Public Perception of Water Quality in Halifax Harbour

by

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This research project report titled *Public Perception of Water Quality in Halifax Harbour* has been examined and approved for the Department of Geography, and it completes the requirements for Geography 4526.0: Honours Research Project.

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ABSTRACT

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The purpose of this research is to identify public perception of water quality in Halifax Harbour in light of ongoing sewage treatment issues and the opening and closure of Black Rock and Dingle beaches for swimming in 2008. An additional research goal was to establish how and from whom the public would prefer to receive water quality data related to Halifax Harbour. Surveys were conducted through interviews in public areas in Halifax and via the internet to determine public perception of Harbour water quality in 2008 and 2009 in comparison to municipal information that was reported during this time. Survey results indicate that public opinion is divided in relation to past and future potential recreational use of the Harbour and its beaches. The goal of this research is to recommend an effective environmental monitoring and management style for Halifax Harbour that improves environmental conditions, engages public participation, and encourages public confidence.

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RÉSUMÉ

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Le but de cette recherche est d'identifier la perception publique de la qualité de l'eau dans le port de Halifax à la lumière des issues continues de traitement d'eaux d'égout et de l'ouverture et la fermeture des plages noires de roche et de Dingle pour nager en 2008. Un but additionnel de recherches était d'établir comment et de qui le public préférerait recevoir des données de qualité de l'eau liées au port de Halifax. Des aperçus ont été menés par des entrevues dans des secteurs publics à Halifax et par l'intermédiaire de l'Internet pour déterminer la perception publique de la qualité de l'eau de port en 2008 et 2009 par rapport à l'information municipale qui a été rapportée pendant ce temps. Les résultats d'aperçu indiquent que l'opinion publique est divisée par rapport à l'utilisation récréationnelle potentielle passée et future du port et de ses plages. Le but de cette recherche est de recommander un contrôle de l'environnement et un modèle de gestion efficaces pour le port de Halifax qui améliore des conditions environnementales, engage la participation publique, et encourage la confiance populaire.

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Halifax, Nova Scotia
April 29, 2010

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Chapter One

Introduction and Literature Review

1.0 Introduction

Halifax Harbour is a natural inlet located on the southeastern shore of Nova Scotia, Canada. It is centrally located in the Halifax Regional Municipality, is home to the Canadian Navy on the east coast, and is designated as the largest port in Atlantic Canada (Buckley & Fader, 1995, NRCAN, 2008). Waterfront facilities located in Halifax Harbour support a variety of interests including recreation, tourism, military, industry, and commercial shipping (NRCAN, 2008).

Halifax Harbour has received a wide variety of contaminants since its founding in 1749. For more than 200 years, raw municipal sewage discharge, waste associated with shipbuilding and repair, urban surface runoff, landfill leaching, and dredging have contaminated Halifax Harbour (Buckley & Fader, 1995, Buckley & Winters, 1992, Robinson *et. al*., 2009). Prior to 2005, there were two sewage treatment plants (STP) treating a portion of the raw sewage that flowed into Halifax Harbour (Robinson *et. al*., 2009). In 2005, construction began on three supplementary STP in Halifax, Dartmouth, and Herring Cove. The Halifax STP was the first to become operational in February, 2008 (Harbour Solutions Project, 2008). The Halifax Regional Municipality (HRM) opened Black Rock and Dingle Beaches for swimming in August, 2008 due to improved water quality (HRM PSA, 2008). These harbour beaches were closed the following day and

declared unsafe for swimming due to high bacteria counts that occurred as a result of heavy rain and sewage overflow into storm drains (CBC, 2008). In January, 2009 the Halifax Wastewater Treatment Facility closed due to a malfunction associated with a power outage and is anticipated to become operational in the spring of 2010. The Dartmouth facility is in operation and the Herring Cove facility is scheduled to become operational in the commissioning phase late this summer of 2009 (HWWTF, 2009).

The hypothesis of this research is that public perception is skeptical towards water quality data presented by the HRM related to recreational activity in Halifax Harbour. The purpose of this research is to recommend an effective environmental monitoring and management style for Halifax Harbour that engages public participation and encourages public confidence. Another important aspect of this research is to determine the source from which the general public would like to receive water quality data and information related to the safety of recreational activities in Halifax Harbour, as well as determining the preferred format of water quality data.

1.1 Marine Pollution: A Global Context

The vastness of the world's oceans has often made them a desirable target for the disposal of anthropogenic waste (Middleton, 2008; Marsh & Grossa, 2005). The collective list of documented pollutants found in the marine environment is complex and is commonly broken down into the following major categories: sewage effluent, pathogens and disease causing agents, solid waste, inorganic chemicals, organic compounds, inorganic plant and algal nutrients, toxic or radioactive waste, sediment,

and heat and noise (Draper, 1998; Garrison, 2002; Middleton, 2008; Marsh & Grossa, 2005; Raven & Berg, 2004; Richard *et. al*., 2007; Sverdrup & Armbrust, 2008). Land-based human activities are the source of approximately 75% of pollutants that enter the ocean (Garrison, 2002), and coastal regions are the primary habitat of the human species (Draper, 1998). The resulting combination of these factors is that estuaries, bays, and the shallow waters of continental shelves have become the most polluted waters of the ocean (Marsh & Grossa, 2005; Middleton, 2008).

Runoff and atmospheric deposition are the source of more than 75% of all ocean pollutants (Marsh & Grossa, 2005; Garrison, 2002). Other major contributing sources to marine pollution are shipping and accidental spills, ocean dumping, and oil and gas drilling (Figure 1.1a). There are spatial and temporal differences in scale that are important to consider in the study of marine pollution. The first is the difference between chronic and acute marine pollution. For example, large and sudden spills from oil tankers are devastating and their environmental effects are severe and readily observable. However, land-based anthropogenic runoff deposits more oil in to the world's oceans than accidental spills and the effects of this chronic deposition are no less devastating to the environment (Garrison, 2002; Middleton, 2008). It is the wide and even distribution of oil from land-based runoff that makes its distribution less apparent than the concentrated accumulation of oil from accidental spills (Marsh & Grossa, 2005).

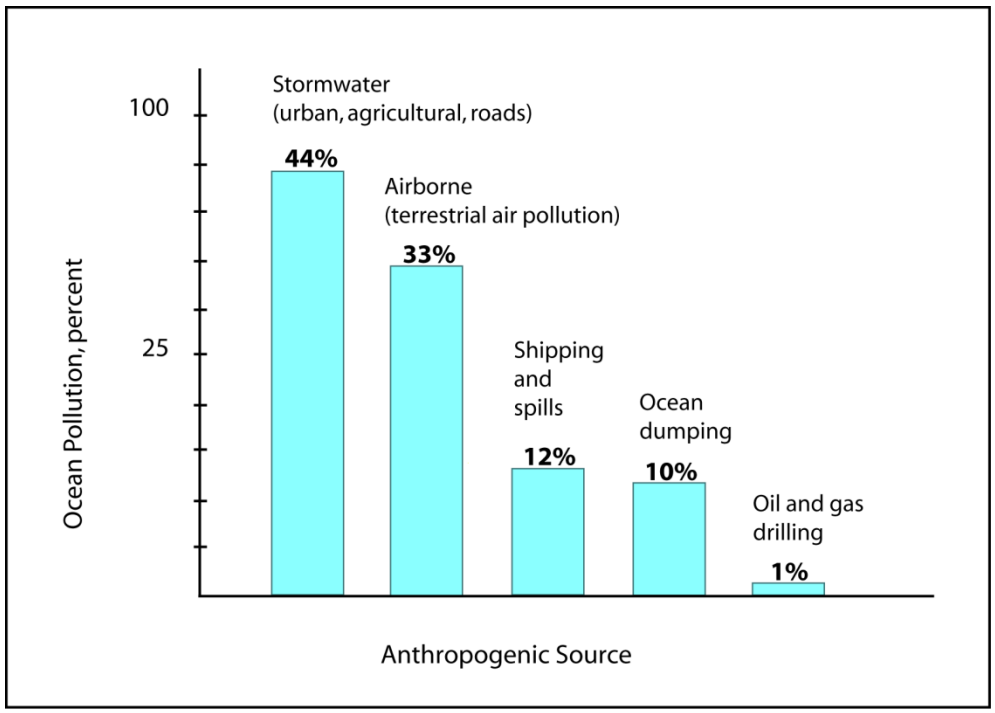

Figure 1.1a: General sources of marine pollution on a global scale (modified from Marsh & Grossa, 2005).

The second scale that is important to consider in the study of marine pollution is the persistence of different types of marine pollutants. Some types of pollutants are broken down in seawater in a matter of days or months, while some pollutants, such as plastics and radioactive materials will persist in the environment relatively unchanged for decades or centuries (Garrison, 2002; Middleton, 2008; Figure 1.1b).

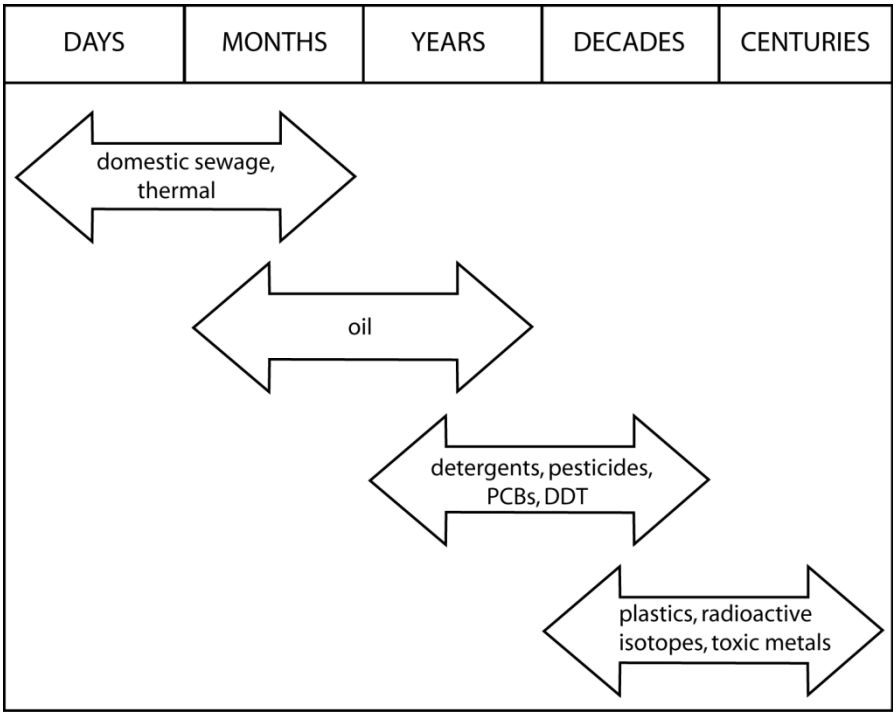

Figure 1.1b: Persistence of marine pollutants (modified from Middleton, 2008).

1.1.1 *Canada*

The primary sources of marine pollution in Canada are municipal sewage, industrial effluents, urban and agricultural runoff, solid waste such as plastics and discarded fishing gear, airborne pollutants from fossil fuel combustion, and coastal development (Dearden & Mitchell, 2009; Draper, 1998). Specific pollutant sources and concerns vary regionally. For example, the Arctic is plagued by long-range transport of atmospheric toxins which has resulted in severe bioaccumulation concerns related to a dietary reliance on marine mammals (Dearden & Mitchell, 2009; Draper, 1998). A comparative example is that the St. Lawrence River has faced serious pollution issues resulting from industrial chemical processing, effluent discharge from pulp and paper

plants and metallurgical activities, and increasing urban populations that are contributing to runoff and sewage pollutants (Draper, 1998).

