INCORPORATING PARTICIPATORY APPROACHES INTO THE MANAGEMENT OF MUSQUASH ESTUARY MARINE PROTECTED AREA

by

Jessica Corkum

Submitted in partial fulfilment of the requirements
for the degree of Master of Marine Management

at

Dalhousie University
Halifax, Nova Scotia
August 2013

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Abstract

Participatory approaches to marine protected area (MPA) management have the potential to offset management costs while promoting a sense of stewardship among communities. This study investigated the enhancement of participatory approaches in the management of Musquash Estuary MPA, including community surveillance and citizen monitoring. A survey was conducted with local residents to investigate the effectiveness of the "Musquash Watch" program, in which community members are encouraged to report observed violations to the Department of Fisheries and Oceans (DFO). The results of this survey indicate that the program has not been very effective. However, there is potential to promote self-enforcement through social norms and peer pressure, provided that efforts are made to promote widespread knowledge of the MPA regulations and their underlying rationale. To investigate the potential and guide the development of citizen monitoring for Musquash Estuary MPA, interviews were conducted with the managers of other MPA citizen monitoring programs, protocols were assessed for their feasibility and potential contribution to Musquash Estuary monitoring efforts, and a survey was conducted with a pool of local volunteers. The findings of this study indicate that citizen-monitoring efforts could be effectively developed and enhanced for Musquash Estuary provided that a source of long-term funding is available, and partnerships are formed with local environmental organizations. Recommendations include the implementation of the Community Aquatic Monitoring Program (CAMP) protocol at Musquash Estuary MPA, promoting the continuation and enhancement of current citizen bird surveys, and increasing the frequency of an annual citizen monitoring paddle in the estuary.

Key words: Musquash Estuary, Marine Protected Area, Participatory Management, Self-enforcement, Citizen Monitoring.

List of Acronyms

DFO	Department of Fisheries and Oceans
MPA	Marine Protected Area
CAMP	Community Aquatic Monitoring Program
AIA	Administered Intertidal Area
NCC	Nature Conservancy Canada
NGO	Non-governmental Organization
CCNB	Conservation Council New Brunswick
MAC	Musquash Advisory Committee
QA/QC	Quality Assurance and Quality Control
ENGO	Environmental Non-governmental Group
UNBSJ	University of New Brunswick, Saint John
CDFW	California Department of Fish and Wildlife

Acknowledgements

Firstly, I would like to thank Dr. Peter Wells, my academic supervisor for providing me with guidance and encouragement throughout the completion of this project.

Also, thank you to the staff of the Oceans and Coastal Management Division of DFO for supporting my research efforts and allowing me the opportunity to travel to Musquash to conduct surveys and attend meetings. Specifically, I would like to thank Penny Doherty, my internship supervisor for overseeing the completion of this project, and Glen Herbert for making sure that all my internship needs were taken care off.

I would also like to acknowledge Matt Abbott of Conservation Council New Brunswick (CCNB) for accompanying me for door-to-door surveys around the Musquash area, and the people of these communities for being so friendly and taking the time to complete the surveys, despite the fact that it was Father's Day weekend.

In addition, I want to thank all the instructors of the Marine Affairs Program for their insights and guidance throughout the year. Also, thank you to my fellow MMMers of the 2012-2013 academic year for sharing in my experiences and for being such a great bunch of people.

Finally, I'd like to thank my family and friends for their support. Last, but certainly not least, I'd like to thank my partner for his patience, love and unwavering support.

Chapter 1.0: Introduction

Widespread human development and overfishing are causing marine biodiversity loss and ecosystem degradation at a scale that exceeds any time in recorded history. The growing awareness of this ocean crisis has triggered increasing calls for effective approaches to protect, maintain and restore marine ecosystems (Allison, Lubchenco, & Carr, 1998). This call is largely being answered on an international scale through the creation of marine protected areas (MPAs). An MPA is broadly defined as, "A clearly defined geographical space, recognized, dedicated and managed, through legal or other effective means, to achieve the long-term conservation of nature with associated ecosystem services and cultural values" (Dudley, 2008). Although there were other forms of protected areas in existence prior to this, in 1997 the Canadian government mandated the establishment of a network of MPAs through the creation of the *Oceans Act*, with the goal of protecting a much larger proportion of the country's diverse and extensive marine environments. The Act identified the DFO as the lead department for the establishment and management of *Oceans Act* MPAs (Jamieson & Levings, 2001). Although MPAs alone are not sufficient to solve all of the oceans' problems, they have the potential to be powerful tools for coastal and marine conservation. However, as the definition indicates, an important caveat is that these areas must be effectively managed (Rife, Erisman, Sanchez & Aburto-Oropeza, 2012). Management activities that are critical to the success of an MPA include surveillance, enforcement, ecosystem monitoring, and stewardship initiatives with coastal communities and industries (DFO, 2013a).

Lack of attention to promoting compliance of regulations is likely to lead to the failure of MPAs to achieve their conservation objectives, since non-compliance can

render an MPA designation meaningless (Agardy, Sciara, & Christie, 2011). Although it is likely to be influenced by a multitude of other normative factors, in most cases enforcement is believed to be a key factor in promoting compliance (Davis & Moretti, 2005). Enforcement is the application of tools, both informal and formal, designed to impose legal sanctions to ensure compliance with a defined set of regulations (Wasserman, 1990, as cited in Davis & Moretti, 2005). To enforce regulations violations must first be detected, which necessitates surveillance. According to General Deterrence Theory, compliance is most heavily influenced by three factors: the potential for gain from illegal activity, the severity of sanctions, and the perceived risk of detection, with the latter two relating to enforcement and surveillance (Davis & Moretti, 2005). Within these factors, it has been shown that probability of detection may have a disproportionately larger influence on compliance than the severity of sanctions, most likely because of the social stigma associated with being caught (Sutinen, Rieser & Gauvin, 1990). Therefore, adequate surveillance of MPAs is a critical element in promoting compliance, and hence the success of MPAs.

For MPAs to be effective at conserving ecosystems, it is necessary to have information on the influence of management interventions, and to be able to detect the impact of threats that may undermine protection efforts; hence the critical role of monitoring MPAs (Danielsen, Burgess & Balmford, 2005). Monitoring is defined as the systematic collection of data or information over time to determine the extent of consistency with a predetermined standard or position (Hellawell, 1991). Therefore, to implement effective ecosystem monitoring, it is first necessary to have a thorough understanding of the natural or baseline functioning of an ecosystem to serve as a

standard, which can be a difficult and time-consuming task given the complexity of marine ecosystems and the spatial and temporal variability within them (Dickey & Bidigare, 2005). Due to these complexities, it is not possible to continuously monitor all marine ecosystem components. Therefore, in developing an ecosystem-monitoring plan for an MPA, indicators are selected based on their ability to detect change in the ecosystem and their ability to measure performance against conservation objectives. Once indicators are selected, monitoring protocols are written and used to assess the state of a particular indicator over time to detect any anthropogenically driven changes. Once detected, such changes may trigger further management interventions in an attempt to restore the ecosystem to its natural or baseline state (Cooper, Curran, Singh, Chang & Page, 2011).

Depending on the MPA, certain activities may be prohibited, while others are allowed because they are not believed to have a significant impact on the ecosystem, or for socio-economic or legal reasons. It is important to monitor all human activities that may pose a threat to the ecosystem in order to assess the impacts of these activities. Without this information, it would not be possible to evaluate human induced change versus natural variability (Cooper et al., 2011). Therefore, both ecological monitoring and the monitoring of human threats should be incorporated into an MPA monitoring plan. Furthermore, monitoring the occurrence of prohibited activities, or violations, informs MPA managers on the level of compliance with regulations and hence where and how they should apply compliance promotion efforts, such as enforcement.

With the global target that was put forth by the UN Convention on Biological Diversity of protecting 10% of the world's oceans by 2020 looming, much of the

international focus has been on dedicating resources to the creation of new MPAs (Cressey, 2011). However, the ongoing management of MPAs also requires significant investment (Balmford, Gravestock, Hockley, McClean & Roberts, 2004). Professional surveillance and enforcement incur substantial and continual costs. For example, surveillance and enforcement activities account for one-third of the annual budget of the Great Barrier Reef Marine Park in Australia (MPA News, 2000). Due to this large expense, surveillance and enforcement activities that are adequate to ensure compliance of MPA regulations can be cost-prohibitive (Davis & Morietti, 2005). Ecological monitoring by scientists is also very costly, difficult to sustain, and requires a long-term commitment from governments (Danielsen et al., 2005). Many countries don't have the resources to effectively enforce and monitor existing MPAs, especially when confronted with budgetary limitations or cutbacks (Cressey, 2011; Christie & White, 2007). Such considerations may be particularly pertinent in Canada given the current fiscal and political climate, which has brought about extensive reductions to conservation and fisheries programs (O'Neil & Hoekstra, 2013). Therefore, it is important to the success and sustainability of MPAs in Canada that effective management operations have sustained financial support and are carried out in a cost efficient manner.

Developed countries, such as Canada, have historically employed a centralized "top down" management approach to MPAs in which one lead agency, typically the federal or state government, takes on full responsibility and authority. However, participatory and co-management processes, which involve both government and local community members, can promote compliance to MPA regulations, thereby increasing their effectiveness (Christie & White, 2007). Furthermore, by promoting a sense of

ownership and support and by involving local organizations, participatory management processes can increase the sustainability of MPAs in the face of declining funding and centralized management capacity (Christie & White, 2007). Therefore, although incorporating public participation into protected area management can sometimes be more complex and expensive initially, it may be a wise investment for the long-term success of these areas (McNeely, 1994).

In recognition of the potential benefits of participatory management, Canada included in its 2002 *Oceans Strategy* a call for participatory processes and collaboration in designing, implementing and monitoring the effectiveness of coastal and ocean management plans, including MPAs. However, thus far Canada has achieved only limited success in putting such an approach into practice (Kearney, Berkes, Charles, Pinkerton & Wiber, 2007). To meet the mandate put forth in the *Oceans Strategy*, and to ensure on-going support for MPAs, it is important that local communities and resource users are included in ongoing management processes, beyond a more traditional advisory role in the planning phase of MPAs.

One means of incorporating citizens into the management of MPAs, and to promote efficient management is to encourage community self-enforcement. Community self-enforcement entails any activities undertaken by individuals or user groups that deter violations by other users, such as informal or opportunistic surveillance (Davis & Moretti, 2005). One common means of facilitating community surveillance is the establishment of hotlines or email addresses to which the public can report violations (Davis & Moretti, 2005). However, in some cases community surveillance or general

support of regulations can promote compliance through social pressure alone, without the need to report violations to authorities (Davis & Morietti, 2005).

The incorporation of citizens into monitoring of protected areas through citizen science programs can also be an effective way to promote citizen involvement and to offset management costs (Armsworth et al., 2013; Danielsen et al., 2005). The term citizen science refers to the use of non-professionals to collect data for scientific projects that have been specifically designed or adapted to accommodate inexperienced participants (Silvertown, 2009). Such programs have become increasingly popular due to the recognition of benefits and the development of enabling technologies, such as digital photography to aid in species identifications (Silvertown, 2009).

1.1 Musquash MPA

Musquash Estuary is a small MPA located on the coast of the Bay of Fundy, approximately 20 km southwest of Saint John, New Brunswick (Figure 1-1). It is made up of a modest subtidal area of about 7km^2 and the surrounding intertidal area, which is titled an administered intertidal area (AIA). The AIA is not technically part of the MPA because under federal legislation an *Oceans Act* MPA, such as Musquash, can only include area up to the ordinary low tide mark[1]. However, to protect the surrounding salt marsh area, an agreement between the provincial and federal governments outlines provisions for the AIA to be managed in a manner that is consistent with the MPA (DFO, 2008). Therefore, DFO is responsible for the management of both the subtidal area within

[1] The ordinary low tide mark occurs at the intersection of mean low tide mark (the average of all low tides over a certain period of time) and the shore.

[2] What is considered an unacceptable reduction or modification is determined through the process of establishing baselines and creating a monitoring strategy.

the MPA boundaries and the surrounding AIA. Also, as of 2010, approximately eighty percent of the land immediately surrounding Musquash Estuary is under some form of conservation ownership by one of many different agencies, including: The Nature Conservancy of Canada (NCC), Ducks Unlimited, and the Government of New Brunswick (DFO, 2008). These conservation lands include several hiking trails so that visitors may access the area. The process of designating the area as an MPA under the *Oceans Act* was a collaborative effort between a local fishermen's group, the local community, the province of New Brunswick and the Federal Government; as such, the area has received wide stakeholder support (DFO, 2008). Therefore, in managing the MPA there are many stakeholders to consider, and sustaining the ecosystem must be balanced with resource use and public enjoyment.

Figure 1-1: Map of Southwest New Brunswick showing the location of Musquash Estuary MPA

An estuary is a partially enclosed coastal body of water, with a free connection to the sea, in which freshwater from rivers and streams mix with oceanic water. Some estuaries, such as Musquash, are surrounding by low-lying coastal grasslands called salt

marshes, which are often covered over by the rising tide (Cooper et al., 2011). Although they tend to be undervalued by general society, the protection of estuarine and salt marsh habitats is of vital importance due to the vulnerable nature of these systems and the important ecosystem services that they provide. These important services include: purifying ocean water by filtering out pollutants; acting as a buffer zone that protects coastal communities from flooding and storm events; supporting high biological productivity; preventing coastal erosion by supporting stabilizing vegetation; offsetting carbon induced climate change though carbon sequestration; and serving as important nursery habitats for many species of fish (Barbier et al., 2011; Beck et al., 2001). Despite the provision of these critical services, more than eighty-five percent of natural salt marsh habitats in the Bay of Fundy have been altered or destroyed by human activity over the past 300 years (National Wetlands Working Group, 1988). Therefore, although it represents only a small geographic area, the protection of Musquash and other estuarine and salt marsh habitats through effectively managed MPAs and other useful measures are prudent and necessary actions.

Musquash Estuary occurs where the Musquash River meets the Musquash Harbour, draining a watershed of 470 km^2 (DFO, 2008). It is a shallow, tidal estuarine ecosystem, with depths of 1-6 m and a tidal range of 6-8 m. The waters of the estuary are vertically well mixed, with the salinity varying between 0-30 ppt depending on the balance of freshwater and seawater inputs (Singh, Buzeta, Dowd, Martin, & LeGresley, 2000). Musquash Harbour is highly turbid, or muddy, due to the re-suspension of bottom sediments by the strong tidal currents (Cooper et al., 2011). The estuary supports many diverse habitats, possessing eight distinct ecosystem types, and an abundance of wildlife

including phytoplankton, zooplankton, invertebrates, salt marsh plants, fish and many rare bird species (Singh et al., 2000). It is one of the few remaining productive estuarine and salt marsh habitats in the Bay of Fundy region that has not been significantly impacted by human development (DFO, 2008).

1.1.1 Conservation Objectives and Regulations

Due to its diverse and productive nature, and relatively pristine condition, the conservation objectives for the Musquash Estuary MPA were designed to protect and preserve the entire ecosystem in its current state. The conservation objectives for the MPA are to ensure no unacceptable[2] reduction or human-caused modification in:

- Productivity, so that each component (primary, community, population) can play its role in the functioning of the ecosystem by maintaining abundance and health of harvested species;
- Biodiversity, by maintaining the diversity of individual species, populations and communities within the different ecotypes; and
- Habitat, in order to safeguard the physical and chemical properties of the ecosystem by maintaining water and sediment quality (DFO, 2008).

[2] What is considered an unacceptable reduction or modification is determined through the process of establishing baselines and creating a monitoring strategy.

To protect the Musquash Estuary and to meet the conservation objectives certain regulatory requirements are imposed on the MPA and surrounding AIA. Activities that are prohibited in the area include:

- The disturbance, damage, destruction or removal from the area of any marine organism or any part of its habitat;
- The carrying out of any activity, including depositing, discharging or dumping any substance, or causing any substance to be deposited, discharged or dumped, that is likely to result in the disturbance, damage, destruction or removal of a living marine organism or any part of its habitat.

Certain activities are exempt from the general prohibitions and are permitted within certain areas of the MPA or AIA under certain conditions. These managed activities include: aboriginal fishing; some types of commercial and recreational fishing; recreational and commercial dulse harvesting; operation of a marine vessel under certain speeds in particular zones; the construction, repair, removal or maintenance of boat launches, wharfs or navigational channels; as well as activities carried out for the purposes of public safety, national defense, national security, law enforcement, or environmental emergency response and clean up (DFO, 2008).

1.1.2 Current State of Management

The current Management Plan for the Musquash MPA recognizes the importance of ongoing surveillance and enforcement of the area, but also acknowledges fiscal resource limitations. Effective resource allocation is particularly important for Musquash, given that ongoing management costs of small coastal MPAs are typically more per unit area

than for larger more remote offshore ones (Balmford et al., 2004). Surveillance of the Musquash MPA and enforcement of the regulations are carried out by DFO Conservation and Protection, and fisheries officers. However, because there is only a limited amount of fishing activity in the area and because parts of the MPA are quite remote, patrols by DFO officers are limited. Generally, the portion of the upper estuary that is visible from the highway is patrolled by vehicle on a weekly basis; occasionally, foot, air or ATV patrols are conducted throughout the estuary (DFO, 2012).

The Musquash Estuary MPA Management Plan states that DFO is to undertake scientific monitoring of the MPA and AIA, but that this is contingent on the availability of funds and other resources (DFO, 2008). A proposed monitoring framework has been developed that identifies a set of potential indicators and proposed monitoring strategies, which link back to the conservation objectives for the MPA (Appendix I). As of yet, no comprehensive monitoring plan has been developed from the proposed framework, but one is expected to be completed within the next year based on the results of preliminary monitoring efforts and science advisory processes (P. Doherty, personal communication, June 24, 2013). Current monitoring efforts are directed at establishing an understanding of the baseline functioning and natural variability of particular indicators within the Musquash Estuary ecosystem, and assessing the use of particular indicators for detecting human induced changes (DFO, 2013b). It should be noted that many of the proposed monitoring activities are associated with substantial costs. For example, the sampling of benthic biodiversity using the proposed methods is expected to cost approximately $65, 000 per year (Cooper et al., 2011).

