	X
Tor Bay	Larrys River	46				X			X	
Whitehead Harbour	Otter Brook and Others	47				X	X	X	X	X

Table D2: 2006-2008 Atlantic Coastal Landscape Water Quality and Land Cover Data

Pri Site No	Sec Site No	Location	Sample Date	Forest Cover	Wetland Cover	Buffered Watercourse	Urban Cover	Agricultural Cover	Distance from Null Point (km)	NH4 (µM)	NO3 (µM)	TIN (µM)	PO4 (µM)	TP (µM)
1	4	Cape St. Mary's	9-Jun-08	0.74	0.07	0.81	0.02	0.02	1.95		1.16	1.16	0.23	1.39
2	4	Lobster Bay	9-Jun-08	0.69	0.09	0.78	0.02	0.01	1.30		1.17	1.17	0.26	1.16
3	4	Yarmouth Harbour	9-Jun-08	0.46	0.05	0.51	0.12	0.07	2.62		1.2	1.20	0.33	1.45
4	4	Chebogue Harbour	9-Jun-08	0.44	0.17	0.61	0.11	0.09	4.50		1.14	1.14	0.29	1.32
5	1	Barrington River	9-May-06	0.62	0.16	0.79	0.02	0.00	0.00	0.08	0.50	0.58	0.30	
5	4	Barrington Bay	23-May-06	0.62	0.16	0.79	0.02	0.00	1.94	0.42	0.77	1.19	0.55	0.52
5	1	Barrington River	28-Jun-06	0.62	0.16	0.79	0.02	0.00	0.00	0.58	2.00	2.58	0.32	
5	4	Barrington Bay	1-Jul-06	0.62	0.16	0.79	0.02	0.00	2.58	0.06	0.6	0.66	0.42	0.96
5	5	Barrington Bay	2-Jul-06	0.62	0.16	0.79	0.02	0.00	5.82	0	0.57	0.57	0.49	0.63
5	5	Barrington Bay	25-Jul-06	0.62	0.16	0.79	0.02	0.00	6.01	0	1.22	1.22	0.4	
5	4	Barrington Bay	25-Jul-06	0.62	0.16	0.79	0.02	0.00	3.13	0.8	0.98	1.78	0.48	
5	1	Barrington River	8-Aug-06	0.62	0.16	0.79	0.02	0.00	0.00	0.28	1.64	1.92	0.43	
5	5	Barrington Bay	19-Aug-06	0.62	0.16	0.79	0.02	0.00	6.55	0	0.92	0.92	0.52	
5	4	Barrington Bay	19-Aug-06	0.62	0.16	0.79	0.02	0.00	2.58	0	0.94	0.94	0.44	
5	4	Barrington Bay	10-Jun-08	0.62	0.16	0.79	0.02	0.00	6.36		1.15	1.15	0.3	1.42
5	1	Barrington River	26-Jun-08	0.62	0.16	0.79	0.02	0.00	0.00	0.47	2.11	2.58	0.25	
6	1	Clyde River	9-May-06	0.66	0.15	0.81	0.01	0.00	0.00	0.00	0.85	0.85	0.21	
7	1	Roseway River	9-May-06	0.71	0.11	0.82	0.01	0.00	0.00	0.00	0.62	0.62	0.21	
7	4	Shelburne Harbour	23-May-06	0.71	0.11	0.82	0.01	0.00	9.50	1.95	0.95	2.90	0.6	0.98
7	4	Shelburne Harbour	23-May-06	0.71	0.11	0.82	0.01	0.00	6.63	1.56	0.96	2.52	0.81	0.39
7	1	Roseway River	28-Jun-06	0.71	0.11	0.82	0.01	0.00	0.00	0.56	1.30	1.86	0.38	
7	5	Shelburne Harbour	1-Jul-06	0.71	0.11	0.82	0.01	0.00	5.46	1.62	1.28	2.90	0.68	0.89
7	4	Shelburne Harbour	1-Jul-06	0.71	0.11	0.82	0.01	0.00	4.32	1.2	1.3	2.50	0.39	0.28
7	5	Shelburne Harbour	20-Jul-06	0.71	0.11	0.82	0.01	0.00	10.41	0.33	1.4	1.73	0.4	
7	4	Shelburne Harbour	20-Jul-06	0.71	0.11	0.82	0.01	0.00	2.29	0.5	1.52	2.02	0.32	
7	1	Roseway River	9-Aug-06	0.71	0.11	0.82	0.01	0.00	0.00	0.40	1.76	2.16	0.47	
7	5	Shelburne Harbour	19-Aug-06	0.71	0.11	0.82	0.01	0.00	9.89	0	1.1	1.10	0.52	