1.1.2 *Atlantic Canada*

Primary agricultural and industrial areas of the United States and Canada produce chlorinated organic compounds and other contaminants that are deposited in Atlantic Canadian waters through long-range atmospheric transport (Draper, 1998). The St. Lawrence River and its pollutants also drain into the Atlantic Ocean (Draper, 1998). Mining and abandoned mines have contributed pollutants into the marine environment in New Brunswick, Nova Scotia, and Newfoundland (Draper, 1998). Untreated sewage is a significant source of marine pollution in Atlantic Canada in considering that approximately 52% of all towns and cities in Atlantic Canada discharge untreated sewage directly into the environment (Dearden & Mitchell, 2009; Draper, 1998). It has been said of Halifax Harbour that "toilet paper, tampon applicators, and condoms have become a familiar sight" (Dearden & Mitchell, 2009, pg. 280).

1.2 Marine Pollution: Prevention, Remediation, and Recreation

Efforts have been made on the global and national scales to prevent marine pollution through legislation. The United Nations Convention on the Law of the Sea (UNCLOS), written in 1982 and enacted in 1994, contains marine pollution prevention guidelines contained in Part XI, Section 2, Article 145 entitled "Protection of the Marine Environment" (United Nations, 1982). International agreements such as UNCLOS have

ended the disposal of radioactive waste into the sea since 1982, with the exception of the Soviet/Russian military which continued dumping toxic waste into the ocean until 1993 (Marsh & Grossa, 2005). The Marine Protection, Research, and Sanctuaries Act was passed by the United States Congress in 1972 and was instrumental in regulating and preventing intentional ocean dumping of sewage and refuse by large cities such as New York and Boston (Marsh & Grossa, 2005 ; Sverdrup & Armbrust, 2008). The Fisheries Act, the Oceans Act, and Canada's Oceans Strategy are important pieces of federal legislation pertaining to the national health and management of Canada's Oceans (Dearden & Mitchell, 2009; Draper, 1998). The Fisheries Act can be effective in preventing marine pollution in the interest of protecting fish habitats. An illustrative example of this potential effectiveness is that the Halifax Regional Municipality (HRM) was under investigation by Environment Canada in June, 2009 due to the discharge of 80 million litres of raw sewage daily into Halifax Harbour as a consequence of the broken sewage treatment plant (Chronicle Herald, 2009; Globe and Mail, 2009). The investigation was to determine if the sewage discharge by the HRM into the harbour is deleterious to fish and therefore in violation of the Fisheries Act (Chronicle Herald, 2009; Globe and Mail, 2009). The investigation is subject to a fine of up to one million dollars and the HRM has been advised to take any measures reasonable or possible to stop the sewage flow into the Harbour (Chronicle Herald, 2009; Globe and Mail, 2009). The HRM is required to report to Environment Canada every 60 days to report on their progress of achieving compliance with the Fisheries Act (Globe and Mail, 2009). Examples of other municipalities in Canada that have been found in violation of the

Fisheries Act for sewage discharge by Environment Canada are Dawson City, Yukon and North Battleford, Saskatchewan (Environment Canada, 2004; Vancouver Sun, 2008).

1.2.1 *Environmental Monitoring: A Regional Scale Approach*

Environmental monitoring is a necessary tool in evaluating progress related to marine pollution prevention, in establishing specific water quality, and in determining areas for marine recreation that pose no risk to human health. Environmental monitoring programs can be initiated and maintained either by governments or by community members or groups. In some cases, government and community organizations collaborate in the monitoring of marine recreational areas (Pendleton *et. al*., 2001, The Boston Harbour Association (TBHA), 2009).

1.2.2 *Certification Programs*

Environmental monitoring of a marine recreation area sometimes takes place in the framework of an adopted certification program. Certification programs are often employed in marine recreational management as a method of communicating to the public that standardized and widely accepted environmental criteria have been met and maintained (Cervantes & Espejel, 2008; Nelson & Botterill, 2002; Nelson *et. al.*, 2000). The most well known organization awarding this type of certification is the Blue Flag Programme (Cervantes & Espejel, 2008; Nelson & Botterill, 2002; Nelson *et. al.*, 2000; Roca & Villares, 2008). The Blue Flag Programme originated in France in 1985 and had 37 participating countries around the world in 2008 (Blue Flag, 2009). Blue Flag

certification is awarded when criteria are met in the following categories: environmental education and information, water quality, environmental management, and safety and services (Blue Flag, 2009). Common criticisms of the Blue Flag Programme are that it is designed for resort beaches and is not adaptable to rural environments, and that its top-down design does not incorporate the needs or desires of beach users (Cervantes & Espejel, 2008; Nelson & Botterill, 2002; Nelson *et. al.*, 2000; Roca & Villares, 2008). In order to avoid these common concerns associated with Blue Flag Certification, the country of Wales in the United Kingdom has designed its own beach certification program, called the Green Coast Award. Evaluation of this program has found that it has been successfully implemented in rural locations in that it has improved environmental quality at local beaches. Examples of improved environmental quality are beaches that are free of litter and that have achieved European Commission bathing water quality guideline standards (Nelson & Botterill, 2002). There are no shortage of beach certification programs, all of which have strengths and weaknesses. A common complaint amongst respondents in Europe was that there are too many environmental certification programs, and that their significance to the public declines as a result of this proliferation (Cervantes & Espejel, 2008; Nelson & Botterill, 2002; Nelson *et. al.*, 2000; Roca & Villares, 2008). The Green Coast award has demonstrated the potential for successful adaptation of a locally derived certification program based on national guidelines such as the European Union Bathing Water Directive. The existence of national and international recreational water quality guidelines are helpful in providing a baseline of safe recreational water quality standards as a reference point for

governments and organizations around the world. On an international level, the World Health Organization has published "Guidelines for safe recreational water environments" (WHO, 2003). In considering the implementation of national or international bathing water quality standards, it is important to scientifically evaluate the parameters of the guidelines and to note the last time that they were updated.

1.2.3 *The Importance of Public Perception*

Public perception plays a significant role in environmental management and in the establishment of water quality standards and beach management practices that are meaningful to the public and successful at improving and maintaining the health of the local environment. The United Nations Economic Commission for Europe established the Aarhus Convention in 1998 on the topic of "access to information, public participation in decision-making and access to justice in environmental matters" (Marin *et. al*., 2009; UNECE, 1998). The Convention has been ratified by 42 European signatories as of June, 2009 and highlights the increasing awareness of the need for public engagement in environmental management practices (Marin *et. al*., 2009).

Public perception research in beach management suggests that even in the case of established certification programs, such as the Blue Flag, it is not uncommon to find that beach users are unfamiliar with its criteria and methods (Nelson & Botterill, 2002; Nelson *et. al.*, 2000; Morgan, 1999). Public perception research in southern California has revealed that although local people who were interviewed perceived that beaches

were polluted, they were not able to identify primary pollution sources and were not familiar with water quality data collected by local government and reported by a non-profit organization called Heal the Bay (Pendleton *et. al*., 2001). This perception of polluted coastal areas existed amongst the public in contradiction with the reality of documented, improved water quality achieved through efforts of organizations like Heal the Bay and of local governments in a collaborative effort through the Santa Monica Bay Restoration Project (Pendleton *et. al*., 2001). These findings highlight the necessity of public perception research in establishing effective methods of communication between the public and decision makers.

1.3 Public Perception, Marine Recreation and Water Quality in Halifax Harbour

The announcement that Black Rock and the Dingle beaches on Halifax Harbour were declared safe for swimming in August, 2008 elicited a mixed response from residents and members of local environmental organizations. Some residents were enthusiastic at the prospect of swimming in the harbour: "I've personally been in the Bedford Basin water many times and you don't see me walking around glowing or with three arms. Open up your mind a little and embrace the fact that the choice of swimming is now available." (CBC Story Comments, Alinang, 2008). Other residents were skeptical: "I definitely will not swim in Halifax Harbour....But if children are allowed to swim in contaminated water Mayor Kelly must also be willing to follow up years later to determine if illnesses these children have are a result of it." (CBC, Your View, Ellen MacKenzie, 2008). Emily Rideout, speaking on behalf of the Sierra Club in Halifax,

expressed concern that the level of advanced primary treatment taking place in the harbour is limited: "It strains out solids and zaps out bacteria, but that does nothing for chemical contamination like medication, PCBs and household contaminants." (Prince George Citizen, 2008). Jennifer Graham, the coastal issues coordinator for the Ecology Action Centre (EAC) in Halifax, expressed similar concerns: "It is something we should aspire to, to have swimmable water in Halifax Harbour; I'm wondering if we really do have enough data to be sure that this water is safe for swimming at the moment...I'm delighted that the water quality tests are coming out clean, but what's the rush? Monitoring water quality isn't something you just do for one year; it's a long-term commitment....[w]e're not looking at dissolved pharmaceuticals in water, " (The Coast, 2008).

It is clear that questions remain regarding whether or not there are potential risks to human health associated with swimming in Halifax Harbour. There is no shortage of literature on the documented presence of pharmaceuticals and personal care products found in sewage sludge and wastewater (Barceló & Petrovic, 2007; Cleuvers, 2003; Coetsier *et. al.*, 2007; Dorne *et. al*., 2007a; Jones-Lepp & Stevens, 2007; Mills *et. al*., 2007; Minh *et. al*., 2009; Nikolaou *et. al*., 2007; Robinson *et. al*., 2007; Ternes, 1998). Research has also documented the presence of pharmaceuticals, personal care products, and caffeine in Atlantic Canada watersheds (Comeau, *et. al*., 2008; Brun *et. al*., 2006, Robinson, *et. al*. 2009). The presence of pharmaceuticals and personal care products in the environment is an emerging concern amongst the scientific community (Barceló & Petrovic, 2007). The concern arises from the lack of

knowledge regarding chronic exposure to these chemicals and a lack of knowledge regarding their synergistic reactions and transformations. Although pharmaceuticals are often found at relatively low levels in water quality testing, their continuous discharge into the environment is of concern because they are designed to be persistently biologically active at low concentrations (Barceló & Petrovic, 2007; Comeau, *et. al*., 2008; Cleuvers, 2003; Dorne *et. al*., 2007b; Jones-Lepp & Stevens, 2007; Mills *et. al*., 2007; Nikolaou *et. al*., 2007;).

Other questions that remain regarding the environmental health of Halifax Harbour are related to a wide range of chemicals associated with industry and urban runoff that can be present in water, as well as questions about the toxicity of harbour sediments. Regarding chemical parameters in water, Jennifer Graham of the EAC has observed that "[w]e don't really test many chemical parameters, which I would worry about in a very industrialized harbour like the Halifax Harbour" (The Coast, 2008). The HRM has posted water quality testing data on the internet (http://www.halifax.ca/harboursol/waterqualitydata.html). However, the reports are not consistent in format, are scientifically sophisticated in presentation, and are therefore potentially difficult for the average HRM resident to interpret. Regarding the toxicity of sediment, the HRM has tested sediments at Black Rock and Dingle beaches for chemical contaminants, and has stated that results are within the recommended safety guidelines for recreational contact of the Canadian Council of Ministers of the Environment residential soil guideline levels (HRM, *Naturally Green*, 2008). What is unclear is whether or not the guidelines pertain to chemical solubility in sediments in

contact with water, as the soil guidelines cited by the HRM pertain only to agricultural, residential and parkland, commercial, and industrial exposure scenarios (Canadian Soil Quality Guidelines, 2007) and not marine recreation. The contamination of sediments in Halifax Harbour has been documented, and the metal and organic contaminants found in surficial sediments are the result of the discharge of raw sewage, industrial waste, and leaching from solid waste deposits on land into the Harbour (Buckley & Fader, 1995; Buckley & Winter, 1992; Buckley *et al*., 1995).