The proposed monitoring framework for Musquash Estuary MPA also identifies the need to monitor managed activities and perceived threats to the ecosystem (Cooper et al., 2011). Currently, some efforts are being made to assess ecosystem pressures and human uses, such as an annual assessment of shoreline dumping and debris, and analysis of records of scallop landings within the outer zone of the MPA (P. Doherty, personal communication, June 24, 2013). Presently, there is no monitoring of the number of visitors or recreational users in the MPA because these are believed to be relatively low and hence are assumed to have little impact. However, this may change with increased outreach by local stakeholder groups, which could justify monitoring of recreational use in the future.

Based on the preceding discussion, management concerns specific to the Musquash Estuary MPA include: on-going enforcement and compliance promotion, as well as the implementation of ongoing ecological and human threats monitoring in a manner that is cost and resource effective. Furthermore, it is important that DFO promote ongoing community involvement in the management processes for Musquash to promote ongoing compliance and support, and to comply with the mandate put forth in Canada's *Oceans Strategy*.

1.2 Involving Citizens in the Management of Musquash MPA

The incorporation and enhancement of participatory approaches to surveillance and monitoring could be an effective strategy to address the management concerns specific to Musquash, as well as to other coastal MPAs that face similar concerns. To this end, the Musquash Estuary MPA Management Plan calls for the establishment of a "Musquash

Watch" community surveillance program to encourage marine users, coastal landowners, and local residents to participate in the surveillance and reporting of violations and suspicious activities (DFO, 2008). Efforts toward the establishment of "Musquash Watch" have primarily consisted of the distribution of promotional material following the MPA's designation; however, there are no records of any reports being made by local residents to date (P. Doherty, personal communication, June 24, 2013). It is not known if this is because no incidents have been witnessed, incidents are being reported elsewhere, or if incidents that are witnessed are going unreported.

The Musquash Estuary MPA Management Plan also proposes the incorporation of community participation in the scientific monitoring of the area (DFO, 2008). To date, there has been one citizen-monitoring activity implemented in Musquash MPA, an ecological monitoring paddle conducted simultaneously with a daylong educational kayak paddle in 2012 (P. Doherty, personal communication, June 24, 2013). However, as of yet no comprehensive, ongoing citizen-monitoring program has been developed for Musquash that includes logistical and cost considerations and makes information gained from such activities available to the broad array of managers and stakeholders (P. Doherty, personal communication, June 24, 2013).

1.3 Research Questions

Given the need to manage small MPAs in Canada in a practical and cost effective manner, and to involve local stakeholders in this process, the purpose of this study is to investigate the feasibility of incorporating and enhancing current participatory approaches into the surveillance and monitoring of Musquash Estuary MPA. This research will

provide direction for the development of cost and resource effective participatory approaches to surveillance and monitoring of Musquash Estuary, and may also provide insight for the development and enhancement of such programs in other coastal MPAs in Canada. Therefore, this study will address two major research topics: community surveillance and citizen monitoring. Within each topic both broad and specific research questions are identified.

1.3.1 Community Surveillance

How effective has the Musquash Watch Program been at encouraging local citizens to report violations?

1a. Are community members aware of the Musquash Watch Program?

1b. Have community members witnessed any unreported violations?

Does community surveillance have the potential to make an effective contribution towards the surveillance and enforcement of Musquash Estuary MPA?

2a. Are local community members supportive of the Musquash Estuary MPA?

2b. Are local community members familiar with the regulations for the MPA?

2c. Is it possible that local community members would witness violations if they did occur (i.e. can they see the MPA from their residence, or do they visit the MPA frequently)?

2d. Would community members be willing to report violations to DFO?

1.3.2 Citizen Monitoring

What is the feasibility of, and some guidance for the incorporation and enhancement of citizen monitoring efforts at Musquash Estuary MPA.

1. What are some important considerations for developing and implementing an MPA citizen-monitoring program?

2a. What citizen monitoring protocols are most feasible and could best contribute to monitoring efforts for Musquash Estuary MPA?

2b.What would be the costs associated with implementing these protocols?

3. What are the potential motivations and interest levels of local volunteers in participating in citizen monitoring at Musquash Estuary MPA?

Chapter 2.0: Community Surveillance

2.1 Literature Review

Enforcement is an ongoing MPA management activity where involvement of citizens can reduce costs and resource requirements, while promoting effective management (Pomeroy, Watson, Parks & Cid, 2005). However, the available literature on such approaches is quite scarce, especially for developed countries that typically employ centralized management approaches to MPAs (Christie & White, 2007). Therefore, in exploring citizen enforcement of MPAs in Canada, it is necessary to draw on examples from developing countries and terrestrial protected areas, as well as literature from outside the environmental and resource management realm, such as neighborhood watch programs.

The majority of the literature that does exist on citizen involvement in protected area enforcement comes from community managed or co-managed examples in developing countries. In such cases, community or citizen based enforcement is often viewed as an effective and complementary alternative to formal centralized approaches (Reis & D'Incao, 2000; Thomas, 2001). Although the socio-economic situation and management approach employed in these cases tend to be substantially different than for developed countries, there may still be insights to be gained from exploring some of the literature (Christie & White, 2007). In the case of MPAs in the Philippines, local community members formed groups called "bantay dagat" or "sea watch" which were officially deputized by state authorities to perform coastal law enforcement activities (Christie & White, 2007). In others cases, community member's ability to enforce regulations comes from traditional social norms, in which social leaders are able to

reprimand violators from within their community (Crawford, Siahainenia, Rotinsulu, & Sukmara, 2004). Alternatively, community members can contribute to enforcement efforts by providing formal or informal surveillance and reporting violations to authorities (Crawford et al., 2004). In a study of the effect of community enforcement on compliance to MPA regulations in Indonesia, Crawford et al. (2004) found the level of compliance to be inversely related to distance between the MPA and the nearest settlement, but not related to visibility. Based on this, the authors propose that shore-based surveillance is not likely to have a direct effect on compliance. However, they did find that overall, community-based enforcement efforts were effective at promoting compliance within communities. Furthermore, the authors propose that community members must feel that violations are morally wrong to be willing to report violations committed by fellow community members (Crawford et al., 2004); this, in turn, often requires a change in the attitudes of community members whereby behaviors that constitute violations are no longer considered acceptable. Therefore, the authors attribute increased compliance to MPA regulations within communities to community awareness and acceptance, as well as peer pressure (Crawford et al., 2004).

RARE, a non-governmental organization (NGO) that works with local communities to inspire conservation, is undertaking efforts to develop and market community-led and collaborative enforcement programs in MPAs throughout South East Asia, the Pacific Islands and Central America. Through their experiences, the program coordinators have found that communication and program promotion is key, both between management organizations and communities, and between peers within communities (MPA News, 2013). They have also found that for programs to be

successful there needs to be a clear call for action, whether it be for resource users and community members to participate in more formalized patrols, or encouraging them to use a hotline to report violations. Furthermore, it is important to understand the target audience for such campaigns to ensure that appropriate communication channels are used. For example, if a campaign is encouraging citizens to report violations on sight, it may be important to know the levels of cell phone coverage and usage (MPA News, 2013).

It is prudent that more research be conducted on citizen involvement in MPA enforcement in developed countries, as part of a more centralized management approach given that such efforts are being made. For example, the MPA Watch program, which is a program in which volunteers monitor human uses of MPAs, encourages participants to report violations so long as it does not interfere with their ability to carry out the monitoring protocol (Sikich, 2013). Furthermore, in addition to recording human uses, one of the groups that administer the MPA Watch program from a boat, called LA Waterkeeper, approaches people in the process of committing violations to educate them on the MPA regulations, and if that is ineffective, reports them to the authorities (Barboza, 2011; Los Angeles WaterKeeper, 2013). Other MPAs may informally encourage citizens to report violations, or more formally through programs such as "Musquash Watch" (DFO, 2008).

The notion of citizen watch groups is not a novel one. The use of neighborhood watch groups that encourage citizens to keep an eye out for and report criminal or suspicious activities have been widely practiced in developed countries for decades (Bennett, Holloway, & Farrington, 2006). Through a review of studies evaluating the

effectiveness of neighborhood watch programs Bennett et al. (2006) found that such groups were effective in reducing crime in about half of all cases. There are several methods through which neighborhood watch groups are thought to reduce crime. The most obvious of these is through the reporting of criminal or suspicious incidents to the authorities. However, it is also theorized that the presence of community surveillance programs might act as a deterrent to would-be offenders by causing them to perceive an increased likelihood of being caught (Bennett et al., 2006). Alternatively, neighborhood watch groups might informally lead to a reduction in crime from within the community through the generation of acceptable social norms and behaviors that discourage criminal behavior (Bennett et al., 2006). Therefore, in some cases, neighborhood watch programs serve to increase surveillance, deter offenders and promote informal social control, thereby reducing criminal activity (Bennett et al., 2006).

In a review of the evolving role of private citizens in environmental enforcement, Thompson (2000) explores the role of American citizens as informants, which he proposes is a growing and important role that has been largely ignored in the literature. For citizens to act as informants, they must first be aware of environmental regulations, which generally requires active promotion by the government or other organizations (Thompson, 2000). However, even if citizens are aware of regulations, they may be unwilling to call and report incidents to authorities due to anti-snitching norms (Thompson, 2000). In North American culture, children often learn from their earliest social interactions that telling or snitching on others is bad, a notion that often carries through to adulthood (Thompson, 2000). Anti-snitching norms embody the view that a functioning democratic society must be tolerant of a small degree of lawlessness. This

live and let live attitude may derive from the fact that many people commit what are considered to be minor legal violations at some point, be it speeding, building without the proper permits, or visiting closed parks after dark (Thompson, 2000). Due to this background noise of lawlessness, most people will only complain about or report violations if they perceive them to be serious enough to threaten personal or societal wellbeing (Thompson, 2000). Furthermore, social norms against reporting violations committed by others within their communities may result from people wanting to deal with such issues internally. The reporting of violations from within the community can break down trust relationships and lead to people not wanting to share information with each other. Also, the idea of spying or snitching on fellow citizens, especially if the government promotes such activities, might trigger deep-rooted societal fears of communist societies such as former East Germany and be regarded as a threat to democracy and liberty (Thompson, 2000; Pecora, 2002). Citizens may also be concerned about authorities interpreting reported events out of context, due to a lack of understanding of the community dynamics (Thompson, 2000). For these reasons, people in a community may be reluctant to report violations by follow community members to outside authorities unless they feel it is clearly necessary (Thompson, 2000). Different people will attach varying degrees of importance to concerns underlying anti-snitching norms (Thompson, 2000). Therefore the willingness of community members to report violations depends on the value they apply to anti-snitching norms, trust relationships within communities, and the seriousness that they attach to the violations being committed.

In a synthesis report on enforcement of U.S. Marine Protected Areas for the National Marine Protected Areas Center, Davis and Moretti (2005) include a brief review of community self-enforcement. They cite Jentoft's (1989) observation that one of the impediments to effective self-enforcement may be reluctance by individuals to serve as informants or otherwise facilitate enforcement against their peers. However, in some cases self-enforcement can be an effective method at ensuring compliance, as is shown by the success of voluntary MPAs found in the island-based county of the San Juan Islands in the state of Washington. Since no government agency has enforcement authority, these MPAs, which form a system of bottom fish recovery zones, rely completely on community self-enforcement. Through educational efforts and social pressures of the tight-knit communities found in San Juan County, this MPA system has achieved nearly 100 percent compliance (Davis & Moretti, 2005; MPA News, 2000).

A study by Hennessey and Beazley (2012) provides insight into some of the issues and obstacles surrounding community environmental enforcement in a terrestrial, rural Atlantic Canadian context. For this study, the researchers conducted interviews with community members in the village of Westport, on Brier Island, Nova Scotia regarding their participation in conservation activities on a significant piece of local conservation land owned by the NCC. Westport is a small fishing community of 200 people. As part of its mandate, the NCC strives to conserve protected areas of natural diversity for their intrinsic value and for the benefit of future generations (NCC, 2013). Therefore, in implementing their mandate, the NCC must balance sustaining ecosystems with public use and enjoyment, a challenge that is common in conservation management. However, NCC's vision for its conservation lands on Brier Island did not align with all members of

the community of Westport, many of whom value the land for firewood harvesting and off-highway vehicle use (Hennessey & Beazley, 2012). This serves as an impediment to the effective management of the area for conservation since, due to the remote location of Westport, any informal enforcement of the NCC's ownership rights and use guidelines for the conservation area is likely to be through peer pressure, cultural norms, or other means of self-policing (Hennessey & Beazley, 2012).

Through their interviews with the residents of Westport, Hennessey & Beazley (2012) found that the need for citizen enforcement of NCC conservation lands on Brier Island inadvertently led to polarization within the community. Many of the residents who were interviewed for the study shared NCC's vision for the conservation land, but felt that these values were in conflict with the some of the relationships they had with other members of the community. This potential for conflict led to a reluctance of these participants to engage their neighbors regarding the regulations for the conservation area (Hennessey & Beazley, 2012). Also, some participants expressed unwillingness to engage in future stewardship and enforcement activities for the area due to frustrations with a lack of follow-up from NCC on reports of vandalism and general degradation, as well as the potential for negative backlash from within the community (Hennessey & Beazley, 2012). This study highlights the importance of developing a large proportion of community buy-in for community enforcement approaches to be effective, as well as the need to follow through with any reports that are made by community members (Hennessey & Beazley, 2012).

2.2 Methods

To assess the past effectiveness and future potential of the "Musquash Watch" community surveillance program, and to further explore some of the issues identified in the literature review, a survey was conducted with members of communities local to the Musquash Estuary MPA (Appendix II). This survey was designed to address the research questions outlined in section 1.3.1 of this report. To comply with institutional standards on the ethical conduct of research involving humans, approval of the research design and survey was sought and received from the Research and Ethics Board at Dalhousie University.

2.2.1 Study Population

The study population for this survey was residents of communities immediately surrounding Musquash Estuary MPA, including: Lorneville, Musquash and Prince of Wales. These are the communities to which DFO distributed Musquash Watch promotional material asking residents to report violations following its designation in 2006 (P. Doherty, personal communication, June 24, 2013). In addition, these are the closest communities to the MPA and its land-based access and vantage points (within 10 km). Although there was no available information at the spatial resolution required to obtain the total number of residents in these three small communities, DFO estimates that they sent out Musquash Watch promotional material to five hundred residences (P. Doherty, personal communication, June 24, 2013). To reduce bias in the current study, only one member from each household was surveyed. Community members under the age of eight-teen were excluded from participating in the survey.

2.2.2 Recruitment

Due to financial and time constraints for this study, and the rural nature of the study communities, a combination of non-probability sampling[3] techniques were used including: snowballing, convenience sampling and consecutive sampling (Denscombe, 2010; Lunsford & Lunsford, 1995). Although such non-probability techniques do not allow for the accurate generalization of results to the broader study population, they allow for an exploratory look at general trends and patterns within a population (Vaus, 1996). A snowballing technique was employed by sending an email to the Musquash Advisory Committee[4] (MAC), asking for those that are members of the study population to participate in the survey and to refer the names of friends and neighbors who may wish to participate to the researcher. A convenience sampling technique was employed by distributing a mail out to all residential addresses in the communities of Lorneville, Prince of Wales and Musquash requesting that residents voluntarily contact the researcher to participate in the survey. Here, participants were given the option of completing the survey via email or over the telephone. Due to the nature of the Canada Post mailing system, the mail out was distributed to communities outside the study population that were along the same mailing routes, including several small coastal costal communities along the Bay of Fundy. In total, the mail out was sent to 798 residencies (two separate mailing routes). Surveys that were completed from any respondents outside of the study population were excluded from the analysis. Several flyers were also placed in public

[3] In non-probability sampling the choice of participants is not random, therefore the probability of sampling a given participant from the population cannot be calculated.

[4] The MAC consists of members from government, NGOs, industry, First Nations and community groups that have an interest in the MPA and AIA. Its purpose is to facilitate a dialogue between DFO, other regulators and stakeholders regarding implementation of the MPA and AIA management plan (DFO, 2008).

locations around the communities included in the study population, asking for their participation. In addition to soliciting participants, the mail out served to alert residents that the researcher would be conducting door-to-door surveys around the communities of Lorneville, Prince of Wales and Musquash over a three-day period, on a weekend in June 2013. Consecutive sampling was employed during the round of door-to-door visits. The researcher spent one afternoon in each of the three communities included in the study population. Within each community the researcher would select locations on an ad hoc basis, generally in areas with clusters of houses, from which to go around to several consecutive houses. If someone answered at a given residence, they would be asked to participate, and if they were interested, they were given the option of completing the survey with the researcher at that time, or of taking a stamped envelope addressed to the researcher, and mailing out the completed survey sometime within the next week.

2.2.3 Data Collection and Analysis

Participants completed the surveys via email, telephone, mail, or in person, depending on the recruitment method and their preference. Surveys consisted mainly of questions that were categorical or binary in nature, but in some cases participants were asked to elaborate on their answers (Appendix II). The surveys were estimated to take twenty minutes to complete, including time for participants to review and complete the consent form.

Answers to survey questions that were categorical, binary or otherwise quantitative in nature were analyzed using descriptive statistics including percentages and frequency distributions. Qualitative answers, which were provided in cases where

participants were asked to elaborate on their selection, were sorted into categories and then summarized or presented as quotations.