Pri Site No	Sec Site No	Location	Sample Date	Forest Cover	Wetland Cover	Buffered Watercourse	Urban Cover	Agricultural Cover	Distance from Null Point (km)	NH4 (µM)	NO3 (µM)	TIN (µM)	PO4 (µM)	TP (µM)
7	4	Shelburne Harbour	19-Aug-06	0.71	0.11	0.82	0.01	0.00	2.84	0	0.94	0.94	0.41	
7	1	Roseway River	11-Jul-07	0.71	0.11	0.82	0.01	0.00	0.00	0.98	2.12	3.10	0.13	
7	3	Shelburne Harbour	12-Jul-07	0.71	0.11	0.82	0.01	0.00	1.93	0.14	2.21	2.35	0.4	
7	2	Shelburne Harbour	12-Jul-07	0.71	0.11	0.82	0.01	0.00	1.67		1.77	1.77	0.25	
7	3	Shelburne Harbour	12-Jul-07	0.71	0.11	0.82	0.01	0.00	0.99		1.86	1.86	0.36	
7	4	Shelburne Harbour	10-Jun-08	0.71	0.11	0.82	0.01	0.00	5.19		1.3	1.30	0.26	1.01
7	1	Roseway River	26-Jun-08	0.71	0.11	0.82	0.01	0.00	0.00	0.81	2.08	2.89	0.34	
8	1	Jordan River	9-May-06	0.73	0.12	0.85	0.01	0.00	0.00	0.00	0.85	0.85	0.23	
8	5	Jordan Bay	24-May-06	0.73	0.12	0.85	0.01	0.00	18.02	0.1	1.01	1.11	0.58	0.75
8	3	Jordan Bay	24-May-06	0.73	0.12	0.85	0.01	0.00	4.75	0.76	1.06	1.82	0.64	0.72
8	1	Jordan River	28-Jun-06	0.73	0.12	0.85	0.01	0.00	0.00	0.00	1.22	1.22	0.34	
8	5	Jordan Bay	1-Jul-06	0.73	0.12	0.85	0.01	0.00	14.96	1.1	1.74	2.84	0.6	0.78
8	5	Jordan Bay	20-Jul-06	0.73	0.12	0.85	0.01	0.00	13.87	0.9	2.16	3.06	0.66	
8	4	Jordan Bay	20-Jul-06	0.73	0.12	0.85	0.01	0.00	10.03	0	0.67	0.67	0.46	
8	1	Jordan River	9-Aug-06	0.73	0.12	0.85	0.01	0.00	0.00	0.00	0.94	0.94	0.52	
8	5	Jordan Bay	19-Aug-06	0.73	0.12	0.85	0.01	0.00	14.48	0	1.4	1.40	0.6	
8	4	Jordan Bay	19-Aug-06	0.73	0.12	0.85	0.01	0.00	9.89	0	0.73	0.73	0.52	
8	1	Jordan River	12-Jul-07	0.73	0.12	0.85	0.01	0.00	0.00	0.17	2.48	2.65	0.09	
8	1	Jordan River	26-Jun-08	0.73	0.12	0.85	0.01	0.00	0.00	0.36	1.87	2.23	0.34	
9	1	Sable River	9-May-06	0.73	0.20	0.93	0.01	0.00	0.00	0.58	1.50	2.08	0.33	
9	4	Sable River	28-May-06	0.73	0.20	0.93	0.01	0.00	12.71	0	1.62	1.62	0.64	0.8
9	4	Sable River	28-May-06	0.73	0.20	0.93	0.01	0.00	9.49	0.6	1.36	1.96	0.72	0.48
9	1	Sable River	28-Jun-06	0.73	0.20	0.93	0.01	0.00	0.00	0.12	1.13	1.25	0.40	
9	5	Sable River	2-Jul-06	0.73	0.20	0.93	0.01	0.00	13.14	0.29	2.09	2.38	0.55	0.72
9	5	Sable River	20-Jul-06	0.73	0.20	0.93	0.01	0.00	13.48	0.18	1.59	1.77	0.52	
9	4	Sable River	20-Jul-06	0.73	0.20	0.93	0.01	0.00	9.30	0.84	1.26	2.10	0.67	
9	1	Sable River	9-Aug-06	0.73	0.20	0.93	0.01	0.00	0.00	0.31	1.16	1.47	0.58	
9	5	Sable River	19-Aug-06	0.73	0.20	0.93	0.01	0.00	12.29	0	1.34	1.34	0.54	
9	4	Sable River	19-Aug-06	0.73	0.20	0.93	0.01	0.00	9.04	0	0.97	0.97	0.44	