Conflicting opinions on behalf of city officials, environmental organizations, and citizens regarding the environmental quality of Halifax Harbour and whether or not swimming in it poses any risk to human health demonstrates the need for collaborative management and the establishment of effective lines of communication between decision makers and the public. The purpose of this research is to establish an effective environmental monitoring program for Halifax Harbour that engages public participation and that is scientifically capable of answering questions of environmental quality raised on behalf of local environmental organizations. Public perception research will be carried out to determine the source from which the general public would like to receive water quality data related to the safety of recreational activities in Halifax Harbour, as well as to determine the preferred format of water quality data.

CHAPTER TWO

STUDY AREA REVIEW

2.0 History of Halifax Harbour

Prior to European settlement, the region that is now known as Halifax was called Chebucto (Fingard *et al*., 1999). It had been occupied by the Mi'kmaq for eleven thousand years, who traveled there to hunt and fish in the summer months. Halifax was officially founded by Edward Cornwallis in 1749, at which point significant numbers of European settlers began to arrive. The Chebucto region was chosen as the founding site of Halifax largely because of its strategic location and because of the attributes of its natural Harbour. Based on colonial military interests, it was a strategic location on the edge of the Atlantic Ocean (Fingard *et al*., 1999).The harbour was ice-free year round, extremely deep, and naturally sheltered (Frost, 2008).

Halifax Harbour was dominated by military activities throughout the 1700's and was an important British colonial outpost. Its proximity to the Fortress of Louisbourg was intended to assist in protecting British North America from the French (Fingard *et al*., 1999, Frost, 2008). The development of trade linkages with Britain, the American colonies and the West Indies continued to increase during this time. In 1750 local merchants were given licenses to build wharves, which began the construction of commercial infrastructure on Halifax Harbour. The Halifax Marine Association was formed in 1787 by local merchants to continue to encourage trade and commerce to the region. By this time, Halifax Harbour had evolved beyond its existence solely as a

military garrison and was becoming a developing centre of trade (Frost, 2008). In the early 1800's, the population of Halifax was 8532 and there were approximately 1000 dwellings (Frost, 2008).

Port infrastructure continued to evolve, and by the mid 1800's diverse trade and commerce activities in Halifax Harbour included trans-Atlantic mail service, privateering, the operation of a large coastal fishing fleet, passenger steamship service, shipbuilding, and the exchange of import and export trade goods such as rum, molasses, salt fish, and lumber (Frost, 2008). Construction of the Shubenacadie Canal began 1826 in an effort to connect import and export activities in the Harbour with the rest of the province. The Age of Sail in Nova Scotia during the late 1800's encouraged the construction of 180 more wharves to accommodate increasing numbers of these large trading vessels (Frost, 2008). The need for military services in Halifax had declined because the establishment of several treaties meant that there was no longer a need to protect British North America from the French (Fingard *et al*., 1999). As such, support money from Britain to maintain and improve Harbour infrastructure was no longer supplied. Port facilities fell into relative disrepair during this time, and the majority of facilities were privately owned (Frost, 2008).

In the 1850's, two railways were constructed from Halifax to Windsor and Truro to maintain accessibility and trade activities with other parts of the province. Halifax was connected to Quebec in 1876 via the Intercolonial Railway (ICR) (Frost, 2008). The Deep Water Terminal was constructed in the middle Harbour in 1877 by the ICR so that trade goods arriving by ship could be transported throughout the rest of the country by

rail (Fingard *et al*., 1999). The first grain elevator on the Harbour was built in 1882 in order to establish Canadian, rather than American, storage and shipping facilities for grain arriving by rail from Western Canada (Frost, 2008). In 1867, the population of Halifax had grown to 29,000 people (Frost, 2008). The construction of the Ocean Terminals adjacent to Point Pleasant Park and the adjoining railroad system began in 1913. This facility served to further increase the trade and commerce capacity of Halifax Harbour. Other examples of activity in the Harbour during this time are the construction of a large sugar refinery in Woodside and the reception of as many as 96,000 immigrants in 1913 arriving by ship through Pier 2 at the Deep Water Terminal (Frost, 2008).

The Port of Halifax once again became a Royal Navy base during the First World War. Anti-submarine nets were strung from the breakwater at the Ocean Terminal to Ives Point, and convoys of ships were dispatched from Halifax to safely transport supplies and soldiers to the frontlines of the War in Europe (Fingard *et al*., 1999). The Halifax Explosion in 1917 was catastrophically destructive to the Richmond Terminals port facilities in the North end. The war continued to stimulate economic and military activity in the Harbour until its conclusion in 1918. Imperial Oil began construction of a large oil refinery in Dartmouth in 1917 which was the largest oil refinery in Canada at the time (Frost, 2008). The Halifax Harbour Commission (HHC) was created in 1928 to transfer control of the Port from federal authority to the local community. The HHC acquired responsibility for the operation of the grain elevator, Richmond Terminals, and Ocean Terminals. The Harbour became a port of call for passenger vessels travelling

from Europe to New York during this time. The construction of a large dry dock facility and cold storage for fish and produce continued the expansion of Port facilities. Pier 21, Halifax's immigration shed, played an important role in maintaining vessel traffic in the Harbour following its opening in 1928. Halifax Harbour also played an important role in the Second World War. It again served as a dispatch point for convoys and was the primary base for the Canadian Navy (Fingard *et al*., 1999). The function of Pier 21 as a 'national gateway' peaked in 1951 when 103, 682 immigrants entered Canada via Halifax (Frost, 2008).

Commercial Port activities passed through fluctuations of prosperity and decline until the beginning of what has been called the "container revolution" that began in the early 1970's and has continued until the present (Frost, 2008, pg. 151). In 1999 Pier 21 was opened as a Museum, and a cruise pavilion opened in Shed 21 to accommodate the increasing cruise ship traffic that is received in Halifax annually (Frost, 2008). The Halifax Port Authority was also established in 1999, and is still the governing body for the Port of Halifax in 2010. The revitalization of the waterfront includes a variety of facilities focused on the cruise industry, arts, and culture (Fingard *et al*., 1999, Frost, 2008). This development is called the Halifax Seaport and is scheduled to be completed in 2010. It includes a new building to house the Halifax Farmer's Market, as well as a new Port Campus for the Nova Scotia College of Art and Design that opened in 2007 (Frost, 2008).

2.1 Physical Environment

Halifax Harbour is located at the approximate midpoint of the southeastern coast of Nova Scotia, Canada (Natural Resources Canada (NRCAN), 2008). It is a large inlet of the Atlantic Ocean, and is defined as an estuary because of the discharge of the Sackville River into Bedford Basin (NRCAN, 2008, Halifax Harbour Task Force (HHTF), 1990). The inlet reaches inland for approximately 28 kilometres in a northeasterly direction (NRCAN, 2008). For research and discussion purposes, the Harbour is often separated into several divisions because of the regionally different physical characteristics that can be observed throughout its length. For the purpose of this research, the study area of Halifax Harbour will be divided into the same subsections as designated by Natural Resources Canada (NRCAN, 2008) because they are both practical and accurate. The main divisions are the Outer Harbour, the Inner Harbour, the Narrows, and Bedford Basin (NRCAN, 2008). Eastern Passage and the Northwest Arm are two projecting arms of the Harbour, and the four islands contained in the study area are Devils, Lawlor, McNabs, and Georges Islands (NRCAN, 2008). The study area is presented in Figure 2.1.

Halifax Harbour is a drowned river valley that was formed by the Sackville River thousands of years ago, and has become submerged because of global sea level rise (HHTF, 1990). The Sackville River is still the primary source of freshwater to the Harbour and plays a major role in the observable circulation patterns (HHTF, 1990). The patterns are consistent with the typical two-layered flow found in estuaries, where outgoing surface flow is driven by freshwater inputs from the Sackville River and terrestrial

freshwater runoff, and incoming flow is saltier, heavier, tide-driven, and moves along the bottom (HHTF, 1990). Any mixing occurs at the interface between these two layers

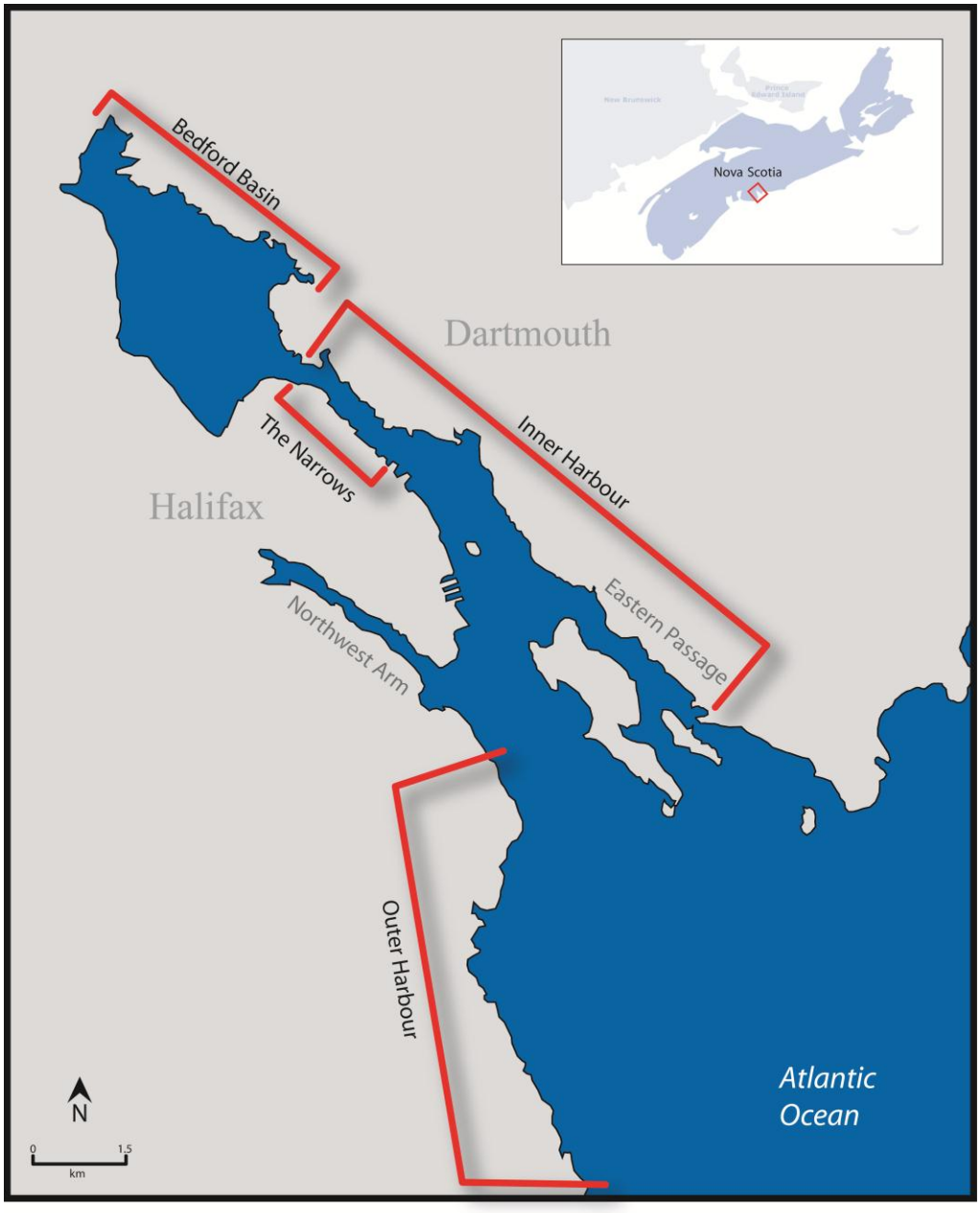

Figure 2.1: Halifax Harbour and Study Area Divisions. (Modified from NRCAN, 2008).