2.3 Results

A total of twenty-seven surveys were completed by members of the communities of Lorneville, Prince of Wales and Musquash, representing approximately five percent of the estimated study population. Three participants were either members of the Musquash Advisory Committee or were referred by a member; therefore they were recruited using a snowball sampling technique. Three participants responded to the mail out, and were therefore recruited through convenience sampling; all three of these were from the communities included in the study population and were included in the analysis. Twenty-one survey participants were recruited via consecutive sampling during door-to-door visits by the researcher; of these, seventeen chose to complete the survey in person, while four choose to mail in the survey after completing it on their own.

All survey participants indicated that they were full-time residents of the communities of Lorneville, Prince of Wales or Musquash. Participants represented a wide range of occupational sectors, with the largest portion representing the health sector (7), followed by those in retirement or otherwise unemployed (5), and those in transportation (4). Other sectors represented included: manufacturing (2), government (3), education (1), construction (1), communications (1), home help (1), and property maintenance (1). Only one participant indicated that they were currently involved in a primary sector that relies directly on natural resources (fish processing). All age categories included in the

study were represented; however, the majority of participants were between 40-69 (22) (Figure 2-1).

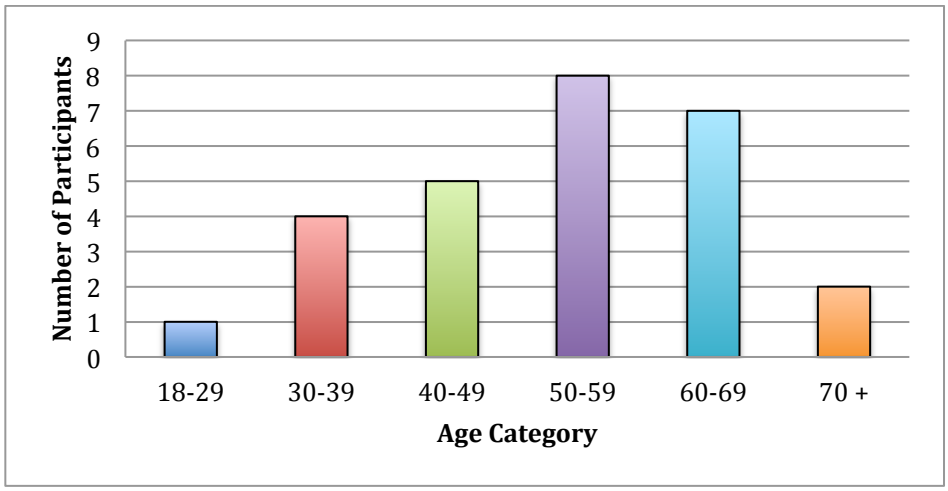

Figure 2-1: Age Distribution of Community Surveillance Survey Participants for Musquash Estuary MPA

Most survey participants were not aware of the "Musquash Watch" program. Out of the twenty-seven survey participants, eight indicated that they recalled receiving promotional material following the MPA's designation that provided information on the regulations for Musquash Estuary MPA and provided a number to which violations and suspicious activities could be reported. Four other participants noted that they only moved to the area within the last three years, and therefore would not have received these materials. Based on this, approximately sixty-five percent of residents surveyed that likely would have received these materials have no recollection of them or the information they contained. One of the participants who recalled receiving the material commented that they, "recalled the info being sent but didn't remember the specifics". Another, who didn't recall receiving it stated that they, "wouldn't have thought to call DFO, people probably don't know who to call."

Of the twenty-seven survey participants, five indicated that they had witnessed violations or suspicious activities in the Musquash Estuary MPA and surrounding area (Table 2-1). All of these participants also indicated that they did not report the incident to DFO. However, three participants indicated that they reported the incident to other organizations including the Conservation Council of New Brunswick (CCNB) and the city of Saint John. The use of trucks on Ducks Unlimited land immediately adjacent to the MPA is unlikely to be of direct concern to DFO. Although it occurs on land outside their jurisdiction, if contaminants are entering the MPA this would be pertinent information to DFO. Dumping within the MPA boundaries constitutes a violation if it is found to cause disturbance or damage to an organism or its habitat, and is a recurring issue in the area surrounding the MPA (P. Doherty, personal communication, June 24, 2013). The participant that witnessed and reported the incident commented that they did not bother to report it to DFO because they felt DFO could not do anything about it. The participant that witnessed a dumping in progress did not report the incident to anyone because they "knew they would never be prosecuted"; however, this person said that they confronted the would-be offender personally and threatened to report the incident. Finally, the participant that witnessed the use of a motorized boat in a restricted zone indicated that they did not report the incident because they did not want to "tell on people in the community if it was not a major incident".

Table 2-1: Participant Reports of Violations or Suspicious Activities Witnessed in Musquash MPA

Incident Witnessed	Reported to Authority?
Trucks on dykes (Ducks Unlimited land)	Yes: CCNB
Contaminants leaking from leachate pond into area surrounding MPA	Yes: City of Saint John
Dumping	Yes: did not specify (not DFO)
Suspicion of dumping in progress	No
Use of motor in restricted area	No

The twenty-seven survey participants all indicated that they were familiar with Musquash Estuary MPA and that they were supportive of the area being managed as an MPA. However, one participant stated that, "everyone knows it's an MPA, but nobody really knows why." Also, a couple of participants made comments that they may not be supportive of further regulations for the area; one stated that they supported the area being, "protected, not over-protected." Another participant indicated that they had misgivings about the restrictions on boat use in the MPA.

Overall, participants of this survey felt that they were not very knowledgeable regarding regulations for human activities for the Musquash Estuary MPA. On a scale of one to five, with one being not very knowledgeable and five being very knowledgeable, the majority of survey participants rated themselves as a one or a two; this represents seventy four percent of those surveyed being on the less knowledgeable side of the scale (Figure 2-2). Two survey participants rated themselves as a five. It's worth noting that both of these participants are associated with the Musquash Advisory Council, and are therefore more likely to be familiar with the regulations.

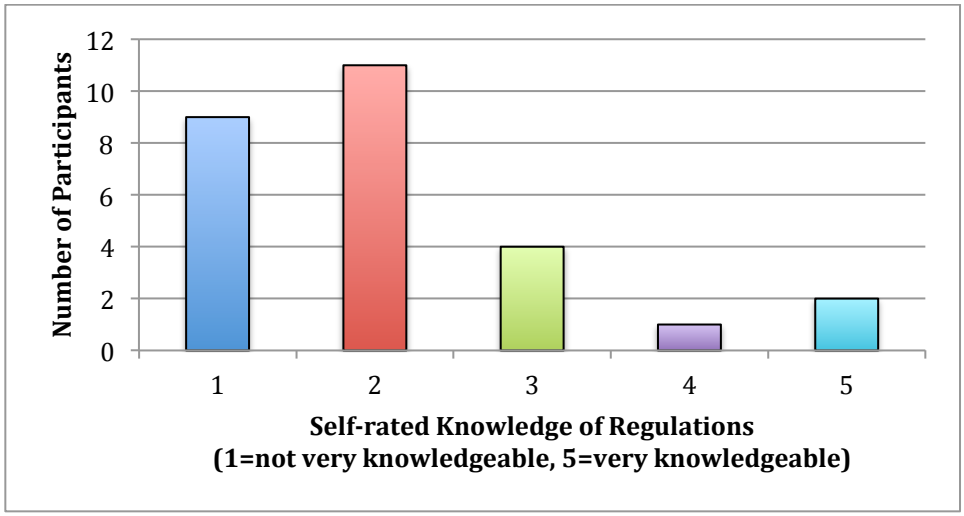

Figure 2-2: Participants Self-rated Knowledge of Musquash Estuary MPA Regulations

In general, it is quite possible that survey participants would have the opportunity to witness violations and suspicious activities that occurred in and around Musquash Estuary MPA given its visibility in some locations and the frequency with which many participants visit the lands immediately surrounding the MPA. Six out of the twenty-seven participants can actually see a portion of the MPA from their home, and all but two live within ten kilometers of the area. Nine, or thirty-three percent of survey participants tend to make use of the MPA and the area surrounding it more than once a week. Overall, a total of twenty-three, or eighty-five percent of participants stated that they use the area at least once a month.

All twenty-seven survey participants indicated that they would be willing to report any violations they witnessed to DFO, except for one who did not respond to that question. However, in elaborating on their answer, seven participants commented that it would depend on the violation, and several specifically mentioned dumping of garbage or oil as violations they would willingly report. One participant stated that they would report a violation "if I thought they were really doing something wrong, especially

dumping". Comments by other participants included: "if it was something really bad, like dumping gasoline or oil", and "if it was something that was harmful to the environment". Two participants mentioned that they would be willing to report a violation, but would not want to give up the name of the violator. One participant mentioned that they felt DFO would not have the resources to respond to an incident if they did report one.

Approximately half of the survey participants indicated that their willingness to report violations to DFO would be different if they knew the violator (Figure 2-3). Of these, eight participants elaborated that they would talk to the person themselves, although some mentioned that this would also depend on the type of violation and whether they perceived it to be serious or major. A couple of participants also commented that their answer would depend on who the violator was. One participant felt that people would not want to report violations committed by other community members due to concerns about backlash.

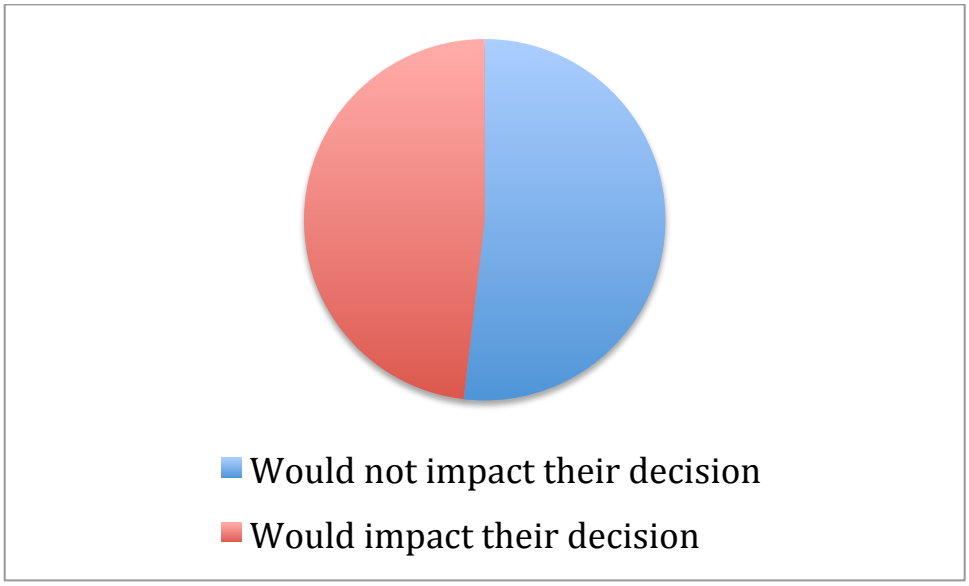

Figure 2-3: Effect that Knowing the Violator Would Have on Participant's Willingness to Report Incidents to DFO

2.4 Discussion

Based on the results of the survey of community members local to Musquash Estuary MPA, the "Musquash Watch" Program was found to be ineffective at encouraging local citizens to report violations. The basis of this assessment is that sixty-five percent of the residents surveyed that are likely to have received "Musquash Watch" materials have no recollection of them or the information they contained. Furthermore, five participants witnessed violations or suspicious activities but did not report them to DFO, while three reported the incident to other agencies. However, "Musquash Watch" materials were distributed approximately five years ago, following the MPA's designation, with no further promotional efforts (P. Doherty, personal communication, June 24, 2013). For community enforcement approaches to be effective, active program promotion is required as well as a clear call for action (MPA News, 2013). Therefore, if the "Musquash Watch" program is to be continued, more emphasis should be put on encouraging local community members to report incidents. One complimentary approach to distributing information to local residents via mail would be to post public "Musquash Watch" signs around the MPA. This would serve to promote the program and may also deter would-be offenders, much like neighborhood watch signs are intended to do (Bennett et al., 2006).

Interestingly, of the five incidents that participants reported witnessing, four were land-based activities, three of which would likely be of concern to DFO. It seems likely that community members would not think to call DFO about incidents occurring on land, because land is not under DFO's jurisdiction. This demonstrates a potential flaw with the "Musquash Watch" system. Estuaries occur where watersheds meet the ocean. This is likely to cause confusion over which institutions have authority over particular areas

within and around the MPA. One approach to reduce this confusion would be to create a central phone number or website to which community members could be encouraged to report all suspicious incidents or violations both within and around the MPA. This could be accomplished collaboratively between organizations that have a stake in the management of Musquash Estuary and the surrounding land, with one organization commissioned with the direct management of reports. Then a triage approach could be applied where a representative from a designated organization could direct reports to the appropriate authorities and organizations.

To assess the potential for a community surveillance approach (such as "Musquash Watch") to make an effective contribution towards the management of Musquash MPA, several key issues were explored including: supportiveness of the MPA, familiarity with regulations, opportunity to witness incidents in and around the MPA, and willingness to report violations to DFO. All survey participants indicated that they were generally supportive of the Musquash Estuary being managed as an MPA. However, most participants rated their knowledge of regulations quite poorly. This strongly suggests the need for DFO to promote widespread knowledge of MPA regulations to local community members in such a way that they will understand and retain the information. Without knowledge of the regulations, community members may not even know if they or other people are committing a violation (Thompson, 2000). It is possible that survey participants would have the opportunity to witness an MPA violation if one occurred. This finding is supported by the fact that several participants reported that they can see portions of the MPA from their house, the majority live within ten kilometers of the MPA and many frequently make use of the lands surrounding the MPA.

Survey questions assessing participants' willingness to call DFO and report violations and suspicious activities yielded some interesting results. All participants except one indicated that they would be willing to call DFO and report violations. However, a significant portion of these elaborated that it would depend on what violation was being committed. Several participants commented that they would report incidents that were wrong, bad, or harmful to the environment. These comments align well with the findings of several studies that people are typically unwilling to report violations unless they perceive them to be morally wrong or to threaten their personal or societal well being (Crawford et al., 2004; Thompson, 2000). Based on some participants' comments, dumping appears to be perceived by many as a morally wrong activity, while some participants did not consider other violations, such as the use of a motorized boat in a restricted zone, to be serious.

Approximately half of survey participants indicated that their willingness to report violations would be affected if they knew the violator. This is reflective of Jentoft's (1989) observation that individuals are reluctant to facilitate enforcement against their peers, but also of Thompson's (2000) that different people will attach varying degrees of importance to anti-snitching norms. As with the previous question, many participants commented that their answer would depend on the seriousness of the violation that was being committed. Of those that indicated that their willingness to report violations would be affected if they knew the violator, the majority commented that they would personally talk to the people rather than report it. Such actions would be a demonstration of peer-pressure being applied, which can be a very effective compliance-promoting tool (Crawford et al., 2004; Davis & Moretti, 2005).

Comments made by survey participants regarding the seriousness of violations and their willingness to report them highlight the need to provide the public with rationales for MPA regulations. Based on these comments, survey participants appear to judge the morality of actions not by what is legal, but by what they perceive as wrong. An example of this is the notion expressed by some participants that the use of motorized boats in restricted areas of the MPA does not constituent a serious violation. If people are unaware of the harm caused by actions, they will be unlikely to perceive them as wrong. Instead of simply providing information on what the MPA regulations are, DFO should provide a clearly stated and accurate rationale for regulations. If people understand and agree with the underlying rationale for regulations, they will be more inclined to perceive violations as wrong; as this perception spreads throughout the community, social norms are created. Widespread acceptance of regulations would reduce the risk of polarization within the community, and hence the fear of backlash or conflict in addressing violations within community (Hennessey & Beazley, 2012). Furthermore, experience has shown that educational efforts and social pressures can be powerful tools for promoting compliance, as is shown by the success of voluntary MPAs in San Juan County (Davis & Moretti, 2005).

Although the "Musquash Watch" program may not be particularly effective at encouraging community members to report violations to DFO, surveys indicate that community self-enforcement still exists in the communities around Musquash through the application of peer-pressure and social norms, which may be more effective at promoting compliance than reporting violations. However, the "Musquash Watch" program still has the potential to be effective, either through encouraging people to report violations or by

acting as a deterrent, provided that the existence of the program is promoted, and that knowledge of MPA regulations and their underlying rationale is spread throughout local communities.

Chapter 3.0: Citizen monitoring

3.1 Literature Review

Citizen environmental monitoring programs, which fall under the umbrella of citizen science, can offer many benefits over professionally conducted monitoring by management agencies. From a narrowly focused management perspective, such programs can help offset costs and provide an efficient way to increase management capacity (Armsworth et al., 2013). Furthermore, they can allow governments and NGOs to obtain important data and complete on-the-ground projects that may not otherwise be possible during times of resource and budgetary constraints (Koss & Kingsley, 2010). Citizen monitoring may also provide continuity to environmental programs through citizen dedication when institutional support collapses (Couvet, Jiguet, Julliard, Levrel, & Teyssedre, 2008). In addition, when properly designed and conducted, citizen monitoring programs can yield locally relevant results that can be as accurate and reliable as those derived from professional monitoring (Danielsen et al., 2005). From a broader governance perspective, citizen-monitoring programs can help promote a sense of stewardship within communities as well as provide benefits to participants. For example, a study by Koss & Kingsley (2010) showed that citizen participation in ecological monitoring of MPAs in Australia promoted feelings of personal satisfaction, learning and a sense of wanting to conserve the marine environment. Furthermore, participants can then disseminate the knowledge that they gain through such programs to others in their social networks (Koss & Kingsley, 2010; Couvet et al., 2008). Such programs can also improve relationships and increase trust between citizens and management organizations, provided that they are conducted with reliability, consistency, transparency and an

understanding of others points of view (Fernandez-Gimenez, Ballard, & Sturtevant, 2008). Indeed, there are a multitude of benefits for carefully and appropriately designed and orchestrated citizen-monitoring programs.