Pri Site No	Sec Site No	Location	Sample Date	Forest Cover	Wetland Cover	Buffered Watercourse	Urban Cover	Agricultural Cover	Distance from Null Point (km)	NH4 (µM)	NO3 (µM)	TIN (µM)	PO4 (µM)	TP (µM)
9	1	Sable River	12-Jul-07	0.73	0.20	0.93	0.01	0.00	0.00		2.36	2.36	0.11	
9	1	Sable River	26-Jun-08	0.73	0.20	0.93	0.01	0.00	0.00	0.28	1.74	2.02	0.48	
10	1	Tidney River	12-Jul-07	0.73	0.20	0.93	0.01	0.00	0.00	0.60	2.40	2.99	0.14	
11	1	West Brook	12-Jul-07	0.67	0.07	0.73	0.01	0.00	0.00	0.78	2.52	3.29	0.12	
12	2	Port Jolie Harbour	12-Jul-07	0.67	0.07	0.73	0.01	0.00	2.84	1.9	1.88	3.78	1	
12	1	East Brook	12-Jul-07	0.67	0.07	0.73	0.01	0.00	0.00	0.80	2.68	3.47	0.15	
13	4	Port Mouton	10-Jun-08	0.71	0.16	0.87	0.01	0.00	2.27		1.22	1.22	0.22	1.39
14	2	Mersey River	9-May-06	0.70	0.08	0.78	0.01	0.00	2.42	0.09	4.31	4.40	0.16	
14	4	Liverpool Bay	28-May-06	0.70	0.08	0.78	0.01	0.00	8.90	0.21	1.18	1.39	0.7	0.56
14	4	Liverpool Bay	28-May-06	0.70	0.08	0.78	0.01	0.00	5.86	1.16	1.32	2.48	0.84	0.6
14	2	Mersey River	28-Jun-06	0.70	0.08	0.78	0.01	0.00	2.53	0.50	3.40	3.90	0.16	
14	5	Liverpool Bay	2-Jul-06	0.70	0.08	0.78	0.01	0.00	7.41	0.32	2.04	2.36	0.68	0.77
14	5	Liverpool Bay	25-Jul-06	0.70	0.08	0.78	0.01	0.00	8.15	0.1	1.37	1.47	0.48	
14	4	Liverpool Bay	25-Jul-06	0.70	0.08	0.78	0.01	0.00	8.08	3.3	2.41	5.71	0.68	
14	2	Mersey River	9-Aug-06	0.70	0.08	0.78	0.01	0.00	2.53	0.50	4.52	5.02	0.15	
14	5	Liverpool Bay	19-Aug-06	0.70	0.08	0.78	0.01	0.00	7.25	0	1.15	1.15	0.51	
14	4	Liverpool Bay	19-Aug-06	0.70	0.08	0.78	0.01	0.00	5.38	0.78	2.6	3.38	0.3	
14	1	Mersey River	10-Jul-07	0.70	0.08	0.78	0.01	0.00	0.00	0.89	8.33	9.21	0.07	
14	4	Liverpool Harbour	10-Jun-08	0.70	0.08	0.78	0.01	0.00	5.38		1.28	1.28	0.39	0.87
14	2	Mersey River	26-Jun-08	0.70	0.08	0.78	0.01	0.00	2.53	0.27	1.18	1.45	0.24	
15	1	Medway River	9-May-06	0.76	0.06	0.82	0.01	0.01	0.00	0.00	0.71	0.71	0.13	
15	1	Medway River	10-Jul-07	0.76	0.06	0.82	0.01	0.01	0.00	0.38	1.81	2.18	0.06	
16	1	LaHave River	9-May-06	0.73	0.05	0.78	0.03	0.03	0.00	0.09	0.83	0.92	0.12	
16	4	LaHave River	29-May-06	0.73	0.05	0.78	0.03	0.03	26.60	0	0.65	0.65	0.6	0.6
16	4	LaHave River	29-May-06	0.73	0.05	0.78	0.03	0.03	20.82	0.21	1.18	1.39	0.78	0.48
16	1	LaHave River	28-Jun-06	0.73	0.05	0.78	0.03	0.03	0.00	0.17	1.64	1.81	0.18	
16	5	LaHave River	2-Jul-06	0.73	0.05	0.78	0.03	0.03	23.03	0.8	1.23	2.03	0.48	0.96
16	5	LaHave River	25-Jul-06	0.73	0.05	0.78	0.03	0.03	22.77	0.48	1.21	1.69	0.52	
16	4	LaHave River	25-Jul-06	0.73	0.05	0.78	0.03	0.03	17.83	1.85	2.6	4.45	0.2	