(HHTF, 1990). The strongest currents can be found in the Narrows and at the Outer Harbour, while currents in Bedford Basin are weak and can cause stagnation in its deepest waters (HHTF, 1990). Halifax Harbour is the second deepest natural Harbour in the world, and remains ice-free all year round (Frost, 2008). Harbour waters are on average deeper than 20 metres, while the greatest depth can be found in the centre of Bedford Basin at 71 metres (NRCAN, 2008).

Sediment types in the Harbour range in size from larger gravel and sand particles found primarily in the Outer Harbour and in the Narrows, to sand grain sediments such as silt and clay which are found primarily in Bedford Basin and the Inner Harbour (HHTF, 1990). Anthropogenic activities that have effected the bathymetry of the Harbour since the founding of Halifax in 1749 are coastal agriculture, shoreline infilling, and the disposal of domestic and industrial waste (HHTF, 1990).

2.2 Impacts

Raw sewage has been been discharged in Halifax Harbour for more than 200 years (Buckley & Winters, 1992). As previously mentioned in Chapter 1, sewage is only one of several sources of pollution causing impacts in the Harbour. There are currently 50 sewers that discharge approximately 170 million litres of sewage into the Harbour daily (NRCAN, 2008). There are a variety of impacts related to the disposal of raw sewage and waste into Halifax Harbour. For example, shellfish harvesting in the Harbour is subject to permanent bacteriological and toxin closure and has been closed since 1965 (DFO News Release, 2005, Walker *et al*., 2006). There are significant areas of contaminated sediment around approximately forty sewer outfalls, and poor water

quality along the shorelines (HRM, 2006). Bacterial contamination is pervasive throughout the Harbour, and the waterfronts along Halifax and Dartmouth are aesthetically poor owing to particulates, floatables, and odour (HRM, 2006). Waterfront business owners expressed frustration to Halifax Mayor Peter Kelly in August 2008 when the malfunction at the sewage plant was once again discharging sewage directly at the waterfront and negatively effecting business during their "make-or-break" summer season (CRFA, 2008). Swimming in Halifax Harbour has been closed for decades, with the exception of the brief opening in 2008. Waste disposal into the Harbour poses acute and chronic risks to public health and to aquatic life (HHTF, 1990). Acute risks to public health include illnesses such as infections or gastroenteritis that can be caused by eating shellfish or swimming in water contaminated by pathogens found in sewage, while acute risks to aquatic life are immediate fish kills that can be caused by acute toxins or low levels of dissolved oxygen (HHTF, 1990). Chronic risks to public health are diseases that can result from swimming frequently in contaminated water or by regularly consuming heavily contaminated seafood, and chronic risks to aquatic life are changes in species composition and cancers and other diseases caused by long-term exposure to toxic contaminants (HHTF, 1990).

2.3 Evolution of Sewage Treatment in Halifax

The evolution of sewage treatment began in Halifax with the prohibition of the direct discharge of 'slops' onto city streets by a by-law introduced in the early 1800's (HRM HSP Timeline, 2009). This prohibition was followed by the construction of

combined sewers in some areas in the late 1800's to early 1900's (HRM HSP Timeline, 2009). The evolution of sewage treatment in the Halifax Regional Municipality (HRM) since this time has taken many forms and has been effected by a variety of factors. The changing administrative divisions of the Halifax region, from counties to the current HRM amalgamation, have influenced the political and economic aspects of developing cohesive regional sewage treatment. The development of regional sewage treatment has spanned decades, and thus has been subject to governments that have changed according to shifting administrative divisions. This temporal relationship has perhaps hindered the development of treatment facilities. This is an observable trend in the events timeline which is visible through the formation and dissolution of advisory committees and organizations such as Halifax Harbour Cleanup Inc. The following table is a summary of the Timeline created by the HRM which provides an overview of the evolution of sewage treatment in Halifax.

1924	Raw sewage is discharged into the Harbour by 13 sewage outfalls.
1969	A study is commissioned to evaluate sewage treatment requirements as the boundaries of the City of Halifax expand significantly.
1960	The treatment of any sewage discharged into Bedford Basin is required by the Provincial Government.
1971	A secondary treatment plant is constructed at Mill Cove.
1974	There is a secondary treatment plant constructed in Eastern Passage.
1977	Another study is commissioned by the Metropolitan Area Planning Commission (MAPC) focused on potential treatment options for the region. Negative impacts of raw sewage in the Harbour are documented.
1978	It is determined that substantial amounts of sewage sludge are entering the Harbour on a daily basis. The study recommends the adoption of alternative sludge disposal options that are environmentally acceptable and economical. It is also documented by a separate study that significant volumes of "special waste" are discharging into the Harbour regularly.

1981	Significant infiltration and inflow issues are identified in Halifax County sewer systems.
1984	A three-phase study is commissioned by MAPC to compile data necessary for designing a regional facility for sewage treatment.
1988	Establishment of Halifax Harbour Review Committee.
1989	Establishment of Halifax Harbour Task Force for the purpose of developing objectives and environmental standards for uses of the Harbour. Pre-design, design, and construction responsibilities of the regional treatment facility are assigned to Halifax Harbour Cleanup Inc. Sewage sludge produced by existing treatment plants in Halifax Count is disposed of in a sludge lagoon at Aerotech Industrial Park.
1990	It is recommended by the Halifax Harbour Task Force that regional treatment plant outfalls should be located in the inner Harbour. A provincial/federal environmental panel assesses the proposed regional treatment plant project.
1995	Halifax Harbour Cleanup Inc. is dissolved in relation to the expiration of the Subsidiary Agreement. The treatment plant project does not proceed.
1996	The Harbour Solutions Symposium is held by the Halifax Regional Municipality (HRM) to discern how to move the treatment plant project forward based on gathered input.
1997	The Harbour Solutions Advisory Committee is appointed by the HRM City Council to address issues not resolved by the Symposium.
1998	A Concept Plan is submitted to Council by a consulting group headed by Jacques Whitford Environment Ltd. Recommendations to Council are made by the Harbour Solutions Advisory Committee.
2000	A Request for Proposals is released by Council to determine who will construct the treatment facility.
2002	Federal and Provincial Governments commit to partially funding the project. HRM Council intends to proceed with the project, and established a water bill to raise additional funds as maximum government financing had been obtained. Ondeo Halifax Regional Environmental Partnership (HREP) is designated by the HRM Council to implement the Harbour Cleanup.
2003	Disagreements ensue between HRM and HREP based on plant discharge and water quality control during long-term treatment facility operation. The working relationship is terminated. Dexter Construction is contracted to build and design the sewage collection system. HRM Council enters negotiations for the construction and design of three sewage treatment plants with the Harbour Solutions Consortium. Construction begins of the project's first Sewage Collection System phase.
2005	Construction begins of the Halifax Wastewater Treatment Plant. Preparation for construction of the Dartmouth Wastewater Treatment Plant begins.
2008	Official opening of the Halifax Wastewater Treatment Facility (HWTF).
2009	A power outage causes wastewater flooding to the HWTF. The plant is shut down. Raw sewage is once again discharged directly into the Harbour, while

	solids are retained from the Harbour by screens on the outfalls. An investigation is launched to evaluate the extent of the damage, determine what caused the malfunction, and what steps will be taken towards resolution. In May, the outfall screens are removed by HRM staff for the purpose of avoiding damage to the sewer system (CBC, 2009a). In June, Environment Canada investigates municipal sewage discharge into the Harbour and determines that pollution regulations in the Fisheries Act are being violated. The HRM is told that they must comply with habitat protection regulations in the Fisheries Act or face a fine of up to one million dollars. In September, dry weather sewage flow is diverted through the sewage plant so that solids can be screened out. HRM states that the HWTF will be fully operational by the spring of 2010.

Table 2.1: A summary table of the Timeline of events provided by the Halifax Regional Municipality outlining the development of sewage treatment in Halifax (Source: CBC, 2009a, HRM HSP Timeline, 2009).

2.4 Current Social Context

Scientific studies conducted as early as 1924 have identified the discharge of raw sewage as a major pollutant in Halifax Harbour (HRM HSP Timeline, 2009). The prevention of the discharge of raw sewage and waste directly into the Harbour has been contended with by the Municipal government since 1956 (HRM HSP Timeline, 2009). The presence of raw sewage in the Harbour is clearly not conducive to the contemporary vision of Halifax Harbour as a tourist destination, and the malfunction of the Halifax Wastewater Treatment Facility in 2008 caused significant frustration amongst the owners of waterfront businesses (CRFA, 2008). The taxpaying residents of the HRM, City Council members, and community and environmental organizations alike were also frustrated that the $54 million dollar sewage treatment plant broke down only months after it was fully operational (Globe and Mail, 2009, CBC 2009c).

Frustration continued to mount throughout the summer of 2009 as results of the forensic investigation to determine the cause of the malfunction were reviewed by City Council but withheld from the public (CBC, 2009b, The Coast, 2009). Frustrations were related to the fact that the HRM stated that investigation results would be shared with 'stakeholders', but to the HRM this term did not include the taxpayers who have funded the $333 million dollar Harbour Solutions Project (CBC 2009c, The Coast 2009). The HRM reasoned that legal implications prohibited the release of the results of the investigation to the public. This topic of local contention has faded from the media forefront as the winter months have progressed. The HRM states that the plant will be fully operational again by spring 2010 (HRM, 2009). The application of public perception research can potentially improve relations and communication between HRM residents and the Municipal government as the evolution of sewage treatment progresses.

CHAPTER THREE

RESEARCH METHODS

3.0 Preliminary Research

A literature review was conducted in order to determine if public perception research had been undertaken on the topic of public perception and water quality. Several examples were found from Europe and the United States (i.e. Langford *et. al*., 2000; Pendleton *et. al*., 2001; Chi Tran *et. al*., 2002; Roca and Villares, 2008, Marin *et. al*., 2009). There is no known research of this kind in Atlantic Canada. Each of the listed examples varied slightly in terms of specific details. For example, some public perception surveys were conducted by telephone and some were conducted through in-person interviews that took place at the beach study area. This was the most common method. The examples also differed in that some survey questions that were asked were location-specific and thus differed necessarily. It is interesting to note that the European surveys all included questions about environmental certification of beaches, and that the public are familiar with these programs which are common throughout Europe. In contrast, the research that took place in Los Angeles did not discuss environmental certification in the survey. Although there were differences among some of the details of the research examples, the overarching purpose of the examples was

the same: to survey public perception of water and beach quality in order to improve existing environmental management techniques, environmental quality, and instill public confidence in local management and marine recreation.

