Developing and implementing a research framework to determine the use and influence of a long-term marine environmental monitoring program:

A Case Study on Gulfwatch in Nova Scotia

by

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Abstract

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Chemical contamination of marine environments can pose numerous risks to both ecosystem and human health. Monitoring trends of chemical contaminants over time and space can provide managers and decision-makers the information necessary to make decisions to improve ecosystem health or to protect human health. However, information obtained through monitoring programs can only inform management and decision making if managers and decision-makers are aware of and are using the information. This study developed a research methodology to study a long-term biomonitoring program: Gulfwatch Contaminants Monitoring Program, a sub-committee of the Gulf of Maine Council on the Marine Environment. Gulfwatch uses blue mussels (*Mytilus edulis*) to monitor chemical contamination in the Gulf of Maine. The overall awareness and use of Gulfwatch information was examined through a cataloguing of all Gulfwatch-related publications, analysis of the Gulfwatch webpage, and interviews of potential users of Gulfwatch information in Nova Scotia and Gulfwatch committee members. It was found that there was some awareness and very little use of Gulfwatch information in Nova Scotia. Reasons for the limited awareness and use were mostly linked to the lack of interest in chemical contamination in both the federal and provincial governments. Recommendations for implementing the methodology for other monitoring programs as well as for improving the use of long-term monitoring information are given.

Keywords: Long-term biomonitoring, Coastal Health, Gulf of Maine Council on the Marine Environment, Information Management, Gulfwatch Contaminants Monitoring Program.

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List of Acronyms and Abbreviations

BoFEP: Bay of Fundy Ecosystem Partnership

CFIA: Canadian Food Inspection Agency

CSSP: Canadian Shellfish Sanitation Program

DDT: Dichlorodiphenyltrichloroethane

DFO: Department of Fisheries and Oceans

EC: Environment Canada

EIUI: Environmental Information: Use and Influence

ENGO: Environmental Non-Governmental Organization

ESIP: Ecosystem Indicator Partnership

GOMG: Gulf of Maine Council on the Marine Environment

HACCP: Hazard Analysis Critical Control Point

HTML: Hypertext markup language

ICZM: Integrated Coastal Zone Management

MPA: Marine Protected Area

MWRA: Massachusetts Water Resources Authority

NOAA: National Oceanographic and Atmospheric Administration

NSDFA: Nova Scotia Department of Fisheries and Aquaculture

PAHs: Polycyclic aromatic hydrocarbons

PCBs: Polychlorinated biphenyls

SPI: Science-Policy Interface

USEPA: United States Environmental Protection Agency

USGS: United States Geological Survey

Chapter 1: Water Quality Monitoring: Importance and Current Efforts

1.1. The Importance of Maintaining Good Water Quality

Estuaries and other coastal bodies of water are at particular risk of anthropogenically introduced chemical contaminants because of their proximity to human activities. The metals, pesticides, and organic compounds that are discharged into the atmosphere or to waterways from land-based activities have many negative influences on the environment. They also pose risks to human health and well-being (Harding and Burbidge, 2013). However, not all chemical contamination is derived from human activities. Contaminants such as oil and gas can also be introduced to the environment through naturally-occurring crevices in the earth's surface. According to the Woods Hole Oceanographic Institution (2014), as much as 50% of the oil and natural gas that is introduced to the coastal environment comes from naturally-occurring oil or gas leaks. Regardless of the source of chemical contamination, monitoring the changes in water quality over time is necessary to help managers and decision-makers discover the sources of such contaminants, implement policies to limit pollution of waterways and the atmosphere, and to manage sea-food harvests to avoid areas where high contamination could pose serious health risks to humans.

1.1.1. Ecosystem and health concerns

There are noted environmental and human health concerns that should be mentioned when discussing the importance of monitoring programs in the marine environment. First, it is necessary to define the types of contaminants that are present in the marine environment. There is an apparent division of contaminant types in the literature between "legacy" contaminants and "emerging" contaminants (Harding and Burbidge; Kidd and Mercer, 2012). Legacy

contaminants are classified as those compounds that have known deleterious effects and that have been heavily regulated to reduce their use and subsequent pollution of ecosystems. Generally speaking, legacy contaminants include trace metals, polycyclic aromatic hydrocarbons (PAHs), and organochlorines, among others. Mercury (a metal) and dichlorodiphenyl-trichloroethane (DDT, an insecticide) are well-known and well-studied legacy contaminants (e.g. Castro-Gonzalez and Mendez-Armenta, 2008; Turosov *et al.*, 2002). The aforementioned natural oil and gas leaks would also be classified as legacy contaminants in that their presence and effect on the environment are known. Emerging contaminants are defined as those that have been recently detected due to analytical advances in water quality monitoring, have been recently recognized as contaminants, or whose fate and behaviour in the environment are not well-known (Hutchinson *et al.*, 2013). Emerging contaminants should not be mistaken as new contaminants that were not found previously in the environment but rather should be defined as those recently brought to the attention of water-quality researchers. They are emerging into our overall awareness and are not necessarily newly-introduced contaminants. Emerging contaminants include pharmaceutical products, hormones associated with birth control drugs, caffeine, illicit drugs, and other contaminants associated with human or medical waste (Hutchinson *et al.*, 2013). Both legacy and emerging contaminants pose risks to ecosystem and human health.

Legacy contaminants have been linked to several environmental and human health issues. For example, there is a link between trace metal exposure and overactive cellular defence genes in ciliates (Kim *et al.*, 2014). There are also many known links to reproductive failure and endocrine disruption in marine birds due to excessive DDT exposure (Turusov *et al.*, 2002). In fact, it has been noted that "there is not a single living organism on the planet that does not contain DDT" (Turusov *et al.*, 2012, pg. 1), indicating that the health impacts of DDT are

widespread. Many contaminants are potentially linked to onset of different forms of cancer or to reproductive issues in humans and other animals. Arsenic, DDT, and PAHs are among those held responsible for the onset of cancer or for reproductive challenges in various animals (Han *et al.*, 1998; Li *et al.*, 2014; Moysich *et al.*, 2002; Persson *et al.*, 2012), but some studies have found that it is not the exposure of one contaminant that increases risk of cancer (e.g. Lopez-Carillo *et al.*, 1997) but rather the compounded effect of exposure to multiple contaminants at a time. For example, Campagna *et al.* (2001) exposed porcine oocytes and fetuses to a cocktail of environmentally-relevant organochlorines and found that there were indications of impaired development at all stages of reproduction. These results are not necessarily found when studying the effect of one organochlorine contaminant at a time. Other researchers have also noted the importance of studying the compounded effects of multiple contaminants rather than studying each contaminant individually (e.g. Yi *et al.*, 2011; Mergler *et al.*, 2007) as a way of simulating true environmental conditions that humans or animals would be exposed to. It is not probable that an individual would be exposed to only one contaminant and if contaminants are studied in isolation, then their actual effect on health will not be established. This principle can likely be applied to ecosystem health as well as to human health, but no studies were found that examined the effects of multiple contaminants on a system.

Emerging contaminants have been linked to their own share of environmental and human health implications. Largely, acute and chronic toxicity by emerging contaminants can result in an overall loss of habitat or biodiversity, or provide threats to human health (Jiang *et al.*, 2014). Few authors discuss in detail what these effects may be, but there are comments to the effect of "little is known about their effects in the marine environment" (Harding and Burbidge, 2013,

pg. 3). The lack of information about emerging contaminants emphasizes the need to monitor and to study their effects on the environment, ecosystems, and human health. Studies should focus on single contaminants as well as multiple contaminants in tandem in order to reduce the uncertainty about emerging contaminants. Armed with this information, better management and legislation can be implemented to reduce the risks of chemical exposure.

The disturbing aspect of chemical contaminants is that they may be very persistent in the environment, lasting decades in various forms, and they are often fat-soluble, accumulating in adipose tissues of organisms rather than being excreted (Walde, 2012). When they are excreted, it is through mediums like breast-milk or placenta-embryo interactions that only exacerbate the overall impact of contaminants on both humans and wild organisms (Mergler *et al.*, 2001; Colborn *et al.*, 1993; Fangstrom *et al.*, 2005). Contaminants are also very accessible to consumers: fish and seafood are a major part of many food-webs, including those involving humans. Monitoring programs that evaluate contaminant loadings in organisms lower in the trophic structure do not capture the severity of bioaccumulation at higher levels (Harding and Burbidge, 2013; Figure 1). Eating fish has been shown to provide cardiovascular and neurological health benefits (Ruxton *et al.*, 2004). However, if the fish are chemically contaminated, the health benefits of eating fish may be outweighed health complications attributed to some contaminants (Hites *et al.*, 2014; Han *et al.*, 1998; Castro-Gonzales and Mendez-Armenta, 2008). Because of the uncertainty surrounding some of the effects of legacy contaminants and the lack of information about the effects of emerging contaminants, ongoing monitoring of both types of compounds is necessary to remain appraised of trends and risks to both ecosystem and human health.

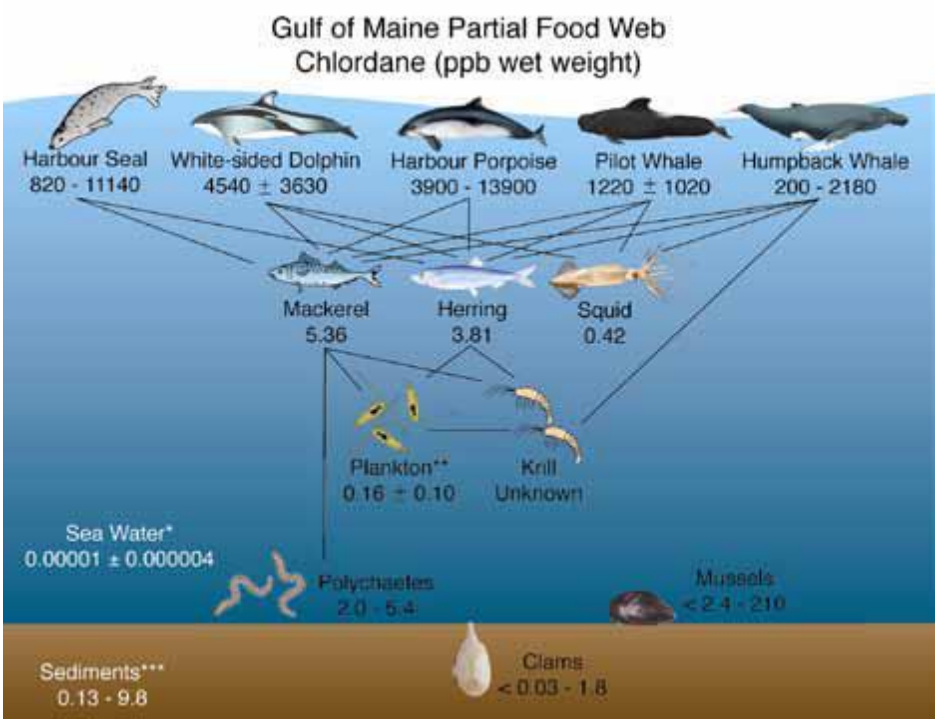

*Figure 1***:** The bioaccumulation of a contaminant, chlordane, from seawater to organisms up the trophic levels and showing the higher concentrations in organisms considered top predators. Values in the figure are derived from previous studies in the Western Arctic Ocean and the Southern Gulf of St. Lawrence. Originally published as Figure 5 in Harding and Burbidge (2013).

1.1.2. The objectives of biomonitoring projects.

Because of the risks to human and ecosystem health, there is an inherent value to maintaining a monitoring program intended to describe trends over time and space. Long-term monitoring projects generate large amounts of invaluable information that have great potential to inform policy and decision-making. Many different disciplines make use of long term-monitoring to meet a variety of goals. Peterson *et al.* (2011) stated that long-term monitoring efforts are required to determine the effectiveness of remediation efforts, to monitor areas where chronic effects of contamination are noted, and to assess trends seasonally or across time and

space. Short term or sporadic monitoring will not provide adequate information for such goals (Table 1). Board (1990) suggested the same objectives for monitoring efforts and adds that monitoring may also act as a means of determining problems sooner rather than later, contribute to scientific knowledge of the ecosystem in question, or provide rationale for allowing or disallowing activities in or near the ecosystem. There are several examples in the literature of long-term monitoring efforts that draw upon one or more of these objectives for monitoring. They are summarized below.

Table 1: The minimum monitoring duration required and example monitoring methodology to gather adequate information to use for various goals of ecosystem measurement. Originally published as Table 5 in Peterson *et al.* (2011).

