Opportunities to Improve and Integrate Coastal Water Quality Monitoring in Nova Scotia

By

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Dedications

I dedicate this to my parents, who have always pushed me higher, and who are always there to catch me when I fall.

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List of Acronyms

CBEMN	Community Based Environmental Monitoring Network
CBM	Community-based monitoring
CCME	Canadian Council of Ministers of the Environment
CFIA	Canadian Food Inspection Agency
COGP	Code of Good Practice
CWES	Canada Wide Environmental Standards
CWQ	Coastal Water Quality
CWQM	Coastal Water Quality Monitoring
DFO	Department of Fisheries and Oceans
EC	Environment Canada
ESIP	Ecosystem Indicator Partnership
GOM	Gulf of Maine
GOM EMP	Gulf of Maine Environmental Monitoring Program
GOMC	Gulf of Maine Council on the Marine Environment
GON	Government of Nova Scotia
HRM	Halifax Regional Municipality
HRMRec	Halifax Regional Municipality Recreational Monitoring Program
IM	Integrated Management
MEQ	Marine Environmental Quality
MWQM	Marine Water Quality Monitoring Program
NGO	Non-Governmental Organization
NOR	Northumberland Strait
NorSt-EMP	Northumberland Strait Environmental Monitoring Partnership
NPRI	National Pollutant Release Inventory
NSDFA	Nova Scotia Department of Fisheries and Aquaculture
NSE	Nova Scotia Department of Environment
PC	Parks Canada
PON	Provincial Oceans Network
QA	Quality Assurance
QC	Quality Control
SCDS	Sustainable Coastal Development Strategy
SOE	State of Environment
SOME	State of Marine Environment
SOP	Standard Operating Procedure
WQ	Water Quality

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Abstract

Coastal water quality (CWQ) has been identified as a priority issue in the development of a Sustainable Coastal Development Strategy for Nova Scotia. While a host of different monitoring programs currently contribute to monitoring of Nova Scotia's coastal waters, there is concern over the effectiveness of these programs to collectively address the province's needs and objectives for CWQ. To address these concerns, actions have been identified to improve and integrate CWQ monitoring. This research evaluates the effectiveness of seven programs conducting monitoring activities in Nova Scotia to meet the needs and objectives for CWQ monitoring in the province. It considers their potential for inclusion in an integrated strategy in the context of Nova Scotia. Key directions for improvement and integration include applying an ecosystem-based approach to monitoring activities, and greater involvement of community-groups to expand coverage.

Keywords: coastal water quality (CWQ); integrated management; Nova Scotia; monitoring; indicators; ecosystem-based management

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Chapter 1. Introduction

1.1 The Management Issue

Coastal areas in Nova Scotia have played a pivotal role in shaping the provincial identity. The coast and nearshore waters attract people for many different reasons; they enable access to marine resources for commercial fisheries and personal shellfish harvesting, provide support to industries such as aquaculture and marine transportation, are used for recreational purposes, and are visited for the appreciation of their striking natural beauty. These activities rely on a healthy and productive coastal environment, indicative of the integral role coastal waters plays in both the ecological and socio-economic well-being of Nova Scotians. These important waters, often host to sensitive ecosystems, are vulnerable to increasing human activities and development; these same activities apply stress on coastal waters and threaten their well-being.

Coastal water quality (CWQ) is impacted by a wide range of human activities that take place in both the coastal zone itself and in the adjacent offshore marine and inland areas. Contamination of coastal waters results from pollutant inputs from many different sources, often classified within one of two main categories: point and non-point sources. Point sourced pollution comes from fixed, identifiable sources, such as sewage outfalls, pulp and paper mills, mining and aquaculture sites, or accidental events like a marine oil spill. Non-point sources include diffuse and not easily identifiable sources, such as agricultural, forestry or urban runoff and atmospheric deposition (Burbidge and Fanning, 2010; Stewart and White, 2001).

There is no single source of overview data on coastal water quality in Nova Scotia (GON, 2009), although thorough discussions on contaminant sources and impacts on the marine environments for the Atlantic region and specific to the Scotian Shelf of Nova Scotia are provided in Wells and Rolston (1991) and Stewart and White (2001), respectively, and a comprehensive review of issues specific to Nova Scotia is provided in the State of Nova Scotia's Coastal Technical Report (GON, 2009). What remains uncharacterized for CWQ in Nova Scotia, and is in general poorly understood in coastal systems worldwide, is the cumulative impact that all these combined pollution sources have on coastal ecosystems (GON, 2009). The province also lacks a way for meaningful evaluation and interpretation of CWQ information such that it is communicable to and meaningful for the general public.

Public concern over these issues and the impacts they have on the state of Nova Scotia's CWQ is evident in the feedback received through the consultation processes following the release of the State of Nova Scotia's Coast Report. Notably, public values reflect both human and environmental health. It was communicated that "clean coastal waters are important to human health as well as the health of coastal ecosystems" (GON, 2010c, p.19). It is also within the public's concern to see the improvement of conditions. "Restoring water quality in shellfish harvesting areas, beaches, and areas of high ecological significance was an important outcome of coastal management for many respondents" (GON, 2010c, p.19).

Recognizing these needs and concerns, the Government of Nova Scotia has identified coastal water quality as one of six priority issues to be addressed in the development of a Sustainable Coastal Development Strategy (Coastal Strategy). This

commitment to sustainable coastal development has been echoed at the federal level, where the Government of Canada and the Province of Nova Scotia have signed a Memorandum of Understanding Respecting Coastal and Ocean Management in Nova Scotia (Coastal MOU), including the issue of coastal water quality (DFO, 2011c).

In order to address the issue of CWQ, and as a means to assess the impacts of human interactions on the coast, there is a need to monitor trends and changes in the health of these waters. Understanding the state of coastal water quality is necessary to inform citizens and respond to their expectations. It is also required by coastal managers as information essential to prompt management action and in order to make informed decisions that allow for safe and sustainable resource use with minimal harm to the environment. Any dedicated CWQ monitoring efforts in the province must aim to achieve the range of needs and objectives of Nova Scotia residents as a whole. In doing so, they must consider the issues as they impact both humans and environment health, the former in terms of recreational and food safety concerns, and the latter regarding the overall ecosystem services coastal waters provide. This means monitoring to satisfy the broader objectives that contribute to the greater understanding of the cumulative effects and overall ecosystem health and services on which coastal resources and resource users rely.

A host of different monitoring programs that contribute to the body of knowledge on coastal water quality in Nova Scotia are currently in operation, with administrative and operational responsibilities spread across the federal, provincial, and municipal levels of government, as well as through initiatives by community groups, non-governmental organizations (NGOs), and the scientific research community. However, concern has

been raised that these monitoring efforts are not coordinated by a single overseeing government agency nor approached through a comprehensive strategy and information gaps regarding the knowledge on the overall state of CWQ in Nova Scotia exist. Presently, these gaps have been identified to include the absence of province-wide information, a lack of understanding on cumulative effects of multiple contaminants, and inaccessibility to long-term data (GONS, 2009). To address these limitations, the Government of Nova Scotia has identified that action should be taken to improve and integrate coastal water quality monitoring (J. Huston, personal communication, March 17, 2011).

1.2 Research Purpose and Methodology

The purpose of this research is to assess the current need for improvement and to identify opportunities to integrate CWQ monitoring in Nova Scotia. The aim in conducting this research is to provide practical and informed recommendations to better define CWQ monitoring activities, ultimately leading to better knowledge of and improved CWQ. This assessment is guided by the following research questions: (1) Does current monitoring effectively address Nova Scotia's CWQ monitoring needs and objectives? (2) How would current monitoring benefit from integration?

The research questions are address by applying the following approach. CWQ monitoring is considered within the unique context of the province of Nova Scotia, based on 5 criteria: 1) environmental, 2) socio-economic, 3) institutional, 4) legislative and 5) political. This serves to identify key opportunities to taking an integrated approach to CWQ monitoring. Second, an assessment is provided of seven different monitoring programs which currently conduct CWQ monitoring activities in the province. These

programs were selected to illustrate a range of program types with varying actors, geographic scope, objectives and statutory requirements. The selected programs are assessed based on ten descriptive (1-10) and five evaluative (11-15) criteria: 1) program purpose, 2) issues addressed, 3) CWQ objectives addressed, 4) actors and responsibilities, 5) parameters and indicators monitored, 6) geographic scope, 7) sampling intensity, 8) start date, 9) statutory basis, 10) current level of integration, 11) ability to meet goals and objectives, 12) level of dissemination of information to public, 13) attention to scientific rigor, 14) contribution to improved CWQ, and 15) contribution to integrated CWQ monitoring. Criteria 1-10 cover details on the capacity of each monitoring program, criteria 11-14 serve to evaluate the contribution of each program to current management process, and criterion 15 identifies the potential contribution each program may offer to an integrated approach to monitoring. Drawing from both analyses, recommendations are provided for integration of monitoring in the province.

1.3 Project Scope and Limitations

The primary focus of this project is to review the current state of CWQ monitoring in Nova Scotia, assess the performance and effectiveness of these efforts to meet current objectives, and suggest actions for how an integrated approach to monitoring efforts will improve CWQ management and monitoring in Nova Scotia. While the results and recommendations may provide guidance in the development of a province wide coastal water quality monitoring strategy, the final product is not intended to provide a structured monitoring program. Although recommendations for specific implementation targets and tactics are included, providing a comprehensive plan of action is beyond the scope of this investigation.

Although an intensive analysis of all programs related to water quality monitoring currently undertaken in Nova Scotia would offer the most complete understanding on current capabilities, given the time restrictions allotted to this project only a limited number of programs have been assessed. While it is recognized that this approach does not demonstrate the complete picture of monitoring efforts in the province, this case study approach has allowed for a more in depth investigation of each of the selected programs, providing for more thorough analysis, discussion and stronger recommendations.

1.4 Report Structure

This research investigation is based on literature and information sourced from peer reviewed journal publications, as well as websites and publications produced by government departments and non-governmental organizations (NGOs). The research results cover the following material, as organized into six chapters.

This chapter, Chapter 1, serves as an introduction to the research investigation. It identifies CWQ as a management issue for the province of Nova Scotia, introduces monitoring and integration as two coastal management tools, states the research purpose, questions and approach, and finally, outlines the report structure and scope.

Chapter 2 provides a background on CWQ monitoring and integrated management. This overview serves to explain these two concepts and their relevancy as management tools for Nova Scotia. Chapter 3 considers the broader environmental, socio-economic, institutional and legislative factors influencing coastal water quality

monitoring in Nova Scotia, and identifies management initiatives that may contribute to integration of CWQ monitoring in Nova Scotia.

Chapter 4 provides an assessment of a selection of CWQ monitoring programs presently operating in Nova Scotia, using the analytical framework described in the research methodology to identify the effectiveness of current monitoring. Chapter 5 provides a comparative analysis of the collective programs, in order to identify key areas for improvement of current monitoring efforts. These results are taken into consideration for inclusion in a comprehensive integrated monitoring strategy.

Based on the these evaluations, Chapter 6 discusses key considerations towards the improvement and integration of CWQ monitoring in Nova Scotia, accounting for potential challenges and opportunities. This chapter provides targeted recommendations that could be applied to improve and integrate coastal water quality monitoring in Nova Scotia, and closes the investigation with final thoughts and conclusions.

Chapter 2. Understanding Coastal Water Quality Monitoring

This chapter discusses how CWQ monitoring factors into coastal management. Key concepts relating to CWQ, monitoring activities and integrated management are defined, and the relationships between them are discussed.

2.1 Coastal Water Quality Monitoring

Environmental monitoring involves the regular and systematic collection and assessment of information about the state of environmental conditions and the identification of changes and trends in these conditions over time (EC, 2009a; EC, 2010; NRC, 1990). Broadly defined, monitoring is accomplished through a series of activities, which for this investigation are considered to include data acquisition through sample collection and processing, data analysis, evaluation, and reporting. What distinguishes monitoring from purely scientific research is "that a monitoring system is integrated and coordinated with the specified goal of producing predefined management information; it is the sensory component of environmental management" (NRC, 1990, p.7). It is this distinction that highlights monitoring as an essential management tool, to be factored into the regulatory, institutional, and decision-making aspects of environmental problems. Monitoring is conducted for a variety of reasons, including the establishment of baseline or reference conditions, to determine spatial and temporal trends, to ensure regulatory compliance, to detect emerging issues and threats, and to measure response to remedial measures and regulatory decisions (EC, 2009a).

Water quality is a term most identified "to describe the physical, chemical, and biological characteristics and conditions of water and aquatic ecosystems which influence

the ability of water to support the uses designated for it" (CCME, 2006, p. 5). Coastal water quality (CWQ) refers to these same properties for the case of salt and brackish water, which in Nova Scotia is considered to include estuaries, salt marshes, inter-tidal areas and embayments, as well as any open marine waters under the influence of freshwater runoff (GON, 2009, p. 177). CWQ monitoring is thus the collection of information regarding these characteristics in order to understand the ability of coastal waters to support designated uses or functions.

Inherent in this definition is the concept of quality and how it relates to coastal water use, which can be considered either from an ecosystem basis in terms of supported aquatic biological populations, and in terms of anthropogenic activities that rely on coastal water. Although the term quality is often used synonymously with 'health' there is a necessary distinction between these two concepts. Whereas the concept of quality represents an element of change over the long-term, and provides an understanding of how things are changing relative to past or non-impacted conditions, the concept of heath is a static description reflective of wellness and productivity, or a snapshot of the immediate conditions of the environment in its most current state (Wells, 2003a). From a strictly biological perspective, health can be seen as an indication of an ecosystem's "capability of supporting and maintaining a balanced, integrated, adaptive community of organisms having a species composition, diversity, and functional organization comparable to that of natural habitat of the region" (Karr and Dudley, 1981, p. 56).