Pri Site No	Sec Site No	Location	Sample Date	Forest Cover	Wetland Cover	Buffered Watercourse	Urban Cover	Agricultural Cover	Distance from Null Point (km)	NH4 (µM)	NO3 (µM)	TIN (µM)	PO4 (µM)	TP (µM)
16	1	LaHave River	9-Aug-06	0.73	0.05	0.78	0.03	0.03	0.00	1.07	2.50	3.57	0.27	
16	5	LaHave River	19-Aug-06	0.73	0.05	0.78	0.03	0.03	23.37	0	0.9	0.90	0.27	
16	4	LaHave River	19-Aug-06	0.73	0.05	0.78	0.03	0.03	17.83	0	0.74	0.74	0.16	
16	2	LaHave Estuary, Bridgewater	12-Jul-07	0.73	0.05	0.78	0.03	0.03	5.85	1.55	3.01	4.56	0.12	
16	1	LaHave River	12-Jul-07	0.73	0.05	0.78	0.03	0.03	0.00	0.44	2.75	3.19	0.05	
16	1	LaHave River	26-Jun-08	0.73	0.05	0.78	0.03	0.03	0.00	0.28	2.18	2.46	0.26	
17	1	Mahone Bay Brook	12-Jul-07	0.71	0.05	0.76	0.04	0.02	0.00	1.18	4.73	5.91	0.38	
18	1	East Mahone Brook	5-May-06	0.71	0.05	0.76	0.04	0.02	0.00	1.40	1.15	2.55	0.13	
18	1	Mahone Bay River	9-May-06	0.71	0.05	0.76	0.04	0.02	0.00	0.00	0.76	0.76	0.10	
18	4	Mahone Harbour	29-May-06	0.71	0.05	0.76	0.04	0.02	8.08	0	0.53	0.53	0.46	0.46
18	4	Mahone Harbour	29-May-06	0.71	0.05	0.76	0.04	0.02	4.35	0	0.56	0.56	0.43	0.6
18	1	Mahone Bay River	28-Jun-06	0.71	0.05	0.76	0.04	0.02	0.00	0.26	0.95	1.21	0.11	
18	5	Mahone Harbour	2-Jul-06	0.71	0.05	0.76	0.04	0.02	3.73	4.66	1.46	6.12	0.82	0.68
18	4	Mahone Harbour	2-Jul-06	0.71	0.05	0.76	0.04	0.02	2.07	0	0.81	0.81	0.42	0.52
18	5	Mahone Harbour	25-Jul-06	0.71	0.05	0.76	0.04	0.02	4.42	0.22	0.64	0.86	0.54	
18	4	Mahone Harbour	25-Jul-06	0.71	0.05	0.76	0.04	0.02	1.86	0	0.84	0.84	0.36	
18	4	Mahone Harbour	19-Aug-06	0.71	0.05	0.76	0.04	0.02	1.62	0	0.96	0.96	0.33	
18	5	Mahone Harbour	19-Aug-06	0.71	0.05	0.76	0.04	0.02	1.80	0.72	1.65	2.37	0.95	
18	2	Mahone Harbour	9-Jul-07	0.71	0.05	0.76	0.04	0.02	1.10		1.64	1.64	0.23	
18	3	Mahone Harbour	12-Jul-07	0.71	0.05	0.76	0.04	0.02	1.20	0.67	1.53	2.20	0.45	
18	2	Mahone Harbour	12-Jul-07	0.71	0.05	0.76	0.04	0.02	1.10	2.52	1.26	3.78	0.35	
18	2	Mahone Harbour	12-Jul-07	0.71	0.05	0.76	0.04	0.02	0.77	0.31	1.95	2.26	0.33	
18	1	Mahone Bay River	12-Jul-07	0.71	0.05	0.76	0.04	0.02	0.00	1.42	2.79	4.21	0.23	
18	1	Mahone Bay River	26-Jun-08	0.71	0.05	0.76	0.04	0.02	0.00	1.02	1.7	2.72	0.37	
19	1	Chester Basin	9-Aug-06	0.71	0.05	0.76	0.04	0.02	0.00	0.31	1.40	1.71	0.26	
19	2	Chester	9-Jul-07	0.71	0.05	0.76	0.04	0.02	1.33	0.35	1.84	2.18	0.27	
20	1	East River	5-May-06	0.71	0.05	0.76	0.04	0.02	0.00	1.00	0.76	1.76	0.19	
21	1	Hubbards River	5-May-06	0.66	0.03	0.70	0.04	0.00	0.00	0.00	0.72	0.72	0.16	

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21	3	Hubbards Cove	8-Jul-07	0.66	0.03	0.70	0.04	0.00	1.07	0.17	1.51	1.68	0.65	
21	2	Hubbards Cove	8-Jul-07	0.66	0.03	0.70	0.04	0.00	0.72	0.53	3.59	4.12	0.47	
21	1	Hubbards River	8-Jul-07	0.66	0.03	0.70	0.04	0.00	0.00	0.62	5.16	5.78	0.17	
23	1	Indian River	8-Jul-07	0.66	0.03	0.70	0.04	0.00	0.00	0.82	2.35	3.17	0.16	
24	1	Mill Lake Outflow	8-Jul-07	0.66	0.03	0.70	0.04	0.00	0.00	0.42	2.66	3.07	0.08	
25	1	Hubley Mill outlet	8-Jul-07	0.66	0.03	0.70	0.04	0.00	0.00	0.51	4.82	5.32	0.15	
25	3	Hd St. Margaret's Bay	9-Jul-07	0.66	0.03	0.70	0.04	0.00	3.47		3.22	3.22	0.37	
25	3	Hd St. Margaret's Bay	9-Jul-07	0.66	0.03	0.70	0.04	0.00	2.62	0.11	1.46	1.57	0.43	
25	2	Hd St. Margaret's Bay	9-Jul-07	0.66	0.03	0.70	0.04	0.00	1.93		1.27	1.27	0.33	
26	1	Moirs Mill Run	8-Jul-07	0.48	0.04	0.52	0.29	0.00	0.00		10.27	10.27	0.04	
27	1	Sackville River	7-Jul-07	0.48	0.04	0.52	0.29	0.00	0.00		7.67	7.67	0.12	
27	2	Sackville Cove	8-Jul-07	0.48	0.04	0.52	0.29	0.00	0.98	6.66	4.79	11.44	0.55	
28	1	Shubenacadie outlet	7-Jul-07	0.48	0.04	0.52	0.29	0.00	0.00	2.63	5.14	7.76	0.07	
29	1	Smelt Brook, Cow Bay	7-Jul-07	0.38	0.05	0.43	0.36	0.01	0.00	0.34	10.78	11.11	0.10	
30	1	Salmon River CH	7-Jul-07	0.64	0.06	0.70	0.09	0.01	0.00		6.78	6.78	0.00	
31	1	Porter's Lake	6-Jun-08	0.63	0.06	0.69	0.04	0.00	0.00		3.62	3.62	0.32	0.63
32	1	Musquodoboit River	5-May-06	0.67	0.07	0.74	0.01	0.06	0.00	0.21	5.59	5.80	0.11	
32	2	Musquodoboit Hbr	7-Jul-07	0.67	0.07	0.74	0.01	0.06	0.85	3.07	4.11	7.18	0.45	
32	1	Musquodoboit River	7-Jul-07	0.67	0.07	0.74	0.01	0.06	0.00	0.23	4.48	4.71	0.03	
32	1	Musquodoboit River	7-Jul-07	0.67	0.07	0.74	0.01	0.06	0.00	0.94	5.31	6.24	0.04	
32	4	Musquodoboit Hbr	6-Jun-08	0.67	0.07	0.74	0.01	0.06	6.84		1.43	1.43	0.36	1.02
33	1	Little River	5-May-06	0.74	0.08	0.82	0.01	0.00	0.00	0.00	1.99	1.99	0.08	
33	5	Ship Harbour	19-Jun-06	0.74	0.08	0.82	0.01	0.00	8.94	0	0.65	0.65	0.38	0.98
33	4	Ship Harbour	19-Jun-06	0.74	0.08	0.82	0.01	0.00	4.46	0	1.44	1.44	0.26	0.35
33	1	Little River	27-Jun-06	0.74	0.08	0.82	0.01	0.00	0.00	0.00	1.70	1.70	0.10	