Ecological measures	Minimum monitoring duration	Example of BMAP measure
Goal: Understanding of an ecosystem baseline		
Population abundance status	Shortterm	Fish and benthic community
Community diversity status	Shortterm	Fish and benthic community
Early warning of stress	Shortterm possible with well established bioindicators; otherwise longterm	Fish health bioindicators
Characterization of stress	Shortterm possible for some stressors	Toxicity testing
Discovery of rare species	Longterm	Fish community sampling
Determination of seasonal variability	Longterm	Contaminants in fish; Fish and benthic community
Determination of annual variability	Longterm	Contaminants in fish; Fish and benthic community
Goal: Response to stress		
Cause of acute effect	Shortterm	Fish kill assessment; Fish health
Cause of chronic effect	Longterm	Community sampling, including fish, benthic macroinvertebrates, and periphyton; Fish health
Evaluation of recovery status	Longterm	Community sampling; Fish health
Evaluation of effectiveness of mitigation/remediation	Longterm	Contaminants in fish; Fish and benthic community

1.1.2.1. Assessing trends and risks.

Long-term biomonitoring studies provide information on changes and trends in the marine environment that managers can use to assess risks and make appropriate decisions. "Due to our increasingly industrialized society, anthropogenic stresses on the environment can only be expected to increase" (Jakšić *et al.*, 2005, p. 1324) so monitoring and evaluating trends and risks

are a necessary part of good management practices. Apeti *et al.* (2010) also cautioned that long term monitoring is necessary to establish trends and status of contaminants of concern, especially because some contaminants, like PAHs, are deposited naturally into the environment and can come from long distances atmospherically and be deposited into water bodies. Monitoring also may determine the sources of contaminants, although in instances where contaminants are atmospherically deposited, this may be more challenging (Drouillard *et al.*, 2013). There are many examples of monitoring programs intended to provide information on contaminant trends. One in particular was undertaken by Nakata *et al.* (2012) who used mussels to monitor chemicals associated with personal care products (an emerging contaminant) in order to establish their status and geographical trends over a period of five years in Asia. Another example is Picer and Picer (1995) who also used mussels to determine the trends of polychlorinated biphenyls (PCBs) and DDT in the Adriatic Sea over the span of 20 years. Over-all, the use of organisms to monitor spatial trends over time has been shown to provide robust and valuable information to decision-makers tasked with ensuring that ecosystem and human health are preserved.

1.1.2.2. Importance in assessing remediation efforts

Madejon *et al.* (2013) suggested that data-sets collected over a long period of time are essential to assessing the success of management or policy efforts. Ultimately, remediation efforts seek to improve ecosystem health either by changing human behaviour (e.g. through legislated bans of certain pesticides or other chemicals), or through changes in how industry is conducted near aquatic ecosystems (e.g. through implementation of waste-water treatment to reduce impacts). As Tripp and Farrington (1985) stated: "a monitoring program is important, not only to warn us of an existing or impending problem, but to inform us that a chosen practice is

functioning as predicted" (p. 201). This is a common employment of biomonitoring methodologies. Approaches can vary from the use of fish in a "canary in a coal mine" type of scenario (Shedd *et al.*, 2001) or to the use of repeated measures of contaminants found in tissues of organisms such as mussels (Tripp and Farrington, 1985).

Perhaps the best-documented monitoring effort, warranting an entire special issue in the journal "Environmental Management", chronicled the changes in East Fork Poplar Creek in Tennessee following a remediation effort. In 1985, the Tennessee Department of Health and Environment issued a piece of legislation that required industries to treat their waste water more effectively (Loar *et al*,, 2011). One particular industry depositing wastewater into East Fork Poplar Creek developed a remediation plan and implemented a 25 year monitoring protocol to measure the effects of the remediation efforts. Using short-lived fish as indicator species in the creek, it was found that remediation efforts did have a positive effect on reducing contaminants such as mercury and PCBs (Southworth *et al.*, 2011). The data served as feedback to decision-makers about the effectiveness of remediation efforts and helped to inform further decisions regarding improving water quality (Peterson *et al.*, 2011).

Another example of monitoring the effectiveness of a remediation effort is documented by Hunt and Slone (2010). The authors described how Boston Harbour water quality was improved after the Massachusetts Water Resources Authority (MWRA) implemented facility upgrades to increase the volume of sewage treated using secondary treatment methods. The result was that 95% of waste water was then subjected to the improved treatment protocol. Sampling of mussels in the harbour, before and after the improved water treatment was implemented, revealed that concentrations of measured contaminants decreased in the Boston Harbour area. The decreasing concentrations of contaminants supported the decision by the

MWRA to improve water treatment and aided in justifying the cost associated with the facility upgrades (Hunt and Slone, 2010).

Another study used canned mussels packaged in the 1940s and compared them to contemporary mussels to determine changes in contaminant loadings in Coastal Maine, USA, from before and after the Second World War (Apeti et al., 2010). This, in part, helped to determine the effect of legislated bans on many contaminants (e.g. pesticides) which took place in the mid-1970s in the United States. It was found that there was a notable increase in contaminant loading between pre- Second World War era and the early 1970s, then a decrease in chemical loadings in mussels after the 1970s. The decrease after the 1970s was attributed to wide-spread legislated bans of some of the measured compounds (Eisler, 1986). Following the decrease, there was a sustained low concentration of measured contaminants, attributed to persistent loading from atmospheric deposition and contaminated sediments and soils that continually leach already deposited contamination (Apeti *et al.*, 2010). This particular comparative dataset also illustrated the complex cycles of some contaminants like PAHs and PCBs, as well as the multi-decadal persistence of many contaminants in the environment, a justification for long-term monitoring to further understand the cycle of contaminants and how long they take to leave the system (Lauenstein and Daskalakis, 1998).

1.1.3. The value of long-term biomonitoring projects

In many instances, it is necessary to make decisions and policies even though evidence or information may be lacking. It is often still necessary to make decisions or polices in these cases. However, where possible, such uncertainty should be reduced. Sustained and rigorous monitoring programs provide sufficient information for determining trends as well as the

influences of human activity on the environment. Shorter-term or more sporadic monitoring may not allow for trends to be observed and the effects of human activity may not be known (Peterson *et al.*, 2011). The value of long-term biomonitoring programs is not just in the data they produce, it is the information they provide that can be used to reduce uncertainty about a problem. Board (1990) stated that "risk-free decision-making is not possible. When well developed, applied, and used, environmental monitoring can help quantify the magnitude of uncertainty, thereby reducing but not eliminating uncertainty in decision making" (p. 4). Therefore, the value of long-term monitoring is that decision-makers can develop policies and make decisions with lower levels of uncertainty because the environment and trends are better understood.

Like any scientific endeavor, the power of the data comes from repeated measurement (Hunt and Slone, 2010) and a long-term dataset that employs repeated measures is very valuable for management and decision-making (Frati and Brunialti, 2006). The application of the robust dataset to initiatives such as those mentioned above provide managers with ample information of high quality on which to base decisions. The effectiveness of decisions and enacted policies can then be assessed using historical data and newly collected data, before and after the advent of a policy-change, to determine the success of such decisions.

1.2. Gulf of Maine Council on the Marine Environment

Mussel Watch is one such marine biomonitoring initiative. Conceptualized in the mid-1970s by Edward Goldberg, the goal of Mussel Watch was to address the noted lack of monitoring occurring in the coastal zone (Goldberg, 1986). Implemented by the National Oceanographic and Atmospheric Administration (NOAA) in the United States, Mussel Watch is

a national program of the United States that monitors both marine and aquatic chemical contaminants (National Ocean Service, 2014). There are also several programs of the same name around the globe (Guitart *et al.*, 2012). Mussels are utilized as an indicator species because their use is a more cost-effective monitoring methodology than chemical analysis of water or sediment samples (Guitart *et al.*, 2012). Also, because mussels are sessile filter feeders, they accumulate persistent chemicals and studying their tissues allows researchers to determine contaminant loads in the environment (Goldberg, 1986). Tripp and Farrington (1985) advocated the use of such organisms as sentinel species in monitoring, as opposed to water or sediment monitoring, because only organisms can give insight into the bioavailability of contaminants and the issues associated with bioaccumulation or magnification of contaminants. However, Mussel Watch only had a small number of sampling locations in the Gulf of Maine, and thus did not provide a comprehensive and robust assessment of the state of the Gulf of Maine region (Chandler, 2001). The Gulf of Maine Council on the Marine Environment (GOMC), a joint Canadian-American council, implemented the Gulf of Maine Environmental Quality Monitoring Program (also known as Gulfwatch) in its first Action Plan to address the limited monitoring of the Gulf of Maine, including the Bay of Fundy (Gulf of Maine Working Group, 1991).

The GOMC identified eight primary target audiences in its most recent Action Plan document. They include policy makers and managers for issues concerning the coastal zone, members of the public, and the scientific community (Taylor, n.d.). It stands to reason that the target audience for the GOMC would be the same target audience as for Gulfwatch. A similar assertion was made by Walmsley (2009) in a discussion about who could stand to use State of the Environment reports put out by the GOMC and partners. Therefore, this study will focus on

all the groups mentioned, except for the general public, to determine the overall awareness and use of Gulfwatch data and information products.

1.2.1. The Gulf of Maine Council Gulfwatch Program

Launched in 1991 as a pilot project of the GOMC, the Gulfwatch monitoring program has been engaged in monitoring various chemical contaminants in the Gulf of Maine, including the Bay of Fundy, as the core of the Gulf of Maine Marine Environmental Monitoring Program. Using blue mussels (*Mytilus edulis*) as sentinel organisms, contaminants such as trace metals, chlorinated pesticides, polychlorinated biphenyls (PCBs), and polycyclicaromatic hydrocarbons (PAHs), are monitored to determine their presence and spatial and temporal trends (Jones *et al.*, 1998). The list of chemical contaminants monitored by Gulfwatch was established using the United States Environmental Protection Agency (USEPA) listing of toxic chemicals. The USEPA lists chemicals that are linked to any of the following: "cancer or other chronic human health effects, significant adverse acute human health effects, [or] significant adverse environmental effects (USEPA, 2014, para. 2). The Gulfwatch program selected chemicals to monitor from the USEPA listing (Dr. Peter Wells, personal communication, November 4, 2014).

The mission of the Gulf of Maine Marine Environmental Quality Monitoring Program is as follows:

> It is the mission of the Gulf of Maine Marine Environmental Quality Monitoring Program to provide environmental and resource managers with information to support sustainable use of the Gulf and allow assessment and management of risk to public and environmental health from current and potential threats. (Gulf of Maine Working Group, 1991, pg. 8)

To this end, the initial pilot program was developed in 1990 and was implemented in 1991. Sampling methodology involved collection of indigenous mussels from reference "clean sites" and "dirty" sites of interest as well as the deployment of caged mussels from clean sites to dirty sites to compare growth (Monitoring Committee of the Gulf of Maine Council on the Marine Environment, 1991). After the pilot period ended, sampling method was reduced to collection of indigenous mussels from sampling sites; the caged-mussel sampling ceased (Jones *et al.*, 1998; Chase *et al.*, 2001). Samples of mussels in the 50-60 mm size range are collected every fall from selected sites in each of the five jurisdictions. In total, 56 sites are sampled (Figure 2), but not every site is sampled every year; rather, in the program up to 2010 a three year sample site rotation is employed with the exception of one benchmark site in each jurisdiction which is sampled annually. Samples are collected from inter-tidal mussel beds at low tide and are analyzed at various laboratories for trace metal, pesticides, PAHs, and PCBs (Jones *et al.*, 1998).

Funding for the Gulfwatch program comes from participants of the GOMC itself, sources such as Environment Canada (EC), NOAA, USEPA, and the United States Geological Survey (USGS) have all provided support. Support has also come from the five jurisdictions in the form of field work, sample processing, data compilation, report writing, and many other volunteer efforts that support the program (Jones *et al.* 1998).