The concepts of environmental health and quality both have inherent ties to the human use of that environment and the water resources within it. There is tendency to define healthy ecosystems "in an anthropocentric sense in which the health of an

ecosystem is determined by its ability to provide the services demanded of it by human populations," where "an ecosystem capable of satisfying the economic and aesthetic demands of a human society is deemed healthy" (Wrona and Cash, 1996, p.91). It is observed that human uses, as well as the values and expectations associated with coastal waters ultimately stand to influence the need and design for CWQ monitoring activities. This highlights the need for formal communication channels between the public and coastal managers, both for the public to voice concerns and expectations regarding environmental health and CWQ, and for information and knowledge learned through monitoring to be communicated back to the public and contribute to understanding on the health and quality of coastal environments.

Goals or objectives for CWQ reflect public input and socio-economic considerations, and incorporate elements of social value and use (EC, 2011e). General use objectives for coastal waters include recreational activities, the provision of fisheries resources for human consumption, and enhancement of the capacity for aquatic environments to support life, which incorporates ideas of coastal health, both for human and natural communities; in common jargon, *swimmable, fishable* and *livable* objectives for CWQ.

The specific use objectives for CWQ contribute to decisions on what are acceptable levels of quality for a particular water use in terms of maximum allowable concentrations of substances that may be harmful to the human user or to the broader environment. These are reflected in recommended guidelines or regulatory standards, which are based on measureable parameters. Established on scientific information and rationale, both guidelines and standards serve as measures to protect water quality. While

guidelines are recommended thresholds, standards are required and enforced through legislation.

2.2 Indicators of Coastal Water Quality

There are many different parameters that can be monitored in order to characterize the chemical, physical and biological components of CWQ. Commonly assessed parameters include, but are not limited to: dissolved oxygen (DO), nutrient concentrations, such as total nitrogen and total phosphorus, chemical contaminants, and pH, which serve as chemical parameters; salinity, temperature, suspended particulate matter, secchi depth (for measures of light penetration), which serve as physical parameters; and microbial and pathogen concentrations, which serve as biological parameters (Håkanson and Duarte, 2008; Chesapeake Bay Program, 2009; Garden, n.d.).

There is a need to establish the connection between data on these individual CWQ parameters and the complex and abstract socially relevant values of quality and health. In order to achieve this connection environmental managers have come to employ the indicator tool. Indicators have been defined as "a sign or signal that relays a complex message, potentially from numerous sources, in a simplified and useful manner" (Jackson et al., 2000, p.vii). In other words, an indicator is a translation factor that uses tangible and measurable parameters to give meaning to the more complex and abstract socially constructed concepts of 'quality' and 'health' and the human associated values. These aspects are encompassed in Mills' broader definition, whereby indicators are "quantitative or qualitative measures that provide information about the status of or changes in natural, cultural, and economic aspects of an ecosystem" (Mills, 2006, p.1).

Taken in this way, data and information related to CWQ can be used to relay information relevant to both environmental and socioeconomic aspects of coastal waters.

What message a given indicator is designed to communicate, as well as the way in which it is interpreted, is context specific. In some cases, interpretation of a given parameter may be obvious and a function of the direct measurement taken, such as the use of secchi depth to measure light penetrability as an indicator of water clarity (Chesapeake Bay Program, 2009). Another example is the concentration of water borne pathogens and the risk they pose to human health. For example, studies have well established the link between fecal indicator bacteria at marine beaches and swimming-related illnesses and have contributed to the establishment, review and strengthening of water-quality thresholds at marine beaches (Haile et al, 1999; Wade et al, 2003; Colford et al., 2007). In other cases the underlying causes, and in turn the relationship between the issue and measurable parameter, may be more complex. Under such circumstances, the use of multiple parameters can be taken in combination to serve as an index of a more complex phenomenon, such as the combined use of measurements for nutrients (such as silicate, phosphate, nitrate, nitrite, and ammonia), dissolved oxygen and trace metals (for example dissolved iron, manganese, lead, nickel, copper, zinc and cadmium) in bottom waters, and physical measurements of salinity and temperature as an indicator of eutrophication in coastal waters (Strain and Yeats, 1999). CWQ in itself may serve as an indicator of a more holistic or ecosystem-based evaluation of the state of conditions of marine environmental quality (Wells, 2003a).

In the Canadian context, the federal government through the Department of Environment (Environment Canada or EC) reports on environmental indicators through

the Canadian Environmental Sustainability Indicators (CESI) initiative, which tracks long-term trends on issues of public concern, including: air quality, air pollutant emissions and greenhouse gas emissions; water quality and quantity; and more holistic ecosystem, protected habitats and wildlife indicators (EC, 2011d). Another way information is translated to the public is through a water quality index (WQI). A water quality index (WQI) is a communication tool to summarize complex and technical water quality data collected over a number of parameters, incorporated into one single measure. This interpretation provides a relative range or scale to rank or compare different sampled area, and a way for non-experts to understand overall water quality (CCME, 2009).

Information and knowledge generated through monitoring activities can be evaluated all together in state of environment reports (SOE) which provide an overall picture on ecosystem health or statements on human risk (Wells, 2003a), such as observed by in Nova Scotia's State of the Coast Report. Another example which reports on results from a network of monitoring programs that identify common indicators is produced in the State of the Gulf of Maine Report produced by the Gulf of Maine Council on the Marine Environment (GOMC) as part of the output of its program on human health and ecosystem integrity (Wells, 2003b).

2.3 An Integrated Approach to Coastal Water Quality Monitoring

Integrated policy is viewed as a way to handle management of coastal areas, which are subject to increasingly intense and diversified use and considered as complex, interacting systems (Underdal, 1980). While benefits to policy integration include improved efficiency and outcomes of management actions, "the outcome which an integrated policy would seek to achieve can . . . be accomplished without integrated

policy considerations and goals" (Underdal, 1980, p.164). The case is made that an integrated policy may be pursued when it serves to create or reinforce interdependence links, or "helps to address management decisions which "appear 'good' from a 'fragmented' point of view turn out to be 'bad' from a 'holistic' perspective" (Underdal, 1980, p.168).

Although an integrated approach to environmental, water resources, and coastal management has been widely encouraged and promoted, it has been difficult to accomplish in practice. One of the key factors for this failure is the lack of agreement among scholars and practitioners regarding the concept and its defining elements (Born and Sonzogni, 1995). There is a call for integrated environmental management initiatives to be comprehensive, including all the critical natural and human components of an ecological system, the uses and objectives for the system, the various actors or entities that affect or can be affected by management, and all the linkages between these elements (Underdal, 1980; Born and Sonzogni, 1995). These considerations can be applied across many different dimensions (Cicin-Sain and Knecht, 1998), including:

- *Intersectoral integration* – involves 'horizontal' integration along coastal, land and-marine based sectors, for example fisheries and aquaculture, agriculture, forestry, and mining.
- *Intergovernmental integration* – involves 'horizontal' and 'vertical' integration along the several levels and agencies of government with coastal and ocean jurisdictions.

- *Spatial integration* – includes integration between the land and ocean sides or the coastal zone, including land and marine-based activities, and geographic features of watersheds and river basins, intertidal zone and the nearshore.
- *Science-management integration* – includes the natural and social sciences, for example the ways in which scientific data corresponds to objectives or indicators in order to address concepts of quality and health.
- *International integration* – includes trans-boundary issues and international law.

Given the complexity and difficulty of incorporating every consideration, integration efforts need to be strategic in order to make "integrated environmental planning and management adaptive, anticipatory, and more attuned to the realities of the political decision arena" (Born and Sonzogni, 1995, p.171).

For water management, there is recognition that water systems are characterized as complex and diverse problems, where there is increasing knowledge of the complexity of processes, a growing demand for information, and increasing recognition of the need for integration of that knowledge across disciplines and sectors (Timmerman et al., 2000). For CWQ, this includes integration with freshwater monitoring and management knowledge, such as nutrient inputs from upstream, non-point sources, which requires management of the coastal zone to address land-based inputs over a large geographic scope (Howarth et al., 2002). Integration between freshwater management and coastal zone management, to reflect the 'continuum' between fresh and coastal waters, is necessary "as freshwater systems, including upstream land-based sources of pollution, are important determinants of conditions in the coastal zone" (Jønch-Clausen and Fugl, 2001, p.505). To address these complex processes that contribute to CWQ, there is a

recognized need for better translation or integration of scientific knowledge into effective policy and management strategies (Howarth et al., 2002).

Chircop and Hildebrand (2006) identify the two distinct approaches to integrated planning and management initiatives that can be taken. Either the problem defines the management area or the boundaries of integration, or a defined area is established through an administrative premise or when traditional jurisdictional boundaries are applied, in this case Nova Scotia's provincial borders or sub-provincial socio-economic regions. The first of these two options, while it may cause management and administrative disadvantages, could in theory better enable an ecosystem-based approach (Chircop and Hildebrand, 2006).

Chapter 3. Nova Scotia Context

Before focusing on the specific monitoring programs contributing to CWQ knowledge in Nova Scotia, it is important to provide a brief overview of the unique environmental, socio-economic, institutional and legislative context of the province. There is also a need to identify key policy initiatives that have relevance to CWQ monitoring and integrated management in the province. This overview serves to address the current factors that contribute to the need for and design of CWQ monitoring activities in Nova Scotia.

3.1 Environmental Context

Nova Scotia is a 580 kilometer-long peninsula, surrounded on all sides by the sea, with no part of the province found more than 56 kilometers from the coast (TTNS, 2007). The province can be divided into 46 primary watersheds with distinct river systems, with the coastline characterized by about 65 coastal estuaries (GON, 2009). It has over 7600 km of coastline that is characterized by numerous headlands, bays and inlets, and thousands of islands (TTNS, 2007).

There are three distinct oceanic environments that influence the province's coastal zone: the Gulf of St. Lawrence, the Scotian Shelf and the Bay of Fundy/Gulf of Maine (GOM) (NSMNH, 1996). It is key to note that two of these three regions have overlapping jurisdictional boundaries, the GOM with New Brunswick and the United States (US), and the Gulf of St. Lawrence with New Brunswick and Prince Edward Island (PEI). Each water body is characterized by unique climates and natural features such that "it is essential to consider these areas separately" (Stephenson and Stephenson, 1954a,

p.15). The Atlantic coast is defined by an open exposed, coast with high wave energy alternated by protected bays and inlets; the Bay of Fundy is as semi-enclosed and influenced by large tide range and more sheltered from wave exposure; and the Gulf of Saint Lawrence is micro-tidal and seasonally wave dominated (NSMNH, 1996; Stephenson and Stephenson, 1954a). Additional distinguishing factors are observed in winter ice conditions, seasonal mixing and upwelling, and influencing marine currents (Stephenson and Stephenson, 1954a).

These broad coastal regions can be further divided by the ecosystems that they support. Thirteen ecosystems have been identified in Nova Scotia. In the coastal zone range these include rocky shores, sandy beaches, estuaries mud flats and tidal marshes. (GON, 2009). Numerous habitats for flora and fauna occupy these ecosystems, making Nova Scotia's shores a biologically rich asset that the province strives to protect and preserve (NSMNH, 1996). These varying physical conditions result in equally varied habitats and supported ecosystems, where the distribution of species in Nova Scotia's different geographical regions and corresponding coastal areas are observed to demonstrate an "extraordinary variety of zonations and general types of population" (Stephenson and Stephenson, 1954b, p.46). As a result, the coastal regions of the province are truly home to a diverse host of physical environments and supported ecosystems, with varying sensitivities to different anthropogenic threats and pressures (GON, 2009).

3.2 Socio-economic Context

The province of Nova Scotia has strong connection to the coast. Statistics show that greater than 60 percent of Atlantic Canadians live within 20 km of the coast

(Manson, 2005). While the population of the province has remained relatively stable, there is a notable steady decline of population in rural areas and increase in more urban areas (GON, 2010a). There is a tendency in the province for development to cluster in areas affording suitable harbours and availability of water for disposal of wastes (NSMNH, 1996).

Both population and industrial development are concentrated in Nova Scotia's coastal areas (Stewart and White, 2001), contributing to many different sources of pollution. In many locations, domestic sewage enters the coastal marine environment directly from residential, municipal and industrial sources without any prior treatment (GON, 2009; Stewart and White, 2001). Significant accumulation of metal and organic contaminants in sediments has been observed in Halifax Harbour as a result of discharge of untreated domestic sewage, industrial waste, leaching from landfill waste, and surface drainage (Buckley et al, 1995). Instances of industrial activities releasing pollutants directly into coastal waters, as observed with steel smelter and coke ovens operations in Sydney Harbour, have left behind legacies of coastal contamination (Stewart and White, 2001). Growing numbers of beach and shellfish closures, loss of species abundance and diversity, and elevated levels of contaminants are observed consequences resulting in increased concern for the quality of coastal waters in Nova Scotia (GONS, 2009; Burbidge & Fanning, 2010).

Research has demonstrated concern for environment by primary stakeholders, identifying coastal water quality as a high area of concern (Baccardax, 2010). Threats posed to the coastal and marine environments have prompted community involvement in coastal planning issues (Weiss Reid, 2004). Community-based management has been

identified as a key method to enhance participation of primary stakeholders in coastal management and planning (Baccardax, 2010).