Citizen monitoring programs also present challenges that must be overcome to achieve the multitude of potential benefits and ensure that the data collected is useful for management. One major challenge is ensuring the accuracy, completeness, and objectivity of data collected by non-professionals (Stadel & Nelson, 1995; Stokes, Havas, & Brydges, 1990; Conrad & Hilchey, 2011). Also, inconsistent funding to such programs can lead to data fragmentation (Bliss et al., 2001). Finally, a lack of participant interest can hinder the development and continuation of citizen monitoring programs (Stadel & Nelson, 1995; Conrad & Daust, 2008). To maximize the attainment of benefits and overcome the challenges of citizen monitoring several key considerations should be addressed from the onset of a program. These include: the general approach taken; the level of citizen participation; monitoring protocols, including training, data management and analysis, as well as associated costs and oversight requirements; participants' motivation and commitment; and in the case of ongoing monitoring programs, sustainability. Each of these is discussed separately below; notwithstanding that such considerations are not mutually exclusive.

3.1.1 Approaches to Citizen Monitoring

There are many different approaches to developing and conducting citizen monitoring. The optimal approach for any situation will vary depending on the objectives of a particular project. Some citizen monitoring programs primarily seek to produce valid

monitoring data, while others are designed to achieve the broader governance objectives of promoting public environmental education and stewardship. Ideally, a well-designed and executed program will meet both these objectives (Silvertown, 2009). The scope of citizen monitoring programs also varies, both in the area and timeframe over which monitoring occurs, and in the number of participants and their commitments to programs. Some programs may use different citizens for each round of monitoring, such as students in a particular grade, while others require the ongoing commitment of a dedicated group of citizens. Alternatively, more and more citizen monitoring programs are employing "crowd sourcing", in which an undefined group of people collect and/or analyze environmental data using modern online applications (Dickinson, Zuckerberg & Bonter, 2010).

The level of citizen participation in monitoring projects varies. To provide a system for classifying the level of citizen participation in monitoring, Stadel and Nelson (1995) developed an adaptation of Arnstein's ladder, in which each rung represents the level of community control in decision making. This Ladder of Participation for Environmental Monitoring ranges from the lowest level of participation, which is simply providing citizens with information on monitoring, to community-based citizen monitoring projects that are developed and led by citizens (Figure 3-1). One level up from information is data collection, which tends to be the most common approach to citizen participation in monitoring (Stadel & Nelson, 1995). The optimal level of participation for any citizen monitoring depends on the project. For example, in the case of the *Oceans Act* MPAs, the level of participation in citizen monitoring is likely to be limited to the level of citizen involvement in the ongoing management of the MPA,

which is primarily restricted to an advisory role in Canada (Kearney et al., 2007). However, it should be noted that many of the broader governance benefits of citizen monitoring previously discussed are likely to be enhanced as the level of citizen participation in monitoring programs increases (Devictor, Whittaker & Baltrame, 2010). Therefore, whenever feasible, efforts should be made to maximize the level of citizen participation in monitoring programs.

Level of Community Based Monitoring	Characteristics
Community-based	Citizens govern program
Partnerships	Community is part of network
Planning	Involvement in defining purpose
Data Management	Data is managed by the community
Data Collection	Citizens collect data for government
Information	Citizens are informed about monitoring

Figure 3-1: Ladder of Participation for Environmental Monitoring (Stadel & Nelson, 1995)

3.1.2 Protocols

Scientific monitoring data are gathered using protocols that specify when, where and how data should be collected. The use of standardized protocols allows for data collected by multiple participants or locations, or that are taken over a time series, to be compared (Bonney et al., 2009). Therefore, if a citizen-monitoring project seeks to produce meaningful results to assess change or impacts to ecosystems, the protocols must be standardized. Also, to be viewed as credible by scientists and managers, the protocols used for these projects should be rigorous, as well as scientifically tested and accepted. On the other hand, protocols should be relatively easy to explain and understand and must be within a skill level that is realistically attainable by non-specialist participants. In addition, protocols must align with participants' motivations and the amount of time and effort they are willing and able to commit (Devictor et al., 2010; Couvet et al., 2008;

Whitelaw, Vaughan, Craig, & Atkinson, 2003). Generally, the number of participants that a citizen-monitoring program attracts is negatively correlated with the level of complexity and time requirements (Roy, Pocock, Preston, Roy, Savage, Tweddle, & Robinson, 2012). Due to these constraints, not all protocols that provide the required monitoring data for scientists and managers translate into citizen monitoring projects that are achievable in practice, because the protocols are either too complex for data to be reliably collected by a particular group of participants, or because they are unappealing to, or too demanding of participants (Danielsen et al., 2005; Roy et al., 2012). In cases where citizen projects are not able to meet the rigorous monitoring needs of scientists and managers, it may still be helpful to develop reconnaissance citizen monitoring protocols. Here, participants collect data that can be used to provide broad descriptions and to detect general trends which, when warranted, can be followed up with professional investigation (Long Point World Biosphere Reserve Foundation, 2002).

Despite its increasing popularity, citizen science has yet to be fully embraced and effectively utilized by North American scientists and managers, with the exception of a few focal programs such as the National Audubon Society's Christmas Bird Counts, which has been generating data for over 100 years (Delaney, Sperling, Adams & Leung, 2008). One of the primary reasons for this unexploited potential seems to be concerns about the reliability and accuracy of data collected by inexperienced participants, and hence the validity of results (Engel & Voshell, 2002; Bradshaw, 2003). However, much of the available research on the subject suggests that non-professionals are able to produce high quality and reliable results, provided that projects are well designed, including appropriately designed protocols, adequate training and data quality checks

(Danielson et al., 2005; Gollan, Lobry de Bruyn, Reid & Wilkie, 2012). Therefore, the key to obtaining high quality data from citizen monitoring projects is determining which types of data can be reliably collected by non-professionals, and under what circumstances this can be accomplished. It is also critical that information on how data are collected and what steps are taken to ensure its reliability are made explicit, so that scientists and managers can objectively assess the validity of data collected by non-professionals, and to add credibility to the results, especially in cases where the data will be used to justify management interventions.

There have been many studies that have investigated the accuracy and reliability of ecological data collected by non-professionals. Although the results vary on a case-by-case basis, there are some overall trends that can help guide the development of citizen monitoring protocols. Multiple studies have demonstrated that some attributes are more difficult than others for non-professionals to measure accurately and consistently (Dickinson et al., 2010). For example, many studies demonstrate that some species are more difficult for non-professionals to identify than others (Dickinson et al., 2010; Gollan et al., 2012). In such cases, protocols may be amended to include only species that are conspicuous and easy to identify, or by grouping some or all species into higher taxonomic categories that differ in apparent physical characteristics (Goffredo et al., 2010; Darwall & Dulvy, 1996; Koss et al., 2009). Another trend with citizen collected data regarding the size and abundance of organisms is that it often has higher variance than professionally derived data, with attributes being consistently under or over estimated (Danielson et al., 2005). Finally, some habitats may be more amendable to reliable data collection by non-professionals than others. Within the coastal

environmental, Koss et al. (2009) found that data collected in the rocky intertidal zone was more reliable than that collected in the subtidal zone using SCUBA gear.

Most researchers of citizen monitoring agree that the quality of data collected using relatively complex protocols can be improved by providing clear and comprehensive instructions, robust training, and using more experienced participants (Danielson et al., 2005). Inadequate guidelines result in ambiguities that can lead to inconsistencies between the data collected by different participants (Foster-Smith & Evans, 2003). Also, without clear documentation, methods can drift, leading to inconsistencies in data collected over time (Danielson et al., 2005). To avoid these issues, protocols should be clearly and comprehensively documented. If guidelines and manuals from other citizen monitoring programs are relevant, these can be used and adapted to suit a given context (Danielsen et al., 2005). Effective training and participant experience are especially important for ensuring the quality of data collected using citizen-monitoring protocols that are relatively demanding or complex (Roy et al., 2012). Training methods should be incorporated directly into citizen science protocols (Whitelaw et al., 2003). These can range from reading of hard copy and online materials, to class room sessions, to hands on experience under the supervision of a professional or an experienced participant (Roy et al., 2012). Several studies have also shown an increase in data quality as participants become more experienced with carrying out a given monitoring protocol (Dickinson et al., 2010; Darwall & Dulvy, 1996; Goffredo et al., 2010). Such improvements can be attributed to increased familiarity with protocols, improved identification skills, or the development of "search images" in which participants' observation skills for particular attributes sharpen over time (Dickinson et

al., 2010). This indicates that participant retention can contribute to the data quality for long-term citizen monitoring programs.

Due to the variation in the accuracy and reliability of data collected in citizen-monitoring projects, assumptions cannot be made about the quality (Danielsen et al., 2005). This demonstrates the need for Quality Assurance and Quality Control (QA/QC) procedures to be incorporated into design of citizen monitoring projects that seek to produce information that is accurate, and hence meaningful for management (Cohn, 2008; Danielsen et al., 2005). This process should begin with the design of the protocols themselves, by running trials of training and field methods prior to implementing a monitoring protocol, and verifying citizen collected data against that collected by professionals. This process allows for common errors to be identified and the protocols to be modified accordingly. It also provides an opportunity for participants to provide feedback on the training process, materials, and field protocols that can be incorporated into the final project, allowing for both improved data quality, and an increased level of citizen participation. Although such trials can be costly and time consuming, they are critical if the results are to be used directly for management (Danielson et al., 2005). If it is not possibly to perform a trial at the onset of a project at a given locality due to logistical constraints, then project designers should be careful to only use broadly accepted citizen monitoring protocols that have been tested elsewhere (Danielson et al., 2005).

QA/QC processes may be incorporated at several points throughout the process of implementing citizen monitoring programs. One method of QA/QC is to test participants on their knowledge, identification and/or field skills; participants may be required to

achieve a certain score prior to collecting monitoring data, or scores may be applied to weight data during analysis (Freiwald, 2013; Silvertown, 2009). Professionals can also verify uncertain data, either in the field at the time of collection, or at a latter time, in the case of species identifications, through the use of digital photographs (Silvertown, 2009, Roy et al., 2012). To maintain cost and oversight efficiencies, professional verifications may be limited to certain types of data or species identifications that are prone to error, or to cases of self-identified uncertainty by participants. Several citizen science studies have found a positive relationship between participants' self-identified confidence level and accuracy of the data collected, suggesting that the former might serve as an effective way to flag potentially inaccurate data (Crall, Newman, Stohlgren, Holfelder, Graham, Waller, 2011; Koss et al., 2009). Alternatively, if professional supervision or photo verification are not possible or logistically feasible, several participants may be asked to come to a consensus on error prone or uncertain data (Cox, Philippoff, Baumgartner, & Smith, 2012). Finally, validation methods can be applied following data entry to remove potentially inaccurate results or incorrectly entered data. Such validation processes can be applied manually, or by using automated filters to remove data that do not meet certain criteria and therefore are unlikely to be accurate (i.e. outside of a specified range or inconsistent with other data) (Bonter & Cooper, 2012; Crall, Newman, Jarnevich, Stohlgren, Waller, Graham, 2010).

In developing a citizen-monitoring program, consideration should also be given to how data are to be managed and analyzed, and the role that citizen participants may play in these processes. Furthermore, it should be decided how the data will be integrated with other monitoring data for an area to allow for a comprehensive ecosystem

assessment (EMAN & CNF, 2003). Deciding this at the onset of a citizen-monitoring project can help guide its development. Most citizen science groups collect data on paper, which is then transferred to computers for processing and analysis (Crall et al., 2010). While this method allows for simplicity, it also creates more opportunity for data fields to be skipped and for data entry errors. User-friendly electronic tools to record data in the field could reduce such data entry errors, but may increase equipment costs and training requirements (Crall et al., 2010). Data may be stored in more traditional in-house databases, or on online ones that allow the data to be shared by managers, participants and other stakeholders (Roy et al., 2012). Finally, consideration should be given to how the data will be analyzed. Clearly, the approach to data collection, management and analysis will vary depending on the type of data being collected and the question that the monitoring is addressing (i.e. are human pressures impacting a marine ecosystem).

3.1.3 Costs

Incorporating citizens into the management of protected and other important natural areas has the potential to offset management costs substantially. For example, a study of protected area volunteer efforts, including monitoring, in the United Kingdom found that these programs supplemented labor costs by a median of thirty-six percent per site (Armsworth et al., 2013). In Canada, an analysis of community-based coastal ecosystem management initiative called ACAP found that it would have cost 12 times what Environment Canada invested in the program for them to produce the equivalent of the outputs that were produced over the period of 1997-2002 (Sharpe & Conrad, 2006).

Furthermore, citizen monitoring provides contributions to other aspects of management, such as education, outreach, and compliance promotion, for which it is difficult to prescribe a monetary value. For example, the simple presence of people showing an interest in an area can deter potential violators (Danielson et al., 2005).

Although citizen monitoring programs are generally less expensive than professionally conducted programs, they incur costs as well. The costs of coordinating citizen monitoring vary depending on the type and intensity of data collection, the accessibility of the area, the degree of management staff involvement, and degree of volunteer participation (Danielson et al., 2005). The costs also vary in time, with costs initially being relatively high during the development of a program, and then decreasing once it becomes established. Following establishment, new sites can typically be added at relatively little cost (Danielsen et al., 2005). The costs of citizen monitoring programs can be broken down into those directly associated with administering the program, such as equipment, training and outreach materials, and transportation costs; and those associated with human resource requirements, which generally also translate into financial costs. A study in the UK found volunteer efforts and paid management costs to be positively correlated due to the demands that these programs made of paid staff time (Armsworth et al., 2013). Depending on the design of the program, paid management staff time may be required for development, facilitation, administration, training, fieldwork and supervision. Staff time is also required for data management and for following through with the results of citizen efforts (Foster-Smith & Evans, 2003; Lynn, 2000). It is important to secure adequate funding and financial commitment at the onset of developing ongoing citizen-monitoring programs. Inconsistent funding can lead to data

fragmentation, discontentment among participants, and ultimately the demise of these programs (Bliss et al., 2001).

3.1.4 Participants

A fundamental consideration that is often overlooked in the initial phases of developing a citizen-monitoring project is the participants. It is critical to have an understanding of the motivations and abilities of the pool of participants that a project is targeting to recruit participants, sustain commitment and design effective and realistic monitoring protocols. This requires audience research (Cuthill, 2010). The first step is identifying who this audience is. For environmental projects the volunteer pool can generally be divided into three broad groups: school children, university students, and those that are, or are interested in being, affiliated with naturalist groups (Scott & Herman, 1995). The motivations of participants vary. Several common motivations include: feeling a connectedness with nature, putting a conservation ethic into practice, looking after their own "backyard", socializing and meeting new people, and gaining practical skills and knowledge (Cuthill, 2010; Tweddle, Robinson, Pocock, & Roy, 2012). Once identified for a target audience, these motivations should be incorporated into participant recruitment strategies and monitoring protocols. Audience research should also investigate what protocols participants are willing to take part in and how much time they are willing and able to dedicate to a citizen-monitoring program. Finally, broad skills such as physical ability and computer literacy should be assessed to ensure that the protocols developed for a project are realistic for the participant pool being targeted.

A communications strategy can serve as a valuable tool for recruiting participants and promoting credibility for new citizen monitoring projects (Devictor et al., 2010). This strategy should aim to promote both the scientific expectations of a citizen monitoring project, and the benefits and opportunities it provides to participants (Koss & Kingsley, 2010). Promotional media can include a press release, networking, a website, scientific publications and other educational outputs (Devictor et al., 2010).

For ongoing monitoring projects, sustaining participant commitment can be a challenge that requires quite a lot of work, but is important for reducing recruitment and training costs as well as increasing the accuracy of collected data (Foster-Smith & Evans, 2003). Generally, it is best to take a proactive approach and consider sustaining participant commitment in the development of citizen monitoring programs. In meeting this end, there are several factors to consider. Several studies have shown that there is a relationship between the distances that participants' live from monitoring sites and their sustained commitment to participatory programs (Armsworth et al., 2013; Koss et al., 2009). Therefore, the closer the participants live from the site of a monitoring project, the more likely they will be to stick with a project. Providing an opportunity for participants to do data entry and some basic analysis also increases the level of participation and provides a rewarding sense of finishing a task (Cuthill, 2010). Also it is crucial that the results, maps and graphs of monitoring data are made available to participants as soon as possible, so that they can visualize the fruits of their labor. Ideally, these should also be made available to the broader public to promote the project (Christie & White, 2007; Devictor et al., 2010; Roy et al., 2012). It is also critical that the results of citizen monitoring are used for management, and that participants are made explicitly aware, and

regularly reminded of this (Stadel, & Nelson, 1995). A common frustration among participants found in studies of citizen monitoring projects is a feeling that results are not being meaningfully integrated into resource management decisions (Sharpe & Conrad, 2006; Groove-White et al., 2007, in Roy et al., 2012). A further element in this is setting accurate expectations amongst participants on how the data they collect will be incorporated into management. Regular communication with participants, via meetings, newsletters, and other media is important for conveying results, their impact on management, and for maintaining general interest and involvement (Fernandez-Gimenez, 2008; Roy et al., 2012).

Preventing burnout is also an important consideration in carrying out citizen monitoring projects that involve volunteers. Volunteer burnout is a phenomenon that occurs when volunteers become exhausted, leading to negative feelings regarding their contributions, personal accomplishments and/or the management organization (Byron & Curtis, 2002). To avoid this, the design of citizen monitoring programs should not be over-reliant on specific individuals. It is also important that expectations are made clear to volunteers regarding their efforts and commitments, and that these expectations are clearly communicated to participants from the beginning. Working towards and celebrating the achievement of attainable goals can also help prevent burnout as well as maintain volunteer interest (Byron & Curtis, 2002).