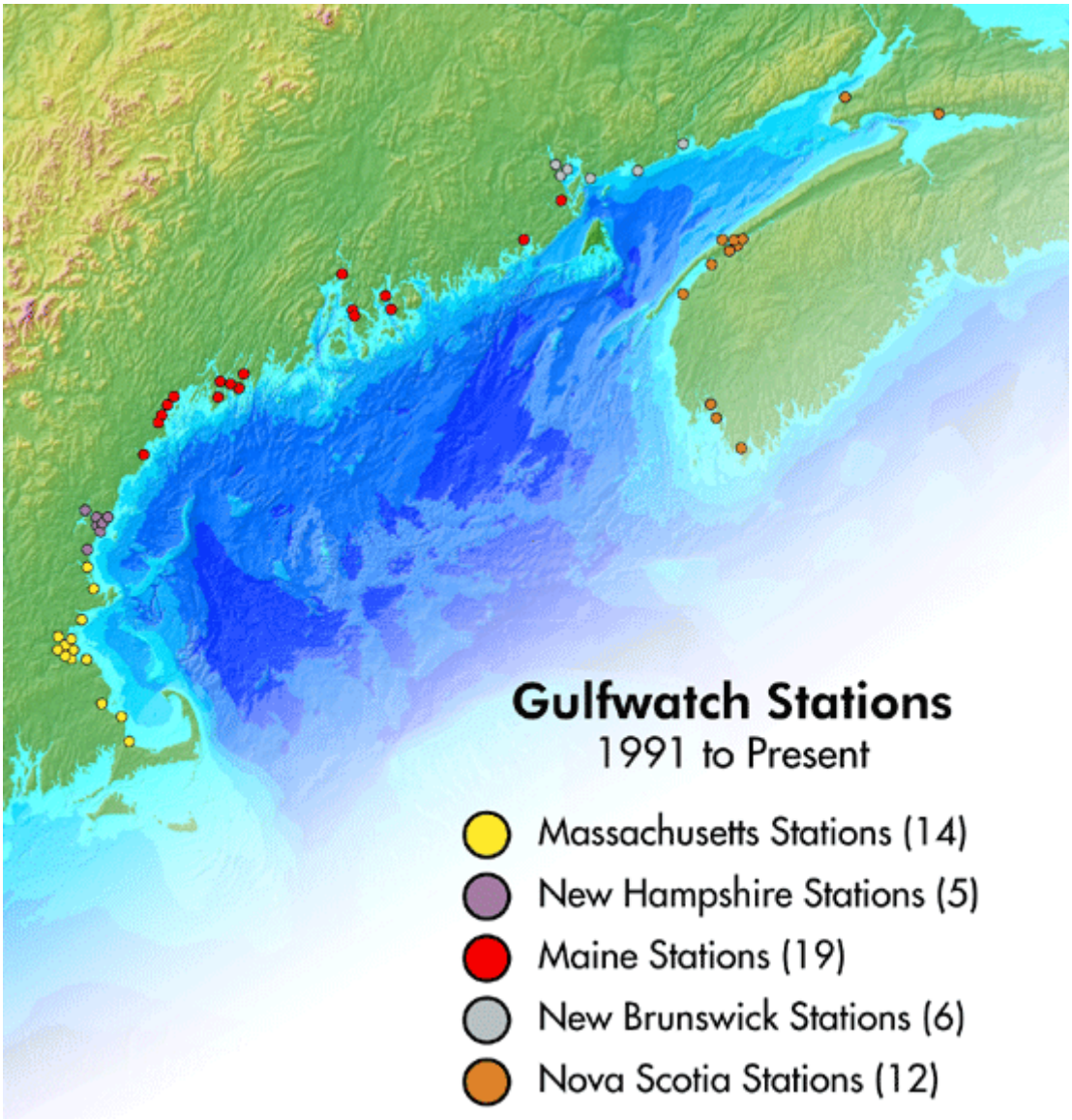

Figure 2: Map of the Gulf of Maine region, including the Bay of Fundy depicting the Gulfwatch sampling locations. In total, there are 14 in Massachusetts (yellow), 15 in New Hampshire (purple), 19 in Maine (Red), six (6) in New Brunswick (grey), and 12 in Nova Scotia (brown). Source: Gulf of Maine Council on the Marine Environment (2014), Gulfwatch Home page (www.gulfofmaine.org/gulfwatch).

1.3. Examining the Use and Influence of Gulfwatch Information

Writers on the subject of the science- policy interface (SPI) tend to be aligned in the position that simply producing scientific information is not enough to ensure its incorporation into policy- and decision-making. The SPI can be defined most simply as a problem where scientific information and advice are not properly incorporated into policy- or decision-making (Lalor and Hickey, 2013). Applied scientists in many fields would agree that the findings they generate should be used to inform policy- and decision-making, but often their results are not utilized in policy. For example, Sutherland *et al*. (2004) found that only 2.4% of conservation management decisions incorporated scientific evidence in the process of decision- making. Findings like this that attempt to quantify the use of scientific information in decision making illustrate the SPI problem, but they also provide some insight into improving the incorporation of scientific evidence into policy- and decision-making.

Different writers suggest different solutions to the SPI problem. The mobilization of information into policy requires more than the "publish or perish" mantra of academia and the research enterprise in general (Rosenberg and Sandifer, 2009). It requires translation into terms and language understandable by the recipients, transfer to relevant individuals in decision-making roles, and needs to be clear in terms of a course of action (McNie, 2007). This is not necessarily the role of scientists, though some authors do endorse the idea that scientists should enter the realm of policy-analysis. Policy analysis is distinctly different from policy advocacy. According to Lackey (2007), policy analysis is "formal assessment of the consequences and implications of the possible options for addressing a policy problem" (pg. 13) while policy advocacy is "active, covert, or inadvertent support of a particular policy or class of policies" (pg. 13). The role of scientists should not be to condone a particular policy or class of polices but

instead to provide "…accurate, relevant, and policy-neutral information…" (Lackey, 2007, pg. 2). The challenge of the SPI is not that there is a scarcity of scientific information, it is that the information that is available in some fields needs to be properly communicated by individuals or organizations that have the ability to span the boundary between science and policy. Scientists can fill this role, but third-party groups that act as "knowledge brokers" can be beneficial (citation).

Plasman (2008) describes the mismatch of science and policy operational timeframes: science tends to be long-ranging and enduring while policy-making operates in tight time frames, often driven by crises. There is a need to reinforce the value of long-term monitoring programs because monitoring programs tend to be proactive and designed to gather more general information and not in response to an immediate threat to the ecosystem. One way to do that is to determine the overall use and influence of such programs to demonstrate their relevance and importance to those who use the information. If a program is found not to be widely acknowledged or used, then serious consideration must be given to either the communication strategy of the program, or its monitoring goals and information outputs, in order to enhance awareness and improve use.

With knowledge of the challenges of the SPI and the methods to improve science communication generally, a question arises: "How can we determine how specific scientific evidence is being used?" It is possible to investigate a research program through determining how a scientific program, such as Gulfwatch, communicates its findings to a policy- and decision-making audience. By establishing how information is communicated, it is then possible to look at the target audience for the information and determine how aware potential users are of

the program, and how they may or may not be using the information. Recommendations can then be made for improving overall awareness and use of the information.

Awareness is simple knowledge of the program, and can vary on a spectrum from knowing the name of the program and general information (i.e. Gulfwatch monitors water quality) to more detailed knowledge about the program's data collection and goals. Use is also defined on a spectrum. Use can be the act of citing a Gulfwatch document as evidence of biomonitoring efforts in the Gulf of Maine region or use can be as in-depth an activity such as using the data and publications to make decisions. Ideally, Gulfwatch information is used for the latter. Use and influence perhaps overlap. Influence is evidence that Gulfwatch information has been used to make decisions or to develop a particular policy or protocol (Nutley *et al.*, 2012).

The GOMC has done several scientific reviews of Gulfwatch, assessing protocols, sampling procedures, and other metrics of project success from a largely scientific standpoint, but never from solely a management perspective. Integrated coastal zone management (ICZM) literature discusses the importance of adaptive management, achieved through rigorous periodic monitoring and evaluation of program goals and achievements, from a management perspective (Kay and Alder, 2005). That is to say, the success of the project in terms of producing high quality scientific data is only one measure of success; adaptive management of the program, its goals, its funding, and its use and influence are also important in developing and maintaining a program that remains relevant through all the years of its life. As a program that has been in place for over 20 years, Gulfwatch is due for a test of this relevance. Is the information that Gulfwatch has been producing being used? How? By whom? Are the methods of disseminating and distributing data effective in maintaining the salience of the project?

The Nova Scotia Department of Fisheries and Aquaculture (NSDFA) initiated this study which aims to develop and apply a methodology to evaluate the overall awareness, use, and influence that Gulfwatch information has had over its lifetime. There is documentation of the Gulfwatch program cataloguing known uses of the data and information (e.g. Jones *et al.*, 1998, Appendix A) but these are dated documents. This study will seek to establish a methodology to study the long-term Gulfwatch monitoring project and test the developed methodology on the GOMC jurisdiction of Nova Scotia. Methodologies used were suggested by the NSDFA and are established by the Environmental Information: Use and Influence (EIUI) research team at Dalhousie University (see www.eiui.ca). Nova Scotia was selected as a case study because of the current research partnership with the NSDFA as well as the location of the researcher. This study examines the outputs of Gulfwatch information, its methods of data and information distribution, and the use of that information over the course of the 20 years of monitoring and assesses the effectiveness of current Gulfwatch data management and distribution. Recommendations will be made as to how, if possible, to improve the distribution and communication of data and information outputs so as to best ensure that the program remains relevant and salient for many years to come. Applications of these recommendations to other monitoring programs, in a general sense, will also be considered.

Chapter 2: Methods

2.1. Citation Analysis

2.1.1. Creating a Gulfwatch Bibliography

A bibliography was compiled of all available documents related to Gulfwatch that were published as well as other outputs (e.g. conference presentations) by Gulfwatch Committee members, persons associated with Gulfwatch, or the GOMC (Appendix B). This was intended to serve as a way of determining the degree of communication about Gulfwatch to the general public, academics, and policy- and decision-makers. Citations of Gulfwatch outputs were compiled through a few different methods. First, the GOMC recently underwent two publication audits, first in 2006 (Cordes et al., 2006) and again in 2014 (Ross et al., 2014). Gulfwatch-related publications (including documents regarding the Gulf of Maine Environmental Quality Program) were identified from those audits. For publications not included in the audits, web searches using Google (*Web* and *Scholar* searches) and *Web of Science* were conducted. Publications about Gulfwatch by Gulfwatch committee members was also incorporated into this list. Individuals were identified through citations of known publications of Gulfwatch material. A total of 37 known publications were used to compile the list of authors and 35 individuals were identified. Each individual was researched using *Google Scholar, Web of Science,* and through researching the individuals' publication lists on personal websites, if available.

To quantify the number of conference presentations, newspaper articles, fact sheets, or other forms of outputs that are not commercially published Gulfwatch information (collectively known as "Grey Literature"), a request was sent to all present members and most past members of the Gulfwatch committee. Many have been quite active communicating Gulfwatch information at scientific conferences and in publications within their respective organizations. In

total, 20 people were contacted but only two responded. A detailed inventory of Peter Wells' (the Canadian Co-Chair of the Gulfwatch Committee and supervisor of this study) expansive library of Gulfwatch-related materials was also done. Numerous fact sheets and conference posters, and presentations (i.e. internal documents of the Gulfwatch program) were discovered in this way that were not available via the web.

Citations were organized according to type of output (Appendix C1) and by year. Comparisons between types of output as well as between five-year blocks of time were performed to determine overall trends of outputs over time.

2.1.2. Analysis of Citations

Citation analysis is a research tool that has been used by the EIUI research initiative in the past, with a high degree of success (see www.eiui.ca). The pre-established protocols for citation analysis were employed in this study. To summarize, the documents that were chosen for citation analysis were researched using *Web of Science's* and *Google Scholar's* citation databases. Both databases were employed to ensure the most comprehensive coverage of citations possible. Cordes *et al.* (2006) has commentary on both of the different databases, their merits, and their limitations.

Only one paper was analyzed for the purposes of this report and was chosen based on it having the highest number of citations: the Chase *et al.* (2001) publication (Appendix B). Many other publications were found to have varying numbers of citations, including some yearly reports of the Gulfwatch program and documents outlining the sampling or processing procedures. However, these papers or technical reports rarely had more than 10 citations and so were omitted from the citation analysis. The Chase *et al*. (2001) paper has over 100 and thus is a better example of the citation analysis methodology.

Citations were extracted from both *Google Scholar* and *Web of Science*, then compared for any overlaps between the two databases. Redundancies were removed and the lists were compiled. The list of citations was then used to describe the number of citations over time since the publication of the Chase *et al.* (2001) paper as well as to determine the most common types of publications that cite the paper (i.e. journal articles, book chapters, graduate theses, etc.). The types of publications were then ordered from most common to least common and inferences about the use of the Chase *et al*. (2001) paper were drawn.

2.2. Tracking the Gulfwatch Website Usage

The Gulfwatch website analysis was accomplished through the use of web server access logs graciously provided by the GOMC webmaster. The GOMC website uses more than one access log software to track data about how individuals use the various aspects of the web-page (e.g. pages visited, files downloads, time spent on specific pages, etc.) The program "*AWStats*" was chosen from the two that were available because it provided full lists of all website data and downloaded files while the other software only provided incomplete lists (Destailleur, n.d.). It is a free access-log analyzing tool that was already set up on the Gulf of Maine Council webpage. Access logs have been collected and retained by *AWStats* since January 2009, providing nearly five years of data. Data captured that are relevant to this study include the pages on the Gulfwatch website that are visited, including the number of visits, as well as the files that have been downloaded by users. Data can be viewed monthly or yearly. The data regarding web pages viewed are available for all five years of archived data, but data on downloads is only available from January 2011 to the present. Unfortunately, the number of unique individuals accessing the

web pages and downloading the online materials was not captured by *AWStats*, but the data that were captured do allow for describing trends in the usage of the online Gulfwatch information.

For the purposes of this study, data on file downloads specifically pertaining to Gulfwatch were captured as yearly totals for the years 2011-2013 inclusive. For web pages visits, the data were captured as yearly totals for the years 2009-2013 inclusive. The year 2014 is excluded because it is not yet complete and therefore would not be directly comparable to datasets encompassing the previous years' full complement of data.