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33	5	Ship Harbour	14-Jul-06	0.74	0.08	0.82	0.01	0.00	8.70	0	0.93	0.93	0.43	
33	4	Ship Harbour	14-Jul-06	0.74	0.08	0.82	0.01	0.00	3.26	0	0.88	0.88	0.34	
33	1	Little River	8-Aug-06	0.74	0.08	0.82	0.01	0.00	0.00	0.00	1.02	1.02	0.22	
33	5	Ship Harbour	17-Aug-06	0.74	0.08	0.82	0.01	0.00	9.30	0.28	1.2	1.48	0.6	
33	4	Ship Harbour	17-Aug-06	0.74	0.08	0.82	0.01	0.00	3.09	0	0.74	0.74	0.3	
33	4	Ship Harbour	6-Jun-08	0.74	0.08	0.82	0.01	0.00	3.26		1.33	1.33	0.34	0.75
33	1	Ship Harbour	23-Jun-08	0.74	0.08	0.82	0.01	0.00	0.00	0.28	1.28	1.56	0.2	
34	1	Tangier Harbour	5-May-06	0.74	0.08	0.82	0.01	0.00	0.00	0.06	0.37	0.43	0.16	
35	1	East River SP H	5-May-06	0.71	0.09	0.80	0.00	0.00	0.00	0.78	0.21	0.99	0.22	
35	1	East River SP H	27-Jun-06	0.71	0.09	0.80	0.00	0.00	0.00	2.40	1.00	3.40	0.32	
35	1	East River SP H	8-Aug-06	0.71	0.09	0.80	0.00	0.00	0.00	0.52	0.75	1.27	0.24	
36	1	West River SP H	5-May-06	0.71	0.09	0.80	0.00	0.00	0.00	0.00	0.62	0.62	0.12	
36	5	Sheet Harbour	22-Jun-06	0.71	0.09	0.80	0.00	0.00	5.04	2.29	1.58	3.87	0.81	0.6
36	4	Sheet Harbour	22-Jun-06	0.71	0.09	0.80	0.00	0.00	2.92	0.2	1.03	1.23	0.36	0.38
36	1	West River SH	27-Jun-06	0.71	0.09	0.80	0.00	0.00	0.00	0.50	2.16	2.66	0.19	
36	5	Sheet Harbour	14-Jul-06	0.71	0.09	0.80	0.00	0.00	6.94	1.84	2.64	4.48	0.8	
36	4	Sheet Harbour	14-Jul-06	0.71	0.09	0.80	0.00	0.00	2.08	0.49	1.72	2.21	0.35	
36	1	West River SH	8-Aug-06	0.71	0.09	0.80	0.00	0.00	0.00	0.20	0.84	1.04	0.24	
36	5	Sheet Harbour	17-Aug-06	0.71	0.09	0.80	0.00	0.00	5.52	2.24	1.89	4.13	0.82	
36	4	Sheet Harbour	17-Aug-06	0.71	0.09	0.80	0.00	0.00	1.60	0	0.92	0.92	0.14	
36	1	East River SH	23-Jun-08	0.71	0.09	0.80	0.00	0.00	0.00	0.17	1.82	1.99	0.32	
36	1	West River SH	23-Jun-08	0.71	0.09	0.80	0.00	0.00	0.00		1.46	1.46	0.2	
37	1	Port Dufferin	5-May-06	0.70	0.10	0.80	0.01	0.00	0.00	0.00	0.39	0.39	0.11	
38	5	Quoddy Harbour	22-Jun-06	0.82	0.07	0.89	0.01	0.00	2.64	0	0.57	0.57	0.43	0.6
38	4	Quoddy Harbour	22-Jun-06	0.82	0.07	0.89	0.01	0.00	1.04	0	0.68	0.68	0.2	0.36
38	1	Quoddy River	27-Jun-06	0.82	0.07	0.89	0.01	0.00	0.00	0.13	0.88	1.01	0.20	
38	5	Quoddy Harbour	14-Jul-06	0.82	0.07	0.89	0.01	0.00	4.07	0	0.58	0.58	0.38	
38	5	Quoddy Harbour	14-Jul-06	0.82	0.07	0.89	0.01	0.00	1.21	0	0.59	0.59	0.34	
38	1	Quoddy River	8-Aug-06	0.82	0.07	0.89	0.01	0.00	0.00	0.53	0.54	1.07	0.34	