One specific research aspect that all of the examples had in common was that all of the surveys were conducted in relation to beaches that are permanently open to the public. This differs from the research conducted in Halifax in that public perception of water quality in this case was based on Harbour beaches that have been closed for decades, opened for one day, and closed since the brief opening in 2008. A second difference between the research examples and the Halifax study is that the example surveys were backed by significant resources, and had large sample sizes ranging from 400-700 participants. In contrast, the Halifax study is a small, experimental study in comparison with a sample size of 106. One element that all of the examples and the Halifax study have in common is that they are all concerned with beaches that are found in a highly urbanized environment. The research of Pendleton *et. al*. is the case study that is most similar to the research presented in this paper in that the research takes place in a large, North American, mixed-use Harbour that is facing a transition from polluted to remediated.

3.1 Survey Design

Based on the literature review, examples of surveys that were deemed to be most relevant to public perception research for Halifax Harbour were analyzed (Marin *et. al*., 2009, Pendleton *et. al*., 2001). A survey was drafted based on the combination of

this analysis, research on the topic of social science survey methods (Frary, 1996, Garson, 2009), and the inclusion of questions specific to Halifax Harbour. The survey was drafted in the form of a questionnaire, and was delivered through personal

How Clean is Your Beach?

Did you know that the Halifax Regional Municipality opened Black Rock and Dingle Beaches for swimming in 2008?

Do you think that swimming in Halifax Harbour **currently** poses any risk to human health? Why or why not?

Do you think that swimming in Halifax Harbour **when all sewage treatment plants are fully operational** poses any risk to human health?

Why or why not?

Do you think that any other type of recreational contact, for example boating or wading, in Halifax Harbour **currently** poses any risk to human health?

Do you think that any other type of recreational contact, for example boating or wading, in Halifax Harbour **when all sewage treatment plants are fully operational** poses any risk to human health?

Why or why not?

Environmental certification of beaches generally focuses on the following criteria: water quality, environmental management, environmental education, and safety and services. **If beaches on Halifax Harbour became environmentally certified, would you swim in Halifax Harbour?**

What individual or organization would you trust in telling you that Halifax Harbour waters are clean and safe for swimming?

Is there a specific format in which you would prefer to receive water quality information about Halifax Harbour? (for example, internet, newspaper, radio, email, etc.)

Age:
Gender:

Where do you live?

What is your occupation?

What is your highest level of education completed?

Additional comments, questions, or suggestions:

Figure 3.1: Public Perception Survey

interviews and via the internet following its approval by the Saint Mary's University Research Ethics Board (REB). This process involves a written application to the Board based on the methodology and purpose of the research. The application is evaluated based on the relevancy of the research and the degree and nature of the proposed interaction with the public. The REB File number for the application and approval of this research is 09-119. A complete list of survey questions can be found in Figure 3.1. Examples of the types of questions included are: yes or no questions pertaining to perceived health risks and recreational contact with Harbour water, open-ended questions pertaining to the public preference of management bodies and data related to Harbour water quality, and basic demographic inquiries. Responses to all questions are discussed in Chapter 4.

The first open-ended question related to the hypothesis that was included in the survey is "What individual or organization would you trust in telling you that Halifax Harbour waters are clean and safe for swimming?". This question was intended to determine whether or not respondents would indicate the Halifax Regional Municipality (HRM), and therefore indicate trust in information presented by the municipal government. The alternative was that organizations other than the HRM would be named, and that this could be indicative of public desire for a style of management for the Harbour that differs from the current style which is managed solely by the HRM.

The second open-ended question related to the hypothesis that was included in the survey is "Do you think that swimming in Halifax Harbour when all sewage treatment plants are operational poses any risk to human health?". This question was

intended to determine if the public were confident that the repair and future operation of the Halifax Wastewater Treatment Facility would mean that Harbour beaches would again be safe and open for swimming again as they had been in 2008. Alternatively, and consistent with the hypothesis, if there were a majority of 'yes' responses to this question, it could indicate that the public are skeptical of water quality data reported by the HRM regardless of whether or not there is an actual improvement in water quality.

Another open-ended question worthy of discussion that was included in the survey is "If beaches on Halifax Harbour became environmentally certified, would you swim in Halifax Harbour?". This question was intended to determine if an environmental certification program would appeal to the public as a management style alternative to the current method that is managed solely by the HRM.

A final question of significance that will be discusses in Chapter 4 is "Is there a specific format in which you would prefer to receive water quality information about Halifax Harbour?". This question was intended to determine the most effective method by which to report Harbour water quality information to the public. Determining this public preference would be valuable in maintaining effective communication with the public throughout the transition from a polluted to a mediated Harbour.

3.2 Survey Application

Personal interviews took place in public areas of Halifax, Nova Scotia between June and August 2009. In order to achieve a random sample of participants, every fifth

person who passed the interviewer's location was asked if they would participate in the survey. If an individual declined, the interviewer would ask the next fifth person who passed by. This process continued until a willing individual completed a survey and then the selection process began again. Face-to-face interviewing was chosen as the survey application method because it maximizes engagement with the participant while also imposing the lowest communication burden on the participant (Garson, 2009). Face-to-face interviewing is also an effective method of choice when the purpose of the research is to obtain a representation of opinions that is in-depth (Garson, 2009).

One potential disadvantage of the face-to-face interview technique is that data collection time can be slow (Garson, 2009). This was found to be especially true in the case of the questionnaires administered during this survey. Participants generally had a lot to say on this topic and chose to discuss the topic in detail with the interviewers. For example, many participants offered their personal memories of changes in Harbour water quality, expressed their frustration towards local officials and the malfunction of the sewage treatment plant, or recounted stories of incidents involving contact with sewage waste. The questionnaire took an extremely disproportionate amount of time to complete in considering that it had specifically been designed to be brief at the length of one and a half pages in order to avoid excessive time consumption. The end of the research period was approaching, and a significant sample size had not yet been achieved. While 80 surveys were delivered via face-to-face interviews, the remaining 26 surveys were completed through a web-based survey tool called SurveyMonkey (http://www.surveymonkey.com/). Surveys were distributed via SurveyMonkey to a

general sample of individuals via the internet in a method called snowball sampling. In this sampling method, further respondents are recruited by referrals from initial respondents (StatPac, 2009). This method is used when it is difficult or cost prohibitive to locate respondents (StatPac, 2009).

3.3 Statistical Analysis

Statistics were employed using Minitab 15 statistical software to analyze the survey results. The majority of the analysis involved tabulation and percentage calculation. Chi-Square tests were also used to analyze the relationship between specific categorical variables.

CHAPTER FOUR

RESULTS

4.0 Introduction

This chapter will analyze the results of the public perception survey that was carried out in June and August 2009. The methods of the survey process have been outlined in Chapter 3. The principle objective of this survey was to obtain public perception data regarding water quality and environmental management in Halifax Harbour. The hypothesis of this research is that public perception is skeptical towards water quality data presented by the HRM related to recreational activity in Halifax Harbour. Results of the survey were compiled to examine whether or not this is true, and to determine what types of changes in management or communication methods could improve public confidence in water quality data reported for Halifax Harbour. Not all respondents chose to complete all of the questions in the survey. Therefore, the results presented in this chapter will indicate each sample size based on how many people responded to the particular question.

4.1 General Demographics

A total of 106 respondents participated in the survey. Of the 106 individuals in the total sample, 40 were male (37.7%) and 66 were female (62.3%). The majority of surveys took place in general public locations during the summer, and it is not known why there would a larger representation of females than males in these locations. Age

distribution of respondents is displayed in Figure 4.1. The highest percentage of respondents (34.91%), were between the ages of 19-29. There is a general decline in percentage of respondents that follows an increase in age, beginning at 22.64% in age category 30-39 and falling to 0.9% of respondents in the age category of 80 years and above. Accordingly, it can be observed that seniors aged 70 and older are underrepresented in the sample. It is likely that the high percentage found in age category 19-29 is owing to the significant number of university students in Halifax.

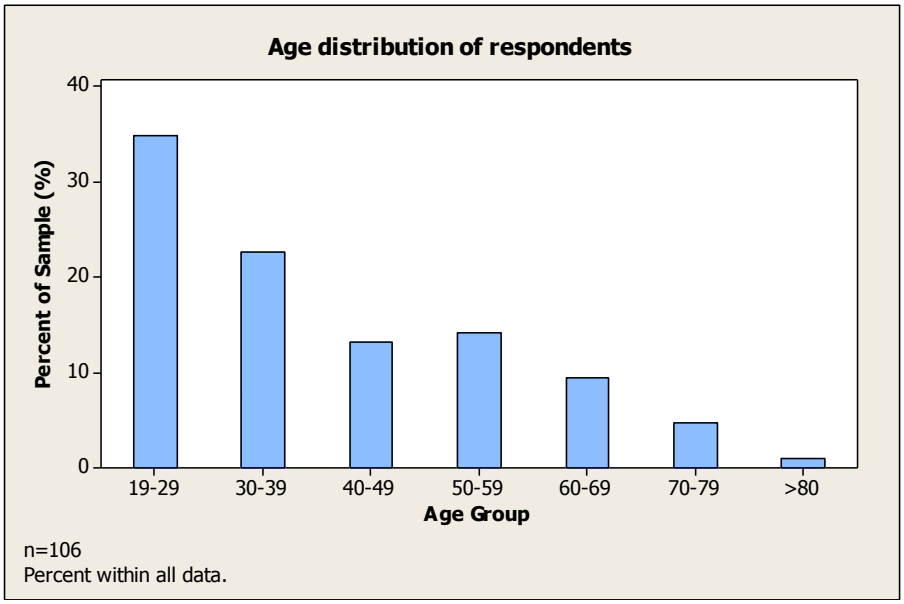

Figure 4.1: **Ages of Survey Respondents by Percent of Total Sample**

Respondents were asked to indicate the highest level of education that they had attended or completed. The results of this inquiry are presented in Figure 4.2. A

significant 49.5% of 103 survey respondents were attending or have completed undergraduate level university. The remaining respondents are distributed almost evenly amongst education levels of Highschool, Masters or PhD, and College or Trade School at 18.4%, 17.5%, and 14.6% respectively. Responses listed in this category are distributed amongst a diverse variety of disciplines and exhibit no general trends. The same can be observed for responses indicating the occupation of respondents.