2.2.1. Analysis of Website Data

The file download data were organized to better capture the usage of the raw data files (Appendix C2). The Gulfwatch website offers raw data as downloadable text, excel, and HTML files for users to access. Data on all the different types of data (PCBs, PAHs, metals, and pesticides) are available for each year from 1991 to 2000, inclusive. To gauge the interest in the different types of data (metals, PCBs, PAHs, or pesticides), the number of downloads of all like-types (e.g. all metals) of data were aggregated to show overall interest in the type of data, rather than specific files of interest (i.e. all metals rather than solely "metals 1995"). Because there are six different ways to access each individual file type for each year of data available, all similar entries were aggregated. For example, metals data from 1996 are available as three different file types from two separate data repositories on the GOMC website. All six locations were aggregated into "metals total" to give an indication of the total number of downloads of raw metal data, rather than individual years or file-types. The rationale behind this approach is that the trends of usage over time should still be apparent even though the files-types have been combined for each of the four types of data (metals, PAHs, PCBs, and pesticides). Although it is

possible that the same individuals are accessing all six data sources (i.e. hypertext markup language [HTML], excel, and text files from two separate locations on the Gulfwatch website) and multiple single-year captures of data, the indication of demand for that particular type of data is still apparent. Similarly, page visit data were also condensed into six different categories (Appendix C2). For both file download and webpage visit data sets, data were analyzed for the total number per year as well as the proportion of each category of file or page in each year. A linear regression analysis was performed on both file download and page view total numbers for each year class captured. This was performed using Microsoft Excel Data Analysis program extension. A Chi-Square test was performed on the proportion of file categories and the proportion of webpage categories between each of the year classes was captured. This test was performed using the free online Quantpsy tool (Preacher, 2014, quantpsy.org).

2.3. Interviews

2.3.1 Choosing and Inviting Interview Participants

The interview aspect of this study focussed only on Nova Scotia Gulfwatch sub-committee members and potential end users. The rationale behind the limitation in scope was 1) to perform a robust analysis of one of the five GOMC jurisdictions rather than a surface-level analysis of two or more jurisdictions and 2) to implement the developed methodology on a trial basis to determine the efficacy of the developed method. In doing so, any inconsistencies, contingencies, or methodological challenges could be identified and addressed before spending time and effort performing a holistic analysis of the entire Gulf of Maine region. Ethics approval from Dalhousie University Faculty of management was obtained for this aspect of research methodology (Appendix D).

Current and past Gulfwatch members, with the exception of Peter Wells (to avoid bias), were interviewed as a means of understanding some of the ways in which Gulfwatch information was distributed or dispersed to potential end users, as well as to discuss potential enablers and barriers to production of Gulfwatch data and publications. Seven current and past Gulfwatch sub-committee members from Nova Scotia were contacted and four were interviewed.

Potential end users were identified in a number of ways. In some cases, there were suggestions of individuals by the supervisors of this project. In other instances, there was anecdotal evidence (Gulfwatch Contaminant Monitoring Sub-Committee, 2014) to suggest that certain organizations or groups were making use of Gulfwatch information. Names and contact information of individuals within these groups were sought out and those individuals were invited to participate in the research. Finally, some individuals were chosen because it could be reasonably assumed that they would use Gulfwatch data. Examples of these types of individuals include fish packing organizations along the South West shore of Nova Scotia, directors of Nova Scotia government districts that lie along the Gulf of Maine or Bay of Fundy, individuals responsible for food safety and security, especially regarding seafood, federal government departments responsible for shellfish harvesting and safety, and government departments interested in ecosystem health. In all instances, it was assumed that each individual or the organization that they were a part of could benefit from the type of data collected by Gulfwatch. In total, thirty individuals were contacted, sixteen replied, and nine were interviewed. Of the nine that were interviewed, six were individuals that worked for either Federal or Provincial departments located within Nova Scotia and three were individuals who worked for industry.

2.3.2. Interview Procedures

Interview participants were asked a series of questions (Appendix E) related to their job responsibilities, their awareness of Gulfwatch, and their use of Gulfwatch information. Gulfwatch Committee member participants were also asked to identify intended users for Gulfwatch information and if they could identify specific users. Finally, they were also asked whether or not Gulfwatch information is used in the organizations they are involved with outside of the Gulfwatch Committee.

In all cases, the use of the word "information" was explained to ensure that all participants understood it to encompass all aspects of Gulfwatch outputs: presentations, published journal articles, the website, raw data, etc. Participants were also asked to add their own thoughts about the Gulfwatch program.

Those participants who agreed were audio recorded and the audio files were transcribed into text following the interview. For those participants who did not want to be recorded, notes were taken of their responses and a transcript of the interview was composed immediately after the interview took place. In all cases, participants were assigned a participant number that was used to describe their responses, and protect their identities.

2.3.3. Analysis of interview data

Interview results were analyzed using established qualitative data analysis methods. As described in the analysis protocol by Green *et al.* (2007), interviews were thematically analyzed through the four step procedure of immersion in the data, coding the data, creating categories based on the codes, and finally by establishing themes. Immersion was achieved through transcribing and reading the interviews. Coding involved summarizing and labelling the data,

collapsing the codes into specific concepts, and then aggregating the concepts into overall themes. For example, if many participants referenced the mandate of their particular organization (e.g. "we aren't concerned with chemicals, that is a Canadian Food Inspection Agency (CFIA) issue) that would be coded as "Department of Fisheries and Oceans (DFO) mandate" or "CFIA mandate" and the overall category would be "Departmental Mandates" and falls into the overall theme of "barriers to research use" (Appendix C3). Ideally, themes should be linked to social theory to be able to determine an overall explanation for the patterns derived from the responses of participants (Green *et al.*, 2007). In this case, the theme of overall research use and the indicators, enablers and barriers are based upon the continuum of research use framework put forward by Nutley *et al.* (2012, p. 51). This framework of research use was used to explain the trends in awareness and use of Gulfwatch information in Nova Scotia.

Chapter 3: Results

3.1. Raising Awareness of the Gulfwatch Program: Gulfwatch Outputs Results

3.1.1. Gulfwatch outreach through publication or presentations.

In the list of outputs that was compiled to indicate the breadth of outreach of the Gulfwatch program, there were 161 citations. Of those, there are 132 complete citations. The majority of "incomplete citations" are conference talks from Gulfwatch reports but where no presentation title or presenting author could be discerned; other incomplete citations include internal working group or Gulfwatch subcommittee meeting documents that are not publically available but are otherwise known (Dr. Peter Wells, personal communication, October 2014). Of the total outputs, certain types of outputs that more common than others (Table 2). Conference presentations are the most common output with at least 44 outputs, combining all conference-related outputs (proceedings, published abstracts, and paper or poster presentations). There are an additional 20 conference presentations with incomplete records and no date not included in these results (Appendix B). Technical reports are the second highest output type with 35 known publications. The highest production years of Gulfwatch communication are 2001-2005 with 48 total outputs. The lowest output years are 2011- present with 12 total outputs (Table 2; Figure 3).

Table 2: The number of each publication type per each year class of the Gulfwatch program's life. Year classes are the same five equal segments of five years each, as per Figure 3.

	1990-95	1996-2000	2001-05	2006-10	2011-Present	Total
Abstracts of Talks (Published)	0	5	6	0	0	**11**
Book Chapter	0	0	2	0	0	**2**
Briefing Note	0	1	1	0	0	**2**
Conference Proceedings	1	1	5	1	0	**8**
Fact Sheet	0	2	3	0	0	**5**
Internal Documents	10	1	4	0	2	**17**
Journal Article	1	1	2	0	2	**6**
Paper/Poster Presentation	1	10	10	3	1	**25**
Technical Report	7	11	8	5	4	**35**
Thesis	0	1	2	1	0	**4**
Other	2	1	5	6	3	**17**
Totals	22	34	48	16	12	**132**

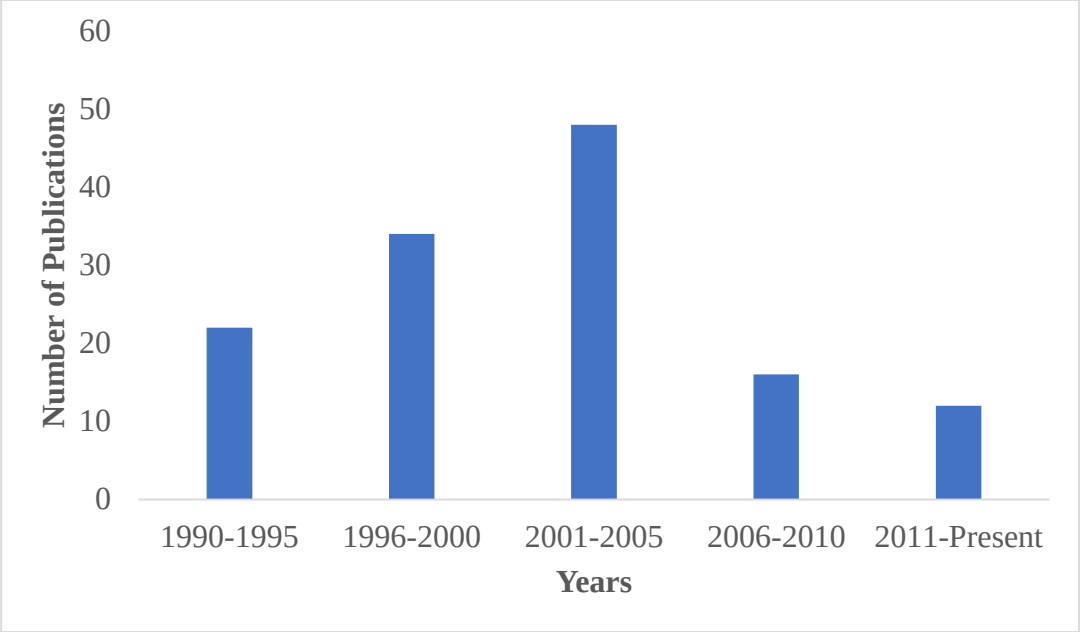

Figure 3: A visual representation of the number of total outputs by the Gulfwatch program over time. The 24 years of the Gulfwatch program have been subdivided into five equal segments representing five years each, except for 2011-present which only represents four years.

3.1.2. Analyzing citations of Chase *et al.* (2001).

As of October 2014, 123 documents cite the Chase *et al.* (2001) paper. 121 were found using Google Scholar and two were found using Web of Science. Of those documents, 16 had no recognizable publisher. The 107 that do have a recognizable publisher can be found in 52 different publishing sources, mostly comprised of scientific journals. The top 10 of these publishing sources contain 53% (53 of 100) of all the citing documents (Table 3).

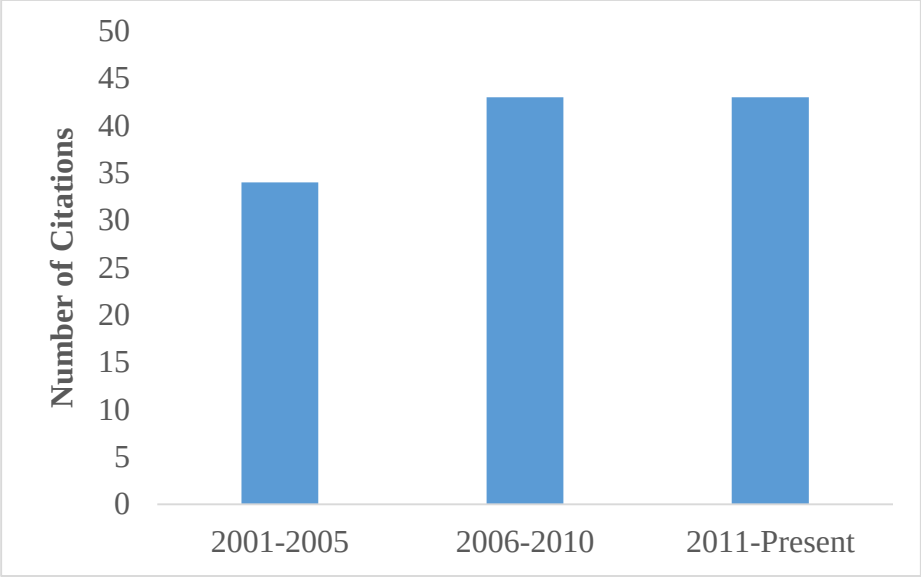

Figure 4: Chase *et al.* (2001) citations over time. Years are broken into five-year segments.

Table 3: Showing the top 10 publishers of publications that cited the Chase *et al.* (2001) paper.

Publisher	Number of Publications
Marine Pollution Bulletin	15
Chemosphere	6
Environmental Monitoring and Assessment	6
Theses (Various Universities)	5
Environmental International	4
Environmental Pollution	4
Environmental Science and Pollution Research	4
Aquatic Toxicology	3
Ecotoxicology and Environmental Safety	3
Marine Chemistry	3

3.2. Identifying Uses of Gulfwatch Information over Time: Website Use

3.2.1. File downloads

There is a visual trend of increasing file downloads over the three years of data collected, however this trend is not statistically significant (R^2= 0.9531, p=0.09; Figure 5, 6). There proportion of file types downloaded by users in each year (2011-2013) is not significantly different (X^2_8=2.788, p=0.999; Figure 6b-d).