Pri Site No	Sec Site No	Location	Sample Date	Forest Cover	Wetland Cover	Buffered Watercourse	Urban Cover	Agricultural Cover	Distance from Null Point (km)	NH4 (µM)	NO3 (µM)	TIN (µM)	PO4 (µM)	TP (µM)
38	5	Quoddy Harbour	17-Aug-06	0.82	0.07	0.89	0.01	0.00	4.58	0	1.1	1.10	0.58	
38	4	Quoddy Harbour	17-Aug-06	0.82	0.07	0.89	0.01	0.00	1.14	0	0.88	0.88	0.5	
38	1	Quoddy River	23-Jun-08	0.82	0.07	0.89	0.01	0.00	0.00	0.23	1.18	1.41	0.24	
39	1	Ecum Secum River	5-May-06	0.73	0.08	0.82	0.02	0.00	0.00	1.51	0.71	2.22	0.11	
39	5	Ecum Secum Harbour	22-Jun-06	0.73	0.08	0.82	0.02	0.00	2.96	0	0.82	0.82	0.5	0.5
39	4	Ecum Secum Harbour	22-Jun-06	0.73	0.08	0.82	0.02	0.00	0.81	0.38	0.82	1.20	0.47	0.52
39	1	Ecum Secum River	27-Jun-06	0.73	0.08	0.82	0.02	0.00	0.00	0.82	0.44	1.26	0.14	
39	5	Ecum Secum Harbour	12-Jul-06	0.73	0.08	0.82	0.02	0.00	3.07	0	0.54	0.54	0.36	
39	4	Ecum Secum Harbour	12-Jul-06	0.73	0.08	0.82	0.02	0.00	1.25	0	0.92	0.92	0.24	
39	1	Ecum Secum River	8-Aug-06	0.73	0.08	0.82	0.02	0.00	0.00	0.70	0.00	0.70	0.40	
39	5	Ecum Secum Harbour	17-Aug-06	0.73	0.08	0.82	0.02	0.00	4.01	0.62	1.5	2.12	0.61	
39	4	Ecum Secum Harbour	17-Aug-06	0.73	0.08	0.82	0.02	0.00	1.45	0.3	0.92	1.22	0.48	
39	1	Ecum Secum River	23-Jun-08	0.73	0.08	0.82	0.02	0.00	0.00		1.15	1.15	0.23	
40	1	Liscomb River	5-May-06	0.68	0.12	0.81	0.00	0.00	0.00	0.00	0.80	0.80	0.13	
40	4	Liscomb Harbour	13-Jun-06	0.68	0.12	0.81	0.00	0.00	7.02	0.21	0.84	1.05	0.44	0.52
40	5	Liscomb Harbour	14-Jun-06	0.68	0.12	0.81	0.00	0.00	11.48	0.6	1.36	1.96	0.6	0.55
40	1	Liscomb River	27-Jun-06	0.68	0.12	0.81	0.00	0.00	0.00	0.39	2.13	2.52	0.22	
40	4	Liscomb Harbour	12-Jul-06	0.68	0.12	0.81	0.00	0.00	4.28	0	0.64	0.64	0.38	
40	5	Liscomb Harbour	12-Jul-06	0.68	0.12	0.81	0.00	0.00	8.76	0	0.96	0.96	0.42	
40	1	Liscomb River	8-Aug-06	0.68	0.12	0.81	0.00	0.00	0.00	0.54	1.30	1.84	0.22	
40	5	Liscomb Harbour	17-Aug-06	0.68	0.12	0.81	0.00	0.00	12.68	0.32	1.34	1.66	0.54	
40	4	Liscomb Harbour	17-Aug-06	0.68	0.12	0.81	0.00	0.00	6.30	0.26	1.12	1.38	0.48	
40	4	Liscomb Harbour	6-Jun-08	0.68	0.12	0.81	0.00	0.00	5.28		1.48	1.48	0.3	0.68
40	1	Liscomb River	23-Jun-08	0.68	0.12	0.81	0.00	0.00	0.00	2.18	1.59	3.77	0.23	
41	1	St. Mary's River	5-May-06	0.76	0.08	0.84	0.00	0.01	0.00	0.00	4.16	4.16	0.08	