The provincial economy is supported by resources which depend on as well as impact healthy coastal waters and good CWQ, including fisheries, aquaculture and tourism (GON, 2009). Activities exploiting land-based resources of forestry, mining and agriculture can all be considered to take place in a zone of influence.

Economic growth and job creation have been identified as primary objectives of the Nova Scotia government (GON, 2010b). One burgeoning industry is observed in marine aquaculture, with coastal bays and inlets being used increasingly for shellfish culture and harvesting (NSMNH, 1996). Given the decline of traditional resource industries, aquaculture is viewed as a tremendous opportunity to provide economic stability and growth in rural and coastal areas (GNFL, 2005). However growth of the marine aquaculture industry has been fraught with controversy, and public concerns pertaining both to environmental threats and aesthetic issues (Grant, 2010). The current lack of public confidence in aquaculture is seen as a limiting factor to the expansion of the industry in Nova Scotia, where a need has been identified for science and monitoring to ensure the industry operates and grows in a safe and sustainable manner (GON, 2010d).

3.3 Institutional Context

In Canadian coastal areas, there are a wide variety of institutional actors, "both in terms of the mantle of authority they bear, the function they perform and the interests they represent" (Chircop and Hildebrand, 2006, p.17). These actors include federal,

provincial and municipal levels of government, NGOs, community-based organizations, academic and scientific research groups.

3.3.1 Government Institutions

Coastal management and CWQ monitoring activities are spread across a variety of federal and provincial agencies. Key federal agencies include Environment Canada (EC), the Department of Fisheries and Oceans, the Canadian Shellfish Sanitation Program (CSSP), and Parks Canada (PC). Key provincial agencies include the Nova Scotia Departments of Fisheries and Aquaculture (NSDFA), Environment (NSE), Natural Resources (NSDNR), and Health and Wellness (NSDHW), as well as Service Nova Scotia and Municipal Relations (SNSMR). Finally, individual municipalities have primary jurisdiction although limited power over land use within their local boundaries (ECEL, 2010). While every one of Nova Scotia's 55 municipalities and 22 incorporated villages and their corresponding decision-making bodies are too many to map in detail, Halifax Regional Municipality (HRM) is identified as an example. A summary of key federal, provincial and municipal government departments and agencies and relevant activities performed pertaining to CWQ monitoring are identified in Table 1.

Table 1: Mapping of Government Activities Pertaining to CWQ Monitoring

Department/ Agency/ Municipality	Management Function	Relevant Coastal and Fresh Water Quality Monitoring Activities
Federal		
EC	To preserve and enhance the natural environment, including water.	Marine Water Quality Monitoring for Canadian Shellfish Sanitation Program (Box 4-1) · Environmental Effects Monitoring (EEM) (Box 4-4) · Canadian Aquatic Biomonitoring Network (CABIN): aquatic biological monitoring program for assessment of freshwater ecosystem health (EC, 2011c)
DFO	To "deliver programs and services that support sustainable use and development of Canada's waterways and aquatic resources" (DFO, 2011).	· Community Aquatic Monitoring Program (CAMP) (Box 4-5) · Atlantic Zone Monitoring Program (AZMP): collection and analysis of biological, chemical, and physical data in offshore Atlantic waters (DFO, 2010a)
PC	To ensure the protection of the ecological integrity of national parks and national marine conservation areas, while fostering public understanding (PC, 2011)	· Ecosystem Management: species inventory and monitoring (PC, 2009em)
Provincial		
NSDFA	Provides services to the province's agriculture and fishing sector	· Environmental Monitoring Program (EMP) for Marine Aquaculture (Box 4-3)
NSE	To deliver effective and efficient regulatory management for the protection of the environment (NSE, 2010b).	· Divisions of Environmental Monitoring & Compliance and Environmental Science and Program Management (NSE, 2010a)
SNSMR	"To provide Nova Scotians with seamless, easy access to government information and numerous services in a cost-effective manner while maintaining the interests of the public and municipalities" (SNSMR, 2011)	· Positioned to disseminate information to the public · Municipal Services Division: maintains the municipal legislative frameworks and connects provincial to municipalities and villages (SNSMR, 2011)
Municipal		
HRM		· Halifax Regional Municipality Recreational Monitoring Program

3.3.2 Non-Governmental Institutions

Non-government organizations (NGOs) are known to contribute to research on CWQ and participate in monitoring activities in the province. Many have a degree of collaboration and integration built in with government, academia, and community groups. Key examples operating in Nova Scotia are as follows:

Gulf of Maine Council on the Marine Environment

The mission of the Gulf of Maine Council (GOMC) is to maintain and enhance environmental quality in the Gulf of Maine (GOM). GOMC is a partnership of government and NGOs from both Canadian and U.S. States bordering the GOM (GOMC, 2011a).

Northumberland Strait Ecosystem Monitoring Project

The Northumberland Strait Ecosystem Monitoring Project (NorSt-EMP), a project proposed through the Canadian Water Network, is an example of proposed integrated monitoring effort under development in Northumberland Strait which proposes integration on a regionally defined basis. The project aims to better address the gaps in understanding of the ecological process that link human activities and freshwater, estuarine and marine health, including cumulative effects of land-based nutrients, sediments and contaminants on coastal economic activities, within a number of drainage basins along Northumberland Strait (CWN, 2011). The project is currently accepting research proposals that will produce recommended sampling strategy to improve assessment of cumulative effects in the Northumberland Strait region (CHONe, 2011).

Bras D'Or Lakes Collaborative Environmental Planning Initiative (CEPI)

CEPI Operates through a steering committee of federal, provincial, municipal, and Mi'kmaq governments, industry, academia and NGOs; CEPI has identified water quality as a priority issue, and has delivered state of the environment reports for the Bras D'Or Lakes ecosystem (CEPI, 2011).

Community Based Environmental Monitoring Network (CBEMN)

The Community Based Environmental Monitoring Network (CBEMN) within the Department of Geography at Saint Mary's University assists community groups and other organizations in environmental monitoring efforts by providing equipment, training and expertise. CBMNE is currently designing an integrated water monitoring program that incorporates training and standardized equipment and a database for data sharing among community groups as well as government agencies and decision makers (A. Shelton personal communication July 14, 2011). This project called CURA-H2O, is a collaborative project between other universities including Dalhousie, Environment Canada, NS Environment and environmental stewardships groups, to establish a community-based integrated water monitoring and management research programs (CBEMN, 2011). Although the program has produced a Marine Community Monitoring Manual with details on monitoring specific to CWQ as a response to the need for very general guidelines for community marine monitoring programs, CBEMN's current focus remains geared towards freshwater rather than coastal systems (CBMEN A. Shelton personal communication July 28 2011).

3.3.3 Community-based monitoring

While community groups can be classified under NGOs, it is important to note the unique considerations for citizen science to contribute to CWQ monitoring. Community based monitoring is defined "as a process where concerned citizens, government agencies, industry, academia, community groups and local institutions collaborate to monitor, track and respond to issues of common community concern" (Whitelaw et al., 2003, p.410). Community groups have formed to address concerns over specific CWQ issues, as well as government capacity to effectively address issues. One example is the Friends of Port Mouton Bay, a volunteer group in Queen's County on Nova Scotia's Southern Shore. This group, which came together to address the issue of local finfish farming, have engaged in monitoring activities to assess the health of the coastal environment (Friends of Port Mouton Bay, 2011). It has been noted that community-based monitoring initiatives are increasing in Canada, attributed to reduced government ability to effectively monitor ecosystems, as a result both of increasingly complex issues and from substantial financial cuts to environmental programs (Whitelaw et al, 2003; Conrad and Daoust, 2008). However it should also be noted that while most CBM groups in Nova Scotia are based on or near the coast, few community-based marine-monitoring programs have yet to be been undertaken in the province (Conrad and Daoust, 2008).

Community-based monitoring has respective challenges and limitations, including concerns for lack of objectivity, high volunteer turnover, lack of funding, and problems with longevity (Whitelaw et al, 2003; Conrad and Daoust, 2008; Sharpe and Conrad, 2006). A lack of interest has been found among decision makers to apply CBM obtained

data to formal management and decision-making processes, particularly when developed apart from rather than within the management and policy development processes (Sharpe, 2006; Whitelaw et al, 2003; Sharpe and Conrad 2006; Conrad and Daoust, 2008).

3.4 Key Legislative Considerations

Current federal and provincial legislation define government legal responsibilities for CWQ monitoring activities. Key acts and regulations at the federal and provincial level, identifying the roles they establish for monitoring, are provided in Table 2. In addition to monitoring requirements, the *Oceans Act* sets the precedent for an integrated approach to coastal and oceans management in Canadian waters, establishing DFO as the lead agency.

Notably, NSDFA responsibilities under the provincial *Fisheries and Coastal Resources Act* include goals for both development and protection of coastal and environmental resources. This places the NSDFA in a conflicting position where monitoring activities contribute to both regulatory and promotion of industry activities, and the provincial government responsible to balance both a regulatory and development role. Regulation of activities falls to DFO under section 35 of the Fisheries Act regarding the possibility of harmful alteration, disruption or destruction of fish habitat (DFO, 2008).

Table 2: Mapping of Key Federal and Provincial Legislation for Monitoring Requirements

Level of Government	Department	Key Legislation and Strategies	Legislated Responsibilities for Fresh and Coastal Water Monitoring
Federal	EC	*Canadian Environmental Protection Act* (1999)	To establish, operate and maintain a system for monitoring environmental quality, and to collect and report on information on the states of the environment (1999, c.33, s.44.1)
		Canada Water Act (1985)	Water resource management, including activities of research, data collection and inventory. No distinction made between fresh and coastal waters.
		Fisheries Act (1985)	· Section 36 prohibits the deposit of deleterious substances, requirement for regulation of monitoring by industry through *Pulp and Paper Effluent Regulations* (1992) and *Metal Mining Effluent Regulations* (2002). · *Management of Contaminated Fisheries Regulations*
	DFO	*Canadian Environmental Assessment Act* (1992)	Triggered under the *Fisheries Act* when activities potentially harm fish habitat (DFO, 2010b).
	CFIA	*Fish Inspection Act*	· Fish Inspection Regulations
Provincial	NSDFA	*Fisheries and Coastal Resources Act (SNS 1996, c.25).*	· To "encourage, promote and implement programs that will sustain and improve the fishery, including aquaculture". Responsibilities include the development of procedures, practices and methods for monitoring and analysis.
	NSE	*Environment Act (1994-95)*	· Management and monitoring of both fresh and marine waters

3.5 Relevant Policy Initiatives

Given the issues impacting CWQ in Nova Scotia, a variety of management responses have been developed at the federal and provincial levels. Some of the key initiatives relating to CWQ management in Nova Scotia that may contribute to the integration of CWQ monitoring efforts include:

Health of the Oceans (HOTO)

The Health of the Oceans Initiatives (HOTO) was established in 2007 as part of a new federal National Water Strategy for Canada, delivered through federal funding for various initiatives over a five-year period (DFO, 2011b). This initiative is aimed at measures to counter pollution, protect marine environments, and strengthen preventive measures, with the intended purpose to address risk posed by issues or challenges to the 'health and quality' of Canada's marine environment. Specific initiatives include issues pertaining to CWQ such as the introduction of pollutants, habitat alteration and degradation, and contamination of resources (DFO, 2011b). HOTO specifically involves Fisheries and Oceans Canada (DFO), Transport Canada (TC), Environment Canada (EC), Parks Canada Agency (PCA), and Indian and Northern Affairs Canada (INAC) (DFO, 2011b).

DFO's Ecosystem Research Initiatives (ERIs)

DFO's ERIs are intended as pilot projects for DFO's ecosystem-based approach to coastal and ocean's management (DFO, 2011a). They focus on seven geographically distinct regions facing different environmental pressures, two of which are found in Nova Scotia. These include the GOM and Northumberland Strait (NOS), both with overlapping administrative boundaries, NOS on the provincial level, encompassing New Brunswick and Prince Edward Island, and the GOM both provincially and internationally, with both New Brunswick and the United States.

EC's Atlantic Ecosystems Initiatives (AEIs)

Similar to DFO's ERIs, EC's AEIs apply an ecosystem-based approach to environmental management to address critical environmental issues. Three focus areas

identified in 2010 include the Northumberland Strait, the Bay of Fundy/Gulf of Maine and the Halifax coastal zone, all of which fall in part or as a whole in Nova Scotia (EC, 2011b).

Nova Scotia's Coastal Management Framework (CMF)

The Government of Nova Scotia has implemented a Coastal Management Framework (CMF), tailored to meet the specific needs for coastal management in Nova Scotia (GON, 2008). The Provincial Oceans Network (PON), chaired by the NSDFA, was established to facilitate the CMF, and is composed of representatives from a host of provincial departments and agencies with responsibilities and interests in the coastal zone, including the NSE, NSDNR, and the SNSMR (PON, 2009). The CMF identified CWQ as one of six priority issues for coastal management in Nova Scotia. One strategic activity under this initiative has been the release of a comprehensive overview on the current state of Nova Scotia's coastal areas and resources, including the issue of CWQ, provided in The State of Nova Scotia's Coast Report (GON, 2009). The information from this report, as well as feedback collected through public consultation process, has been applied in the development of the Coastal Strategy, which will include management tools for addressing the priority coastal management issues.