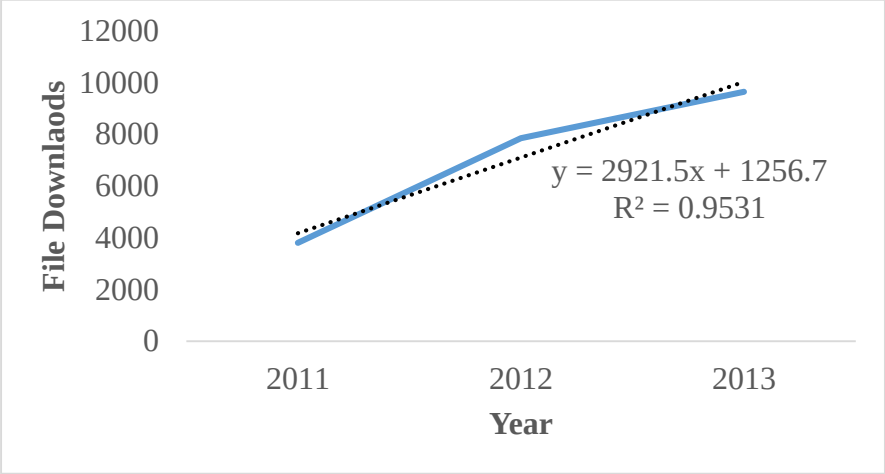

Figure 5: The number of file downloads from the Gulf of Maine Council on the Marine Environment website related to Gulfwatch. Line of best fit with equation and R^2 value are also shown.

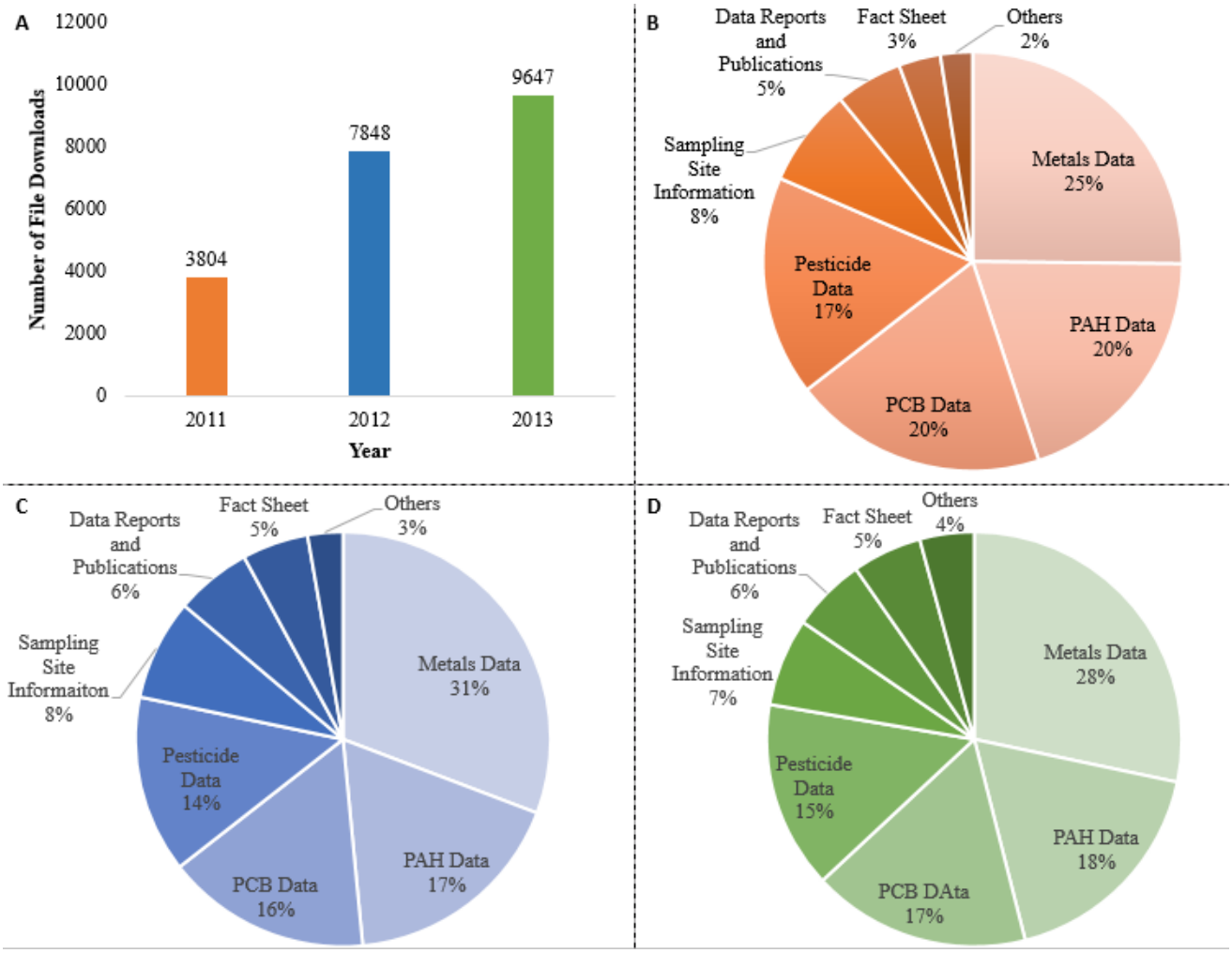

Figure 6: Analysis of filde downloads; *a*) Total file downloads for the Gulfwatch website for the years 2011, 2012, and 2013. *b)* proportion of file types in the year 2011, *c)* proportion of file types in the year 2012, *d)* proportion of file types in the year 2012.

3.2.2. Page Views

There is not a significant trend of increase or decrease in page views related to Gulfwatch on the Gulf of Maine Council on the Marine Environment website (R^2= 0.127, p=0.43; Figure 7). There is a statistically significant difference of page views between years (X^5_6=71.412, p<0.001; Figure 8).

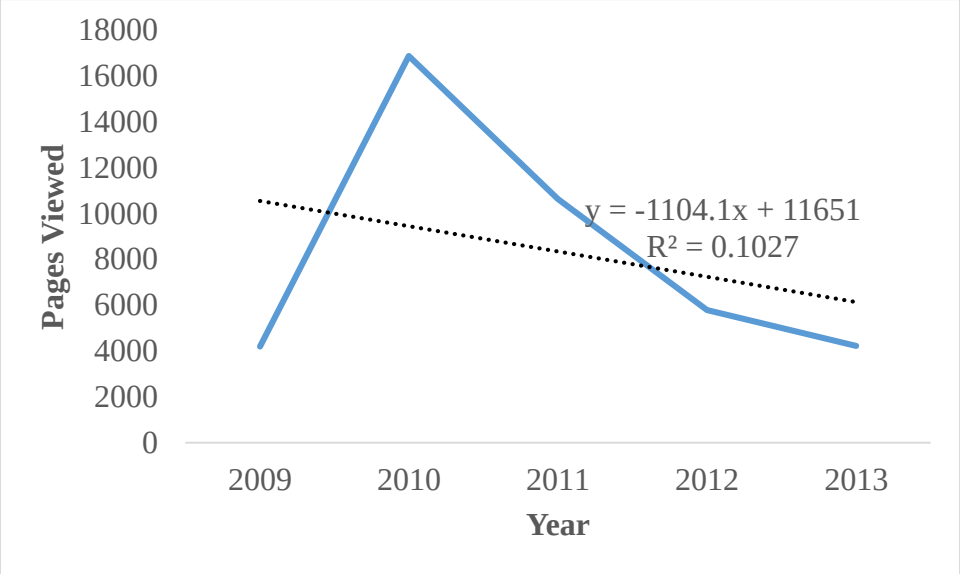

Figure 7: The number of webpages viewed on the Gulf of Maine Council on the Marine Environment related to the Gulfwatch program. Line of best fit with equation and R^2 vale are also shown.

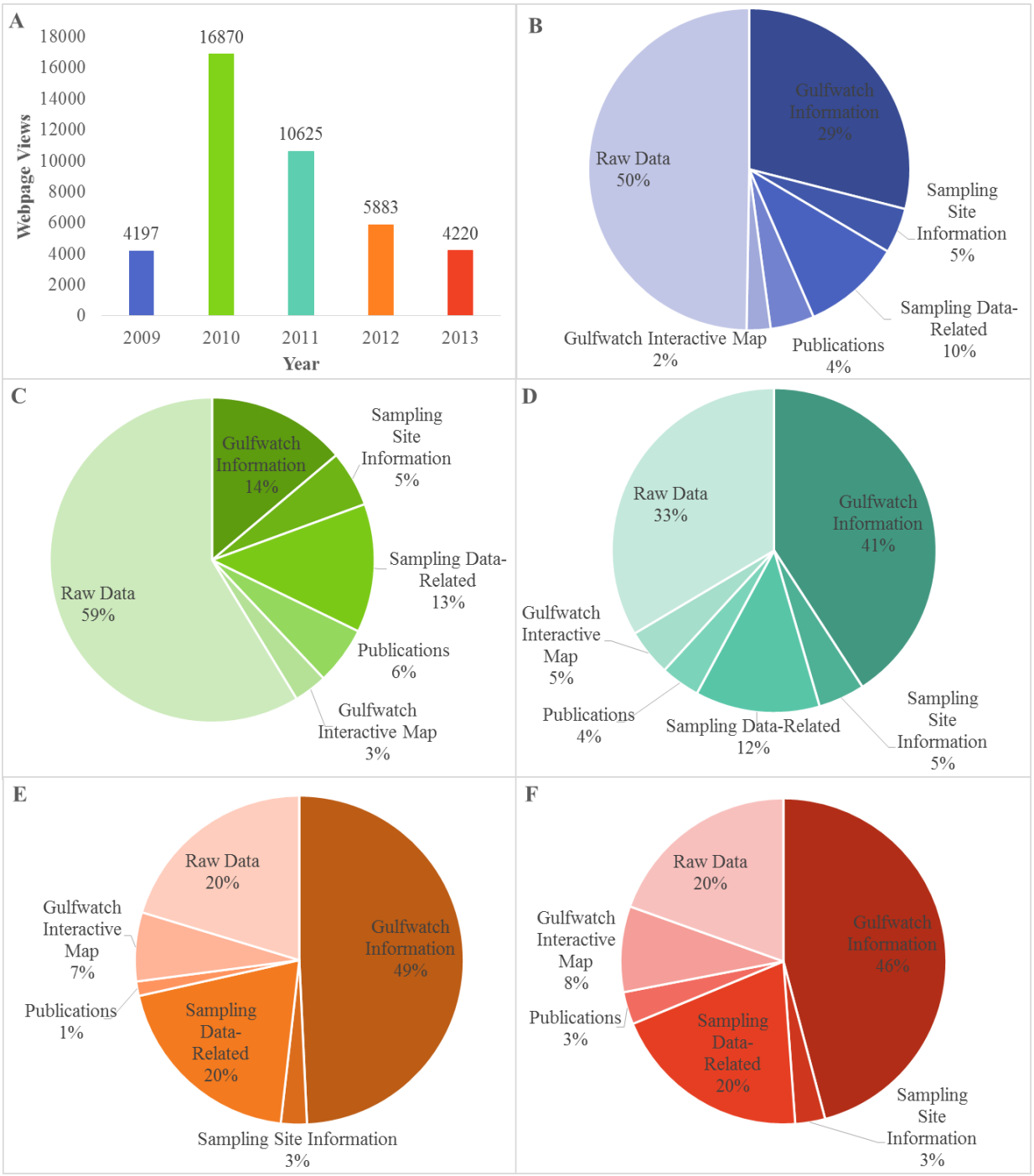

Figure 8: Analysis of webpage views; *a)* Total number of webpage views per year from 2009 to 2013; *b)* the proportion of webpage categories for 2009; *c)* the proportion of views per webpage category in 2010; *d)* the proportion of views per webpage category in 2011; *e)* the proportion of webpage categories for 2012; *f)* the proportion of views per webpage category in 2013.

3.3 Use and Influence of Gulfwatch in Nova Scotia: Interview Results

3.3.1. Demographics of Participants

In total, 30 people were contacted, 23 replied, and 13 were interviewed (Table 4). Some of those participants who replied but were not interviewed still provided some information of their awareness or use of the Gulfwatch program; these results are included in the data set. Of course, the data are limited only to indications of general awareness and there are no further data available to suggest why these individuals were unaware of the program or did not use Gulfwatch data. Participants who replied but were not interviewed were from the CFIA, one environmental non-governmental organization (ENGO), and an employee of the Nova Scotia provincial government department associated with shellfish-related activities. Of those who were interviewed, many were directly involved with the Canadian Shellfish Sanitation Program (CSSP) either through classifying areas for harvest, enforcing closures, or through issuing licenses or leases in open areas. Other individuals were involved with managing overall ecosystem health. All three industry participants' work in the seafood processing industry and the organizations ranged from small whole-sale operations to larger scale vertically integrated operations that harvest, process, and sell products.

Table 4: The recruitment and participation of individuals for interviews. If indicated in parentheses, one or more of the participants interviewed were current or past members of the Gulfwatch committee. Asterisks (*) indicate that there was an individual who responded to a request for an interview with some indication of awareness or use, but did not agree to be interviewed in full. In those cases, the individuals are not counted in the "Individuals interviewed" tally, but are denoted by the asterisk to indicate the organizational association of some of the individual responses regarding awareness of the Gulfwatch program.