A further consideration in providing incentives and maintaining volunteer commitment over time is establishing a volunteer recognition program and allowing for progression within projects. Volunteer recognition can be in the form of achievement badges, awards or certifications (Crall et al., 2011). Providing an opportunity for

participants to advance through participation in increasingly complex protocols, or to become a project leader or mentor overtime can also encourage sustained commitment (Roy et al., 2012).

3.1.5 Sustainability

The sustainability of a citizen-monitoring program is a key consideration for ongoing projects. Two key factors related to this are sustaining participant commitment and funding, which are addressed in previous sections. There are several additional factors to consider in the development of citizen monitoring that may enhance sustainability. One is to develop programs at a slow pace, paying sufficient attention to capacity building (Danielson et al., 2005). Sustainability may also be enhanced when programs are institutionalized within existing management structures (Danielsen et al., 2005). Studies of citizen monitoring have also found that projects with strong local champions are much more likely to stand the test of time (Pollock & Whitelaw, 2005). In meeting this end, it is advisable to collaborate and develop partnerships with organizations already involved in environmental monitoring through partnership development (Long Point World Biosphere Reserve Foundation, 2002). Finally, to enjoy longevity, citizen-monitoring projects should be as simple and locally appropriate as possible, while still achieving the desired goals and objectives (Danielsen et al., 2005).

3.2 Methods

To assess the feasibility of, and provide guidance for the development of future citizen monitoring efforts at Musquash Estuary MPA, several research approaches were undertaken, including interviewing managers of MPA citizen monitoring programs in North America, an assessment of potential and current citizen monitoring protocols and their associated costs, and a survey of the local environmental volunteer pool.

3.2.1 Interviews with managers of MPA citizen monitoring programs

Managers of citizen monitoring programs in MPAs in North America were interviewed in order to determine how the data collected is integrated into management and how the challenges and considerations identified in the literature review were addressed in the development and implementation of their respective programs. Where available, this information is supplemented with literature on these programs. MPA citizen monitoring programs were identified through literature and Internet searches, and in the case of *Oceans Act* MPAs administered by DFO, by asking managers directly if citizen monitoring is conducted in their MPA. The interview questions were informed by the results of the literature review (Appendix III). These questions were asked of managers during a semi-structured interview. Research ethics approval was not sought for these interviews since managers were interviewed in their professional capacities and only factual information was requested. The information obtained from these interviews was then categorized by theme and summarized to provide insight into the development and enhancement of citizen monitoring in Musquash Estuary MPA.

3.2.2 Assessment of Citizen Monitoring Protocols

The feasibility of developing and implementing particular citizen monitoring protocols, as well as their potential to contribute to monitoring needs for Musquash Estuary MPA were assessed. These protocols were identified in the Musquash proposed monitoring framework (Cooper et al., 2011) and/or discussed at the Musquash Estuary MPA Monitoring Assessment Review meeting held in St. Andrews, New Brunswick in June 2013. Information on each protocol, and where possible on associated costs and oversight requirements was obtained from the available literature, as well as from professionals who coordinate or are involved with these protocols elsewhere. The citizen monitoring paddle currently being undertaken in Musquash Estuary MPA was also assessed, and the coordinator contacted for information. The assessment of protocols was based on their potential to be developed, continued, or enhanced in an effective and economically feasible manner, for their potential or current contributions to monitoring needs of Musquash Estuary MPA, and for their potential to build on current and past monitoring efforts.

3.2.3 Survey of Potential Volunteer Pool

To develop an understanding of the interests, motivations and abilities of the pool of potential volunteers to participant in citizen monitoring in Musquash Estuary MPA, a survey was conducted with local volunteers and environmental enthusiasts (Appendix IV). The design of the survey was informed by the results of the literature review, and incorporated questions that assessed participants' willingness and ability to partake in tasks associated with the protocols that were assessed in this study. The survey was

originally designed to also assess participants' willingness to participate in monitoring of human use and recreation in the Musquash Estuary MPA; however, these questions were omitted from analysis after it was ascertained that there is not currently enough recreational use in the MPA to warrant such monitoring by citizens (P. Doherty, personal communication, June 24 2013). Approval for the research design of this survey was sought and granted from the Research and Ethics Board at Dalhousie.

Study Population

The study population for this survey was volunteers, or people that are otherwise associated with naturalists groups or environmental non-governmental organizations (ENGOs) in the region of Musquash, including those based out of Saint John, New Brunswick. This segment of the volunteer pool was selected due to logistical constraints, and based on the assumption that such groups would allow for a greater involvement by volunteers as well as more potential for continuity between years (as opposed to school children), thereby allowing for more accurate and reliable collection of monitoring data at a resolution that would be appropriate for MPA management (Scott & Herman, 1995). Furthermore, it was assumed that those associated with naturalist and environmental groups are more likely to be knowledgeable and engaged in conservation and therefore would be more representative of the potential volunteer pool than the general public. Ideally, surveys would also be conducted with students of natural science programs in nearby universities, such as the University of New Brunswick, Saint John campus (UNBSJ); however, time and resource constraints did not allow for this in the present study. ENGOs and naturalist groups approached for this survey include: Friends of

Musquash, CCNB, NCC New Brunswick office, Ducks Unlimited New Brunswick office, Saint John Naturalists Club, Atlantic Coastal Action Program (ACAP) Saint John, and Eastern Charlotte Waterways. All of these groups except the latter two are involved in the ongoing conservation efforts for Musquash Estuary MPA and the surrounding conservation lands. Due to the need to recruit survey participants through the previously mentioned groups, and in many cases a lack of a formal volunteer network, there were no estimates available as to the size of the study population.

Recruitment

Survey participants were recruited using ENGOs and naturalists groups as a liaison. This can be considered purposive non-probability sampling, since people currently affiliated with a subset of environmental groups in the area are assumed to be most representative of the potential volunteer pool for Musquash Estuary MPA (Denscombe, 2010). Groups were contacted and asked to distribute an email to their volunteer network requesting their participation in a survey on citizen monitoring in Musquash Estuary MPA. Where possible, it was also requested that these organizations make announcements about the survey at volunteer events, such as a beach cleanup by NCC. Where formal volunteer networks did not exist, announcements were made using public media (i.e. facebook page). Those that were interested in taking the survey were asked to contact the researcher and complete the survey via email or over the telephone.

Data Collection and Analysis

Participants completed the survey through email or over the telephone, depending on their preference. Surveys consisted of questions that were quantitative, categorical, or binary, or asked participants to select from a list of answers. In some cases participants were asked to elaborate on answers (Appendix IV*)*. Surveys were estimated to take twenty to thirty minutes to complete, including time for participants to review and complete the consent form.

For answers that were categorical or selected from a list, data were analyzed quantitatively using descriptive statistics including percentages, arithmetic means, standard deviations and frequency distributions. Qualitative answers, which were provided in cases where participants were asked to elaborate on their selection, were categorized by theme and then summarized or presented as quotations.

3.3 Results

3.3.1 Interviews with Managers of MPA Citizen Monitoring Programs

In total, four cases of citizen MPA monitoring programs were identified for which managers could be contacted for an interview. Of Canada's eight *Oceans Act* MPAs, the managers of two programs were interviewed: the Community Aquatic Monitoring Program (CAMP) in Basin Head MPA, PEI, and a fishermen lobster-monitoring program in Eastport MPAs, Newfoundland (DFO, 2013c). Tarium Niryutait Marine Protected Area in the Canadian Arctic is also incorporating local fishermen into a monitoring program, but managers were unable to be contacted for an interview (DFO, 2012b). In addition, managers from two citizen monitoring programs for a system of Marine

Protected Areas spanning the coast of California were interviewed: Reef Check California, and Heal the Bay's MPA Watch program; the former uses recreational SCUBA divers to monitor kelp forests and rocky reefs within MPAs, while the latter uses volunteers to monitor human uses of coastal MPAs in Southern California (Reef Check, 2007; Heal the Bay, 2013). Key information about these four programs is provided in Table 3-1.

In all four cases of citizen MPA monitoring outlined in Table 3-1, managers indicated that collecting data for management was the primary goal of their program. Furthermore, all of these programs were designed to be long-term MPA monitoring programs. Of the four programs, all except Heal the Bay form part of the official MPA monitoring efforts, and were, or currently are being developed simultaneously with monitoring strategies for these areas. Therefore, the data collected by citizen scientists in these programs feed directly into management of the MPAs. In the case of Heal the Bay, coordinators maintain close connections to the California Department of Fish and Wildlife (CDFW), the institution directly responsible for the management of the MPAs, to ensure the data gathered is useful for management (S. Sikich, personal communication, June 19, 2013).

Table 3-1: Information on Citizen MPA Monitoring Programs from which Managers Were Interviewed

Program	Primary Management Agency (Representative interviewed)	Background Information	Protocols	Number of participants/ year
CAMP, Basin Head, PEI	DFO (Marie-Helene Theriault /coordinator of CAMP)	CAMP program monitors 35 estuarine sites throughout the Gulf of St. Lawrence, including Basin Head, a lagoon estuary on the coast of PEI. The main goal is to provide a method of characterizing estuarine health that community groups find useful and easy to apply (Weldon et al., 2005).	Standardized beach seining is used to collect and monitor the presence and abundance of estuarine species at 6 sites within each estuary, once a month between May-Sept. Physical data is also collected for vegetation cover, temperature, salinity, dissolved oxygen, sediment, and nutrient analysis.	3-4 per estuary site. Total of 140
Eastport MPAs, NFL	DFO (Laura Beresford /coordinator of Eastport MPA monitoring)	A collaborative lobster-monitoring program between DFO and fish harvesters in the community of Eastport, NFL. The primary goal of the MPA is to conserve lobster stocks.	Voluntary logbook and tag return program. Commercial at sea sampling (in season, outside of MPAs), fall sampling (out of season, within and outside MPAs).	Commercial sampling: 3 crews of 2. Fall sampling: 2 crews of 2.
Reef Check California	Reef Check California (Part of Reef Check, an international NGO) (Jan Freiwald / Director of Reef Check California)	Volunteer monitoring program that utilizes volunteer recreational SCUBA divers to monitor the health of kelp forests and rocky reefs in California's system of MPAs, which are managed by the California Department of Fish and Wildlife.	Divers complete surveys of indicator organisms (fish, invertebrate and seaweed) and physical characteristics along transects.	250 active volunteers/ year
MPA Watch, Heal the Bay, Southern California	Heal the Bay (NGO) (Sarah Sikich / Science and Policy Director of Coastal Resources at Heal the Bay)	Heal the Bay is one of several organizations implementing an MPA Watch protocol in MPAs along California's coast. The main goal is to produce data on ecosystem pressures resulting from all human use and on compliance to regulations to inform MPA management.	Coastal areas adjacent to MPAs are divided into transects. Volunteers walk a transect recording human use using standardized methods and data sheets.	55 active volunteers in 2013

Protocols

Monitoring protocols for citizen MPA monitoring programs examined here were developed using a range of citizen involvement, all of which included the involvement of scientists. The CAMP protocol was developed and field-tested over the course of a sampling season by DFO scientists at four pilot sites (M-H Theriault, personal communication, June 19, 2013). Scientist's developed the Reef Check California protocol by adapting an existing CDFW monitoring protocol. This citizen science friendly protocol was trialed using 20 recreational divers with a range of abilities as participants. Following development and testing, the Reef Check protocol was reviewed by a panel of scientists, management agencies and diving experts to ensure it was scientifically sound and appropriate for volunteers (Reef Check, 2007). Heal the Bay, consulted with Ocean Science Trust on MPA Watch protocols; Ocean Science Trust is a government-funded organization whose mission is to advance the role of science in decision-making and coordinate the MPA monitoring enterprise in California (OST, 2011). In the case of Eastport, lobster-monitoring protocols were developed over the course of several decades through collaborative efforts between DFO, scientists at nearby universities, and local harvesters (L. Beresford, personal communication, June 18, 2013).

Both the CAMP and the Reef Check California monitoring protocols include the identification of a wide range of species by participants; however, each takes a different approach. In the case of CAMP, participants are asked to identify fish and invertebrate species captured in beach seines, as well as dominant plant species in quadrats. In addition, participants are asked to distinguish between juvenile (young of year) and adult fish (Weldon et al., 2005). Several years after the implementation of the CAMP, a

QA/QC program was carried out at several sites, which compared data collected by "citizens" to that collected by scientists. Overall, agreement between the numbers of taxonomic groups identified was very high, disagreements in abundance counts were generally less than ten percent, but some less experienced citizen participants had some difficulty identifying juvenile fish as compared to scientists (Theriault, Courtenay, & Weldon, 2008). For the Reef Check California protocol, participants are asked to identify a list of indicator species that serve as a proxy for overall biodiversity. The list was informed by the field testing process and based on the following criteria: ease of identification, commonly observed by divers, species of special interest or concern, commonly targeted by fishing activities, ecologically important species (Reek Check, 2007). One key different between these protocols is that participants of Reef Check must identify species *in situ*, where as CAMP participants have specimens temporarily at their disposal and hence have the opportunity to refer to the CAMP field guide.

The degree of training and supervision varied between the citizens MPA monitoring programs examined here. Reef Check California and Heal the Bay's MPA Watch require participants to take a training program at the onset of participation, with Reef Check requiring participants to re-train every year and achieve a minimum passing grade of eighty-five percent on a written and field test (Reef Check, 2007). Reef Check also sends a staff member or intern along with divers for every survey, or in some cases an experienced volunteer (J. Freiwald, personal communication, June 17, 2013). Initially, the CAMP program offered training for participants from all sites once a year; this has recently been reduced to once every two-three years (M-H Theriault, personal communication, June 19, 2013). They also try to send a DFO representative to each site

for the first sampling of each season. In addition, CAMP summer interns are hired through a partnership with the Southern Gulf of St. Lawrence Coalition on Sustainability. Summer interns travel to CAMP sites each month and assist groups with carrying out the protocol, as well as supply groups with transportation and equipment (M-H Theriault, personal communication, June 19, 2013). Training for the Reef Check, Heal the Bay, and CAMP programs all include classroom components as well as a run through of the protocol in the field.

In the case of Eastport MPAs, training primarily consists of booklets provided to participants, since the fishermen are quite adept at catching, measuring and sexing lobsters. The exception to this is the fall sampling, which is completely separate from commercial catches. For the first year of fall sampling DFO staff went out with participants and completed in the field training. Training will likely be conducted again if new crews are used for the fall sampling (L. Beresford, personal communication, June 18, 2013). In addition, a part-time community coordinator was hired between 2005 and 2011 to help with tagging, and to accompany crews on sampling trips whenever possible. Currently, it is felt that a community coordinator is not required due to the fishing community's familiarity with the current monitoring program. However, this position may be required again when the majority of these fishermen retire (L. Beresford, personal communication, June 18).

In all citizen monitoring programs examined, participants record data using a standardized sheet and pencil. In all cases the analysis of data collected is left up to professionals. For the CAMP, Eastport and Heal the Bay programs, data entry is completed by student interns or staff. In the case of Reef Check, a data captain is

identified for each survey that ensures sheets are filled out correctly, and reviews sheets for any potential errors or red flags. If these are identified, the group of divers involved must come to a consensus, or the survey is rejected and must be redone (Reef Check, 2007). In all four citizen-monitoring programs examined, professionals inspect all data following entry. Likely errors are either removed, or are further investigated with participants.

Costs, Oversight and Funding

Managers of all citizen MPA monitoring programs examined stated that equivalent professional monitoring efforts would be significantly more expensive than current citizen monitoring. Both the CAMP and Eastport MPAs programs are financially supported by DFO and required approximately one full time staff member (or several part time staff members) over the first couple of years for setting up sites, developing materials, training, etc. In both cases, staff requirements and costs diminished significantly over time. In the case of the CAMP program, a collaborative agreement was reached between DFO and the Southern Gulf of St. Lawrence Coalition on Sustainability, whereby DFO would pay the coalition to hire students, and provide transportation and equipment (M-H Theriault, personal communication, June 19, 2013). In the Eastport MPAs program, crews that take part in the commercial sampling and fall sampling are paid to help offset their gas costs and provide incentive. The part-time position of community coordinator from 2005-2011 was an additional cost (Laura Beresford, personal communication, June 18, 2013). As a large program with many volunteers, Reef Check California requires three full time and one part time staff as well as several student

interns. As part of the official MPA monitoring, funding for the program is provided by California's MPA Monitoring Enterprise (J. Freiwald, personal communication, June 17, 2013). Heal the Bay's MPA Watch program currently requires ¾ of a full time position, and is funded internally (S. Sikich, personal communication, June 19, 2013). Some of the major costs other than staff requirements identified by some or all of the program managers interviewed include: transportation to survey sites, equipment, training, training and outreach materials, and data sheets.

Participants

Participant recruitment for the citizen monitoring programs reviewed here relied either on partnerships, or existing networks. The CAMP program is conducted with watershed groups or other partners at each of the thirty-five sites. These groups typically rely on student interns and existing volunteers to carry out surveys, although some recruitment materials are provided by DFO and the Coalition on Sustainability. Participant retention is typically low because of the turnover of student interns, but the coordinators of watershed groups and other partners for each site tend to be consistent participants (M-H Theriault, personal communication, June 19, 2013). The Reef Check California program partners with dive shops and universities that have marine biology programs to recruit participants. Generally, about fifty to sixty percent of participants return the following year, but there tends to be less retention with students (J. Freiwald, personal communication, June 17, 2013). As a well established NGO, Heal the Bay relies on its existing volunteer network for the MPA Watch program, as well as reaching out to schools and universities that require community service hours from their students.