A second strategic activity that has been achieved is the establishment of the Memorandum of Understanding Respecting Coastal and Ocean Management in Nova Scotia (Coastal MOU), to provide for further collaboration between federal and provincial levels of government in order to advance both Nova Scotia's and Canada's priorities for coastal and oceans management, including the priority issue of CWQ (DFO, 2011c). It establishes DFO and NSDFA as the federal and provincial lead agencies

responsible for the development of future initiatives such as subsidiary agreement, working groups or other implementation instruments, open to participation by other parties as required, and identifies specific geographic areas of the Atlantic coast/Scotian Shelf, Southern Gulf of St. Lawrence, Bay of Fundy/Gulf of Maine and the Bras d'Or Lakes ecosystems.

Nova Scotia's Water Resource Management Strategy (Water for Life)

The development of the Water for Life: Nova Scotia's Water Resource Management Strategy (Water for Life) was overseen by an Interdepartmental Water Management Committee and led by Nova Scotia Environment (NSE) (NSE, 2011). Noted within the strategy is the aim to complement and support Nova Scotia's natural resources strategy and the province's coastal strategy. Actions proposed in Water for Life include an Integrated Water Management (IWM) as a comprehensive approach to management of water resources and improved understanding on Nova Scotia's watersheds (NSE, 2011). Key outcomes include a Water Portal to provide a clearinghouse of information with respect to provincial water resources, which provides a consolidation of information relevant to fresh water resources and management in the province, including a links to The State of Nova Scotia's Coast Report and the 2010 Nova Scotia's Natural Resources Strategy. Other forthcoming projects include a Nova Scotia Watershed Assessment Project (NSWAP), undertaken through collaboration with the Hydrologic Systems Research Group at Dalhousie University (NSE, 2011). Intended outcomes of this project are to include a watershed analysis models to evaluate Nova Scotia's watersheds in terms of watershed health and risks to human impacts, as well as a

Nova Scotia Water Geodatabase and watershed report cards to facilitate the dissemination of watershed information researchers, government and public stakeholders (NSE, 2011).

Chapter 4. An Evaluation of Coastal Water Quality Monitoring Programs in Nova Scotia

This chapter provides an evaluation of a representative selection of CWQ monitoring programs currently operating in Nova Scotia. This evaluation serves to identify the strengths and weaknesses of current monitoring efforts, as well as to identify any gaps in monitoring, as a means to assess the adequacy of current programs in meeting CWQ monitoring needs, and to identify if and how integration could serve to better meet these needs. Recognizing the breadth of programs to be selected from, criteria were identified to ensure selected programs for analysis illustrated the breadth and diversity of current monitoring programs across the various dimensions for integration. Specific criteria for selecting programs were identified as follows:

- Actors: considering all levels of government as well as non-governmental parties.
- Space: with geographic scope varying from local to regional to province-wide programs, with monitoring activities based predominantly in coastal zone.
- Objectives: covering a range of problems impacting CWQ in Nova Scotia, inclusive of each of the swimmable, livable, and fishable objectives.
- Statutory basis: considering programs which are operated on a required or voluntary basis.

Table 3 identifies the seven programs selected for evaluation, and illustrates the degree of variation across the four selection criteria.

Table 3: Programs by Selection Criteria

Program	Selection Criteria			
	Actors	**Space**	**Objectives**	**Statutory Basis**
Marine Water Quality Monitoring Program (MWQM)	Federal Government	National	*Fishable*	Yes
Gulfwatch Contaminants Monitoring Program (Gulfwatch)	International NGO	International and Sub-regional (Gulf of Maine)	*Livable*	No
Environmental Monitoring Program (EMP) for Marine Aquaculture	Industry, Provincial and Federal Governments	Provincial	*Livable Fishable*	Yes
Environmental Effects Monitoring (EEM) Program for Industry	Industry, Federal Government	National	*Livable and Fishable*	Yes
Community Aquatic Monitoring Program (CAMP)	Federal Government, Volunteers	Sub-regional (Northumberland Strait)	*Livable Fishable*	No
Atlantic Coastal Action Program (ACAP)	Community NGOs	Regional (Atlantic Provinces)	*Livable Swimmable Fishable*	No
Halifax Regional Municipality (HRM) Recreational Monitoring Program	Municipal Government	Municipal	*Swimmable*	Yes

A summary of each program's monitoring activities based on 10 descriptive criteria is provided in Table 4, followed by an assessment of the program based on the 5 evaluation criteria provided in Table 5.

Table 4: Descriptive Criteria

Descriptive Criteria	**Covers**
1. Purpose	Primary purpose of the program
2. Issues Addressed	What issues impacting CWQ that the program serve to address
3. CWQ Objectives	Which of the three CWQ objectives the program intends to address
4. Actors and Responsibilities	Who performs monitoring activities
5. Parameters and Indicators	What chemical, physical and biological parameters and indicators are monitored
6. Geographic Scope	Extent of coverage, defined administratively or geographically
7. Sampling Intensity	Frequency of sampling
8. Start Year	Year program was initiated
9. Statutory Basis	Program is required or voluntary
10. Current Integration	Current dimensions along which program is integrated

Table 5: Evaluation Criteria

Evaluation Criteria	Justification
11. Effectively Addresses CWQ Objectives	Does the program effectively address their intended CWQ objectives?
12. Dissemination of Information to Public	Information from monitoring reported to the public to increase awareness on issues of CWQ?
13. Scientific Rigor	Is the program scientifically rigorus, allowing for incorporation into a province-wide program?
14. Contribution to Improved CWQ	Has the program contributed to policy decisions and management actions for better management of CWQ?
15. Contribution to Integrated CWQ Monitoring	Is there a benefit to integration of the program in a provincial strategy for CWQ Monitoring?

4.1 Marine Water Quality Monitoring Program

The primary role of the Marine Water Quality Monitoring (MWQM) program is to support EC's mandate required by the CSSP, which is principally designed as a food safety program for the sanitary control of the shellfish industry; as such, MWQM's primary goal or objective is to ensure that the *fishable* objective is met for CWQ.

Box 4-1: Marine Water Quality Monitoring program (MWQM)

1. Purpose To identify safe shellfish harvesting areas in Canada (EC, 2009b)
2. Issues Addressed Shellfish contamination from point and non-point source pollution; health risk to human consumers
3. CWQ Objectives *Fishable*
4. Actors and Responsibilities EC conducts CWQ monitoring and assessment of environmental conditions; CFIA coordinates overall CSSP program and the management of the Marine Biotoxins Control Program; DFO conducts enforcement of closure regulations, enacts opening and closing of shellfish harvesting areas, as based on the respective information provided by CFIA and EC.
5. Parameters and Indicators Faecal coliform bacteria
Monitoring coverage is high intensity: Broad geographic scope on national scale, surveys a total of 15,000 stations in Canada (Suavé, 2010); Currently over 3400 stations surveyed in Nova Scotia, covering essentially every piece of coastline (personal communication, David MacArthur, August 4, 2011)
7. Sampling Intensity Monitoring frequency is low intensity: Five times in a three year cycle (personal communication, David MacArthur, August 4, 2011).
8. Start Year Available to 1981 (personal communication, David MacArthur, August 4, 2011).
9. Statutory Basis Management of Contaminated Fisheries Regulations enabled by the *Fisheries Act*
10. Current Integration Horizontal integration between federal government departments

Effectively Addresses CWQ Objectives

CSSP's MWQM monitoring is conducted in order to determine sanitary and CWQ conditions, which in turn contribute to site assessments and classification of shellfish harvesting areas. These monitoring results have a direct impact on management decisions for classification and closures of site, as well as an impact on decisions regarding the establishment of new aquaculture growing areas (Suavé, 2010). In doing so, the program meets its goal to address the *fishable* CWQ objective, in terms of maintaining access to the shellfish resource while ensuring for protection of human health.

Dissemination of Information to Public

Data results are not made publically available. Results of monitoring are reflected in site closures which may generate a negative perception of state of CWQ.

Scientific Rigor

Sampling and analysis is done by government scientists following validated analytical procedures (CFIA, 2011; Suavé, 2010). All sampling requirements, including standards, sampling frequency, and data analysis are as outlined in the US Food and Drug Administration's (FDA) National Shellfish Sanitation Program (NSSP) Guide for the Control of Molluscan Shellfish (2009). This guide, as well as the laboratory procedures outlined in the Manual of Operations, requires the development of a written quality assurance plan that includes training provisions, standardized sample collection, maintenance, transport and analysis methods and procedures and dedicated QA/QC programs (US FDA, 2009; CFIA, 2011). These measures demonstrate a high degree of scientific rigor, showing suitability of CSSP for inclusion in an integrated program.

Contribution to Improved CWQ

These management actions taken using CSSP results can be interpreted as reactionary to symptoms of poor water quality, rather than to generating management measures to improve or remediate the issues. While monitoring results first and foremost serve to protect human health, they do not seek to assess or improve CWQ or environmental health. Also, while monitoring needs are directly linked to issues impacting CWQ in Nova Scotia, the program as intended does not serve to directly monitor and evaluate impacts to overall coastal ecosystem health. The information collected in site classification surveys has a role in achieving a broader understanding of ecosystem health, as relating to issues of concern over increasing urbanization, sanitary and biotoxin closures and accountability for toxic substances (Suavé, 2010). The potential to use monitoring information collected on the frequency of harvesting area closures to contribute to knowledge of changing CWQ has been recognized (Charles et al, 2009), however specific closure guidelines set according to food safety regulations and are not necessarily a correlation to measures of environmental health. While there may be a role for integration of CSSP monitoring into broader understanding of downstream impacts and cumulative effects of pollutants in coastal environments, closure information and shellfish contamination levels to assess trends in CWQ may be misleading.

Contribution to Integrated CWQ Monitoring

Integration of CSSP may serve to improve province wide monitoring through significantly expanding geographic coverage. As effort and resources are already expended to conduct sampling in these areas, collection of additional water samples could

extend data coverage to a greater number of locations throughout the province with minimal effort added.

4.2 Gulfwatch Contaminants Monitoring Program

The Gulfwatch Contaminants Monitoring Program (Gulfwatch) is an environmental monitoring program with the aim of allowing for characterization of the ecosystem conditions in the Gulf of Maine (GOM). This is sought through the collection of information on the status, trends, and sources of risks to both public and ecosystem health (GOMC, 1991), thus serving to address the *livable* objective for CWQ.

Box 4-2: Gulfwatch Contaminants Monitoring Program (Gulfwatch)

1. Purpose To collect information on the status, trends, and sources of risks to both public and ecosystem health in the Gulf of Maine (GOM). (GOMC, 1991)
2. Issues Addressed Contaminants in coastal waters
3. CWQ Objectives *Livable*
4. Actors and Responsibilities Administered by the Gulf of Maine Council for the Marine Environment (GOMC) under the Gulf of Maine Environmental Monitoring Program (GOM EMP), Gulfwatch is a collaborative program with representatives from academia and government environmental agencies (EC, DFO), and non-governmental organizations (NGOs). Volunteers perform monitoring, but depend on government labs for sample analysis (personal communication, Peter Wells, June 13 2011).
5. Parameters and Indicators The blue mussel (*Mytilus edulis*) serves as an indicator of exposure to contaminants, to assess the status and trends of chemical contaminants in coastal habitats (LeBlanc et al, 2009). Sample analysis includes metals and organic contaminants, as well as ancilliary parameters including individual shell length, tissue wet weight, shell width, and shell height (GOMC, 2009)
6. Geographic Scope A regional, trans-boundary program Gulf of Maine (GOM). Sampling is conducted in two provinces and three states bordering the GOM, with 4 monitoring sites in Nova Scotia: Yarmouth, Digby, Five Islands, and Apple River (Le Blanc et al, 2011)
7. Sampling Intensity Two tiers of sampling are identified based on sampling intensity: once every two years (temporally intensive) and once every six years (spatially intensive). The sites are sampled on a rotating basis and repeated in each six year cycle, resulting in three temporal samples and one spatial sample at the end of each 6-year cycle for designated sites (LeBlanc et al, 2011).
8. Start Year 1993
9. Statutory Basis None
10. Current Integration International, scientific research community and federal government, science to inform management

Meets Nova Scotia's CWQ Objectives

The program meets its goals of monitoring trends and can serve as one indicator of CWQ. However the parameters monitored falls short of achieving broader ecosystem monitoring and assessment. While analysis covers a broad range of contaminants, analysis does not provide for assessment of impacts of these contaminants on biological integrity or ecosystem health. As such, Gulfwatch is limited in terms of addressing *livable* objectives for CWQ.

Dissemination of Information to Public

The program is geared towards coastal resource managers who make decisions on issues related to contaminants in the Gulf of Maine's nearshore waters, with the intent to inform both researchers and others living in the Gulf of Maine Environment (LeBlanc et al., 2009). As such, dissemination of results to a wider audience is inherent to the program's nature. Data results contribute to a 'coastal contaminants' indicator of the Ecosystem Indicators Project (ESIP), which serves to communicate information on environmental quality to public and other stakeholders (GOMC, 2011b). Results are featured online a through a Gulfwatch Interactive Mapping Tool where users can map contaminant data by year and by sampling location (GOMC, 2011c). At present time it is limited to 11 contaminants including 9 metals and 2 pesticides, and only data collected between 1993 and 2001 is available. However, full summary reports are available for download in the form of yearly data reports, currently available to the 2009 sampling season.

Scientific Rigor

The program provides a scientifically validated approach in the assessment of the degree pollution and variation in chemical contamination at and between coastal sites, contributing to the understanding of trends in coastal contamination (Chase et al., 2001). The monitoring type (mussel tissue), as well as the Gulfwatch program itself, has been studied and reported on in the peer reviewed scientific and technical literature (Chase et al, 2001; LeBlanc et al., 2011). The program provides Standard Operating Procedures which offers both Quality Acceptance (QA) and Quality Control provisions within set protocols for the collection, processing and analysis of samples, with sample analysis performed at government laboratories. Measures provide for accuracy and precision as well as for comparability to other monitoring methods (LeBlanc et al, 2011).