Organization	**Individuals contacted**	**Individuals who replied**	**Individuals interviewed**
Department of Fisheries and Oceans (DFO)	5	5	5 (1 GW)
Canadian Food Inspection Agency (CFIA)	4	3	0 *
Environment Canada (EC)	3	3	1 *
Health Canada	1	1	1 (GW)
Nova Scotia Department of the Environment or Fisheries and Aquaculture (NSDFA)	10	7	3 * (2 GW)
Industry (ENGOs and Fish Processing Companies)	8	4	3 *
Totals	30	23	13

3.3.2. Awareness of the Gulfwatch program among interview participants

Only 40% (6 of 15) of respondents indicated that they were aware of the program, including one participant who was not interviewed but indicated his lack of awareness when he responded to the interview invitation. This, of course, excludes the members of the Gulfwatch Committee who are obviously aware of the program. Of the five who were aware and interviewed 60% (3 of 5) were confident that they were aware of the goals and mandate of the Gulfwatch program. All six participants who are aware seem to have become aware through their association either with the Gulf of Maine Council on the Marine Environment directly, or through colleagues who are involved in the GOMC. For example, one individual who works for a branch of DFO that is heavily involved with Gulf of Maine Council activities stated:

> My group, we basically have roles and responsibilities related to intergovernmental stakeholder engagement and that, so that's how we have been involved with the Gulf of Maine Council. So I became aware there. But prior to my role here at DFO, I don't recall being aware of it, I know it was been going on for some time. I even did some of my graduate research in the Gulf of Maine, [though not related to water-quality issues]. I would say my knowledge of it is based on my role here and based on the work that the people in my group do that have a more direct role [in the Gulf of Maine Council] (EU3).

Of industry participants, none of the four respondents from industry indicated awareness of Gulfwatch at all, but one participant expressed surprise at his ignorance:

> I wasn't [aware], which surprised me because I consider myself pretty educated in a lot of what is going on in the ecosystem, the science of the ecosystem… It's funny, I guess, my ignorance. I know that in a lot of species that we handle, that mercury contamination or

> heavy metals we are occasionally faced with or asked about [by customers in other countries], but I wasn't familiar [with Gulfwatch] (EU8).

3.3.3. Use of Gulfwatch information as shown by interview participants

In total, of the six participants who indicated awareness and the four participants associated with the Gulfwatch program, 60% (6 of 10) indicated some knowledge of use either by others in their departments or their own personal use. Only 40 % (4 of 10) cited specific instances of direct use of the Gulfwatch information; three participants indicated that Gulfwatch information was used directly in Gulf of Maine Council projects such as the State of the Gulf of Maine Report or the ESIP Fact Sheet (it was not specified which fact sheet), but these documents are not specific to Nova Scotia. The fourth participant who indicated use of the information stated that prior to his/her retirement, colleagues interested in chemical contaminant research would ask for information about the program but he/she did note that chemical monitoring and research within his/her department was no longer a priority. Many of the participants indicated that they thought the information must be used either by their staff or by others in government, but no participant was able to cite examples with any degree of certainty that indicated use within Nova Scotia:

> "I would say yes, my staff do use the information. I don't personally, but I would say that some of my staff do. I would have a hard job, other than the State of the Gulf of Maine report which I know referenced it, to quote examples but I think that over time we probably have used some of their stuff just looking at long term trends or dealing with the Gulf…but I would be hard pressed to cite specific examples" (EU5).

One example of a potential use was a Marine Protected Area located in the Gulf of Maine region that may have used Gulfwatch data or methodology to develop a monitoring protocol for the MPA as indicated by three of the participants, all associated with DFO.

In total, 54% (7 of 13) of interviewed participants indicated personal use of the material for their role within the Gulf of Maine Council (including Gulfwatch), using the website or communication with GOMC colleagues to obtain information. Only participants involved in some capacity with the GOMC, either with the Gulfwatch sub-committee or other committees, seek out reports or have a casual interest in the Gulfwatch program. Participants indicated that they look at the Gulfwatch information only for their roles within the GOMC but do not use it directly as part of their full-time positions within government. This includes Gulfwatch committee members who did not indicate that they use Gulfwatch information for their government positions. When asked why they participated in the program if they were not making use of the information, participants explained that they were asked by colleagues or superiors to become involved in the program.

Finally, one Gulfwatch committee participant indicated that, in their experience working for the program, it was clear that the information was used in other jurisdictions because individuals within those jurisdictions contacted them regarding Gulfwatch. Specific reference was made that the State of New Hampshire definitely uses Gulfwatch information but that no one in Nova Scotia had ever contacted him/her regarding the program. This participant freely provided information regarding methodology and the existence of the program to those individuals that he/she thought could make use of the data. The other three Gulfwatch committee participants indicated that they only provided information when asked about it but this tended to

be limited to explaining the program goals and monitoring activities, rather than providing actual data or information to be used by inquirers.

Overall, interviews of potential users and of Gulfwatch committee members indicated that awareness and use are not prevalent in Nova Scotia. There are few known recorded uses of Gulfwatch information to inform water quality management, shellfish harvesting, or aquaculture within Nova Scotia.

3.3.4. Enablers and Barriers to use of Gulfwatch information

3.3.4.1. Barriers

The most common barrier to use as cited by participants is that chemical monitoring is not in the mandate of most government jurisdictions. In total, 77% of participants (10 out of 13) indicated that chemical monitoring in the marine environment was not part of their organization's mandate or that the lack of monitoring is due to their departmental mandate. Of that 77%, 90% (9 of 10) work for either federal or provincial department like DFO or the NSDFA. The other 10% (1 of 10) was a representative from industry who noted that budget cuts to DFO resulted in much of the responsibility to be aware of emerging issue in the environment has been downloaded to industry. Other participants within the federal government corroborated this position by stating that "DFO has decided to cut all contaminant research due to funding cuts, so it is not a concern anymore, really" (GW4). The general sentiment is that water quality belongs to a different department. For example:

> "Well, and I think too that water quality and sediment quality and biota quality tends to fall between the cracks. Different departments have different interests and CFIA and DFO and EC all have their own responsibilities. I think that because it is so divided, it is

> a difficult one to pin down. People say that one program should be doing this, another one should be doing that, it seems to be challenging to coordinate. Of course, DFO has a strong interest in that, but deciding who does what and who is more proactive in a way seems to be very challenging" (EU4).

Most participants, when discussing mandates as a barrier to use, stated that the CFIA is the organization that is responsible for chemical contaminants in seafood (including shellfish) but none of the three CFIA individuals who responded to a request for an interview had any knowledge of the Gulfwatch program.

Other known barriers to use include lack of awareness of the Gulfwatch program, inability of potential users to comprehend or digest Gulfwatch information, and a general overload of information. Lack of awareness was cited by 23% (3 out of 13) of participants as being a barrier to use. An industry participant suggested that the information may be valuable but "I've never been made aware of it" (EU7) and a Gulfwatch committee member indicated that Gulfwatch "does not have an outreach section anymore" (GW2). The usability of the information in terms of comprehension or digestibility were cited by 15% (2 out of 13) of participants. A federal government user who is also involved with the GOMC suggested that "Gulfwatch may not be in a format that, in its current state, is a value to people" (EU5). An industry participant indicated that "people aren't necessarily knowledgeable, if you don't have a science background you're not going to get anything out of it" (EU9). Finally, information overload was mentioned by 23% (3 out of 13) of participants, without necessarily being asked specifically about potential barriers to use. All three indicated that the large volume of information available and the high demands on time would deter potential users from actively seeking out more information.

Seven participants answered questions related to the timeliness of data. They were aware that Gulfwatch annual data reports have been delayed in recent years due to lack of funding. They were asked if they thought that this backlog would affect use of the information. Of the seven participants who answered this question: 14% (1 of 7) were unsure; 57% (4 of 7) indicated that, because Gulfwatch provides a long term data set with good baseline trends, data being backlogged was not an insurmountable problem; 14% (1 of 7) indicated that it would be a personal judgement whether or not the timeliness of the data was an issue; and 14% (1 of 7) indicated that the backlog was unavoidable because of funding problems. In general, participants agreed that, for situations where a drastic change was occurring in the marine environment, information would need to be very current to be of use; however, for baseline trend comparisons, the strength of the Gulfwatch program was its long-term data set and data did not necessarily need to be immediately available.

3.3.4.2. Enablers

A potential enabler to use of Gulfwatch information is the inherent value of the program through providing one indicator of toxic contaminant levels in marine organisms in the Gulf of Maine. Several participants indicated, without being asked directly, what they felt was the value of the Gulfwatch program. In total 77% (10 of 13) of participants provided an opinion on the value of Gulfwatch. Only 10% (1 of 10) of participants indicated that the program was not valuable, stating that he had heard of Gulfwatch previously but that in recent years the program, as far as he understood "was pretty dead" (EU1). Another participant questioned the value of continuing the project just for the sake of continuing if it is not clear how the information is being used. However, the other 80% of participants who gave an opinion on the value of the

program stated “we need to protect these long time series” (EU3) and that “long-term data looking at indicators of ecosystem health are helpful” (EU5). Another user suggested that Gulfwatch and similar monitoring programs were filling gaps left by Government mandates. Three participants also indicated that, now that the interview process had made them aware of the program, that they could use the benefit from the information and its potential application to their own work. This was an especially common sentiment among industry participants. Other than two dissenting voices, the majority of participants felt that the Gulfwatch program was a value because of its long-term nature and the ability to use the long time series to discern trends from the data.

3.3.5. Improving the awareness and use of Gulfwatch information

3.3.5.1. Potential uses of Gulfwatch

A potential use of Gulfwatch information is to tie the program into the prospective re-shifting of legislated responsibility to better cover chemical contaminants in government-led monitoring. One participant stated: “DFO did that for a long time, sediment chemists, water chemists, but they decided that it is not DFO’s legislated responsibility. So it was decided that it should be done by departments whose legislated responsibility it is” (EU4). Two participants, one involved with EC and the other with the NSDFA, indicated that there seems to be talk within the CSSP about who is responsible for chemical monitoring. As participants explained: at this time, EC monitors potential shellfish “growing areas” for bacteriological contamination and recommends to DFO that an area be open or closed. DFO then enforces the closures for areas. The province is then responsible to some extent for issuing leases within the open areas for things like aquaculture. The CFIA then monitors chemicals in meat using the recommended

health guidelines put forward by Health Canada. All the agencies involved in this process rely on the other agencies for information and indicate that they do their own monitoring for contaminants within their mandates. Both participants who discussed a potential shift in mandate indicated that chemical contamination such as metals may be included in the mandates of the province or EC (EU1 and EU2).

Participants indicated that use of Gulfwatch information as baseline information to inform users of trends, the sampling methodology, and a few more specific applications are all potential applications of the data. In total, 38% (5 of 13) of participants indicated that use of Gulfwatch's long time series would be beneficial to their operations. This was especially evident among industry participants who all indicated that baseline data and the ability to determine trends would be very useful to them in making decisions regarding purchasing fish products or in helping them communicate with foreign markets concerned with issues such as metal contamination. "It is important for us to be on top of things that are out there… I would like to see if a trend is coming in" (EU9).

Regarding the use of methodology, 15% (2 of 13) of participants indicated that the Gulfwatch methodology could be adapted for use within monitoring activities already performed within their respective agencies. Both of these participants were involved in either the federal or provincial government. Other specific examples of potential applications of the Gulfwatch program emerged over the course of the interviews. Several participants suggested a myriad of potential applications. For example, Gulfwatch information could be used more directly to help planning and decision-making in the soft-shell clam industry as well as other fisheries in the Gulf of Maine. As a long-term data set, Gulfwatch data can serve as a general indicator in overall ecosystem health. Participants also indicated that the Gulfwatch data should be incorporated into

the CSSP programs, a logical application of shellfish contamination data. One participant noted that the Gulfwatch data could be useful in managing oil-spill responses to determine when fisheries are safe to re-open in the event of oil-related closures. Gulfwatch data could also be incorporated into the Environmental Health Index study being conducted by BoFEP for the Bay of Fundy. Finally, one participant suggested that the data could be used by graduate or undergraduate students at any of the multitude of universities in the five GOMC jurisdictions. This would be a way of both raising awareness of Gulfwatch and improving the use. As this participant aptly put it: "Use the data, it's there" (GW3).

3.3.5.2. Ways to improve use of Gulfwatch data and information

Participants were also asked to indicate how information use could be improved. It was mentioned by 30% (4 of 13) of participants that they were unaware of the program before and that they would look into it as a result the interview process. Several other participants also indicated that improving awareness was the biggest challenge and the most important step to improving overall use. In total, 38% (5 of 13) suggested targeted awareness-raising campaigns aimed at bringing, not only the existence of the program to potential users' attention, but also how the program could be relevant to their activities. "It's going to need to be reinforced to individuals and organizations that would use the data and use the information and be more targeted than, you know, just to be out there [for people to find on their own]" (GW5). One exception to this is a Gulfwatch committee participant who argued that the current means of communicating Gulfwatch information are sufficient. Another Gulfwatch committee member indicated that increasing conference talks or other presentations to potential users would be a good place to start improving awareness. His caveat was that demonstrating potential

applications of the data and information to potential users would be essential. Two industry participants indicated that, though they liked being aware of the information, they would like to see DFO or other related federal departments using the information and interpreting the trends and then providing guidance to the fishing industry. The reason for this is that potential users within industry may not have the scientific expertise to be able to confidently interpret the available data.