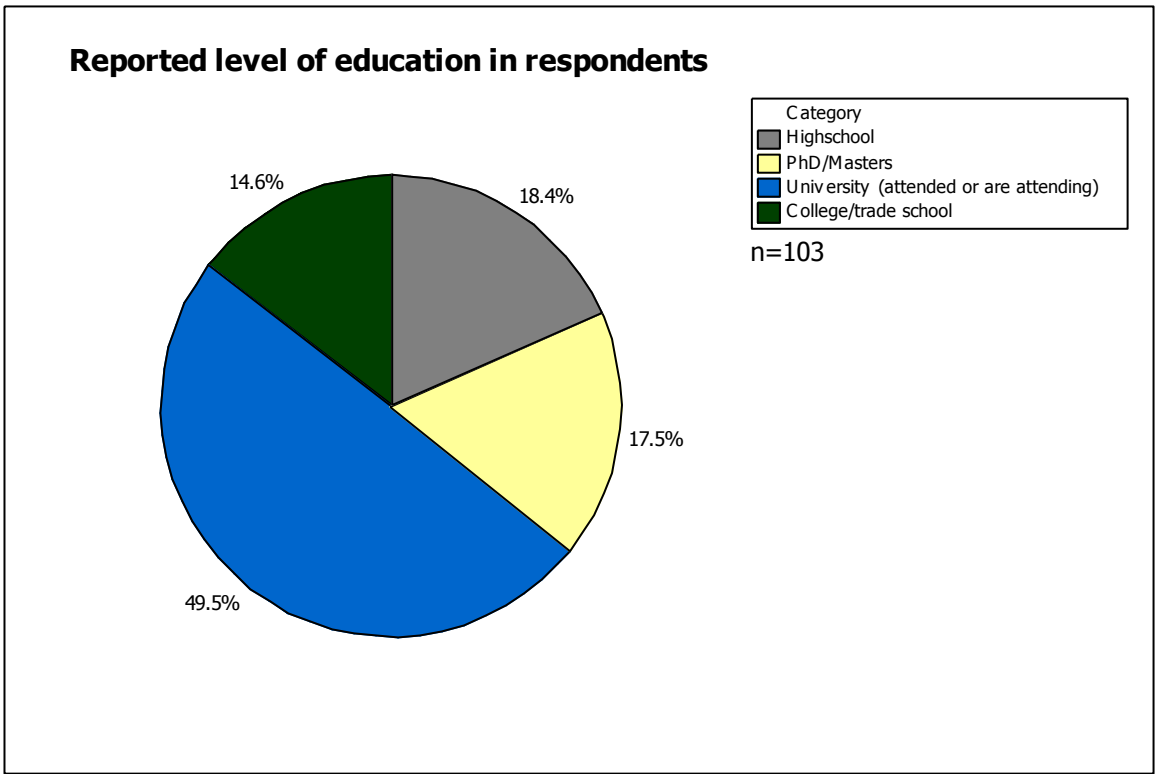

Figure 4.1: Level of education as reported by survey respondents

4.2 Public Perception of Water Quality

Two questions in the survey were designed to directly investigate the hypothesis of this research, which is that public perception is skeptical towards water quality data

presented by the HRM related to recreational activity in Halifax Harbour. The first question related to this hypothesis is “What individual or organization would you trust in telling you that Halifax Harbour waters are clean and safe for swimming?”. A summary of responses to this question are displayed in Figure 4.3.

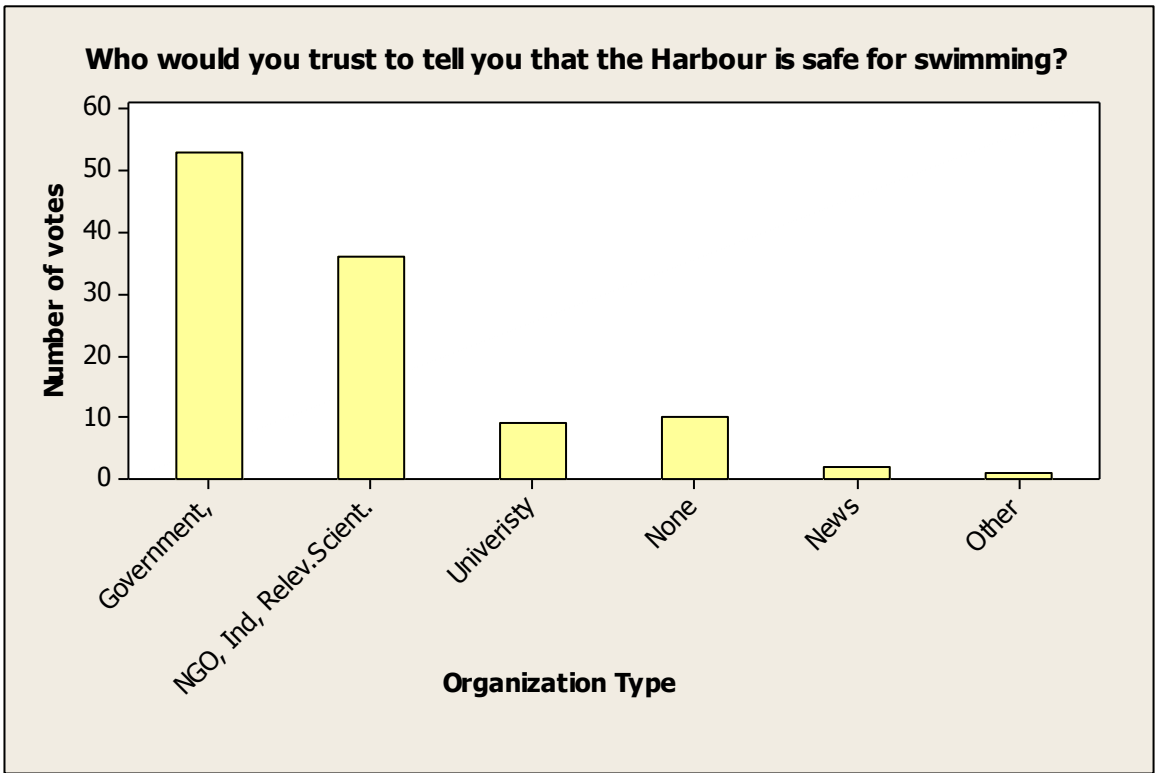

Figure 4.3: Preferred individual or organization to report Halifax Harbour Water Quality Data

The categories in this graph were derived from observing general trends in responses and grouping them accordingly. The ‘Government’ category includes municipal, provincial, and federal levels. The category that begins with ‘NGO’ includes non-

governmental organizations, independent consultants, and relevant scientists. In the 'Government' category, the HRM or municipal government was listed 14 times in a total of 51 government entries. Thus, 27.5% of government bodies that were listed as a trusted source of water quality data were municipal while 72.5% were provincial or federal. Specific organizations that were named in this category include Environment Canada, Health Canada, the Nova Scotia Departments of Environment and Health, the HRM municipal government, Halifax Water, the Ecology Action Centre, Clean Nova Scotia, and Saint Mary's and Dalhousie universities.

The second survey question designed to directly relate to the hypothesis is "Do you think that swimming in Halifax Harbour when all sewage treatment plants are operational poses any risk to human health?". Figure 4.4 displays the distribution of responses to this question. A majority percentage of 60.6% of respondents responded 'yes' to this question, 34.6% answered 'no', and 4.8% answered 'maybe'. The sample size for this response is 104.

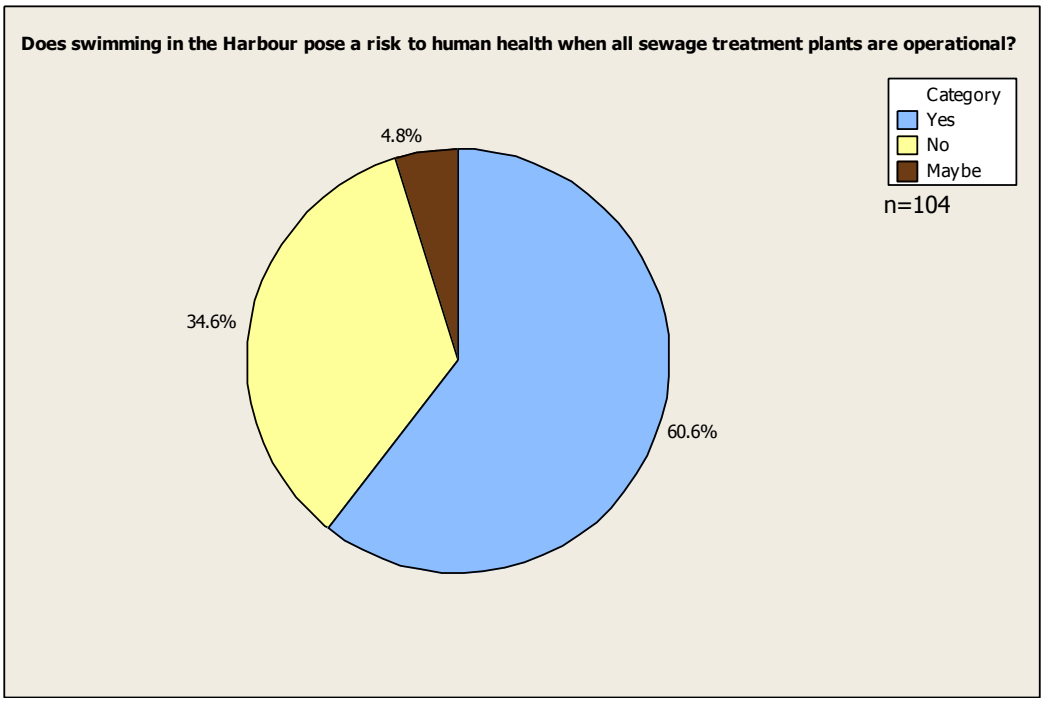

Figure 4.4: Response by percent of perceived future risks to human health from swimming in Halifax Harbour when all sewage treatment plants are operating

A further question of significance that was asked in this survey is "If beaches on Halifax Harbour became environmentally certified, would you swim in Halifax Harbour?". The results of this inquiry are presented in Figure 4.5. Of a sample size of 106, 56.6 % answered 'yes', 38.7% answered 'no', and 4.7% answered 'maybe'.

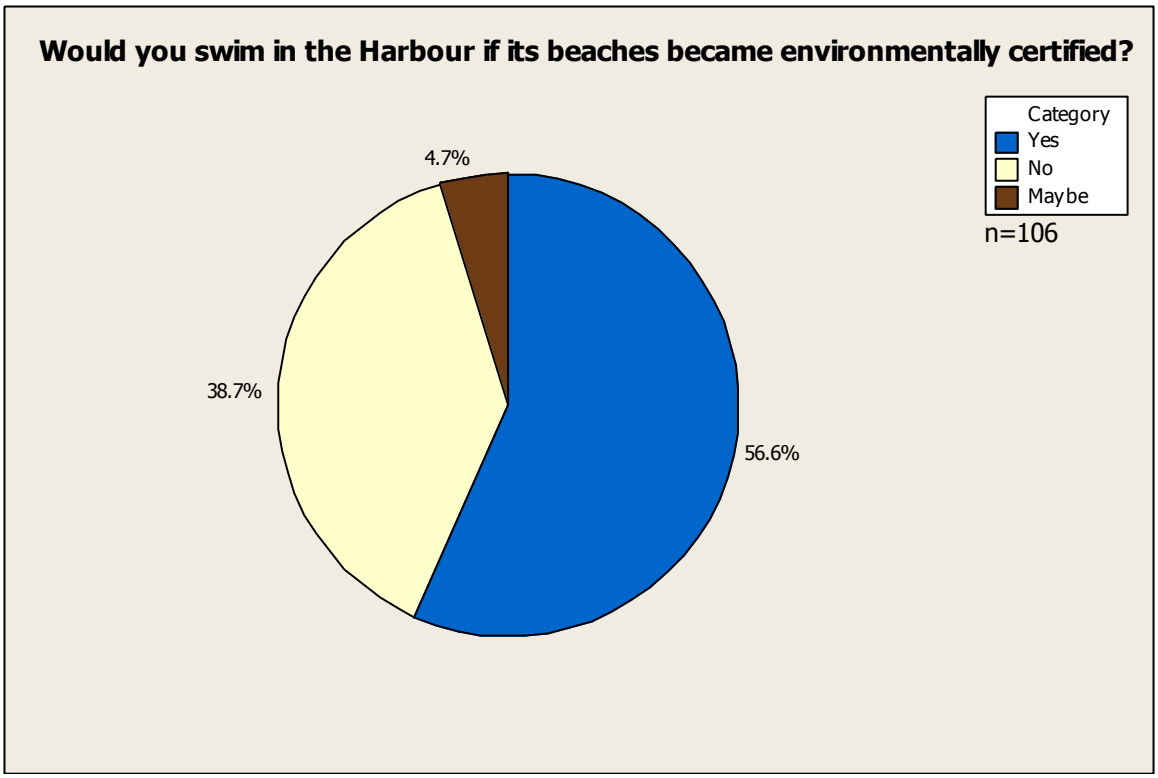

Figure 4.5: Response by percent of interest in environmental certification of Halifax Harbour beaches

A final question of significance that will be reported in this section is "Is there a specific format in which you would prefer to receive water quality information about Halifax Harbour?". The results of this survey question are presented in Figure 4.6. Newspaper, Radio, and Internet/online news clearly stand out as the most preferred methods; each having 48, 42, and 40 votes respectively.