Contribution to Management for Improved CWQ

As Gulfwatch monitoring efforts provide baseline data to assess trends and changes, these results can be used to identify and assess new problems or changes in pollution sources in order to both prompt management response and evaluate effectiveness of management actions taken. Gulfwatch results have been used in this manner to determine the impact and fate of spilled oil in the biota of the Great Bay estuary in New Hampshire (GOMC, 2011c).

There is observed overlap between the methods employed by Gulfwatch with monitoring efforts used to assess environmental conditions within a regulatory context. For example, *Mytilus edulis* has been used by Environment Canada in a study to assess tributyltin (TBT) concentrations in coastal waters, prompted by the need to evaluate the effectiveness of international regulatory measures regarding use of TBT as a base in

antifouling paint used on ships hulls (Carter et al., 2004). Although these monitoring activities were not conducted through the Gulfwatch program, they serve as an example of how a monitoring program of this design has been applied to coastal management actions in other areas of Nova Scotia.

Contribution to Integrated CWQ Monitoring

The Gulfwatch program can serve as a comparable indicator of CWQ between different coastal locations. As a sessile (fixed location), filter-feeding organism that accumulates contaminants present in surrounding sea water, and with wide geographic distributed, mussels have been extensively used by monitoring programs over extensive coastal areas (Viarengoa and Canesia, 1991). *Mytilus* and other bivalve shellfish species has been utilized as indicator organisms in monitoring programs found worldwide, with locations including Europe (Baumard et al., 1998; Airas, 2003), and North, Central and South America (Sericano et al., 1995; Jaffe et al.,1998). As such, Gulfwatch provides an opportunity for data comparability to expand from a local or regional characterization to comparable studies conducted on a truly global scale. For instance, results have been used by the GOMC to assess contaminant concentrations in the GOM relative to other locations in North America (GOMC, 2011c). Following these examples, Gulfwatch could serve to expand to other regions of the province for a use as a common CWQ indicator.

4.3 Environmental Monitoring Program for Marine Aquaculture

The Environmental Monitoring Program of Marine Aquaculture (EMP) is an industry effects monitoring program specific to aquaculture activities, established in order to examine the relationship between aquaculture and the marine environment, with the primary objective to mitigate environmental harm (NSDFA, 2011a). Although clearly a connection to *fishable* use of coastal waters, monitoring serves to address the impact the *use* has on CWQ, not the impact CWQ has on the use. Thus EMP primarily serves to meet the *livable* objective for CWQ. As aquaculture in itself is dependent on *livable* waters in order to sustain aquaculture activities, and as the industry activities are permissible only if they meet required monitoring, EMP monitoring activities could also be considered to work to ensuring that coastal waters meet *fishable* CWQ objective.

Meets Nova Scotia's CWQ Objectives

As an industry monitoring program, EMP has direct linkages to management and regulatory measures. The program focus is to address identification and assessment of a specific CWQ issue that has been flagged by coastal managers, government, academia and the public of Nova Scotia alike. Information is collected from monitoring parameters which are selected based on their contribution to understanding of these impacts. However the program considers environmental impacts in a very specific context, taking a siloed and issues-based approach. While based on scientific reasoning, it is limited to a small perspective, not inclusive of broader ecosystem consideration or cumulative or far-field effects.

Box 4-3: Environmental Monitoring Program (EMP) for Marine Aquaculture

1. Purpose
To examine the relationship between aquaculture and the marine environment, with the primary objective to mitigate environmental harm (NSDFA, 2011a).

2. Issues Addressed
As primary concern with marine aquaculture is increased waste production and organic enrichment in the benthic environment, where a concentration and persistence of effects is observed in settled bottom sediments, relative to the more dynamic water column which is flow through by currents and tides (Grant et al., 1995; NSDFA, 2006).

3. CWQ Objectives
Livable, Fishable

4. Actors and Responsibilities
The program is administered by the Government of Nova Scotia's Department of Fisheries and Aquaculture (NSDFA). Monitoring is conducted by aquaculture sites as a mandatory requirement and an integral part of the lease and license progress (NSDFA, 2011b). DFO serves as a regulatory body (NSDFA, 2006).

5. Parameters and Indicators
Monitoring define environmental performance include (NSDFA, 2006):
Continuous video recording, sediment type and condition, and any benthic macrofauna/flora present.
Benthic sediments: total dissolved sulfide, redox potential, porosity and sediment organic matter; and,
Field observations: water depth and temperature, location, date, names of people involved, site description, distance/direction from waypoint, weather conditions, sediment type, flora/fauna, depth of sediment sampled, photograph of sediment cores, odour (descriptive).
Additional requirements that may be applied in the cased of baseline monitoring include sediment grain size and water current monitoring.

6. Geographic Scope
Operates on a province-wide geographic scale:
As of January, 2010, there were 274 marine aquaculture sites (including 243 shellfish, 29 finfish, 1 shellfish/finfish, 1 shellfish/marine plants): status: active and non-active (incl. opportunistic) (NSDFA, 2011a)

7. Sampling Intensity
Both the temporal and spatial sampling intensity is dependent the type of farmed species (finfish or shellfish), production levels, percent of bay volume and historical environmental performance at a given site. These requirements are scaled according to a risk-based approach, where lower risks shellfish sites may be sampled as infrequently as once every 5 years, versus the lowest risk finfish sites which are to be re-sampled once every 1-2 years. For sites evaluated as high risk or assessed to have low environmental performance, enhanced monitoring and assessment actions may be required. These actions include increased monitoring and site assessment to capture seasonal variation and continuous visual recording. (NSDFA, 2011a)

8. Start Year
Baseline data collected from 2003-2006, in order for reference to evaluate effects of aquaculture activities against baseline (NSDFA, 2011a).

9. Statutory Basis
Monitoring is a mandatory requirement for all aquaculture sites and integral to the lease and license progress (NSDFA, 2011b).

10. Current Integration
Industry and government

Additional Information
Data is submitted to the NSDFA and EMP database of NS Marine aquaculture, and reviewed by both NSDFA and DFO as regulatory partner (NSDFA, 2006).

Dissemination of Information to Public

It is notable that this programs calls for adherence to principles of transparency and collaboration, where a specific program goal is for information on the EMP monitoring results and responses to be released and made available with clarity on the employed reasoning and methodology, to be delivered in annual presentation and summary report form (NSDFA, 2011a). Although well intentioned, the only release of information to date comes in a 2006 summary report on the province-wide baseline data. Consequently, EMP is already met with criticism (Lura Consulting, 2010). This could be a reflection of the controversy surrounding the aquaculture activities, and the position of the NSDFA as responsible for both monitoring and promotion of the industry. By its failure thus far to adhere to these underlying principles, EMP is not meeting a key opportunity to address key public concerns over the impacts of aquaculture on CWQ.

Scientific Rigor

Standard Operating Procedures (SOPs) are provided in recently released (March 2011) *Standard Operating Procedures for the Environmental Monitoring of Marine Aquaculture in Nova Scotia* (NSDFA, 2011b). These SOPs outline sampling protocols including number and location of sampling sites, video recording and sampling methodologies, field observations and sample analysis, and QA/QC provisions such as standardized record keeping, requirements for baseline reference monitoring, and auditing (conducted annually for non-NSDFA monitored sites), compliance measures and data reviews (NSDFA, 2011b). As such, provisions for auditing and reporting are appropriately factored into the management design.

Contribution to Management for Improved CWQ

The EMP program is issues based, serving to regulate the negative impacts of a particular industry. It takes a silo approach to monitoring, considering only the near-field effects of aquaculture, focusing on a narrow range of parameters, rather than considering far-field effects and full ecosystem considerations.

Reviewed information from monitoring results contributes in multiple ways to the management of aquaculture activities, which include to ensured compliance and that environmental quality objectives and standards are met, measure effects on the environment, determine actions to be taken and audit the results of self-monitoring (NSDFA, 2011a). Should it be required, the licensee are responsible to implement a site remediation plan to improve conditions. However, as noted in the EMP framework, based on DFO review results for potential impacts to fish and fish habitat, site operators may require authorization to stay in compliance with Section 35 of the Fisheries Act. This clause raises concerns that while monitoring may provide information on impacts to water quality monitoring, appropriate management actions might never be taken.

Contribution to Integrated CWQ Monitoring

The scope, scale and parameters collected through the EMP program offers a minimal contribution to integration. Integration of biological indicators would serve to provide a better ecosystem-based approach to understanding of the effects of aquaculture on aquatic ecosystems. Given the concern surrounding the impacts of aquaculture activities on CWQ, EMP sites would benefit from spatial overlap with a monitoring program conducted independently of the industry and the NSDFA.

4.4 Environmental Effects Monitoring Program for Industry

The Environmental Effects Monitoring Program for Industry (EEM) is a monitoring program designed to measure changes in aquatic ecosystems potentially affected by human activity (EC, 2011a).

Box 4-4: Environmental Effects Monitoring (EEM) Program for Industry

1. Purpose To evaluate and regulate the effect of effluent on fish, fish habitat and the use of fisheries resources by humans (EC, 2011a; NEEMO, 2010)
2. Issues Addressed Near-field environments effects caused by effluent released from pulp and paper and mining activities (EC, 2011a).
3. CWQ Objectives *Livable* and *Fishable*
4. Actors and Responsibilities Industry self-monitoring by the pulp and paper and metal mining sectors (EC, 2011a) Environment Canada (EC) coordinates and regulates the program, analyzes and interprets data at a national level, and communicates results to stakeholders (EC, 2011a)
5. Parameters and Indicators Subleathal toxicity testing on effluent from outfall structures (NEEMO, 2010) Fish tissues and benthetic invertebrate community as biological indicators, monitoring at the population-level to provide for ecosystem-based assessment (EC, 2011a)
6. Geographic Scope National coverage. Specific industry site locations in province.
7. Sampling Intensity Sublethal toxicity testing is required one to two times per calendar year , depending on site activities and frequency of effluent deposits (NEEMO, 2010) Operates over long-term cycles (15-20 years) (EC, 2011a)
8. Start Year Metal Mining EEM program development began in 1993 (EC, 2011a)
9. Statutory Basis Yes: discharge limits set through *Metal Mining Effluent Regulations* (2002) and *Pulp and Paper Effluent Regulations* (1992), under the *Fisheries Act* (1985)
10. Current Integration Industry and government, science-management
Additional Information

Meets Nova Scotia's CWQ Objectives

As with EMP, EMM is an industry monitoring program with direct linkages to management and regulatory measures The EEM monitors impact of industry on the

environment considering more complex issues of biological integrity and specific to fish populations, serving to address both *fishable* and *livable* objectives for coastal waters.

Dissemination of Information to Public

Industry is required to submit all monitoring data to EC. Public accessibility to this data was not assessed in this investigation.

Scientific Rigor

QA/QC measures are required, with a description to be provided to EC (National EEM Office, 2010).

Contribution to Management for Improved CWQ

As with EMP, EEM provides a silo or issues based approach to monitoring, serving as a preventative rather than proactive tool for management.

Contribution to Integrated CWQ Monitoring

The EEM program addresses questions of biological integrity, approaching monitoring through a more holistic approach to address questions of ecosystem health. However as the program is site specific depending on industry locations, there is limited use of the program.

4.5 Community Aquatic Monitoring Program

The Community Aquatic Monitoring Program (CAMP) is a community-based monitoring program designed with the purpose to address the health of local watershed ecosystems in the Gulf Region. CAMP thus serves to meet the *livable* and *fishable* CWQ objectives.

Box 4-5: Community Aquatic Monitoring Program (CAMP)

1. Purpose To collect baseline and long-term data to detect changes and trends over time, to assess overall coastal and estuarine health, and to more clearly determine factors affecting the relationships between biological communities and the ecological health of the coastal ecosystems (Weldon et al, 2005; Weldon et al, 2008). To enhance integrated management between DFO, community groups, academia and NGOs, serving as an outreach program to community groups (Weldon et al, 2005).
2. Issues Addressed Ecosystem degradation due to human activities (Weldon et al, 2008). Pilot projects addressed impacts of effluent from fish processing and water treatment facilities (Theriault et al., 2006).
3. CWQ Objectives Goals serve to meet objectives for livable and fishable waters.
4. Actors and Responsibilities Administered by DFO: coordination of data acquisition, provide hands-on training, monitoring equipment, and conduct in-depth data analysis (Thériault et al., 2008). Relies on partnerships between NGOs, universities, other government agencies and volunteers. Community-based NGOs provide manpower for sample collection (Thériault et al., 2008; DFO, 2010c).
5. Parameters and Indicators Biological indicators: species count and identification, general aquatic vegetation profiles. Water temperature, salinity and dissolved oxygen. Chemical analysis of waterborne nutrients (starting in 2006): nitrate, nitrite, phosphate, ammonia and silicate (Thériault et al., 2008). Sediment samples (once at end of sampling season) characterized by grain size, organic content, and moisture content (DFO, 2010c; Thériault et al., 2008).
6. Geographic Scope Sub-regional: Southern Gulf of St. Lawrence Trans-boundary: northeastern New Brunswick, the Gulf coast of Nova Scotia, all of Prince Edward Island. For 2011 season, monitoring is being conducted at 35 sampling sites (personal communication, Marie-Helene Thériault, June 28, 2011).
7. Sampling Intensity Temporal intensity: monthly, from May to September
8. Start Year 2003 (pilot project)
9. Statutory Basis None
10. Current Integration Inherently integration data and information to address broader values of ecosystem health; Integration of government, NGOs, community and academia.