Pri Site No	Sec Site No	Location	Sample Date	Forest Cover	Wetland Cover	Buffered Watercourse	Urban Cover	Agricultural Cover	Distance from Null Point (km)	NH4 (µM)	NO3 (µM)	TIN (µM)	PO4 (µM)	TP (µM)
41	5	St. Mary's River	14-Jun-06	0.76	0.08	0.84	0.00	0.01	14.17	0	0.84	0.84	0.44	0.53
41	4	St. Mary's River	14-Jun-06	0.76	0.08	0.84	0.00	0.01	9.20	0	0.81	0.81	0.42	0.42
41	1	St. Mary's River	27-Jun-06	0.76	0.08	0.84	0.00	0.01	0.00	0.19	3.18	3.37	0.16	
41	5	St. Mary's River	12-Jul-06	0.76	0.08	0.84	0.00	0.01	11.93	0	0.9	0.90	0.38	
41	4	St. Mary's River	12-Jul-06	0.76	0.08	0.84	0.00	0.01	9.27	0	0.77	0.77	0.39	
41	1	St. Mary's River	8-Aug-06	0.76	0.08	0.84	0.00	0.01	0.00	0.13	2.77	2.90	0.21	
41	5	St. Mary's River	16-Aug-06	0.76	0.08	0.84	0.00	0.01	13.15	0.1	1.36	1.46	0.54	
41	4	St. Mary's River	16-Aug-06	0.76	0.08	0.84	0.00	0.01	9.42	0.42	1.13	1.55	0.25	
41	4	St. Mary's River	5-Jun-08	0.76	0.08	0.84	0.00	0.01	9.26		1.99	1.99	0.46	1.59
41	1	St. Mary's River	23-Jun-08	0.76	0.08	0.84	0.00	0.01	0.00	0.19	3.12	3.31	0.23	
42	1	Indian River	5-May-06	0.76	0.07	0.84	0.02	0.01	0.00	0.00	1.22	1.22	0.09	
43	1	Country Harbour River	5-May-06	0.70	0.11	0.80	0.01	0.01	0.00	0.00	1.83	1.83	0.13	
43	5	Country Harbour	13-Jun-06	0.70	0.11	0.80	0.01	0.01	6.36	0.77	1.4	2.17	0.6	0.6
43	4	Country Harbour	13-Jun-06	0.70	0.11	0.80	0.01	0.01	11.29	0.62	0.86	1.48	0.56	0.46
43	1	Country Harbour River	27-Jun-06	0.70	0.11	0.80	0.01	0.01	0.00	0.26	3.05	3.31	0.15	
43	5	Country Harbour	11-Jul-06	0.70	0.11	0.80	0.01	0.01	5.44	0	0.96	0.96	0.45	
43	4	Country Harbour	11-Jul-06	0.70	0.11	0.80	0.01	0.01	11.00	0	0.78	0.78	0.06	
43	1	Country Harbour River	8-Aug-06	0.70	0.11	0.80	0.01	0.01	0.00	0.00	0.00	0.00	0.32	
43	5	Country Harbour	16-Aug-06	0.70	0.11	0.80	0.01	0.01	6.08	1.84	2.78	4.62	0.77	
43	4	Country Harbour	16-Aug-06	0.70	0.11	0.80	0.01	0.01	12.54	0	0.97	0.97	0.32	
43	1	Country Harbour River	23-Jun-08	0.70	0.11	0.80	0.01	0.01	0.00	0.4	1.38	1.78	0.27	
44	1	Isaac's Harbour River	5-May-06	0.70	0.11	0.80	0.01	0.01	0.00	0.05	0.57	0.62	0.11	
44	4	Isaac's Harbour	13-Jun-06	0.70	0.11	0.80	0.01	0.01	2.53	0.2	0.84	1.04	0.46	0.46
44	1	Isaac's Harbour River	27-Jun-06	0.70	0.11	0.80	0.01	0.01	0.00	0.32	1.12	1.44	0.18	
44	4	Isaac's Harbour	11-Jul-06	0.70	0.11	0.80	0.01	0.01	2.52	0	0.88	0.88	0.18	