Participants tend to be students and those that live close to the MPAs (S. Sikich, personal communication, June 19, 2013). The Eastport MPA citizen-monitoring program recruits participants through existing relationships that were created or strengthened through the MPA designation process. Participation in the fall sampling program is distributed throughout the fishing community, with different crews each year; while the same crews participate in fall sampling each year, which is more training intensive (L. Beresford, personal communication, June 18, 2013).

All of the managers of the MPA citizen monitoring programs pointed out the benefits of participating in citizen monitoring as incentive, such as the experience, learning, contributing to conservation, and social interactions. However, it should be noted that in several cases, participants had financial incentive as well. The majority of CAMP participants are student interns, paid either through the coalition or the watershed groups associated with each site. However, many unpaid volunteers have participated in this program as well (M-H Theriault, personal communication, June 19, 2013). Eastport MPAs sampling participants are also paid by DFO. However, there is no direct financial incentive for the broader fishing community to complete voluntary logbooks and return tags. Here, the main incentives are likely general interest and the preservation of their livelihoods (Laura Beresford, personal communication, June 18, 2013). In encouraging unpaid participation in MPA monitoring, both the managers of the Reef Check and the Heal the Bay program stressed the importance of communicating to volunteers that the data they are collecting is making an important contribution to marine conservation.

Each of the citizen monitoring programs examined have strategies for communicating with and reporting results back to participants, although several of the

managers noted that this is something they feel should be improved upon. Strategies for maintaining communication with participants included: emails, newsletters and online forums. All programs, except for Eastport, noted that it was a challenge to get participants to complete the number of surveys they would like to see them commit to. One manager interviewed suggested that putting more effort into communicating with participants might help address this issue (S. Sikich, personal communication, June 19, 2013). Most of the programs distribute reports or summaries of results to participants on a recurring basis (usually once a year), in addition to hosting presentations or workshops. In the case of Reef Check, data are publically available on the Nearshore Ecosystem Database, were the public can explore data graphically or download it for further analysis (J. Freiwald, personal communication, June 17, 2013).

3.3.2 Assessment of Citizen Monitoring Protocols

Citizen monitoring protocols assessed in this study include: CAMP; NaGISA; bird surveys including Maritime Marsh Monitoring Program, the Atlantic Canadian Shorebird Survey, and the Maritime Breeding Bird Atlas; monitoring paddles; photo monitoring; and beach debris surveys. In the following sections the application of each of these protocols to the monitoring of Musquash Estuary MPA is explored.

CAMP

The main goal of the CAMP monitoring protocol is to characterize estuary health through the collection of data on the presence and abundance of nearshore fish and crustacean species, fish age structure, macrophytes, physical characteristics of the water column and

water quality for estuarine marine environments (Weldon et al., 2005). A 30 x 2 m beach seine with 6 mm mesh is used to collect invertebrate and fish species, which are identified to species or genus, separated by developmental growth stage, counted, and released. Macrophytes are sampled using a 50 x 50 cm quadrat, which is used to determine percent cover and dominant species. Physical measures are taken using a YSI meter that measures temperature, dissolved oxygen and salinity. It addition, benthic and water samples are collected from each station and sent away for analysis (Weldon et al., 2005). Recently, a DFO Science Advisory Meeting was held to assess the value of CAMP data collected from multiple sites in assessing estuary health. Preliminary analyses found that there was a relationship between the abundance of certain species and the degree of human activity at sites. However, there were mixed opinions on the capacity of the program to infer ecological health of estuaries, and some scientists felt that more analysis and data review was necessary (Morin & Theriault, 2011).

There are several criteria for identifying suitable CAMP sites, and sampling stations within these. Sites should be estuaries with a salinity range of 15-30 ppt. Before implementing the protocol at a given site, DFO CAMP coordinators generally scout the site to determine its suitability (M-H Theriault, personal communication, June 19, 2013). Typically, six sampling stations are identified within each site, ideally with three sites on each side of the estuary. However, the protocol can be conducted using less than six stations (M-H Theriault, personal communication, June 19, 2013). All stations within each site are sampled once a month between May and September. Stations within a site should be comparable to one another, with salinity, temperature, depth, bottom type and vegetation being as similar as possible (Weldon et al., 2005). For logistical reasons, road

access is also a requirement for sampling stations (M-H Theriault, personal communication, June 19, 2013). It is also recommended that sampling is done near eelgrass, because there tend to be more fish in these areas, but this is not a requirement (M-H Theriault, personal communication, June 19, 2013).

Conducting the CAMP protocol, or a modified version of it, in Musquash Estuary would address the proposed monitoring action of surveying juvenile fish species and nutrient levels in the MPA waters (Appendix I). A graduate student from UNBSJ collected data on nearshore fish communities in the estuary over a two-year period between 2009-2010 (Ispen, 2013), but such efforts are not ongoing. Data was collected from three stations throughout the estuary, each representing different habitats, using beach seines and fyke nets. Sampling was also conducted at neighboring sites. The presence and abundance of fish species at these sites were not found to be significantly different, suggesting that these sites can be used for comparison to Musquash Estuary. No baseline data on nearshore fish communities in Musquash were calculated. However, it was determined that it would be possible to calculate baseline values for summer months using the data that was collected (Ispen, 2013). Based on the discussions at the Musquash Estuary Monitoring Assessment Review, there are currently no surveys of nutrient concentrations being conducted in the estuary. The implementation of the CAMP protocol would allow for samples to be collected throughout the summer season, but the analysis would need to be performed by professionals. The sampling of macrophytes in Musquash Estuary may not be possible using the CAMP protocol due to high turbidity (Weldon et al., 2005).

Implementation of the CAMP monitoring protocol in Musquash Estuary may not allow for comparison with the baseline data on nearshore fish communities previously collected by a UNBSJ graduate student. This Data would likely be comparable to data collected using CAMP if the same three sampling stations were used. However, the previously collected data stations were selected to represent different habitats. Alternatively, the CAMP monitoring protocol calls for sampling stations within a site to have similar habitat characteristics. Ultimately, the potential for the comparison of data collected using the CAMP protocol to previously collected data should be scientifically reviewed. If the data collected using CAMP was found not to be comparable it may be possible to modify the CAMP protocol to accommodate existing baseline data. Otherwise, the CAMP protocol could be implemented unmodified and new baseline data could be collected.

Implementing the CAMP protocol at Musquash Estuary would have associated costs and oversight requirements. However, these costs could be substantially reduced if existing resources from the Southern Gulf of St. Lawrence Program were used. This program is based out of the nearby DFO office in Moncton, New Brunswick. CAMP equipment costs are approximately $3,000, including $1500 for a beach seine and $1500 for a YSI probe. The analysis of water samples from the Gulf CAMP program by DFO scientists costs between $1.25 and $4.00 a sample, depending on where it is sent. There are also costs associated with shipping water samples for analysis. Transportation of equipment and participants to monitoring sites also incurs substantial costs, and would be a particularly important consideration for Musquash, where access to sites can be challenging (M-H Theriault, personal communication, June 19, 2013). There would also

be costs associated with developing new, or modifying existing training and field materials to be appropriate for the Bay of Fundy, such as an identification guide. Staff oversight requirements would be relatively higher in the initial stages of implementing the CAMP protocol in Musquash Estuary. However, it is estimated that once the program is established, a single CAMP site would require approximately five percent of a full time position (M-H Theriault, personal communication, June 19, 2013).

NaGISA

The NaGISA protocol provides a standardized method for biodiversity surveys in rocky shore and seagrass coastal ecosystems using an annual survey. It was developed as part of an international collaborative effort to inventory and monitor coastal biodiversity (Rigby, Iken, & Shiravame, 2007). The NaGISA protocol is designed to sample both the intertidal and subtidal area up to a depth of twenty meters. However, carrying out the protocol subtidally within Musquash Estuary is not likely to be feasible due to the nature of the terrain and the poor water clarity (Cooper et al., 2011). When conducting this protocol in the exposed intertidal zone, 3 x 30 m transects are laid out running parallel to the shore, one at high shore, mid shore and low shore. At five randomly selected spots along each transect, three separate quadrats are positioned: one
1 x 1m for an estimate of ground cover, one 0.5m x 0.5 m in which all plants are identified and abundance estimated, and one 25 cm x 25 cm in which all plants and animals are removed, identified and weighted (Cooper et al., 2011). It is estimated that this process would take two days and between five to ten people to complete (Cooper et al., 2011). In the Musquash Estuary Monitoring Framework it is also recommended that a

mudflat and a saltmarsh transect be added to the protocol (Cooper et al., 2011). The protocol is designed for citizens to conduct sampling. However, processing and identification of most species requires substantial training and taxonomic skills and therefore must be carried out by professionals in a lab (T. Trott, personal communication, June 21, 2013). Students in summer camps have carried out incomplete NaGISA protocols (using only the 1m x 1m quadrat and identifying all invertebrates over 1 cm long), but the data collected is of limited value for scientific monitoring (T. Trott, personal communication, June 21, 2013).

Due to the nature of the protocol, NaGISA primarily collects data on exposed benthic invertebrates and plants. Currently there is extensive professionally conducted benthic monitoring in subtidal and intertidal portions of the estuary collected from a boat using a grab (Cooper et al., 2011). Data collected using this method, which surveys many infaunal species, would not be directly comparable with data collected using the NaGISA protocol. The NaGISA protocol was carried out for one season in Musquash Estuary; however, the samples have not been processed (G. Pohle, personal communication, June 24, 2013). Continuing NaGISA monitoring in Musquash Estuary would fill a monitoring gap of exposed epifauna in the upper intertidal area (G. Pohle, personal communication, June 24, 2013). However, baseline data would need to be established before NaGISA could be used for ongoing monitoring efforts (A. Cooper, personal communication, June 24, 2013).

The largest cost associated with conducing the full NaGISA monitoring protocol for Musquash Estuary MPA would be for processing samples (T. Trott, personal communication, June 21, 2013). This is estimated to cost $100 to $500 per sample

depending on the size and time it takes to process (M. Wong, personal communication, June 28, 2013). Therefore, processing and analysis of a complete season of sampling would likely cost from $2,500 - $12,500 each year. Once a baseline has been determined, it may be possible to identify indicator species or use a higher taxonomic resolution, which would reduce costs and may allow citizen participants to play a greater role in the processing of samples (M. Wong, personal communication, June 28, 2013). Additional costs would be associated with training and development, as well as transportation to the NaGISA monitoring site annually. Requirements of staff would likely include administration, field supervision, and interpretation of results.

Bird Surveys

Bird surveys within and around Musquash Estuary MPA are important components of the monitoring framework that are not addressed through DFO led monitoring efforts. Salt marsh oblique and breeding birds, in particular, may serve as good indicators of estuarine health (Karel Allard, personal communication, June 25, 2013). Several bird survey protocols that incorporate citizen science approaches have the potential to provide valuable information for the monitoring of Musquash MPA, including: The Marsh Monitoring Program, the Atlantic Canadian Shorebird Survey, and the Maritime Breeding Bird Atlas.

The Marsh Monitoring Program, run by Bird Studies Canada, is a wildlife-monitoring program for coastal and inland marshes in which surveyors, which include both interns and volunteers, record information about marsh birds and habitat (BSC, n.d.). This program is well established in other areas of Canada and is currently being

developed and implemented in the Maritimes. The program uses the well-established Standardized North American Marsh Bird Monitoring Protocol (Conway, 2011). In short, participants walk along pre-established routes through monitoring sites and stop at pre-determined stations along the way to conduct fifteen-minute surveys. Each survey begins and ends with five-minutes of silent listening, with five-minutes of broadcasting a recording of bird calls in between in an attempt to elicit the calls of normally secretive species. Participants record the presence of all bird species heard or encountered during the surveys, but the protocol specifically targets the presence of focal species whose presence are good indicators of wetland health (BSC, n.d.). Also, each year a vegetation survey is conducted at each site to estimate the percentage of cover types using very basic standardized methods (M. Campbell, personal communication, June 25, 2013).

The current season of the Maritime Marsh Monitoring Program is the first to include sites within Musquash, with several monitoring stations along each of three routes around the estuary (M. Campbell, personal communication, June 25, 2013). Currently, paid staff and interns conduct monitoring of these sites, but once a network is established citizen volunteers will be carrying out the protocol as well. Time commitments of volunteers for each route include conducting the survey, which takes approximately two hours, three times a season (a total of ten hours). In addition, a four-hour training session is required at the beginning of each field season (M. Campbell, personal communication, June 25, 2013).

Costs associated with the Maritime March Monitoring Program include overhead costs to Bird Studies Canada, equipment (speakers and MP3 players to loan to participants), costs of having GIS maps of results developed, and costs to reimburse

volunteer per kilometer to access more remote monitoring sites (M. Campbell, personal communication, June 25, 2013). Many of the costs are covered with in kind support from organizations that work closely with the program, such as the New Brunswick Department of Natural Resources, which provides support in the creation of GIS maps and for transportation to sites (M. Campbell, personal communication, June 25, 2013).

The goal of the Atlantic Canadian Shorebird Survey, which is administered by Environment Canada, is to identify important sites for shorebirds in Atlantic Canada and to follow long-term population trends. Participants are asked to count all shorebirds, by species, at specific locations. Surveys are to be conducted at the same tidal height and in the same manner each time (North American Bird Monitoring Project Database, 2004). To date, there have not been any shorebird monitoring sites immediately surrounding Musquash Estuary, but there is one in the nearby community of Lorneville. It should be possible to set up a site in Musquash by contacting Julie Paquet at Environment Canada, who coordinates the program and trains volunteers (K. Allard, personal communication, June 5, 2013).

The Maritime Breeding Bird Atlas is a scientifically derived five-year field project that uses volunteers to collect data to assess the status, distribution and abundance of breeding bird species (Maritime Breeding Bird Atlas, n.d.). Monitoring breeding birds provides an indication of productivity of a system, particularly in the absence of biomass data on lower trophic levels including invertebrate prey (Cooper et al., 2011). This project is typically completed every twenty years to document long-term changes in ecosystems. The most recent iteration of the project (ended in 2010) had volunteers use three sampling methods within predefined square regions to find evidence of as many

breeding birds as possible, estimate relative abundance, and detect breeding sites of rare and colonial species (Maritime Breeding Bird Atlas, n.d.).

One of the predefined areas for the Maritime Breeding Bird Atlas includes the Musquash Estuary as well as parts of the surrounding region (square 19GL10). The website provides access to the data that was gathered in this area during the past two iterations of the project (Maritime Breeding Bird Atlas, n.d). Members of the Saint John Naturalists Club were the principal investigators in collecting this data (Cooper et al., 2011). Although the intervals between data collection may be too long for MPA monitoring purposes, the protocols could be utilized in Musquash on a more frequent basis to provide baseline and ongoing monitoring data for the MPA and surrounding area.

Monitoring During Educational Paddle

The Proposed Monitoring Framework for Musquash Estuary presented the idea of incorporating a monitoring element into the Annual Musquash Paddle event held in July or August (Cooper et al., 2011). For the annual paddle event participants travel in non-motorized boats, mainly kayaks, from the upper portion to the mouth of the estuary. The proposed framework suggests that monitoring be conducted in conjunction with this event, in which one or two participants record small-scale changes in vegetation, erosion, wildlife and bird sightings, and act as a watchdog for potential issues (Cooper et al., 2011). This idea was implemented at the 2012 annual paddle. A DFO oceanographer developed the protocol, which includes monitoring of physical parameters. It consists of two to three participants paddling to ten predetermined waypoints, located by GPS, and using a probe to create a temperature and salinity at depth profile. Participant training

took place over a one to two hour period the week before the paddle at the local DFO office. At each station, participants recorded GPS coordinates, while temperature and salinity data was stored in the monitoring device (M. Abbott, personal communication, June 16, 2013).

Currently, the monitoring paddle represents the only effort to monitor temperature and salinity profiles for Musquash Estuary. Ideally, there would be several long term mooring stations placed throughout the estuary taking continuous readings of physical parameters. However, this is not currently possible due to equipment costs and security issues. Therefore, even though physical data collected during the monitoring paddle only provides a snapshot of physical characteristics of the estuary, it is very valuable to current MPA monitoring efforts. Even in the case that long term mooring stations can be deployed, the monitoring paddle can still provide data on how physical characteristics change along the estuary. Furthermore, the data could be used to verify model predictions based on mooring data (F. Page, personal communication, June 27, 2013). The DFO staff member who developed the protocol for the monitoring paddle and oversees the process indicated that it would be beneficial to have monitoring paddles conducted more often throughout the seasons, and at various tidal states to establish a baseline (currently, the monitoring paddle is biased towards high tide) (F. Page, personal communication, June 27, 2013).

The annual monitoring paddle is carried out through a partnership between the DFO and the CCNB. DFO supplies the equipment, and conducts training and analysis. CCNB oversees the monitoring paddle, and coordinates participants. In 2012, participants consisted of a student intern for CCNB and a volunteer recruited through personal

networks. Costs include the cost of equipment, which was supplied by DFO, several hours of staff time from both CCNB (training, paddle, transportation to site) and DFO (training, equipment preparation) (M. Abbott, personal communication, June 16, 2013).

Intertidal and Marsh Image Monitoring

The use of intertidal and marsh images to monitor changes in marsh structure was also put forth in the framework as a potential monitoring strategy for Musquash Estuary MPA (Cooper et al., 2011). The exploration of such monitoring was incorporated into the monitoring paddle in 2012. At each pre-determined waypoint along the paddle, participants took a photo of the riverbanks on either side. The plan is to assess the usefulness of this monitoring over the next couple of years (M. Abbott, personal communication, June 16, 2013). At the Musquash Estuary monitoring assessment meeting there was some discussion that capturing images of particular points of interest every year using GPS cameras might be more useful (i.e. places that are vulnerable to erosion). It was also suggested that it might be better to have time-lapse photographs from cameras mounted at specific locations. Costs and oversight requirements associated with this monitoring include the costs of cameras, and time to upload and analyze the photographs.