Meets Nova Scotia's CWQ Objectives

The program provides and ecosystem-based approach to monitoring by considering indicators of health and integrity, thus meeting *livable* objective for coastal water quality.

Dissemination of Information to Public

There is direct exposure of the public to the program through volunteer involvement, as the program is guided by the purpose of providing an outreach program for DFO to interact with community environmental groups.

Results are made public in yearly summary report form. As with other monitoring programs, there is a notable delay in the amalgamation of data into a publically accessible form, where the last yearly overview report was published for the 2007 sampling season (DFO, 2010c). DFO is presently working on a multi-year report, to include data from 2004 up to 2010 (personal communication Marie-Helene Thériault, June 28 2011).

The program serves to provide communities with common direction, resources and scientifically sound methods comparable between different locations within the geographical region. Initial summary reports evaluate success in meeting some objectives, noting particularly that the involving local individuals provided a positive way for local communities to gain direct knowledge of the importance of estuaries to the environmental health of their communities (Weldon et al., 2005).

Scientific Rigor

The program operates using set protocols developed and updated by DFO; these protocols have been kept constant to permit comparisons over time, but have evolved to incorporate new monitoring parameters (Theriault et al., 2008).

CAMP provides theoretical and hands-on training programs, with yearly modification depending on experience levels of coordinators, employees and volunteers

(Weldon et al., 2008). Methods have been "designed to be user-friendly requiring little technical expertise or infrastructure, and ideally suited to local community groups with some support from DFO" (Thériault et al, 2004). Chemical analysis is performed at the Bedford Institute of Oceanography (BIO) government lab.

In 2007, a QA/QC program was conducted to assess accuracy and precision of professional versus volunteer collected data (Thériault et al., 2008). As audit protocols were specific to accuracy and precision of species identifications and abundance estimates, it is important to note that this audit was conducted for data collected on fauna only and not for the aquatic vegetation survey or for the physical data collected through CAMP, thus not extending to many of the more direct parameters correlating to CWQ. Regardless, results of program demonstrated that overall data quality was high, provided incentive for program continuation, identified areas for training and overall program improvements, such as the aforementioned water sample analysis for nutrient content, and prompted recommendations made for continued QA/QC measures. With the government audit showing the strength and quality of data collected through community-based means, these results offer encouragement for other such programs.

Contribution to Management for Improved CWQ

Significant example of CAMPs integrative capacity is along the lines of science-management integration. As described, CAMP is a specific example of scientific monitoring designed for as an indicator of ecosystem health applicable to particular issues impacting this unique section of coastline. The potential use of the program to affect management decisions is evident in the four preliminary pilot sites which were selected based on proximity to seafood plants and water treatment plants, using indicators

to evaluate stress of effluent on the receiving environment (Theriault et al., 2004). Monitoring activities are directed at the evaluation of these issues in order to improve management measures, such as the antiquated guidelines for Fish Processing Operations Liquid Effluent released in the mid 1970's (Theriault et al., 2004; Environment Canada 1975). Taking these factors into consideration, as designed, CAMP is a monitoring program well situated within greater IM process.

Contribution to Integrated CWQ Monitoring

The CAMP program offers an ecosystem-based approach to monitoring, accounting for more complex biological indicators of CWQ.

4.6 Atlantic Coastal Action Program and the Clean Annapolis Rivers Project

The ACAP program aims to help individual communities in Atlantic Canada to develop their own management plans, with the aim of restoring and sustaining local watersheds and adjacent coastal areas (Rousseau et al., 2006). Although ACAP itself is not specifically a CWQ monitoring program, many of the ACAP groups engage in watershed and CWQ monitoring activities, as noted for CARP. CARP is drawn on for specific monitoring examples, as well as assessment of ACAP programs taken collectively.

Box 4-6: Atlantic Coastal Action Program and the Clean Annapolis Rivers Project

1. Purpose
To sustain and restore water quality while involving public in decision-making

2. Issues Addressed
Anthropogenic influence on watersheds and coast

3. CWQ Objectives
Livable, Swimmable, Fishable

4. Actors and Responsibilities
Community groups, EC

5. Parameters and Indicators
For groups surveyed, majority (10 of 14) monitoring dissolved oxygen (DO), pH and water temperature parameters; other commonly observed parameters included fecal coliforms, nitrate, salinity and phosphorus (Sullivan and Beveridge, 2005). Oftentimes, bacterial and nutrient data were analyzed by provincial or EC government laboratories (Sullivan and Beveridge, 2005), providing credibility to results, and providing the potential for data comparison between sites.

6. Geographic Scope
EC operates ACAP on a regional basis, with 16 ACAP sites spread throughout the Atlantic provinces.
In Nova Scotia, five ACAP groups have been established, located in distinct geographic regions of the province (Rousseau, McNeil and Hildebrand, 2006):

- ACAP Cape Breton Inc., Sydney (Cape Breton)
- Bluenose Coastal Action Foundation (BCAF), formerly the Bluenose Atlantic Coastal Action Program, Lunenburg (South Shore/Atlantic Coast)
- Clean Annapolis River Project (CARP), Annapolis Royal (Annapolis Valley)
- Pictou Harbour Environmental Protection Project (PHEPP), (Northumberland Straight/Southern Gulf of St. Lawrence).
- Sable Island Preservation Trust; Sable Island

7. Sampling Intensity
Although locally specific in nature, programs concern over common issues, such as fecal contamination (Sullivan and Beveridge, 2005), utilize common protocols and monitor for the same CWQ parameters. Monitored conducted using similar protocols, often implementing pre-established protocols developed by government or other research institutions.

8. Start Year
1993

9. Statutory Basis
No

10. Current Integration
Integration between government and communities is also an intrinsic feature of the program. For example the ACAP group Clean Annapolis River Project (CARP) operating in Annapolis Valley, while community and volunteer based, CARP cites support from partners including EC, DFO, industry, independent organizations, provincial government (NSE), and scientific research community (CARP, n.d.).

Additional Information
Many sites report using EC's Canadian Aquatic Biomonitoring Network (CABIN), which provides standard monitoring protocols using benthic macroinvertebrates as indicators of water quality as well as chemical and physical parameters (water temperature, nutrients, pH, dissolved oxygen and stream flow). Although not inclusive of ACAP groups in Nova Scotia, ACAP in other Atlantic provinces have participated in DFO's CAMP program (Sullivan and Beveridge, 2005) (Box 3-5)

Addresses Nova Scotia's CWQ Objectives

One of the most notable features of ACAP is that the program has evolved to address broader issues than simply that of water quality, focusing on broader issues of sustainability and community use of natural environments. Issues of CWQ are situated within a greater socio-economic and human context, as well as are relevant to the bigger picture of ecosystem health.

Dissemination of Information to Public

Drawing from the CARP example, current monitoring results contribute to a number of studies and publications which are provided online. One example is an annual Water Quality Monitoring Report which reports on monitoring data.

Scientific Rigor

CARP cites support from partners including EC, DFO, industry, independent organizations, provincial government (NSE), and scientific research community, including a Science Advisory Group that provides input on study design, methodology and the analysis of results (CARP, n.d.)

Contribution to Management for Improved CWQ

Evaluation of the success of ACAP to influence policy decisions has received mixed review. Rousseau, McNeil and Hildebrand (2006) identify that all of the ACAP groups have in some way influenced local and/or regional decision-making, and that an important contribution of such a community-based program is "the ability of the communities involved to bring to light potential and existing environmental, social and economic problems to decision-makers at all levels and in all sectors" (Rousseau et al,

2006, p.487). While monitoring data may not itself be of use, results have been used to launch formal investigations by those agencies with mandates for enforcement, or have led to response to issues by communities through remediation and restoration activities (Rousseau et al., 2006).

Sullivan and Beveridge (2005) provide a more balanced picture, identifying that while monitoring has in some cases proved effective, such as through improved municipal and private wastewater treatment, concerns have been raised that a one-way or lack of dialogue exists, undermining the role of community-based monitoring to contribute to the IM policy cycle. Surveys of community programs describe low engagement by decision makers, where there is a lack of formal feedback, or when feedback is given it is found to be non-constructive, and where "most of the solutions were action-oriented, based on specific instances, rather than changes to written policy (Sullivan and Beveridge, 2005, p.6). While both reviews demonstrate that monitoring results appear to have less impact on province wide management decisions, success does occurs albeit on a case-by-case, issue specific and local basis.

Contribution to Integrated CWQ Monitoring

Again taking CARP as an example, monitoring data is analyzed and results presented in project report documents, including a watershed summary report card and an annual comprehensive review report on status and trends of water quality in the watershed, contributing to awareness on local issues of environmental health and quality. Individual studies have been conducted to investigate locally specific issues or problems, including DO levels in downstream estuarine areas, as well as weekly monitoring of bacteriological levels at beaches in relation to shellfish harvesting. However these short,

one-off programs only operate for one or two seasons, and projects have ceased due to lack of continuation of government funding (Levi Cliché, personal communication, June 17, 2011). While the ability for CARP and ACAP to respond immediately to new issues, albeit locally specific ones, is a strength of the program, apparent challenges are longevity and capacity.

4.7 Halifax Regional Municipality Recreational Monitoring Program

The Halifax Regional Municipality Recreational Monitoring Program (HRMRec) is a recreational water quality monitoring conducted by the Halifax Regional Municipality (HRM) through a summer supervised beaches recreational program. The objective is to ensure safe recreational waters for the public, thus serving to meet the *swimmable* CWQ objective.

Meets Nova Scotia's CWQ Objectives

The HRMRec addresses the *swimmable* CWQ objective. Some concern could be raised on the frequency of sampling relative to frequency of use, where weekly sampling would not capture day to day variation, although safety measures for recreational closures are triggered in the event of heavy rainfall.

Dissemination of Information to Public

Information regarding CWQ conditions is communicated to the public through posted closure notifications, an online website, and over phone through the HRM Beach Phone Line (HRM, 2011).

Box 4-7: Halifax Regional Municipality (HMR) Recreational Monitoring Program

1. Purpose To ensure for safe use of recreational waters
2. Issues Addressed Contamination of recreational waters
3. CWQ Objectives *Swimmable*
4. Actors and Responsibilities The program is administered at the municipal level, overseen and operated by employees of the Halifax Regional Municipality (HRM).
5. Parameters and Indicators Sample analysis is specific for Escherichia (E.) coli and Enterococci bacteria and beach closures are determined if levels of indicator bacteria exceed guidance thresholds, as per Health Canada guidelines (HC, 2009)
6. Geographic Scope 24 supervised HRM beaches (3 coastal) Locations: Black Rock Beach/Point Pleasant Park, Dingle Beach/Fleming Park in Halifax, and the Government Wharf in Musquodoboit Harbour (HRM, 2011).
7. Sampling Intensity Temporal intensity: weekly/frequent One sample per beach per week Approximately ten weeks, July 1 to end of August, the summer swimming season (personal communication Cameron Deacoff, July 5, 2011).
8. Start Year NA
9. Statutory Basis None
10. Current Integration Science to inform management
Additional Information At present, the only CWQ monitoring conducted by the HRM is through this program. Formerly, a separate but similar program, the Halifax Harbour Water Quality Sampling Program, was in operation, initiated to address the specific issue of sewage outfalls in Halifax Harbour as part of a Harbour Solutions Project, concluded in 2010 (HRM, 2010a). However, while monitoring for similar parameters and overlapping spatial areas, important to note the two programs were never connected (personal communication Cameron Deacoff, July 5, 2011). HRM has committed, through its Regional Plan, to planning on a watershed basis, to strive to meet body contact recreation standards in its lakes, waterways and coastal waters, and to attempt to stem the decline of lakes from eutrophication, sedimentation and other impacts from urban runoff by managing development on a watershed basis. (HRM, 2010b)

Scientific Rigor

Samples analysis is conducted by commercial contract laboratory, and training, advice and support are provided to staff on sampling collection, sample management, transport, and documentation (personal communication Cameron Deacoff, July 5, 2011). Standardized monitoring and analysis protocols exist and are practiced; QA/QC measures

are employed in analysis but are only under development in the field (personal communication Cameron Deacoff, July 5, 2011).

Contribution to Management for Improved CWQ

HRMRec provides a limited, reactionary management response, rather than providing a way to contribute towards management action for improved CWQ. The program shows limited integration with management process. While monitoring results are used to make informed management decisions to protect the public through beach closures, it targets very specific issues of CWQ in relation to a very specific coastal use; the program is not designed to evaluate broader coastal management decisions.

Contribution to Integrated CWQ Monitoring

As the program is spatially localized and sampling frequency relative to other programs is intensive, opportunities to contribute to integration lies in frequency of sampling. Integration of results from across different municipalities could be included in a clearinghouse for accessibility to the public to show the relative *swimmable* quality of recreational coastal areas.

One identified benefit to integration is observed in opportunities to work within a local watershed and integrate freshwater monitoring activities in the HRM, providing for assessment along a watershed basis, as the HRM currently operates a seasonal WQ monitoring program for fresh waters. However this program would need to be expanded to coastal waters (HRM, 2010b).