Chapter 4: Discussion

4.1. Efficacy of Research Methodology

In general, the methodology employed in this study provided a good measure of the awareness and use of Gulfwatch information in all five jurisdictions and in Nova Scotia in particular. Once the method is expanded to include all five jurisdictions of the GOMC, rather than only Nova Scotia, then more robust conclusions may be drawn. For now, a discussion will be presented on the challenges of the methodology that need to be resolved before its further application to the other jurisdictions of the GOM.

One common issue through the interview process was that some individuals who were not aware, or stated awareness but no use of Gulfwatch information, did not feel that they could contribute to the data collection and thus declined the interview. In these instances, the data layer of general use or awareness was captured but offered little in the way of informing the deeper question of "why were the data not used" and "why was the individual not aware?". When this happened, an attempt was made to assure the individual that their participation would still be valuable and that an interview was still desired. However, in some cases this did not sway the individual's position. Unfortunately, though some data were still collected in this manner, it did little to inform the sub-questions of this study. In many instances, the individual would offer to put the researcher in touch with others who may have been able to provide more information; however, this may have introduced some unintended bias into the sample selection and certainly limited the amount of data to analyze regarding patterns of awareness and use.

Another challenge in data collection arose when attempting to quantify the distribution of Gulfwatch data and information over the life of the program. Gulfwatch committee members, past and present, were contacted to help inform this aspect of data collection, but very few of

them replied. Furthermore, documents related to GOMC Working Group meetings are available online dating back only to 2011. Some Gulfwatch sub-committee meeting minutes were provided by Peter Wells, but this was not a comprehensive list. These documents are not readily available online, but are available from the co-chairs. The methods that were employed (web searches, document inventories, and relying on previous publication audits) provided many examples of outputs from existing Gulfwatch literature, documenting items such as conference posters or presentations. However a more complete overview of the breadth of awareness-raising undertaken by the Gulfwatch program over its lifetime could be accomplished with more input from Gulfwatch committee members and GOMC Working Group members. It is challenging with a program that has been operating for over 20 years because it is likely that many of the presentations or other output types are not captured in internet databases, or other sources, from the very early years of the project. Also, many individuals involved in the project in the early years are no longer involved or may not be available to provide documentation of outputs. In more recent years, it is common to find conference proceedings or agendas that list paper titles and authors and it is much easier to find instances where this has occurred, such as in the Working Group meeting minutes that are available or in some of the Gulfwatch annual reports that are available online.

Finally, though response rate and the number of interviews collected were adequate given that this was a test of methodology, the individuals who responded did not provide a sufficient representation of potential Nova Scotia users. No individual from CFIA provided an in-depth interview, and far fewer industry participants replied than was hoped. Other notable gaps in data are the few interviews conducted with Nova Scotia Fisheries and Aquaculture or Department of the Environment employees who are not directly associated with Gulfwatch, despite contacting

many individuals for an interview. Finally, individuals who did respond either from EC or DFO were clustered into similar branches and the breadth of investigation into all the various branches of these departments that could employ water quality information in their programs was not achieved. Again, this was due to limited response rates of contacted participants. One possible explanation for the gaps in data is that participants who were previously aware of the program recognized the name and consented to an interview or were prompted by individuals who were engaged with the GOMC to participate. This potentially resulted in unintended bias and is a limitation of this methodology.

4.2. Use and Influence of Gulfwatch Information

4.2.1. Overall Use and Influence

The overall output of technical reports, conference talks, fact sheets, and other forms of publications or outreach indicate that the Gulfwatch committee has been actively attempting to report on the program and its findings. The various forms of conference presentations seem to be the most common form of output, though it is possible that the list of publications is incomplete as some publications may not be readily available through web searches. The most prolific years of output were from 2001-2005. Lack of funding and participation of government employees in recent years is attributed to the decline in published output since 2005 (Peter Wells, personal communication, October 2014), although limited funding has been an issue since the advent of the program in 1991 (Tripp and Bothner, 1997).

Chase *et al.* (2001) citations illustrate that papers of this kind are mostly used by scientific researchers. The majority of citations are found in academic journals or graduate theses, indicating that use of the paper was mostly limited to other scientists and not to managers

or decision-makers. However, there was one example of a paper cited in a management journal: a 2002 paper published in Ocean and Coastal Management[1]. As a scientific paper itself, the expected use of the Chase *et al.* (2001) paper is by other scientists or those with continued access to the published peer-reviewed scientific literature. Furthermore, studies investigating the use of this literature by policy- and decision-makers has been found to be quite low, either from lack of access to academic resources, though challenges imposed by time constraints, or through the lack of comprehension of such materials (Jacobson *et al*., 2013). Therefore, the predominant use of Gulfwatch's most-cited scientific paper by other scientists is not a surprising finding, but it does illustrate the need to perhaps communicate research findings in other ways as well, in order to capture the attention of policy- and decision-makers. Even though five fact sheets have been published with the intention of communicating Gulfwatch findings to a policy audience, there is little indication that the information has been assimilated into Nova Scotian coastal policy. This ultimately indicates that new avenues of information transfer are necessary.

Though the webpage and data download analyses do not provide insight into the number of individual users or their organizational associations, they do provide concrete evidence that the program is being sought out for information related to water quality in the Gulf of Maine. The analysis of use of the website over time provided inconclusive results. There is a significant increase in data downloads from 2010 to 2013, but there is no such increase for webpage views. In fact, the highest number of webpage views was in 2010 and then generally decreased subsequently. One possible explanation for this is the BP oil spill in 2010 in the Gulf of Mexico that sparked mounting concern for shellfish contamination by PAHs, a major component of oil (Peter Wells, personal communication, November, 2014). Furthermore, because it is not possible

[1] Strain, P. M., & Macdonald, R. W. (2002). Design and implementation of a program to monitor ocean health. Ocean & coastal management, 45(6), 325-355.

to identify numbers of individual users, it is impossible to determine if the use of the webpage resources is by scientists, the general public, managers, government staff, or any other potential users. The lack of information about the demographics of web-users poses a challenge when trying to suggest ways to improve overall use of web resources and Gulfwatch products. It is possible to say, however, that file download patterns were statistically the same for all three years of data collection, with raw metals data being the most popularin all three years. One interview participant, when he/she asked about the progress of the study, commented that the popularity of metals data could be because "for the last five or six years there has been a lot of interest in mercury and that would cause them to hit [the files that have] all the metals" (GW4).

The Gulfwatch program, as previously mentioned, suffers from chronic under-funding. The unfortunate result of this is that staff dedicated to science-translation to managers, decision-makers, or the general public are no longer a part of the GOMC programs. The loss of an information broker who can perform this science-translation limits the effectiveness of communication of Gulfwatch information products. Scientific papers like the Chase *et al.* (2001) paper or technical reports describing trends of contaminants over time may not be directly useful to potential users in those forms. Without an information broker to translate scientific findings into lay terms, uptake of Gulfwatch information products by users other than scientists can be expected to decrease.

4.2.2. In Nova Scotia

In their discussion of thematic analysis, Green *et al.* (2007) suggested that in order for themes to be given proper consideration, they must be linked to social theory. In this case, the general use of Gulfwatch information, as described by the participants of this study, can be

explained using Nutley *et al.*'s (2012) "Continuum of Research Use" (Figure 9). Ranging from conceptual uses such as awareness to more instrumental uses leading to policy and practice change, every instance of use (including awareness) can be described using this continuum. The continuum was designed to aid in the development of effective strategies to ensure conceptual and instrumental use of research findings in policy- and decision-making (Nutley *et al.*, 2012). In each interview, there were indications of use, discussion of barriers or enablers to use, and a comment on improving use. Each suggestion or comment of participants can be classified into the broad themes of conceptual or instrumental use (Appendix C3).

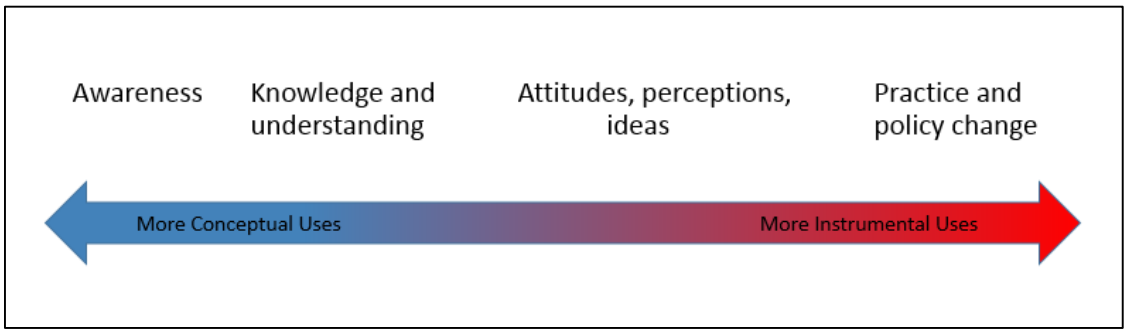

Figure 9: The continuum of research use, adapted from Nutley, Walter, and Davies (2012, pg. 51) describing the use of research findings in policy-making. The use of research findings ranges from raising awareness of the research to direct changes in policy and practice.

Interviewees from Nova Scotia who were in some way associated with the Gulfwatch program or the GOMC indicated a high degree of awareness of the Gulfwatch program, but lacked knowledge and understanding of program goals. Those who were not involved with the GOMC were not aware of the program. Therefore, it can be concluded that use of Gulfwatch information in Nova Scotia is limited to the conceptual end of the continuum of use (Figure 9). Aside from the use of Gulfwatch information in documents such as the State of the Gulf of

Maine report, as indicated by participants, there are no substantial examples of Gulfwatch information used in any instrumental way in Nova Scotia.

Barriers to conceptual use of Gulfwatch information include "information overload", departmental mandates, and the sources of water quality information that participants rely upon. Participants indicated that it is hard to assimilate new information in an era where they are bombarded with demands on their time and attention every day. Even participants, like those in industry who indicated that they actively seek out information such as that provided by Gulfwatch, were not aware of the information prior to being contacted about this study. Barriers to instrumental use are that the program is simply not within the monitoring or regulatory mandate of the organizations represented by interview participants. This is not to say that there are no examples of instrumental use in Nova Scotia; however, no known examples were revealed by this study. Other barriers to instrumental use include the reliance on other organizations for research data. It seemed, from the way information transfer was described by participants, that information that was collected and distributed by organizations such as EC and the CFIA were the only sources of information used in decision-making, despite other relevant monitoring programs within the region, such as Gulfwatch. Finally, the timeliness of Gulfwatch information and the noted backlog of data reports in recent years were not noted as a barrier to use; rather, the backlog was expected to those accustomed to working within government and the overarching sense was that, as a long term data set, the strength of Gulfwatch data was its ability to show trends rather than provide information on imminent crises.

A potential explanation for the lack of awareness of the Gulfwatch program in Nova Scotia is that managers and decision-makers are not as concerned about chemical contamination as their counterparts in other jurisdictions. According to the State of the Gulf of Maine Toxic

Chemicals theme paper (Harding and Burbidge, 2013), Nova Scotia sites monitored by Gulfwatch have shown consistently low levels of pesticides, PCBs and some metals, with varying levels of PAHs and slightly higher levels of metals (e.g. lead and nickel). Compared to other jurisdictions like Massachusetts and New Hampshire, Nova Scotia is not as likely to be negatively impacted by chemical contamination in most of its coastal areas, though there are exceptional areas with high industrial activity like Halifax and Sydney. One interview participant associated with the Gulfwatch program also indicated that "Nova Scotia is the clean area" (GW5), even in comparison to New Brunswick which shows consistently "medium" levels of all monitored chemical contaminants (Harding and Burbidge, 2013). Other participants indicated that population levels in Canada, and Nova Scotia in particular, are much lower than those found in the United States so they did not expect to see the same levels of chemical contaminants and thus did not have great concerns about potential risks. This perception may not be accurate and is certainly a barrier to using Gulfwatch information.

Though many of the interview participants seemed concerned or interested in water quality, especially those contaminants measured by Gulfwatch, the responses were very clear that "that is not our mandate". In Nova Scotia, it seems as though very few organizations are using metal, pesticide, PCB or PAH data at all, let alone from Gulfwatch, because of the federal food safety and regulatory guidelines that are already in place. The CFIA is the organization that determines if seafood is safe for human consumption. However, as one participant very aptly put it "They only deal with seafood that is commercially harvested and processed and sold that way. They don't check seafood that people harvest themselves." There is an obvious missing link in this system. However, these results are consistent with the inventory of monitoring programs in the Gulf of Maine compiled by Chandler (2001). In this inventory, the CSSP, the CFIA, the

Disposal at Sea Program, and Cooperative Bacterial Monitoring Program in New Brunswick are all operating in parallel with the Gulfwatch program but are not monitoring the same contaminants. Contaminants monitored tend to be bacteriological or related to shellfish toxins rather than metals, pesticides, PAHs or PCBs, although the Disposal at Sea program is noted to measure PCBs in sediments (EC, 2014). Even though no individuals in the Disposal at Sea program were interviewed, further investigation into the program suggests that all monitoring associated with the program's mandate is conducted in-house; no mention is given to adopting methodologies of any other program or comparing in-house results to other monitoring programs (EC, 2014).