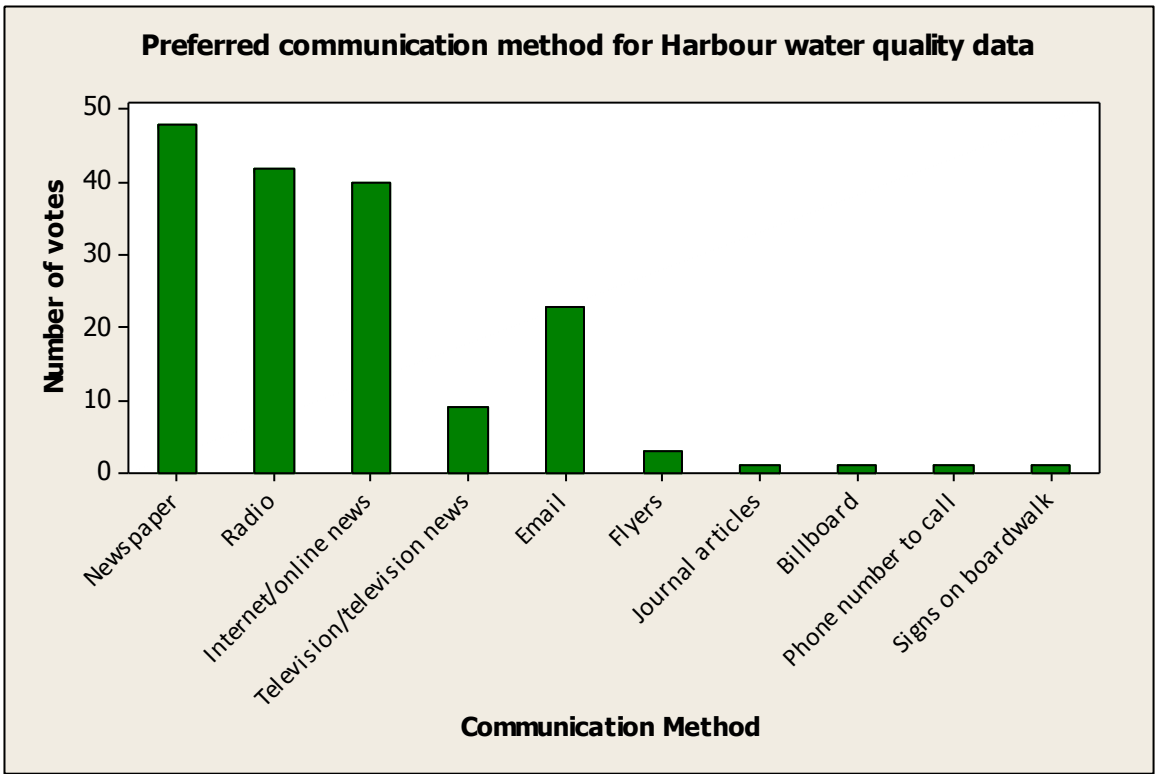

Figure 4.6: Preferred communication method for Harbour water quality data

4.3 Potential interrelationships between variables

Chi-Square tests were used to test for potential interrelationships between selected categorical variables. The first test was to determine if there was a relationship between respondents' reported level of education and whether or not they think that there will be a risk to human health from swimming in the Harbour once all sewage treatment plants are operational. Results of this test are reported in Figure 4.7. The null hypothesis for this test was that there is no relationship between the variables. Accordingly, the alternative hypothesis was that there is a relationship between the

variables. The test statistic value is 8.720, and the P-Value is 0.033. Based on the P-Value, it is observable that the test was significant and that the null hypothesis is rejected. It is possible to conclude that there is a relationship between these variables. The response category that contributed most to the Chi-Square statistic is the PhD/Masters category, in both the yes and no responses.

Expected counts are printed below observed counts
Chi-Square contributions are printed below expected counts

	Highschool	PhD/Masters	University	College/tradeschool	Total
Yes	14	5	28	10	57
	10.69	9.50	25.53	11.28	
	1.027	2.132	0.239	0.146	
No	4	11	15	9	39
	7.31	6.50	17.47	7.72	
	1.501	3.115	0.349	0.213	
Total	18	16	43	19	96

Chi-Sq = 8.720, DF = 3, P-Value = 0.033

Figure 4.7: Chi-Square results testing the relationship between education level and perceived risk from swimming in the Harbour once all sewage treatment plants are operating

The second test was to determine if there was a relationship between respondents' reported level of education and whether or not they think that Harbour beaches would be safe for swimming if they became environmentally certified. Results of this test are reported in Figure 4.8. The null hypothesis for this test was that there is no relationship between the variables. Accordingly, the alternative hypothesis was that there is a relationship between the variables. The test statistic value is 0.628, and the P-

Value is 0.890. Based on the P-Value, it is observable that the test was not significant and that the null hypothesis is not rejected. It is possible to conclude that there is no relationship between these variables.

Expected counts are printed below observed counts
Chi-Square contributions are printed below expected counts

	Highschool_C	PhD/Masters_C	University_C	College/tradeschool_C	Total
Yes	11	10	28	7	56
	11.67	8.75	28.00	7.58	
	0.038	0.179	0.000	0.045	
No	9	5	20	6	40
	8.33	6.25	20.00	5.42	
	0.053	0.250	0.000	0.063	
Total	20	15	48	13	96

Chi-Sq = 0.628, DF = 3, P-Value = 0.890

Figure 4.8: Chi-Square results testing the relationship between education level and perception that environmental certification would be a reliable source in determining that Harbour beaches are safe for swimming

4.4 Conclusion

Public perception of water quality throughout the sample is moderately low. This can be observed in Figure 4.4, where 60.6% of respondents answered that swimming in the Harbour once all sewage treatment plants are operating would still pose a risk to human health. Figure 4.3 indicates that respondents voted most highly in favour of government, non-governmental organizations, relevant scientists and independent consultants as their preferred or trusted source(s) in reporting reliable water quality information related to the safety of recreational activity in Harbour water.

Figure 4.6 displays responses indicating by what method the public would prefer to receive water quality data about Halifax Harbour. Newspaper, Radio, and Internet/online news were the most highly represented choices for this question. Votes were distributed in these categories in descending order beginning with Newspaper, having 48, 42, and 40 votes respectively. Results and their potential application will be discussed further in the following chapter.

CHAPTER FIVE

DISCUSSION AND CONCLUSION

5.0 Introduction

Halifax Harbour is a mixed-use Harbour that supports a variety of interests including recreation, tourism, military, industry, and commercial shipping. As such, management of water quality in the Harbour is complex. It involves both stakeholders who are interested and invested in water quality improvement, and stakeholders who are representative of the sources that are contributing pollutants to the Harbour. It is critical to examine the identities of the stakeholders, the nature of their interactions, and the science behind water quality to gain a broad understanding of the environmental state of Halifax Harbour and its potential remediation.

This chapter focuses on the findings of this research, which surveyed public perception of water quality in Halifax Harbour. For the purpose of this research, residents of the HRM will be considered stakeholders owing to their vested interests in improved water quality related to tourism, recreation, the Harbour Solutions project and specifically the investment of their tax dollars, public health, and the health of aquatic life. Other stakeholder groups indentified in this research are federal, provincial, and municipal governments, industry, local non-governmental organizations, academia, shipping, and the military. This research focuses on the public and their perspective on the current approach to the management of Halifax Harbour. The findings presented in this study can be used as a foundation for future research in

assessing management approaches for Halifax Harbour and in making recommendations towards improving both water quality and public participation in its management.

5.1 Discussion of Survey Results

The hypothesis of this research was that the public are skeptical towards water quality data that is reported by the HRM and related to recreational water quality in Halifax Harbour. One specific question posed in the survey that is directly related to this hypothesis is “What individual or organization would you trust in telling you that Halifax Harbour waters are clean and safe for swimming?”. Of the respondents that named a type of government in this category, 27.5% named the municipal government specifically while the remaining 72.5% named either provincial or federal government departments. In order to disprove the hypothesis, it would be expected that the majority of responses would name the municipal government as their trusted source of water quality data. The survey results do not present a majority of responses that named the municipal government in response to this question, therefore the hypothesis may not be rejected.

A second question of importance in this survey is “Do you think that swimming in Halifax Harbour when all sewage treatment plants are operational poses any risk to human health?”. This question was intended to determine if the public were confident that the repair and future operation of the Halifax Wastewater Treatment Facility would mean that Harbour beaches would again be safe and open for swimming again as they had been in 2008. A majority percentage of 60.6% of respondents responded ‘yes’ to

this question, 34.6% answered ‘no’, and 4.8% answered ‘maybe’. Therefore, the majority of respondents believe that there will still be a risk. This finding could indicate that the public are skeptical of water quality data reported by the HRM regardless of whether or not there is an actual improvement in water quality. This is an important consideration in future management of the Harbour. In Los Angeles, it has been observed through similar research that the public perceives that local water quality is poor. This perception exists despite significant improvements in water quality and efforts on behalf of the local government and NGO’s to educate the public about the improvement process and provide readily available water quality data (Pendleton et al., 2001). The HRM could conduct public research to determine if the same results found in the survey presented in this research paper would be present in a larger sample size of HRM residents. If so, it would be advantageous for the HRM to determine this perception early on in the transition from a polluted to remediated Harbour, and to engage the public in a participatory management approach that would facilitate an accurate public perception of improving water quality.

The following question was posed in order to determine the communication method preferred by the public for reporting water quality data: “Is there a specific format in which you would prefer to receive water quality information about Halifax Harbour?”. The preferred methods that emerged from the survey results were newspaper, radio, and internet/online news as the most preferred methods; each having 48, 42, and 40 votes respectively. Further public perception research on this topic by the HRM could also result in the engagement of the public in a participatory

management approach that would facilitate an accurate public perception of improving water quality.

Respondents were asked whether or not environmental certification of Halifax Harbour would confirm for them that it was safe for swimming. This question was intended to determine if an environmental certification program would appeal to the public as a management style alternative to the current method which is managed solely by the HRM. Of a sample size of 106, 56.6 % answered 'yes', 38.7% answered 'no', and 4.7% answered 'maybe'. This finding is the opposite of what this research might expect. It was predicted that this type of program would appeal to the public because of its involvement of a variety of stakeholders as decision makers and because of its comprehensive approach to environmental management. While these types of programs are common throughout Europe (Langford *et. al*., 2000; Pendleton *et. al*., 2001; Chi Tran *et. al*., 2002; Roca and Villares, 2008, Marin *et. al*., 2009), respondents to the survey in Halifax do not seem to be familiar with the concept. In addition, these types of programs are not without criticisms and are not a simple solution to the management of Halifax Harbour. However, there are features of these programs that are successful and that could be included in management of the Harbour, such as clear criteria for environmental management goals that are somewhat strict, a management committee consisting of all local stakeholders, and an environmental education component (Blue Flag, 2009). While survey results show that the public may prefer a management style that is collaborative between multiple sectors rather than managed solely by the HRM, Halifax residents are not familiar with beach certification programs

and this sample does not display public confidence in a certification program.