Table 6: Summary Comparison of Monitoring Programs

Research Questions	Program						
	MWQM	**Gulfwatch**	**EMP**	**EEM**	**CAMP**	**ACAP**	**HRM**
1. Purpose	To monitor shellfish harvesting areas for safe human consumption	To monitor changes and trends relative to ecosystem and human health	To monitor environmental effects of aquaculture industry	To monitoring environmental effects of metal mining and pulp and paper industries	To monitoring trends and changes in watershed and ecosystem health	To sustain and restore water quality while involving public in decision-making	To monitoring recreational beach to ensure for public health and safety
2. Issues Addressed	Bacterial contamination from point and non-point sourced pollution	Anthropogenic pollution of coastal waters	Aquaculture impacts on coastal waters	Industry Effluent	Anthropogenic impacts and cumulative effects on coastal ecosystems	Anthropogenic influence on watersheds and coast	Bacterial contamination from point and non-point sourced pollution
3. CWQ Objectives	*Fishable*	*Livable*	*Livable, Fishable*	*Livable, Fishable*	*Livable, Fishable*	*Livable, Swimmable, Fishable*	*Swimmable*
4. Actors and Responsibilities *performs monitoring activities	EC*, CFIA, DFO	GOMC, volunteers*, NGOs, scientific research community, EC, DFO	Industry*, NSDFA, DFO	Industry*, EC	Community volunteers*, students*, NGOs*, DFO	Community groups*, EC	HRM*
5. Parameters and Indicators	Faecal coliform bacteria	Organic and inorganic contaminants in blue mussel tissue	Benthic sediments, visual, water depth and temperature	Subleathal toxicity testing on effluent, fish tissues and benthetic invertebrate communities	Species diversity and abundance; Water salinity, temperature, DO, and chemical analysis, waterborne nutrients, sediment samples	Varies by ACAP group, see Box 3-2 for details	Escherichia (E.) coli and Enterococci bacteria

Research Questions	Program						
	MWQM	**Gulfwatch**	**EMP**	**EEM**	**CAMP**	**ACAP**	**HRM**
6. Geographic Scope	National: Extensive coverage of Nova Scotia Coastline	Regional: Gulf of Maine, trans-boundary considerations with New Brunswick and United States	Provincial: Specific to Nova Scotia, locations specific to industry sites	National: Locations specific to industry sites	Regional: Northumberland Strait/Southern Gulf of Saint Lawrence	Regional: Atlantic Provinces, with 5 ACAP sites in Nova Scotia	Local: Recreational beaches (coastal and fresh water) in HRM
7. Sampling Intensity	5 times every 3 year sampling cycle; varies by site classification	Tiered: One time per 2 years (temporally intensive) One time per 6 years (spatially intensive).	Varies by risk classification	Varies by industry effort	Monthly from May to September	Varies by ACAP group, see Box 3-2 for details	Weekly over 10 weeks from July to end of August
8. Start Year	1920s	1993	2003	Metal Mining: 1993 Pulp and Paper:	2003	1993	NA
9. Statutory Basis	Statutory Requirement	NGO/Research Community incentive	Statutory Requirement	Statutory Requirement	Voluntary	Community incentive	Municipal by-aw requirement?
10. Current Integration	Horizontal between federal government departments	International, NGO, federal government, science-management	Industry and government, science-management	Industry and government, science-management	Science-Management, Government, NGOs, Community	Community and Government	Science-management

Table 7: Summary of Monitoring Program Evaluations

Research Questions	Program						
	MWQM	**Gulfwatch**	**EMP**	**EEM**	**CAMP**	**ACAP**	**HRM**
Effectively Addresses CWQ Objectives	Yes	Yes	No – does not consider far field effects	Yes	Yes	Yes	Yes
Dissemination of Information to Public	Limited: Closure announcements	Yes, inclusion in broader GOM ESIP indicators, delay of publications	Stated objective but lack of follow through	At request of public	Yes, delay observed in publications	Yes, direct involvement of public, CARP publications	Limited: Closure announcements
Scientific Rigor	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Contribution to Management for Improved CWQ	Limited – protects public, but addresses symptoms not problems	Identifies trends and changes – contributes to adaptive management process	Limited – meets regulatory requirement	Limited – meets regulatory requirement	Identifies trends and changes – contributes to adaptive management process	Engages public in decision making, provides local solutions to local problems	Limited – protects public, but addresses symptoms not problems
Contribution to Integrated CWQ Monitoring	Extensive Spatial Coverage, Province wide CWQI	Long-term trends and changes, indicator for CWQI	Benefits from an integrated program	Benefits from an integrated program	Contribution to broader ecosystem-based understanding of CWQ	Continuity between fresh and coastal waters	Continuity between fresh and coastal waters

Chapter 5. Analysis of Case Study Findings

The following chapter is a cross analysis of the seven case studies evaluated. This analysis serves to identify key strengths and weakness of the current monitoring capacities in Nova Scotia.

5.1 Range of Temporal and Spatial Coverage

Programs evaluated demonstrated a range of geographic scale, as was determined to be represented in the program selection criteria, where programs ranged from operating from national to local level. The MWQM, through CSSP, a nationally administered program, covers the greatest sampling area. EEM and EMP, as an industry effects monitoring program, are limited in range by aquaculture, metal mining and pulp and paper plant site locations. HRM is localized and has minimal coverage.

There is varying intensity of monitoring within the sampling season, ranging from annual/biannual scale to weekly sampling frequency. Many programs operate over the summer-fall season, however it is noted that weather conditions limit access to coastal waters outside of this season (personal communication David McArthur, August 4, 2011). The Gulfwatch model, applying two different sampling tiers, offers a compromise to meet both temporal and spatial needs, however temporally intensive monitoring still operates on low frequency (annual) basis.

5.2 Connectivity to Adjacent Waters

A key observation is found in the difference between how programs define monitoring areas. In the cases of Gulfwatch, ACAP and CAMP, monitoring is operated on a scope defined on geographic considerations and on a watershed or ecosystem-basis.

The CSSP, HRMRec, monitoring efforts reflect the specific coastal water use that monitoring is intended to address.

For all monitoring programs, while monitoring is conducted in the coastal areas, only the CAMP considers the interface between fresh and coastal waters in estuaries. Monitoring activities are also defined on a watershed basis by different ACAP groups conducting monitoring. These programs would serve to increase understanding on CWQ issues on a watershed basis.

5.3 Scientific Rigor

All seven programs demonstrate an appropriate degree of sound scientific methods and thus can contribute scientifically valid data and information to enable management decisions. Key findings include the role of government, although not responsible for monitoring activities, to provide community-groups with accredited laboratory analysis facilities, access to equipment and resources, and formal connections to advisory groups. Also notable is the audit of CAMP results against data collected by government scientists, which suggest that to ensure trust-worthiness for volunteer or community-based monitoring, there is a need for a government or research institution to take a facilitative role in order to ensure confidence in results for inclusion in management decisions.

5.4 Address Single and Complex Issues

The seven programs can be divided into two groups in terms of the approach taken and types of issues addressed: a single issue, silo approach versus a complex issue, integrated, or ecosystem-based approach.

The MWQM, EMP, EEM and HRMRec programs fall into the former category, where monitoring addresses a specific coastal water use or activity, or in response to a particular issue. These programs serve specific functions that provide essential information to meet management and regulatory needs. In the case of MWQM and the HRMRec programs, paramount concerns for public safety and health ensure that these needs are met as required. Evaluation of the EMP program raises concerns that current monitoring is too limited in scope to effectively evaluate broader and cumulative effects to the ecosystem. These programs are assessed as being reactive to issues impacting CWQ, rather than using CWQ proactively to facilitate management decisions.

Inclusion of these issues-based programs into an integrated monitoring program could provide additional data and information that could contribute to a more holistic understanding of the problems impacting CWQ. However, given the limited parameters covered and their industry site-specific spatial range, these programs serve to target very specific areas of use and have limited use as indicators of very specific anthropogenic impacts or CWQ problems. Consequently they represent only a small contribution towards targeting a much larger understanding of ecosystem health. EEM falls somewhere in between; while it is an issues-driven program, monitoring indicators that incorporate biological, ecosystem-based considerations, the EEM's monitoring range is specifically determined by industry sites, and is thus limited.

In comparison, CAMP and Gulfwatch are geared towards addressing broader changes and trends, and aim to contribute to an understanding of bigger ecosystem pictures, serving as indicators relating to more complex and abstract concepts of quality and health. As well, ACAP groups incorporate a broader ecosystem-based approach to

watersheds, incorporating sustainability principles and socio-economic considerations. These intrinsically integrated programs demonstrate better suitability to facilitate a broader and more holistic approach to coastal management.

5.5 Dissemination of Results

An apparent gap common across all programs is the release of monitoring results and information to the public. This delay is most notable for programs addressing questions pertaining to the *livable* CWQ objective which deals with more complex issues and questions, versus those programs addressing issues pertaining to the *fishable* and *swimmable* CWQ objectives. In these cases, driven by priority concerns over public health and safety, there is quick management response met through recreational or harvesting area closures.

For the programs aiming to serve the *livable* CWQ objective, the problem is not unique to one program type; and the process appears slow at all levels. The interpretation and summary of monitoring results suggest it is a lengthy process, perhaps slowed by the complicated and complex natures of addressing issues from an ecosystem-based perspective. This suggests the need for more streamlined process, including established indicators and a CWQ or ecosystem health index.

5.6 Community-Based Monitoring

Two different community-based programs were evaluated and two different types of organizational structure and pattern for monitoring were observed. CAMP is a monitoring network versus ACAP which monitors through individual community-based groups. These two types are distinguishable in that networks work over a broader

geographic range, with the main role of providing data for use by government agencies or researchers, whereas community-based groups are more geographically focused and work within a defined local area such as a watershed; data is transmitted through formal partnerships or informal communications, showing greater group to group variation, and providing higher opportunities for community and volunteer education (Lukasik, 1993).

While both programs have developed to contribute to coastal management and are based on motivation for increased public involvement, differences in administration and structure affect the degree to and ways in which each contributes to the coastal management process. CAMP, led and developed by government through a top-down approach with integration of the public into the monitoring process, provides for common protocols and consistency of methods, allowing for site-to-site comparability, and designed to monitor long-term change and trends, in many ways contributing to management decisions. Conversely, ACAP developed through facilitated bottom-up approach, resulting in locally developed programs to address locally specific monitoring needs and issues that may not transfer across the whole province. ACAP type monitoring contributes to public awareness and issue identification, but is locally and issue specific and less suitable for integration within a broader provincial CWQ process. Where commonalities lie is in the use of government protocols such as EC's CABIN monitoring protocols which can allow for comparability between groups and between fresh and coastal areas of a given watershed. The use of these methods is indicative of the need for government involvement, at least at the inception phase, to facilitate output consistency should community-based monitoring be incorporated into an integrated monitoring program.

5.7 CWQ Objectives

Of the three CWQ objectives, those of *fishable* and *swimmable* are met in terms of management response for the safety and protection of human health. Monitoring in terms of meeting these two objectives would not significantly benefit from integration; it is necessary that they be managed on sectoral and on a needs-basis.

Where integration stands to serve the greatest benefit is in addressing more complex issues of environmental health and quality, that being the *livable* CWQ objective across the province. By incorporating various monitoring information from across different programs and issues, integration can help to cover more extensive areas on both the temporal and geographic scales, monitor greater number of parameters, factor those parameters into a broader ecosystem-based understanding, and streamline results and resources to reach both public and coastal managers.

Chapter 6. Recommendations and Conclusions

Having assessed the current effectiveness of Nova Scotia monitoring programs in addressing the objectives of CWQ, identified key opportunities and barriers to integration of CWQ monitoring efforts in the province, and assessed priority areas for improvement among the monitoring program case studies, this chapter draws on those findings to address the two research questions: (1) Does current monitoring effectively address Nova Scotia's CWQ needs and objectives? (2) How would current monitoring benefit from integration? Based on the answers to these questions, strategic recommendations are provided for the improvement and integration of CWQ monitoring activities in Nova Scotia.

6.1 Effectiveness of Current CWQ Monitoring

The objectives of *swimmable*, *fishable* and *livable* coastal waters were identified as three key objectives for Nova Scotia. The ability of current monitoring programs to meet these needs was addressed as follows:

Swimmable and Fishable Waters

CWQ monitoring activities effectively address the state of Nova Scotia's coastal waters for recreational and resource extraction purposes when there is a concern for the health and safety of the public. This is observed with the HRMRec recreational and the CSSP harvesting site closures. However the impact these monitoring activities have on coastal management measures can be viewed as highly reactionary to the problem at hand, rather than contributing proactive management actions to improve the *swimmable* and *fishable* quality of coastal waters.

Livable Waters

While some cases of CWQ monitoring activities address the *livable* quality of Nova Scotia's coastal waters and provide indicators of health and integrity, for example the CAMP and EEM programs, there is a need to expand these types of programs to cover a greater portion of the province. This is particularly the case of problem areas such as aquaculture, where current monitoring efforts are ineffective in addressing key issues.

In addition to meeting these three objectives, two key requirements that need to be fulfilled by monitoring activities were identified; the contribution of monitoring efforts to the collection of knowledge on CWQ, and the contribution of monitoring to affect decision making in the broader coastal management process.

Contribution to Public Awareness

While there are cases of community engagement in monitoring and enhancement of public awareness of CWQ, the communication of the results of monitoring to the public is not effectively carried out. Nova Scotia CWQ monitoring efforts would benefit if the information collected from various programs were brought together in a means that is more publically accessible. This need is both in terms of access to information and the reporting of information in a way that is easily decipherable and reflects social values, such as a CWQ index or broader sustainability indicators. This type of reporting could contribute to better public awareness and understanding of the state of CWQ.