Pri Site No	Sec Site No	Location	Sample Date	Forest Cover	Wetland Cover	Buffered Watercourse	Urban Cover	Agricultural Cover	Distance from Null Point (km)	NH4 (µM)	NO3 (µM)	TIN (µM)	PO4 (µM)	TP (µM)
44	1	Isaac's Harbour River	8-Aug-06	0.70	0.11	0.80	0.01	0.01	0.00	0.64	1.41	2.05	0.18	
44	4	Isaac's Harbour	16-Aug-06	0.70	0.11	0.80	0.01	0.01	3.04	0	0.9	0.90	0.26	
44	1	Isaac's Harbour River	23-Jun-08	0.70	0.11	0.80	0.01	0.01	0.00		1.16	1.16	0.21	
45	1	New Harbour River	5-May-06	0.61	0.06	0.67	0.01	0.00	0.00	0.65	0.56	1.21	0.16	
45	5	New Harbour	13-Jun-06	0.61	0.06	0.67	0.01	0.00	1.91	0.16	1.08	1.24	0.48	0.56
45	3	New Harbour	13-Jun-06	0.61	0.06	0.67	0.01	0.00	0.64	0.46	0.96	1.42	0.5	0.52
45	1	New Harbour River	27-Jun-06	0.61	0.06	0.67	0.01	0.00	0.00	2.18	1.94	4.12	0.14	
45	5	New Harbour	11-Jul-06	0.61	0.06	0.67	0.01	0.00	2.30	0.18	2	2.18	0.62	
45	3	New Harbour	11-Jul-06	0.61	0.06	0.67	0.01	0.00	0.00	0.44	0.64	1.08	0.49	
45	1	New Harbour River	8-Aug-06	0.61	0.06	0.67	0.01	0.00	0.00	0.00	0.32	0.32	0.34	
45	5	New Harbour	16-Aug-06	0.61	0.06	0.67	0.01	0.00	1.91	1.07	1.9	2.97	0.69	
45	1	New Harbour	16-Aug-06	0.61	0.06	0.67	0.01	0.00	0.00	0.2	0.96	1.16	0.23	
45	3	New Harbour	5-Jun-08	0.61	0.06	0.67	0.01	0.00	0.64		1.76	1.76	0.26	1.08
45	1	New Harbour River	23-Jun-08	0.61	0.06	0.67	0.01	0.00	0.00	0.33	1.67	2.00	0.27	
46	1	Larry's River	5-May-06	0.41	0.10	0.50	0.01	0.00	0.00	4.53	0.84	5.37	0.18	
46	4	Tor Bay	5-Jun-08	0.41	0.10	0.50	0.01	0.00	3.20		1.15	1.15	0.31	1.24
47	1	Otter Brook	5-May-06	0.45	0.11	0.56	0.01	0.00	0.00	0.00	0.03	0.03	0.30	
47	5	Whitehead Harbour	13-Jun-06	0.45	0.11	0.56	0.01	0.00	11.36	0.58	1.26	1.84	0.54	0.7
47	4	Whitehead Harbour	13-Jun-06	0.45	0.11	0.56	0.01	0.00	5.17	0	0.68	0.68	0.38	1.01
47	1	Otter Brook	27-Jun-06	0.45	0.11	0.56	0.01	0.00	0.00	0.20	0.52	0.72	0.24	
47	5	Whitehead Harbour	11-Jul-06	0.45	0.11	0.56	0.01	0.00	10.32	0.46	2.86	3.32	0.66	
47	4	Whitehead Harbour	11-Jul-06	0.45	0.11	0.56	0.01	0.00	6.85	0	0.75	0.75	0.28	
47	1	Otter Brook	8-Aug-06	0.45	0.11	0.56	0.01	0.00	0.00	0.26	0.30	0.56	0.47	
47	5	Whitehead Harbour	16-Aug-06	0.45	0.11	0.56	0.01	0.00	11.03	1.36	4.02	5.38	0.8	
47	4	Whitehead Harbour	16-Aug-06	0.45	0.11	0.56	0.01	0.00	5.17	0	0.96	0.96	0.2	
47	4	Whitehead Harbour	5-Jun-08	0.45	0.11	0.56	0.01	0.00	8.76		1.23	1.23	0.23	1.31
47	1	Otter Brook	23-Jun-08	0.45	0.11	0.56	0.01	0.00	0.00		1.21	1.21	0.31	

Table D3: Data on Hydrodynamic Conditions in Nova Scotia Embayments (extracted from Gregory et al. (1993))

Coastal Embayment	Area Km2	Tidal Range (mean) m	Tidal Range (large) m	Flushing Time hrs	Tidal FW Volume Ratio	Watershed Area Km^2	FW Discharge m^3/s
Barrington Bay	40.1	2.0	2.5	35.7	509.74	341.5	5.4-12.4
Shelburne Harbour	21.1	1.7	2.4	52.6	68.29	748.0	9.2-38.3
Jordan Bay	57.6	1.7	2.4	70.4	202.5	704.5	9.5-36.5
Sable River Estuary	5.8	1.7	2.4	18.6	61.7	357.9	4.8-18.6
Port Jolie	15.8	1.6	2.3	47.3	499.43	78.3	1.1-4.3
Port Mouton	55.6	1.5	2.1	111.7	386.04	302.3	4.1-15.7
Liverpool Bay	6.7	16	2.2	65.0	8.67	2015.4	49.8-72.4
Port Medway Harbour	16.2	1.6	2.2	23.9	26.52	1730.7	14.4-98.5
La Have Estuary	16.8	1.6	2.2	38.7	27.1	1741.6	13.2-100.6
Mahone Bay	209.1	1.5	2.1	170.5	344.53	1390.8	9.8-74.8
St. Margarets Bay	138.0	1.6	2.3	294.1	416.32	819.1	8.6-50.7
Bedford basin	16.2	1.5	2.1	261.3	109.38	281.5	2.8-18.0
Halifax Harbour	89.9	1.6	2.1	155.3	373.01	480.4	5.3-31
Musquodoboit Harbour	4.2	1.4	1.8	12.4	39.75	765.3	9.4-46.0
Ship Harbour	6.6	1.4	2.00	66.2	23.87	444.7	7.4-33.4
Sheet Harbour	17.6	1.5	2.00	54.0	35.15	944.0	14.4-71.3
Quoddy Harbour	8.1	1.4	2.2	17.5	270.75	50.1	.8-3.8
Ecum Secum	6.1	1.3	2.00	59.5	93.59	95.0	1.6-7.2
Liscomb Harbour	42.6	1.4	2.00	78.4	109.3	634.3	10.2-46.1
St. Marys Estuary	6.9	1.5	2.00	37.2	12.53	1512.4	18.6-101.4
Indian Harbour	9.8	1.4	2.00	102.8	299.86	63.8	1.0-4.4
Country Harbour	8.9	1.2	1.7	104	39.5	313	5.2-23.6
Tor Bay	69.4	1.3	1.9	83.3	394.82	269.1	4.5-20.2

APPENDIX E
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Print Authorization

June 23, 2009

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