In the monitoring framework it is suggested that the broader public be incorporated into image monitoring by establishing specific spots in the Musquash MPA and AIA where people would be instructed by a posted sign to take a photograph of a particular location and submit it to a blog or website (Cooper et al., 2011). Costs associated with this approach would likely be greater than for the incorporation of photo

monitoring into the paddle because of the additional costs of signage, and ongoing costs of maintaining a website or blog. However, it would provide a way to involve the greater community in MPA monitoring. A concern with this approach would be consistency between photos (i.e. orientation), and therefore the quality of the data gathered. An additional consideration would be whether enough people make use of the MPA and the surrounding area to warrant investment in such an approach.

Beach Debris Survey

Currently, DFO contracts out a beach debris clean up and survey at two sites around the Musquash Estuary MPA to CCNB. Debris found at survey sites are itemized, recorded on a standardized data sheet, and then removed. Once a year, a report is prepared summarizing the results of the survey. This provides information to MPA managers on one type of human threat to the MPA, namely, the dumping and washing in of garbage and marine debris (M. Abbott, personal communication, June 16, 2013). The survey is conducted at two sites, Black Beach and Gooseberry Cove, once a month over the summer season, which is currently June-September inclusive. Generally, two participants conduct these surveys: a staff member from CCNB and a volunteer recruited from personal networks (M. Abbott, personal communication, June 16, 2013).

The Proposed Monitoring Framework for the Musquash Estuary MPA recommends that efforts be made to involve the wider community in conducting beach debris surveys, including local youth organizations and students. It is suggested that such efforts might help address dumping issues around the MPA (Cooper et al., 2011). On the other hand, the current coordinator of the survey from CCNB noted that, given the size of

the survey areas, it would be more time and cost efficient to coordinate the survey with few participants (M. Abbott, personal communication, June 16, 2013).

3.3.3 Survey of Potential Volunteer Pool

Following recruitment through several naturalist and environmental groups in New Brunswick, only four people responded and participated in the survey. Due to the low level of response, no quantitative analysis of results was conducted. Instead, some general qualitative observations are presented here.

Those that did respond to the survey were associated with several different organizations including: Friends of Musquash, Saint John Naturalists' Club, NCC and Nature New Brunswick, the latter of which was not directly contacted for recruitment. Of those that responded, all except one indicated that they would be willing to donate their time to citizen ecological monitoring of Musquash Estuary MPA. The remaining participant commented that they would not physically be able to do this due to health conditions. Among those that indicated their willingness to participate in citizen monitoring, all stated that they would be willing to donate at least one day a month to such programs.

3.4 Discussion

3.4.1 Interviews with Managers of MPA Citizen Monitoring Programs

The analysis of the interviews with managers of MPA citizen monitoring programs in North America provided several insights that should be considered in development and enhancement of citizen monitoring for Musquash Estuary MPA. First, such programs,

like those explored here, should only be developed if there are resources and capacity available to provide long-term support. Otherwise, investments in citizen monitoring programs are likely to yield little if any benefits for management, especially given that the implementation of new monitoring protocols would require that baseline data be collected for at least several years before data could be reliably used for management. This finding corresponds with the advice of Bliss et al. (2001) on the importance of securing adequate funding and commitment at the onset of developing citizen-monitoring programs to reduce the potential for data fragmentation and disenfranchised participants.

In regard to the development of new citizen monitoring protocols, interviews with managers of MPA programs highlighted the importance of scientific input in ensuring protocols are scientifically valid and useful for management. Such input can be included in the writing, testing and reviewing of protocols for monitoring, or ideally all of these. Scientific advice should also be sought when implementing an existing or slightly modified protocol into a new site, such as Heal the Bay consulting with the Ocean science Trust regarding the implementation of the MPA Watch program, which was already being conducted elsewhere in California. This science review process ensures that protocols are appropriate for a given location and management context.

Training for citizen monitoring programs should involve both classroom and field training. Classroom led sessions can help participants understand the scientific theory underlying methods, in addition to providing them with knowledge of how their contributions are integrated into MPA management. Field training provides hands on experience and allows a supervisor to identify and correct common mistakes that could otherwise lead to consistent errors (Roy et al., 2012). Ongoing supervision is also

important to ensure the quality of data collected by citizen scientists. All MPA programs examined here sought to include supervision of more rigorous protocols by staff or interns whenever possible, except when very experienced participants were present. This speaks to the importance of having staff available and in the vicinity of citizen monitoring sites, such as student interns for CAMP, and the community coordinator in Eastport.

All managers interviewed from citizen MPA monitoring programs stated without hesitation that equivalent professional monitoring efforts would be much more expensive than current citizen monitoring programs. This is indicative of the economic efficiencies that are created by citizen approaches to environmental monitoring (Sharpe & Conrad, 2006). However, citizen monitoring is certainly not free, and incurs significant time and resource investment by management organizations. The development and implementation of both DFO coordinated citizen monitoring programs examined here initially required approximately one full-time dedicated staff member. However, in both cases the managers noted that staff oversight requirements decreased significantly over time. Relatively high initial time and resource investments that decrease once programs become established appear to be the norm for citizen monitoring (Danielson et al., 2005). Investment in equipment, and the development and production of training and outreach materials and data sheets also result in relatively high initial costs for citizen monitoring. A further approach to offsetting staff requirements, and potentially costs is to contract out coordination responsibilities for citizen monitoring programs to partners, such as the agreement between CAMP and the Coalition on Sustainability.

Participant recruitment, incentives and retention are important considerations for citizen monitoring programs. In this regard, the best approach for DFO to take in implementing citizen monitoring in Musquash Estuary would likely be to follow suit with CAMP, and partner with existing environmental groups. This approach could provide the program with an established network of potential participants and developed recruitment strategies that could be applied to MPA citizen monitoring. For the CAMP, the majority of the participants were paid interns associated with local partner groups or the Coalition on Sustainability; those that were volunteers were associated with local environmental groups. In regard to participant retention, several managers who were interviewed stated that it is critical that the results of citizen monitoring are used for management and that participants are made explicitly aware and regularly reminded of this, reflecting the findings of Stadel & Nelson (1995). Managers also generally supported the notion found in citizen monitoring literature that regular communication with participants via meetings, newsletters, as well as conveying the results of monitoring, is important for maintaining general participant interest and involvement (Fernandez-Gimenez, 2008; Roy et al., 2012).

3.4.2 Assessment of Citizen Monitoring Protocols

Of the citizen science protocols assessed for monitoring in Musquash Estuary MPA, CAMP has the most potential to contribute to direct monitoring efforts, while being cost efficient. Citizen conducted bird surveys also have great potential to contribute to MPA monitoring and should be supported by DFO. Consideration should also be given to stepping up current citizen monitoring efforts within the MPA, namely the monitoring

paddle, while others should be considered for further development in the future in order to reach a wider audience.

Although it hasn't been definitively concluded, thus far results seem to indicate that assemblages of fish and crustacean species identified using the CAMP protocol may be useful for monitoring estuarine health (Morin & Theriault, 2011). The results of estuarine monitoring around the Southern Gulf of St. Lawrence cannot be generalized to sites in the Bay of Fundy, such as Musquash. Nonetheless, the CAMP method seems like a promising candidate for assessing estuarine health. The ecological characteristics of Musquash Estuary meet the requirements for a CAMP estuary site, including the presence of well-mixed waters and salinities ranging from 15-30 ppt in the outer portions of the estuary (Singh et al., 2000). To assess the usefulness of this approach for monitoring Musquash Estuary, several years of baseline data would need to be collected. Preferably, neighbouring estuary sites would also be sampled for comparison using the CAMP protocol. Ideally, results from previous sampling of nearshore fish assemblages using beach seines would contribute to baseline data for the estuary and neighbouring sites. However, this may not be possible due to differences in sampling station selection criteria within sites; scientific consultation would be required to determine this. Implementation of the CAMP protocol could also provide valuable data on nutrient concentrations in Musquash Estuary.

There are several benefits and challenges that would be associated with implementing the CAMP protocol in Musquash Estuary MPA. On the plus side, equipment and staff resources could likely be utilized from the Southern Gulf program, which is based in Moncton, NB. Staff located there could provide support in scouting the

site and sampling stations within it. There is also a possibility that CAMP student interns could help with and provide support for sampling. On the other hand, accessibility may limit the number of possible sampling stations within the estuary and it may not be possible to include six stations in the site. Also, some materials would likely need to be modified to facilitate the identification of species found in the Bay of Fundy. However, the biggest challenge in implementing the CAMP protocol in Musquash would likely be finding a local partner organization to carry out sampling once a month throughout the summer; this is discussed below.

Although implementing the NaGISA protocol in Musquash Estuary MPA would address the current gap for monitoring exposed epifauna (G. Pohle, personal communication, June 24, 2013), it may not be a wise use of limited resources given that extensive intertidal benthic surveys are already being conducted. Furthermore, ongoing costs associated with processing and analyses of samples are relatively high. On the other hand, this protocol would involve less of a time commitment from participants, with the protocol being carried out only once a year.

Citizen conducted bird surveys have the potential to provide valuable bird monitoring information for the Musquash Estuary MPA and surrounding area, and may also serve as indicators of ecosystem health (DeLuca, Studds, King, & Marra, 2008; Karel Allard, personal communication, June 25, 2013). The Maritime Marsh Monitoring Program may be particularly valuable for monitoring birds associated with the MPA since it includes several monitoring stations along three routes around the Musquash Estuary (M. Campbell, personal communication, June 25, 2013). Furthermore, the protocol utilized by this program specifically targets species whose presence are thought

to be good indicators of wetland health (BSC, n.d.). Although currently paid staff and interns carry out the Marsh Monitoring Program in the Maritime region, the goal is to eventually incorporate volunteer participants once a network is established (M. Campbell, personal communication, June 25, 2013). Due to the valuable data that this program can provide for the monitoring of the Musquash Estuary MPA, it would be prudent for DFO to form a partnership with or otherwise provide support to the program to promote the continued implementation of the protocol at this site. Also, MPA managers should consider having an Atlantic Canadian Shorebird Survey site created around the Musquash MPA, so that volunteer collected data on shorebirds can be incorporated into MPA monitoring.

The annual monitoring paddle currently provides basic but valuable information on temperature and salinity profiles throughout the estuary, in addition to exploring the use of digital images to monitoring changes in marsh structure. The DFO scientist who developed the protocol for the monitoring paddle expressed an interest in carrying out monitoring paddles more frequently, outside of the Annual Musquash Paddle event (F. Page, personal communication, June 27, 2013). This is something that should be investigated by MPA managers. One obstacle in increasing the frequency of the monitoring paddle may be interest on behalf of CCNB in carrying out the protocol more often and the costs associated with this. Therefore, increasing the frequency of monitoring paddles would likely involve covering the costs of the paddle, and potentially involving other groups. Also, until the usefulness of digital images collected during the monitoring paddle for monitoring changes in marsh structure is assessed, it would not be prudent to invest in expanding this protocol for other recreational users. However, if this

method proves effective, the crowd sourcing of photo monitoring in Musquash Estuary may provide an innovative way to involve a wider audience in citizen monitoring efforts in the future.

Although the expansion of the beach debris surveys and clean ups to the broader community including youth would provide an excellent outreach opportunity, logistically, it might be challenging. For example, getting youth groups to the remote clean up sites might prove difficult. Also, given the relatively small clean up areas, only a few people are needed to do the survey. On the other hand, the simple presence of people showing an interest in the area might deter potential dumpers (Danielson et al., 2005).

3.4.3 Survey of Potential Volunteer Pool

Recruiting participants using ENGOs and naturalist groups as liaisons resulted in a very low number of survey respondents (4). There are several possible reasons for this. First, recruitment was impersonal, and potential participants were asked to go out of their way to contact the researcher. The reason for this approach was that volunteers and people associated with ENGOs and naturalists groups are not identifiable populations in the absence of being provided with lists of volunteer networks. Second, due to time constraints, potential participants were only given one to two weeks to reply to recruitment attempts, depending on when the liaison group forwarded the email or posted the announcement on their Facebook wall. Finally, although every effort was made to inform perspective participants that taking part in the survey involved no commitments, and that all responses were welcome, it seems likely that those who were not interested in participating in citizen monitoring chose not to participate in the survey. Modest support

is provided for the latter possibility by the fact that of the four survey participants, three indicated that they would be willing to participate in citizen monitoring for Musquash Estuary MPA on a monthly basis. For future surveys assessing interest and motivations of local volunteers in participating in citizen monitoring, a more personal and direct approach is recommended. Such an approach may yield results that could inform the recruitment of participants (Cuthill, 2010).

The lack of response for this survey may be indicative of a lack of strong interest among local volunteers in participating in citizen monitoring for Musquash Estuary MPA. Although this result may seem discouraging, and needs to be confirmed, the recruitment of citizen monitoring participants would realistically require substantial effort. Several studies suggest the use of communications strategies to recruit citizen-monitoring participants (Devictor et al., 2010; Koss & Kingsley, 2010). Partnering with organizations with existing volunteer and membership networks can provide an effective method of recruitment. Furthermore, citizen monitoring projects with strong champions are much more likely to stand the test of time (Pollock & Whitelaw, 2005). Therefore, in developing citizen-monitoring programs for Musquash, the identification of partner organizations with existing networks and strong champions is likely to contribute to the recruitment and retention of participants

Chapter 4.0: Conclusions and Recommendations

Based on the results of this study, participatory methods, including citizen self-enforcement and citizen monitoring, currently contribute towards the management of Musquash Estuary MPA, through some degree of informal community enforcement via social norms and peer pressure, and monitoring efforts that incorporate a small number of citizen participants. However, there is much room to expand on these, thereby increasing management effectiveness in a resource efficient manner, while encouraging a sense of stewardship among the public.

4.1 Community Surveillance

Based on the results of the survey with community members from Lorneville, Prince of Wales and Musquash, the "Musquash Watch" Program has not been effective at encouraging the public to report violations, as most are not aware of the program and survey participants who did witness violations pertinent to the MPA did not report these to DFO. Furthermore, participants' comments indicate that there is some confusion regarding what institution reports of incidents that occur in and around the MPA should be made to.

Community surveillance has the potential to make an effective contribution toward the surveillance and enforcement of the Musquash Estuary MPA, provided that knowledge on MPA regulations and the underlying rationale become more widespread. Survey participants are supportive of Musquash Estuary being managed as an MPA; however, overall they do not feel that they are very knowledgeable about its regulations. Many survey participants can either see portions of the MPA from their place of

residence, or visit the surrounding lands on a frequent basis. Therefore most survey participants would have the opportunity to witness violations if they were to occur. All survey participants indicated that they were willing to report observed violations to DFO, but many commented that they would only take this action if they perceived violations to be serious. Approximately half of survey participants indicated that their willingness to report violations to DFO would be affected if they knew the person committing the violation; of these, the majority commented that they would speak to the person themselves about the violation rather than report it.

Recommendations

- Should DFO continue with the Musquash Watch program, further efforts should be made to promote the program. These could include the distribution of information to residents, as well as the posting of signs around the estuary.
- In implementing an effective Musquash Watch program, DFO should consider partnering with other stakeholders in the area to create a centralized portal to which all violations or suspicious activities in and around the MPA can be reported.
- Efforts should be made to advance knowledge of the Musquash Estuary MPA regulations and the underlying rationale among local community members in order to promote the creation of social norms and hence compliance.

4.2 Citizen Monitoring

Based on the results of this study, there is potential to implement new and enhance existing citizen monitoring in Musquash Estuary MPA. However, an important prerequisite to such actions would be to secure adequate and ongoing funding. Given the results of a literature review, interviews with managers of such programs elsewhere, and the lack of response from the local volunteer pool, the best approach to further developing a citizen monitoring program would be to partner with a local organization. Such an approach could provide a local champion to oversee the program and recruit participants. Due to the level of commitment that would likely be involved, finding a partner organization may present a significant challenge. Therefore, it may be necessary to contract out citizen monitoring efforts to a local organization. Although this would incur costs, it is likely to be more cost efficient than conducting professionally conducted monitoring and would promote community involvement in MPA management.

There are several citizen monitoring protocols that would be suitable for development and enhancement for Musquash Estuary MPA. The use, or modification of existing protocols would be advisable given the extensive effort required to develop novel citizen monitoring programs, as was demonstrated through the results of the literature review and interviews with managers of such programs elsewhere. Implementing the CAMP protocol would fill the currently unaddressed role of monitoring juvenile fish, as well as provide data on nutrient concentrations in the estuary. Furthermore, this protocol could likely be implemented at a relatively low cost due to the presence and resources of the Gulf program based out of the Moncton DFO office. Due to the potential value of monitoring the health of Musquash Estuary MPA, it would be

prudent to support and enhance bird surveys conducted in the area that incorporate citizen monitoring. In particular, it would be a worthwhile investment for DFO to provide in kind support to the Marsh Monitoring Program efforts currently being undertaken in Musquash Estuary, to promote the continuation of such efforts and the production of useful outputs such as GIS maps. Also, the creation of an Atlantic Canadian Shorebird Survey monitoring site along the MPA would provide valuable monitoring data on shorebirds for the area. Finally, given the current challenges associated with monitoring physical characteristics of the estuary, such as temperature and salinity, increasing the frequency of the monitoring paddle would also be a prudent action.

Recommendations

- Secure adequate long-term funding for citizen monitoring efforts prior to developing new and enhancing current programs.
- Look for opportunities to form partnerships with local organizations interested in getting involved with citizen monitoring for Musquash Estuary MPA.
- Consider contracting out citizen monitoring efforts to environmental organizations local to Musquash.
- If funds and partnerships are available, further investigate the implementation of the CAMP protocol in Musquash Estuary MPA.
- Develop and maintain a partnership with the Maritime Marsh Bird Monitoring Program, and consider providing in kind support to encourage the continual monitoring of the area surrounding Musquash Estuary.