Contribution to Management Decisions

There is a need to expand programs which offer a contribution to the coastal management decision making process. Current government led programs, such as CSSP/MWQM, and EMP, fulfill their legislative requirements for regulatory monitoring, however these efforts stop short of contributing to a broader understanding of CWQ. The programs which affect the best understanding of CWQ, in terms of increasing knowledge of impacting issues, evaluating the effectiveness of management practices, and prompting constructive and remedial actions, are inherently integrated programs with ties to NGOs and community groups such as Gulfwatch, CAMP, and ACAP. Programs with a voluntary component demonstrate an effectiveness to address issues for the improvement of CWQ.

6.2 Benefits of Integration

The following opportunities for integration were identified as providing key benefits to coastal monitoring activities in Nova Scotia:

(a) Improve Science-Management Integration

Science-management integration includes establishing stronger linkages between the natural and social sciences. In the case of current CWQ monitoring activities, there is a benefit to using scientific data collected from monitoring to develop indicators to better report on the concepts of quality and health of coastal waters.

Efforts to expand and improve CWQ monitoring activities in Nova Scotia should be geared towards providing indicators that allow for the assessment of changes and trends over time, as is observed in the Gulfwatch monitoring program. Incorporating this

type of program would allow for the assessment of how CWQ is changing over time and provide a feedback mechanism to evaluate both emerging issues and the effectiveness of coastal management actions.

There is a need for CWQ monitoring activities to be factored into a broader management process, where the collection of data from individual monitoring programs would contribute to a better overall understanding of the state of Nova Scotia's CWQ and coastal health. While monitoring activities performed by federal and provincial levels government generate a specific management response, this is reactionary to a problem as opposed to contributing to improvement of CWQ. This is the case with the federal level CSSP/MQWM and EEM, the provincial level EMP, and the municipal level HRMRec programs. There is a need for formal inclusion of monitoring activities designed to contribute to the assessment of trends and changes over time, such as observed with the Gulfwatch, ACAP/CARP, and CAMP programs.

(b) Spatial Integration to Address Complex Issues through an Ecosystem-Based Approach to Monitoring

Spatial integration between the land and ocean sides or the coastal zone would provide a means to better address the *livable* CWQ objective. Rather than expanding programs to cover the most extensive geographic range determined by administrative boundaries, there is incentive to focus efforts on integration of programs that better address the interconnectivity of the coastal zone and reflect the variation and diversity of the ecological conditions that Nova Scotia's coastal waters support. This would require monitoring programs that are locally developed to assess specific ecosystems.

Efforts to improve and integrate CWQ monitoring efforts should focus on programs where assessment is based on indicators that contribute to a broader understanding of CWQ and coastal health, rather than single parameters, to allow for a broader understanding of ecosystem-based considerations of integrity and health and to better evaluate the *livable* CWQ objective. Monitoring through an ecosystems-based approach would benefit the assessment and understanding of more complex CWQ issues, such as non-point source pollution or cumulative impacts in coastal waters. While this is achieved in some cases, as with the CAMP and EEM programs which incorporate biological indicators that account for impacts on species diversity and ecosystem integrity, these programs currently operate on a limited geographic range. There is a need for programs of this nature to cover the full extent of Nova Scotia's coastal waters.

This need is again best served by programs that apply multiple parameters or more complex indicators that link assessment of CWQ to ecosystem health. It would also be served by integration of monitoring activities and assessment on an ecosystem basis, considering natural or geographic boundaries as opposed to administrative ones.

(c) Integration with Communities and NGOs

As the Nova Scotia coastline represents a significant area for monitoring and management activities to cover, integration of community groups which are spatially located in coastal areas could serve to significantly increase the range of monitoring coverage. As socio-economic values are integrated with coastal and other resource uses, many of which depend on healthy waters, there are many stakeholders with an interest in the state of CWQ who would benefit from integration. Integration of community groups

in monitoring efforts provides a means for primary stakeholders to participate in coastal management and planning activities and could contribute to awareness of issues impacting CWQ. Many NGOs are currently demonstrating collaborative efforts between academia, government and community groups, as well as approaching coastal management and monitoring on an ecosystem-basis. It would be beneficial to build on these existing networks and collaborative monitoring efforts.

Citizen engagement in monitoring has benefits to the community, including direct access to information on local issues and resources of personal interest, serving as a way for citizens to access environmental information, community engagement, building of social capital, greater connection to existing agencies and institutions, educational benefits and increased public awareness, and identification of community and resource values that might have otherwise be overlooked (Lukasik, 1993; Grant, 2010; Whitelaw, et al, 2003). It also provides benefits to government, helping to fill the void in government monitoring activities to provide information regarding more complicated ecosystem-based questions and help to address more complex ecosystem based issues (Conrad and Daoust, 2008; Grant, 2010).

As identified in Chapter 3, there are limitations to the inclusion of community-based monitoring activities into formal management decision making process. These limitations are observed in Nova Scotia, as demonstrated by the comparison between the CAMP and ACAP/CARP monitoring programs, where there is a need for formal involvement between policy and decision makers in order for community-based monitoring to be factored into a larger decisions making process. Whitelaw et al (2003) identify best practices to overcome these limitations, which include: employing

straightforward and scientifically rigorous methodologies, incorporating measures for field training and data verification, and focusing on programs which deliver outcomes that address issues and values relevant to the needs of informed policy and management decisions.

(d) Horizontal and Vertical Government Integration

Fresh and coastal water quality monitoring and management are taking place at all levels of government, with key departments identified in the investigation to be EC and DFO at the federal, and NSE and NSDFA at the provincial level. Defining monitoring efforts on a geographic basis would require strong horizontal and vertical ties between these levels, particularly in the case of Nova Scotia where coastal waters overlap with New Brunswick, PEI and the United States through the Gulf of Maine.

6.3 Recommendations

Based on these findings, the following recommendations for actions to improve and integrated CWQ monitoring in Nova Scotia are provided:

(a) Develop a province wide set of indicators for CWQ

In order to better inform the public on the results of monitoring and in order to better report on the quality and health of coastal waters, there is a need for the province to develop a set of indicators that incorporate the full range of chemical, physical and biological CWQ parameters. Information from established indicators could be used to evaluate trends and changes and contribute to annual state of the coast reports on key ecosystems in the province.

These indicators should be representative of both simple and complex issues affecting CWQ. As the CSSP program accesses the greatest extent of coastline, there is an opportunity to contribute to added understanding of CWQ by expanding the program to analyze for additional parameters. Expanding the Gulfwatch program to other areas of the province would contribute to the assessment of trends and changes with coverage across all areas of the province. This could be conducted through present volunteer model but could also be facilitated through the CSSP program, as the two programs operate on similar sampling intensities and as there is an existing connection between Gulfwatch and federal laboratories for sample analysis. As Gulfwatch allows for comparative assessment between areas, expanding the program to additional sites in Nova Scotia would serve as a relative indicator between different coastal areas.

(b) Define monitoring efforts based on geographic boundaries

While there is a benefit to have a common suite of indicators defined on a province wide basis, there is a need to recognize the variation between different areas, taking into consideration the connectivity of fresh and coastal waters. In order to better address the *livable* objective for CWQ for coastal waters in the provinces, there would be a benefit from expanding monitoring efforts that incorporate a suite of indicators that assess ecosystem integrity and health for greater coverage. This should be conducted on a regional basis, reflecting the variability between ecosystems. This would better contribute to understanding cumulative effects from multiple pollution sources. The research called for in the NorSt-EMP project offers a key contribution to developing an indicator of this type.

In order to undertake monitoring efforts through an ecosystem approach, it is recommended that integration efforts be focused within geographically defined areas identified in the Coastal MOU. Key ecosystem-based initiatives in these areas are recognized with the EC's AEIs and DFO's ERIs, as defined research and management areas. These federal efforts could contribute to knowledge of CWQ in a broader ecosystem-based, coastal health, and sustainability context.

(c) Expand coverage through a community-based monitoring network

Given the recognized benefits of integration through community-based monitoring both to local communities and government, it is recommended that greater integration of community groups be undertaken to improve CWQ monitoring efforts. While there are limitations with community based-monitoring, CAMP overcomes many of these limitations by operating as a government led network of local NGOs and volunteers, and by incorporating training, standard protocols and equipment. This could be facilitated through a program like CBEMN that is focused on supporting community-monitoring efforts in coastal waters.

It is recommended that the Government of Nova Scotia establish a community-based monitoring network for the province. This could be implemented following the CBMEN model, where training and expertise are provided to local coastal groups across the province. This kind of monitoring network would require a common set of protocols designed by a government or science research institution. The CBEMN Marine Community Monitoring Manual could be incorporated as a starting point for this

initiative, or a government sponsored initiative such as CAMP or EC's freshwater CABIN program.

There is need for this initiative to be led either by the provincial government through the NSDFA, or through partnership with an academic group or NGO agency. There is a key opportunity in that the Government of Nova Scotia has already committed to building a provincial coastal research network as a partnership between public, private and academic research institutions. This network would facilitate connections between these institutions and local community groups, in order to ensure that best practices for monitoring are employed. This linkage would better enable monitoring efforts to be used in the coastal decision making process, would ensure that methods and results are comparable between community groups, and could be designed to meet the identified need for a province wide set of indicators. There is a recognized limitation in that few community groups in the province are engaged in coastal monitoring activities, however this limitation could also be viewed as an opportunity to build-in scientifically rigorous methods and comparability between local groups, rather than having monitoring efforts develop independently as observed with the individual ACAP programs. A community-based monitoring network could also serve to link current fresh and coastal water monitoring initiatives along a single watershed, for instance identifying the current areas where there is overlap between CABIN and CAMP monitoring activities.

(d) Establish workplans between DFO, EC and PON/NSDFA

Each level of government currently performs CWQ monitoring activities. While these activities were assessed at responding to CWQ issues in a reactive manner, they

nonetheless contribute to a significant extent of CWQ monitoring. In particular, EC's monitoring responsibilities through the CSSP/MWQM program covers the most extensive area of coastline, and could contribute to a province wide indicator with comparability to other regions on a national level.

While the Coastal MOU is a clear step towards collaboration between these parties on the issue of CWQ, an MOU provides only a non-binding agreement between parties. It has been observed that there are a large number of MOUs in existence in Canada, yet few are successfully implemented without consistently facilitated cooperation (McCrimmon and Fanning, 2010). Successful MOU cases highlight the importance of communication between parties, a clear understanding of the purpose of the MOUand an appropriate balance of expectations (McCrimmon and Fanning, 2010). A short-term priority is to follow through on the Coastal MOU in a timely manner and to start building on these working relationships as soon as possible to ensure the Coastal MOU comes to fruition.

A priority action for both federal and provincial parties is to agree upon collective actions, goals and timelines and establish a clear and solid workplan outlining individual responsibilities regarding efforts to improve and integrate CWQ monitoring. There is a need for such agreements and workplans to be written with a demonstrated degree of detail and clarity, to include provisions for annual revisions, and to be adaptive and flexible (McCrimmmon and Fanning, 2010). A priority area to address is the potential for linkage between DFO's CAMP and EC's CABIN program, as well as the linkages between the respective AEI and ERI

(e) Integration between provincial strategies

It is recommended that actions taken by the PON be aligned with NSE's actions for integrated water management, as called for in the Water for Life strategy. This would provide a key opportunity to identify linkages between fresh and CWQ monitoring efforts, contributing to better knowledge on the particular land-based issues impacting individual coastal ecosystems and pollution of coastal waters from land-based sources. This includes incorporating the watershed information NSWAP project, which would contribute to determining how and where monitoring efforts should be focused. This project could also be taken as a model to apply in coastal areas to better map the individual ecosystems.

(f) Provide a clearinghouse of information to the public

It is recommended that the Government of Nova Scotia produce an indicator reporting tool to disseminate information on CWQ to the public. This could be provided through a publically accessible clearinghouse of information which could be modeled on the Water Portal produced by the NSE. Regardless of whether this is provided as a separate website or included as subheading of the Water Portal, there should be linkages between the two. This portal would provide a key tool for dissemination of CWQ information to the public, which could be organized by geographic region, by watershed, and by local community.

6.4 Conclusions

CWQ quality has been identified as a priority issue in Nova Scotia. While a host of monitoring efforts are underway in coastal waters across the province, performed by

government, NGOs, communities and through collaborative efforts, there remains a gap in CWQ monitoring information in the ability to address more complex questions of coastal health.

This assessment has covered only a limited number of programs and addressed specific questions reflecting the integration of monitoring, in order to suggest priority avenues for efforts to improve and integrate water quality monitoring. The programs were selected to demonstrate the breadth of programs in operation and illustrate the many different factors that would need to be considered in an integrated strategy. It has served to demonstrate the many degrees of complexity in attempting to integrate all programs and operating on a province wide basis.

This research has identified keys areas for efforts to improve and integrate CWQ monitoring in Nova Scotia. In many ways, integration is in itself a key strategy to improve monitoring activities. While covering this breadth of programs has allowed the drawing of these conclusions, it has also highlighted key areas for further investigation. One question raised in this investigation is the degree of connectivity between fresh and coastal waters. While research efforts were focused on monitoring activities conducted in coastal waters defined as salt and brackish waters, findings identified some cases where linkages could be made between monitoring efforts conducted in fresh and coastal waters, including HRMRec and CARP and other ACAP groups, as well as where monitoring was conducted at the interface between fresh and coastal waters through CAMP. Future studies to assess integration of monitoring on a watershed basis could approach a more in depth comparison between these programs. As the results suggest that integration of monitoring activities should be approached by taking a geographic or watershed

approach, future case studies assessing integration performed on a watershed basis would help to assess the potential for integration in this domain. While this research has focused on the land to coast connection, this is not to exclude influence from marine waters.

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