It was determined through the Chi-Square tests that there is a relationship between education and whether or not respondents think that the Harbour will be safe for swimming when all sewage treatment plants are operating. The strongest contribution to this relationship was that respondents in the PhD/Master category answered ‘yes’ (there will be a risk) less times than the expected counts and ‘no’ (there will not be a risk) more than the expected count. This is the opposite of what was predicted. Further research on this relationship is recommended. It was predicted that respondents with the highest level of formal education would respond that the Harbour will not be safe for swimming when the treatment plants are operating because the treatment level is at advanced primary level and no remediation of contaminated sediments is currently planned. It is possible that respondents were not aware of the level of advanced primary treatment that is in use by the Harbour Solutions project, or that the disciplines of respondents in the PhD/Masters category are not science related. It is also possible that formal education does not play a role in public perception of future water quality. In understanding the relationship between education and perception of water quality, it would be possible to understand what the primary source of public education is on this topic. This knowledge could result in effective public education on this topic that would help to facilitate an accurate public perception of improving water quality.

5.2 Recommendations

Although this research was conducted with a relatively small sample size of 106 participants, the results exhibit potential for positive public engagement on a topic of public contention. Communication between the municipal government and its residents could improve significantly through further public perception research on this topic and the implementation of its findings. It is recommended that the HRM to conduct a similar study and support it with a significant amount of resources so that a larger sample size could be obtained. A recent study of public opinion on a variety of topics conducted by the HRM from December 2009-January 2010 has revealed that 75% of respondents believe that water quality in the Harbour is poor, and that the condition of the Harbour and the status of the Harbour Solutions Project are the primary environmental concerns of HRM residents "by a significant margin" (Chronicle Herald, 2010). Further public perception research on this topic by the HRM is recommended in order to establish an effective environmental monitoring and management style for Halifax Harbour that engages public participation and encourages public confidence. Research by Pendleton *et. al* demonstrates that even in the case of improved water quality in an urban Harbour, residents can still perceive that the water is not clean if it has a history of chronic pollution (Pendleton *et. al*., 2001). The Harbour Solutions projects is a costly project at $333 million dollars, and the public will not enjoy the full benefits of its success if they perceive the Harbour to be unsafe or unclean even when water quality potentially begins to improve. The public are stakeholders with an interest in the environmental health of Halifax Harbour owing to their vested interests in

improved water quality related to tourism, recreation, the Harbour Solutions project and specifically the investment of their tax dollars, public health, and the health of aquatic life. It is important that they are included in any process of water quality improvement.

5.2.1 *Survey Specific Recommendations*

Additional recommendations regarding specific aspects of the survey can be made. Several open-ended questions were used in order to obtain an answer that was genuinely indicative of public preference and did not lead the respondent to any particular type of answer. While this was helpful in obtaining candid and sincere responses, it poses limitations to the depth of statistical analysis that may be conducted. This aspect is worthy of careful consideration in any similar future research.

Respondents were asked to indicate where they lived, and to circle whether the named location was a city or a town. The structure of this question caused confusion amongst some respondents who circled ‘city’ or ‘town’ without naming the specific location where they lived. If interested in obtaining this aspect of demographics in future research, it is necessary to indicate more clearly that the respondent must name the specific location where they live. It was therefore not possible to analyze relationships between perception and whether or not respondents lived in urban or rural locations. All surveys that were used for this research were those that had been completed by residents of Nova Scotia.

There were two questions included in the survey on the topic of public

perception regarding whether or not there is a difference in any risk posed to human health from swimming in the Harbour in comparison to boating or wading on the Harbour. The assumption is that boating or wading would result in slightly less significant exposure to the water and sediments than swimming. The question asked respondents if they thought that there would be a risk to human health from boating or wading in the Harbour (Summer 2009), and if there would be a risk when all sewage treatment plants are operating at some point in the future. Survey participants often answered a particular response for boating and a different response for wading. It was therefore not possible to utilize or analyze responses from this question. In order to determine whether or not there is a perceived risk from swimming compared to recreational activities which result in less direct contact with water and sediments, it would be necessary to structure the question more clearly.

A final recommendation on the application of the survey is to note that the survey discussed in this research was conducted when poor water quality in Halifax Harbour and the malfunction of the Halifax Wastewater treatment facility were forefront in the media in a predominantly negative light. It would be a valuable comparison to conduct similar research when the topic is not forefront in the media.

5.2.2 *Public Health and Recreational Activity in Halifax Harbour*

It is clear that questions remain regarding whether or not there are potential risks to human health associated with swimming in Halifax Harbour. The limitations of advanced primary treatment are an area of concern in relation to human health and

recreational contact. Advanced primary treatment removes up to 70% of suspended solids found in wastewater (Municipal Group of Companies, 2004). Following the removal of solids, the effluent is disinfected by UV rays to remove bacteria before it is discharged into the Harbour. It is notable that the use of UV rays was chosen over a common method of using chlorine which would then be discharged into the Harbour and is known to be ecologically harmful in concentration (Municipal Group of Companies, 2004). In comparison, secondary and tertiary levels of sewage treatment degrade organic matter before it is released into the environment and remove excess nutrients from effluent such as phosphorus and nitrogen (Cornell University, 2009). The Halifax Wastewater Treatment Facility has been designed so that it can be upgraded to a higher level of treatment in the future. However, even tertiary level treatment does not remove other hazardous chemicals that may be found in storm water and sewage effluent. Contaminants of concern that may be found in urban runoff or in sewage effluent include pharmaceuticals, industrial chemicals such as polychlorinated biphenyls and heavy metals, paints and solvents, engine fuels and fluids associated with automobiles and ships, pesticides, household chemicals, personal care products and synthetic hormones (HRM, 2007; HRM 2009; Robinson *et al*., 2009). None of these contaminants would be removed by sewage treatment of any level. Therefore, a holistic management approach that integrates a variety of techniques in pollution prevention and remediation are recommended.

There are a variety of techniques and points of concern that may be considered in developing this type of integrated management approach. Educational campaigns

related to the prevention of the disposal of hazardous contaminants into the sewage system and into the Harbour directly are necessary to improve water quality, as are strict regulations and enforcement against industrial discharge of contaminants. The HRM “Don’t Dump This” campaign has been one effort towards the prevention of hazardous materials entering household rains. Further campaigns of this type are recommended. Upgrading the level of sewage treatment to secondary or tertiary and storm water diversion and treatment are also recommended actions for improvement of water quality in Halifax Harbour. These methods have been found to be effective in the improvement of coastal water quality in the case of Santa Monica Bay (Heal the Bay, 2010). The capping of selected toxic sediments, bioremediation, and ecological restoration are recommended areas of further research and potential application in the remediation of Halifax Harbour. The Nova Scotia Department of Environment has proposed a ban on the sale and application of cosmetic pesticides. The approval and application of this ban would also assist in general prevention of the pollution of Harbour waters. Long-term research is another recommended component of determining if recreational activity in the Harbour poses any risk to human health. Research on the synergistic reactions between chemicals in the Harbour is the first recommended topic. The second is to research effects on human health related to chronic exposure to chemicals, pharmaceuticals, heavy metals contained in sediments, and synthetic hormones in the context of recreational contact. A restoration plan including remediation and pollution prevention techniques such as those listed here is recommended to ensure the safety of recreational activities in the Harbour.

When the Halifax Wastewater Treatment Facility is not fully operating, the status of the poor water quality and the high bacteriological count should be more clearly indicated to the public. This recommendation results from respondents expressing this verbally throughout the survey process. In addition, the incidental proximity of researchers to Black Rock Beach resulted in the observation of adults and children on the beach and making contact with the water. There is one nondescript sign on Black Rock beach stating that the water is not safe for recreational contact, but based on the frequency of observation of people making contact with Harbour water; it is not apparent that the sign is effective.

A final recommendation is that storm drains throughout Halifax should be clearly and consistently labeled to inform the public that they drain into the Harbour. While there are a few of these warnings painted next to storm drains in Halifax, a more clear, consistent, permanent method of labeling is recommended. Examples are illustrated in Figure 5.1. In addition, all institutional washrooms in the HRM should bear similar but adapted signage representing the fact that toilets also drain directly into the Harbour. Even when all treatment plants are operating, heavy rains will result in sewage and runoff deposition in the Harbour through the combined sewer overflow. Signage in washrooms may help to prevent items such as tampon applicators and condoms from being deposited on the shores of the Harbour.

Figure 5.1: Examples of Visual Warning in Urban Areas That Storm Drains Empty Directly Into the Ocean (Source: United States Environmental Protection Agency, 2007, Flickr, 2010, New Jersey Department of Environmental Protection, 2009).

5.2.3 *Alternative Management Approach*

It was predicted that an environmental certification program would appeal to the public as a management style alternative to the current method which is managed solely by the HRM. Survey results from this study do not confirm this prediction. While

the results show that the public may prefer a management style that is collaborative between multiple sectors rather than managed solely by the HRM, Halifax residents are not familiar with beach certification programs and this sample does not display public confidence in a certification program. An environmental certification program is not recommended as an alternative to the current management approach.

The establishment of a non-governmental organization representing Halifax Harbour is recommended. Throughout the research process for this project, it has been observed that Santa Monica Bay in California and Boston Harbour in Boston, Massachusetts are similar case studies to Halifax in that they are mixed-use harbours located in an urban environment that have historically received significant amounts of pollution. Boston Harbour and Santa Monica Bay are useful examples in this research because they are further along in the transition from polluted to remediated than Halifax Harbour. Both of these Harbours have more than one non-governmental organization that strongly advocates for pollution prevention and remediation. 'Heal the Bay' in Santa Monica has worked with the local government to report improving water quality data to the public through an online beach report card, has been vigilant in reporting unauthorized industrial pollution and preventing it through legal action, and has been involved in creating the Santa Monica Bay Restoration project along with representatives in local government, industry, and academia (Heal the Bay, 2010). It is notable that Heal the Bay was granted 'Friends of the Court' status and met with city officials quarterly to ensure municipal compliance with the Clean Water Act (Heal the Bay, 2010). The Boston Harbour Association has worked with the local government to

clean up Boston Harbour, to educate the public throughout this process, and to encourage public recreation and tourism through the revitalization of the urban perimeter of the Harbour which is called the Harbour Walk (The Boston Harbour Association, 2009). The establishment of a similar organization in Halifax could play a significant role in pollution prevention and remediation in the Harbour, as well as serve as an interface for communication between local stakeholders on this issue. This type of organization is consistent with the survey findings that indicate that the public may prefer a management style that is collaborative between multiple sectors rather than managed solely by the HRM.

5.3 Conclusion

This research has studied public perception of water quality in Halifax Harbour in order to recommend an effective environmental monitoring and management style for Halifax Harbour that engages public participation and encourages public confidence. The results of this study provide insight into information that can be collected in this type of survey and how it can be applied to achieve a management approach that engages the public and continues to improve water quality in the Harbour. Boston Harbour and Santa Monica Bay both provide positive examples of how to improve water quality in a major urban Harbour. Both of these major transitions involved integrated management inclusive of a collective of remediation techniques and a variety of stakeholders. Non-governmental organizations played a key role in integrating a collaborative restoration effort between the public, local government, and academia. The potential of Halifax

Harbour to follow such positive transition models can be increased by adopting approaches that have proven to be successful in these similar transitions. The information in this study can be advantageous to decision makers in managing a successful transition of Halifax Harbour from polluted to remediated.

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