- Contact the organizers of the Atlantic Canadian Shorebird Survey about creating a site adjacent to Musquash Estuary.
- Investigate the potential for increasing the frequency of monitoring paddles in Musquash Estuary MPA.

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Appendix I: Summary of the proposed monitoring framework for Musquash Estuary MPA (adapted from Cooper et al., 2011)

Conservation Objective	Operational Objective	Indicator	Monitoring Action
Productivity (P): Each component (primary, community, population) can play its role in the functioning of the ecosystem by maintaining abundance and health of harvested species.	Maintain biomass of secondary producers, primary and secondary consumers in each ecotype	Biomass (e.g. benthic invertebrates, invertebrate predators, fish, birds, mammals) in each ecotype (**P1**)	Survey of species in each ecotype using transect or quadrat sampling
	Maintain recruitment of juvenile fish to preserve perceived value as a nursery habitat for healthy populations of adults that inhabit the Bay of Fundy	Abundance of juvenile fish within the estuary (**P2**)	Survey of juvenile fish species in the estuary
	Maintain primary production levels that do not limit productivity at higher levels	Concentrations of primary producers in the estuary (**P3**)	Survey of planktonic community concentrations in the estuary
	Maintain abundance and state of harvested species perceived to be of value to the MPA and AIA	Commercial and recreational fishery landings per standardized unit effort in the estuary relative to statistical fishing area (**P4**)	Survey of landings by fishery and species that occur in and adjacent to the MPA
Biodiversity (B): Maintaining the diversity of individual species, communities, and populations within the different ecotypes	Maintain alpha diversity in each ecotype	Number of species in each ecotype (**B1**)	Survey of species in each ecotype using transect or quadrat sampling
	Maintain species community structure relative to long term changes in the region	Number and type of dominant species in each ecotype (**B2**)	Survey of species in each ecotype using transect or quadrat sampling
	Maintain number of rare species that inhabit the estuary based on perceived value as a refugium for rare or threatened species	Number of species at risk in each ecotype (**B3**)	Survey of species in each ecotype using transect or quadrat sampling
	Minimize fisheries induced impacts on non-target species	By-catch number, size, age, and sex per impacted species (**B4**)	Survey of by-catch, size, age and sex of captured individuals per fishery

Summary of the proposed monitoring framework for Musquash Estuary MPA (Continued)

Conservation Objective	Operational Objective	Indicator	Monitoring Action
Habitat (H): Safeguard the physical and chemical properties of the ecosystem by maintaining water and sediment quality	Maintain diversity and area of habitat ecotypes	Total area and location of each ecotype in the estuary (**H1**)	Map area distribution of each ecotype in the estuary using aerial photographs and GIS software
	Maintain biogenic structure for habitat ecotypes	Total area and location in estuary of species that provide biogenic structure (**H2**)	Map area distribution that supports species that provide biogenic structure
	Maintain hydrodynamic regime for habitat ecotypes	Changes in wave, tidal, freshwater outflow and sediment regime in the estuary (**H3**)	Field sampling coupled with hydographic and sediment models that predict the deposition/erosion of sediment, as well as the hydrological regime
	Maintain physical/chemical regime for habitat ecotypes	Temperature, salinity, turbidity in the estuary ecotypes (**H4**)	Survey of temperature and salinity in estuary
	Maintain nutrient loading for habitat ecotypes	Nutrient concentrations in the estuary ecotypes (**H5**)	Survey of nutrient concentrations in the estuary
	Avoid contaminant loading for habitat ecotypes	Contaminant concentrations in the estuary ecotypes (**H6**)	Survey of contaminant concentrations in bottom sediment and water column

Appendix II: Survey of members of communities local to Musquash Estuary MPA

Who can take this survey?
Residents of the communities surrounding Musquash Estuary Marine Protected Area (MPA) including Lorneville, Prince of Wales and Musquash that are over the age of 18 are invited to participate in this survey. Residents include anyone who has a mailing address in one of the local communities and may be a full-time or seasonal resident.

Why take part in the survey?
This survey will provide knowledge that will help inform effective management strategies for Musquash Estuary MPA, which protects important salt marsh and estuary habitat. Furthermore, by taking part in this survey you will be helping a Master of Marine Management student, Jessica Corkum, answer her primary research question: What is the feasibility of undertaking a citizen monitoring program in Musquash Estuary MPA.

Musquash Estuary MPA: Musquash Estuary MPA is a small protected area located approximately 20 km Southwest of St John New Brunswick. The primary purpose of the MPA is to protect what is considered to be the last salt marsh and estuary habitat within the Bay of Fundy that has not been significantly impacted by human activities. It consists of about 7 km^2 of underwater habitat, and about 4 km^2 of the surrounding shoreline. The lead agency responsible for the management of Musquash MPA is the Department of Fisheries and Oceans (DFO).

MPA: Marine Protected Areas (MPAs) are one type of management tool that can help protect, maintain and restore fragile, biologically important areas.

If completing this survey by hand, select answers by circling that option. If completing this survey through email, please select answers by typing the word select in bold beside that option.

1. **Which of the following occupations have you recently been involved with?**
    a. Hunting/trapping
    b. Commercial fishery
    c. Fish processing
    d. Aquaculture
    e. Forestry
    f. Renewable energy
    g. Manufacturing
    h. Construction
    i. Transportation and storage
    j. Retail or wholesale trade
    k. Finance or insurance
    l. Real estate
    m. Business services
    n. Government (federal, provincial, or municipal)
    o. Educational services
    p. Health or social services
    q. Home help or housekeeping
    r. Accommodation, food and beverage services
    s. Tourism guide (i.e. whale or bird watching tours)
    t. Landscaping/property maintenance
    u. Shellfish harvesting
    v. Other(s)
    _____

2. **To which of the following age categories do you belong?**
    a. 18-29
    b. 30-39
    c. 40-49
    d. 50-59
    e. 60-69
    f. 70 and more

3. Were you familiar with the Musquash Estuary MPA prior to this survey?
    a. Yes
    b. No

4. If you answered yes to question 3, are you in support of the ongoing management of Musquash Estuary as an MPA?
    a. Yes
    b. No (please briefly state why you do not support this)_____

5. If you answered yes to question *3*, on a scale of 1-5, how well would you rate your knowledge of the regulations on human activities in Musquash Estuary MPA?

Not very knowledgeable			**Very knowledgeable**
1	**2**	**3**	**4**
5			

6. Can you see Musquash MPA from your place of residence?

a. Yes
b. No

7. Approximately how far away do you live from Musquash MPA in road kilometers?

a. Within 10 km
b. 10-20 km
c. 20-30 km
d. 30-40 km
e. 40-50 km
f. 50-60 km
g. Greater than 60 km

8. How often do you visit Musquash Estuary MPA and the surrounding parks and conservation areas (i.e. walking trails)?

a. More than once a week
b. About once a week
c. About once every 2 weeks
d. About once a month
e. A couple of times a year
f. Very rarely
g. Never

9. Are you a seasonal or full time resident at the residence you referred to in question *6* and *7*?

a. Full-time
b. Seasonal (if so which seasons are you a resident for?)_____

10. Do you recall receiving promotional material (i.e. flyers and a fridge magnet) that provided information on the regulations for Musquash MPA and provided a number which violations could be reported?

a. Yes
b. No

Note: The following questions are intended to assess the effectiveness of a "Musquash Watch" community surveillance program through which residents of communities local to Musquash can report violations Rest assured that your answers will remain

confidential (as per the informed consent form) and will not be used to get anyone in trouble or reported to either enforcement agencies or other members of the community.

11. Have you ever witnessed any violations or suspicious activities in the Musquash MPA and surrounding area?

a. Yes
b. No

12. If you answered yes to question 11, did you report this incident to DFO?

a. Yes
b. No

13. If you were to witness an activity within Musquash MPA and the surrounding area that you knew was a violation would you be willing to call DFO and report the incident?

a. Yes
b. No (if you chose, you can briefly elaborate using the space below)

14. Would your answer to question *13* be different if the violator was a person who was known to you?

a. Yes
b. No (please briefly elaborate using the space below)

Thank you for taking the time to complete this survey. Your contribution will provide valuable knowledge for this research!

Appendix III: Interview Questions for Managers of MPA Citizen Monitoring Programs

1. Is your citizen monitoring program primarily designed as an outreach and education program, or is it intended to produce scientific data that can be used for management?

2. If you answered yes to question 1, how is data obtained from participants used for/integrated into management?

3. Briefly, what tasks are volunteers asked to complete (include a description of protocols including training)?

4. What are the time commitments required of volunteers over the course of a year (including time in the field, time dedicated to training, and time dedicated to self-led activities such as learning or data entry)?

5. Approximately how many volunteers participate in this program over the course of a year?

6. Is this an ongoing or long-term program?

7. What are the oversight requirements for the program (paid staff time)?

8. What are the costs of coordinating the program (including field work, training, recruitment, equipment, communications, etc.)?

9. Would it be more or less expensive to have professionals collect the same data?

10. Does the program involve partnerships with other organizations?

11. Was citizen monitoring included in the development of a formal monitoring plan for the MPA, or was the program developed once management had already developed indicators and protocols?

12. What are some general characteristics of you volunteers (i.e. demographics/ occupations)?

13. How were volunteers recruited?

14. Are there any incentives (financial or otherwise) for volunteers to take part in this program?

15. What Quality Assurance/Quality control process are in place (i.e. testing of volunteers, verification of observations, review of data by professionals)?

16. How is data managed (i.e. is it entered by volunteers, is this done by hand or online)?

17. Do volunteers take part in data analysis and interpretation?

18. Are results communicated back to volunteers? If so, how?

19. Is there a communications strategy in place to keep connected with volunteers (i.e. newsletter, events)?

20. What is the average volunteer retention (years)?

21.Based on your experience, what advice would you give to managers looking at developing a citizen monitoring program for an MPA?

Appendix IV: Survey of volunteers associated with local ENGOs and community groups

Who can take this survey?
Volunteers who work with local NGOs and community groups that have been associated with Musquash Estuary MPA are invited to complete this survey. These organizations include: Saint John Naturalists Club, New Brunswick Conservation Council, Fundy Baykeeper, Friends of Musquash, The Nature Conservancy Canada and Ducks Unlimited. Volunteers include anyone that has in the past, or is interested in contributing their time and efforts towards projects associated with one of the previous listed organizations without payment.

Why take part in the survey?
Currently there are no specific plans to start a citizen-monitoring program for Musquash Estuary MPA. The intent of this study is to gauge the interest and capacity for local volunteers to participate in citizen monitoring programs. This survey is part of a study designed to assess the feasibility of citizen monitoring programs for the ongoing management of Musquash MPA, and to guide the development of any such programs for the area. Furthermore, by taking part in this survey you will be helping a Master of Marine Management student, Jessica Corkum, answer her primary research question: What is the feasibility of undertaking a citizen monitoring program in Musquash Estuary MPA.

Musquash Estuary MPA: Musquash Estuary MPA is a small protected area located approximately 20 km Southwest of St John New Brunswick. The primary purpose of the MPA is to protect what is considered to be the last salt marsh and estuary habitat within the Bay of Fundy that has not been significantly impacted by human activities. It consists of about 7 km^2 of underwater habitat, and about 4 km^2 of the surrounding shoreline. The lead agency responsible for the management of Musquash MPA is the Department of Fisheries and Oceans (DFO).

The following definitions are used for the purposes of this survey:

MPA: Marine Protected Areas (MPAs) are one type of management tool that can help protect, maintain and restore fragile, biologically important areas.

Citizen Monitoring: The process of gathering information about variables, or changing characteristics, within a system of interest, such as a marine protected area, by volunteers. For the purposes of this study citizen monitoring has been divided into the following two categories: citizen ecological monitoring and citizen human activity monitoring.

Citizen Ecological Monitoring: The process of gathering information about ***variables that characterize and monitor the quality of the environment*** within a system of interest by volunteers.

Citizen Human Activity Monitoring: The process of gathering information about ***the types and degree of human activities*** that take place within a system of interest, by volunteers, ***including any activities that are in violation of rules and regulations for the system of interest***.

Note: The word seasonal used below generally refers to once per season (fall, winter, spring, summer), however for some activities winter may not be included for logistical reasons.

If completing this survey by hand, select answers by circling that option. If completing this survey through email, please select answers by typing the word *select* in bold beside that option, unless otherwise indicated.

1. Please select which one of the following organizations are you currently, or are interested in volunteering with?

a. Ducks Unlimited
b. The Nature Conservancy Canada
c. Friends of Musquash
d. The New Brunswick Conservation Council
e. Fundy Baykeeper
f. Saint John Naturalist Club
g. Other (please specifiy) _____

2. How long have you been volunteering with the organization identified in the previous question?

a. Less than 1 year
b. 1-2 years
c. 2-5 years
d. More than 5 years

3. Which of the following occupations have you recently been involved with?

w. Hunting/trapping
x. Commercial fishery
y. Fish processing
z. Aquaculture
aa. Forestry
bb. Renewable energy
cc. Manufacturing
dd. Construction
ee. Transportation and storage
ff. Retail or wholesale trade
gg. Finance or insurance
hh. Real estate
ii. Business services
jj. Government (federal, provincial, or municipal)

kk. Educational services
ll. Health or social services
mm. Home help or housekeeping
nn. Accommodation, food and beverage services
oo. Tourism guide (i.e. whale or bird watching tours)
pp. Landscaping/property maintenance
qq. Shellfish harvesting
rr. Other(s)

_____

3. To which of the following age categories do you belong?

g. 18-29
h. 30-39
i. 40-49
j. 50-59
k. 60-69
l. 70 and more

4. Please indicate the highest level of formal education that you have attained?

a. High School Diploma or equivalent
b. An undergraduate or Bachelor's degree from a University
c. A graduate degree from a University
d. A college diploma
e. None of the above

5. Were you familiar with the Musquash Estuary MPA prior to this survey?

a. Yes
b. No

6. Approximately how far away do you live from Musquash MPA in road kilometers?

h. Within 10 km
i. 10-20 km
j. 20-30 km
k. 30-40 km
l. 40-50 km
m. 50-60 km
n. Greater than 60 km

7. Are you a seasonal or full time resident at the residence you referred to in question *5*?

c. Full-time
d. Seasonal (if so which seasons are you a resident for?)_____

8. Would you be willing to donate some of your time to citizen monitoring activities at Musquash MPA.

a. Yes
b. No (If not please briefly elaborate in the space below)

9. If you answered *yes* to question *8*, please indicate which of the following answers best describe your top 3 reasons for wanting to participate in citizen monitoring at Musquash MPA (please put a 1, 2, or 3 beside each respective answers).

a. Feeling connected with nature
b. Wanting to maintain and protect the health of the natural world and its resources
c. Wanted to look after natural spaces in and around your community
d. Socializing and meeting new people
e. Gaining practical skills, experience and knowledge
f. Other _____

10. To which of the following ongoing ecological monitoring activities at Musquash MPA would you be willing to donate your time (please select all that apply)?

a. Nesting bird survey: locating nests and identifying breeding pairs of birds within a defined area.
    a. On a yearly basis
    b. On a seasonal basis

b. A general bird count
    a. On a yearly basis
    b. On a seasonal basis

c. A Monitoring paddle in which volunteer's record and document environmental characteristics and changes to these. This would likely involve participation in a daylong training session as well.
    a. On a yearly basis
    b. On a seasonal basis

d. A systematic survey of ground cover, animals and plants within small randomly selected spots both above the waterline and in swallow water areas (most likely up to 1 meter in depth). This would require some training in addition to two days performing the survey once every year or two.

e. Collecting information on animals and plant species, water quality and seafloor characteristics using a step-by-step procedure. This would require a day or two of training every spring, and would be completed over the course of a day, once a month between May and September of every year.

f. Photo monitoring: taking photos at specific spots in the MPA and surrounding area and submitting these to a website at unspecified times to monitor changes.

11. Please below indicate if you are already participating in one of the above activities, and if so which one(s), and how often?

12. How much time would you be willing to contribute to any or all of the activities listed in question *10*, and other monitoring activities that would involve collecting environmental information in the MPA and surrounding area (not including prior inside training time or self-led activities)?

a. On a yearly basis?_____
b. On a monthly basis (May – September)?_____

13. In addition to the time indicated in question *12*, how much time would you be willing to contribute to professionally led training sessions?

a. On a yearly basis?_____
b. On a monthly basis (May – September)?_____

14. In addition to the time indicated in question *12* and *13*, how much time would you be willing to contribute of your personal time for self-led learning or recording data on your own?

a. On a yearly basis? _____
b. On a monthly basis (May – September)? _____

15. Would you be willing to participate in a monitoring program that involves patrolling the MPA area on foot and recording human activities and/or violations?

a. Yes
b. no

16. If you answered yes to question *15*, how much time would be willing to dedicate to patrolling the Musquash MPA?

a. On a monthly basis (May – September) ? _____
b. On a weekly basis (May to September)? _____

17. If you answered yes to question *15*, would you feel comfortable reporting any violations witnessed directly to DFO so that they could address the violation, or would you prefer to simply record the activity for monitoring purposes (i.e. direct action would not be taken to enforce specific violations)?

a. I would feel comfortable reporting violations to DFO directly.

b. I would prefer not to report violations and to simply record activities for monitoring purposes (if you chose to do so you may elaborate on this answer below).

18. On a scale of 1-5 please indicate your comfort level using or learning to use computers and their applications (i.e. entering data, uploading photos, etc.)?

Not very comfortable			**very comfortable**	
1	**2**	**3**	**4**	**5**

Thank you for taking the time to complete this survey. Your contribution will provide valuable knowledge for this research!