A recurring theme throughout interviews was that the Gulfwatch information could be quite useful to participant organizations' operations. Many participants also indicated that this study brought their attention to Gulfwatch and that they may now use the information and data. One interviewee, when asked how he might use the information now that he is aware, suggested that the information could keep his fish packing organization to be kept appraised of any changes or continuing trends in water quality that could affect their harvesting or exporting of products (EU7,8,9). Two of the three industry participants had gone searching for Gulfwatch information when contacted regarding the interview and had looked at the information by the time they were interviewed. However, industry participants also indicated that, though many responsibilities to stay appraised of available research information had been downloaded from government to industry, the expectation was that government should be the driving force behind finding and communicating available research that is relevant to the fishing industry.

Two other potential uses of Gulfwatch information that fall into the "instrumental" end of the continuum of research use (Figure 9) were the potential use of Gulfwatch information or

methodology in the Musquash Marine Protected Area (MPA) in the Bay of Fundy or for the Environmental Ocean Health Index for the Bay of Fundy program that is being developed by the Bay of Fundy Ecosystem Partnership (BoFEP). Further investigation into the Musquash MPA revealed that Gulfwatch was not used in any way for the development of monitoring protocols. However, there is indication of use within the Environmental Ocean Health Index program. It is known that Gulfwatch data was used as part of the EcoSystem Indicators Partnership (ESIP) fact sheets in 2010 and 2014 (e.g. Gulf of Maine Council on the Marine Environment, 2009; ESIP, 2014). The Health Index team incorporated ESIP information into their catalogue of potential indicators of overall ecosystem health and made special mention of the Gulfwatch program as a potential source of indicator information (Kidd, 2013).

The incorporation of GOMC data and information into BoFEP programs is not surprising. According to the 6th Bay of Fundy Workshop Proceedings: "The Bay of Fundy Ecosystem Partnership (BoFEP) was formally linked through an agreement (2004-2007) that promotes shared goals and common projects in the Gulf of Maine" (Percy *et al*., 2004; pg. xliii). Applying this information to the continuum of research use, this application of Gulfwatch information falls into the "attitudes, perceptions, and ideas" category of instrumental use as the information is more than knowledge or understanding of the Gulfwatch program but has not yet been fully employed to influence practices or policy. As far as the available documents indicate, the Environmental Ocean Health Index program is still in the early phase of determining which indicators of health to use and has not yet fully decided to use Gulfwatch information (Kidd, 2013).

The CFIA employs the Hazard Analysis Critical Control Point (HACCP) method to ensure food safety. This involves seven steps, two of which are directly addressed by Gulfwatch

monitoring: 1) Identify critical control points and 2) Establish rigorous monitoring for those critical control points (CFIA, 2012). A critical control point could be the growing area classifications established by EC and enforced by DFO. If critical contaminant levels were established for those areas for the contaminants that Gulfwatch monitored, classifications of growing areas could be based, in part, on levels of chemical contamination. One interview participant engaged in the growing area classifications indicated the application of Gulfwatch information in the growing area classification scheme as a potential use. He stated that it would be beneficial to the program's efficiency to be able to plan in advance the most appropriate aquaculture sites based on available chemical contamination data. Other marine spatial planning applications are also possible.

Despite the potential for Gulfwatch data and information to be used by the CFIA, none of the three CFIA participants who responded indicated being aware of the Gulfwatch program. This does not indicate that the above process of basing growing area classification in part on chemical contamination levels is not occurring, it only indicates that those individuals contacted are not aware of and thus are not using Gulfwatch to implement their mandated programs.

There is a discrepancy between the indication of use provided by citation and web analysis data and the information provided by interviewees. Citation and web analysis data indicate that there is awareness and use of Gulfwatch information. Interview participants in Nova Scotia, however, are not among those who are using Gulfwatch information products. This suggests a need to focus awareness-raising initiatives on Nova Scotia. As demonstrated above, there are many potential uses of Gulfwatch information products within Nova Scotia; the largest barrier to instrumental use is the lack of awareness of the program.

Overall, uses of Gulfwatch information in Nova Scotia were limited to conceptual "awareness" and "knowledge and understanding" and there were few known instrumental uses. Participants provided ample insight into the enablers and barriers to both conceptual and instrumental use and provided many examples of how research use could be improved.

Chapter 5: Recommendations

5.1. Methodology

This research was limited to Nova Scotia. In future, the tri-method approach developed for this study to determining the awareness, use, and influence of Gulfwatch materials should be applied to each of the other four jurisdictions of the GOMC (New Hampshire, Maine, New Brunswick, and Massachusetts). Interview questions would be asked as shown in Appendix E, and an updated audit of the Gulfwatch publications and outputs list should take place at the time of the study to capture any outputs missed in previous audits or to document new outputs. Similarly, for the website usage research component, an audit of the usage of the Gulfwatch part of the GOMC website (www.gulfofmaine.org) should be done periodically, ideally each time a jurisdiction is analyzed. The longer the information is collected, the more information about trends in usage can be identified to better tailor the website to maximize the salience of Gulfwatch.

Four groups were omitted from this application of interview methodology: writers of Gulfwatch summary reports, environmental non-governmental organizations (ENGOs), non-governmental scientists, and the general public. Future researchers using this methodology for other jurisdictions in the GOMC or for auditing other environmental monitoring programs should interview writers and collaborators of the summary reports to determine enablers and barriers to publications and address those specific concerns. The Chase *et al* (2001) paper was found to be used mostly by scientists, so interviewing researchers and scientists, including those in academia, may provide detailed insights into how these individuals are using the Gulfwatch information products. ENGOs often fill gaps that are left by government and could very well make use of information such as that provided by the Gulfwatch program. This study attempted to contact

some indivials associated with ENGOs, but with no success. Finally, future applications of this methodology could also include interviews of the general public about their concerns regarding chemical contaminants and their health, both to determine if ongoing monitoring is a priority of the public but also to inform those concerned with public outreach where public education campaigns should be aimed.

The fact that some individuals did not wish to participate in this study limited the amount of data that were gathered. Ideally, even participants who are not aware of or who are not using the Gulfwatch data should be interviewed in order to determine why this may be the case. Interviews of individuals with little to no awareness can also inform the researcher of any potential applications of Gulfwatch information as well as the information delivery mechanism that is most appealing to potential users. To address this limitation in future application of the methodology, it is suggested that a survey be conducted to capture data from a larger number of individuals. It is also possible that individuals would be more willing to participate in an anonymous survey rather than in a personal interview when they feel like their knowledge or usefulness to the study is limited. More individuals may be willing to participate in an anonymous survey, increasing the robustness of data collection. It may also be possible to reach a wider audience and achieve a larger sample size using a survey method. Furthermore, if a well-designed and statistically robust survey is distributed to individuals not hand-picked by the researcher, it will help to reduce the bias inherent to interviewing methodologies. Another potential solution to this problem could be in changing the way recruitment messages are phrased. In the context of this study, surveys could put less emphasis on knowledge of the Gulfwatch program and instead refer more to an individual's role as it relates to water quality or monitoring in general.

Initially, it was found that the questions asked of participants who were not previously aware of the program or those who did not use the information were not eliciting substantial responses from participants. For this reason, the interview questions were adapted in an ad hoc fashion to gather information on subjects, such as whether the timeliness of the data was a priority for potential users, when and in what way chemical contamination data could be used by organizations, and general indications of how to improve overall awareness and use of the program. Although not all participants were asked these questions, using the adapted interview question methodology drew more information from each participant. Examples of subjects that were addressed in the modified interview methodology included how important data timeliness was to their organization and suggestions of potential awareness- or use-improving strategies. The unplanned change to the methodology allowed for the development of a stronger set of interview questions, designed to gain as much information from interviewees as possible.

5.1.1. Proposed methodology for examining use in a long-term project

The tri-method approach: cataloguing and analyzing outputs, web analytics, and interviews of potential users and those involved with the project provided a robust means of determining use. The following is a brief description of the methodology employed, incorporating the necessary adaptations described in the previous section.

1. Web analysis tools should ideally be set up so as to gather more information about the total number of users accessing web resources alongside, total page views and file downloads.
2. The audit of published outputs should be updated with each iteration of the research (e.g. each time a GOMC jurisdiction is evaluated). Citation analysis of select publications could also analyze how citing authors are using academic papers (i.e. are they only citing

the Chase *et al*. (2001) paper as an example of a biomonitoring program or are they drawing upon the findings and conclusions to discuss their own findings). This should be done along with the publishing journal analysis employed in this study.

3. Interviews should be targeted to a wide range of potential users. A survey may help to reduce the bias introduced by hand-selecting potential interviewees. All potential end-users, including academic researchers (i.e. university), government researchers, managers, decision-makers, the general public, ENGOs, and any other identified users should be contacted. All participants should be asked about their awareness, their use (including potential uses), their opinions of barriers or enabler to research use, a description of how they access information for their job responsibilities, as well as any other questions that are relevant to the monitoring program being studied.

5.2. Improving Awareness and Use of Gulfwatch Information

This study only offers specific insights from Nova Scotia. However, suggestions for improving awareness and use of the information products of the program can be generally applied to all five GOMC jurisdictions as well as other long-term monitoring programs.

This study showed the general lack of use of Gulfwatch data and information in Nova Scotia. The lack of relevance to current federal or provincial contaminant monitoring mandates could be the reason for this. Even though many Gulfwatch committee members are current staff members of either the provincial or federal government, they do not use the Gulfwatch information for their roles within the governments. When asked why they were involved in Gulfwatch if the data is not seen as useful, the response was that they are involved because they were asked by current members of the Gulfwatch program rather than actively participating of their own volition. This was a surprising observation. However, because current federal and

provincial departments do not seem to be monitoring for the same contaminants as Gulfwatch, and in light of the potential human and environmental health impacts especially from high levels of shellfish tissue contamination (from chemicals such as metals like lead or mercury, PAHs, PCBs, etc.), the Gulfwatch program is filling an information niche. For this reason, the federal and provincial departments whose mandates generally encompass ecosystem health and human health preservation should be made more aware of the program and its relevance to their overall mandates. Suggestions on improving awareness given by interview participants support this recommendation. Several interview participants noted specific potential applications, such as oil spill response monitoring, where Gulfwatch could be applied. The overall recommendation is to determine how biomonitoring programs could be relevant and applicable to potential users and then market them as such to improve overall awareness and use of the programs. Nutley *et al.* (2012) identify several criteria for improving research use:

> Research is more likely to be used that:
>
> - Is high quality and comes from a credible source;
> - Provides clear and uncontested findings;
> - Has been commissioned, or carries high-level political support;
> - Is aligned with local priorities, needs, and contexts;
> - Is timely and relevant to policy-makers' and practitioners; requirements;
> - Is presented in a 'user-friendly' way – concise and jargon-free and visually appealing. (Nutley *et al*., 2012, pg. 83-84)

Gulfwatch information, according to participants, aligns with the Nutley *et al*. (2012) criteria for improving research use except for the last three points. Due to budget cuts, the data are not provided in a timely fashion. The information is not necessarily in line with local

priorities, no one governmental body is responsible for chemical contamination. It is also not user-friendly, several participants indicated having no scientific background to aid them in interpreting the Gulfwatch information. The Gulfwatch committee could act to improve overall awareness and use by seeking funding to publish yearly data summaries more regularly and to re-instate a position of "information broker" to translate the scientific information into a format that is accessible and useable to all potential users. Then, the information could be marketed to potential users.

An adaptation of Gulfwatch monitoring could be implemented to improve the relevance of the program. The literature on research use in policy-making emphasizes the importance of the relevance of the research to the needs of potential users (Nutley *et al.*, 2012). Gulfwatch in particular could accomplish this by adding emerging contaminants to the list of monitored contaminants. Monitoring programs more broadly should make an effort to engage their potential users and gain insight into what managers and decision-makers need in terms of research information, then seek to deliver what is requested. One of the values of the Gulfwatch program is the tissue sample archive that has been established with samples from various years of collection. This archive at the Bedford Institute of Oceanography has the potential to be used for retroactive analysis of new contaminants, such as emerging contaminants, when analytical tools become available to do so. Tanabe and Ramu (2012) implemented such a study and have championed the development and maintenance of tissue sample banks for the purposes of retrospective analysis of emerging chemical contaminants. One Gulfwatch committee participant indicated that a proposal for funding to do this has been submitted, indicating that the Gulfwatch Committee is committed to remaining relevant and to providing needed information to coastal managers.

Alternatively, a clear case for the importance and need of monitoring a particular contaminant could be made to managers in the event that they were not previously aware of an issue or did not realize the level of concern. Overall, a case needs to be made to managers and decision makers that information gathered through monitoring research will be valuable to their decision-making needs. Though Gulfwatch is actively attempting to improve its relevance by choosing to focus on emerging contaminants, doing so will be of little good if the awareness of the program and its research are not made clear to potential users, including government departments and industry. Collecting information and having it available for such a long time period are admirable and useful. However, this is only if end users are aware of the existence of the information to be able to use it as a resource for their information needs. Several participants indicated that selecting potential users and providing them directly with information about the Gulfwatch program and how it could be relevant to their operations is a way to bring the program to the attention of potential users.

One of the challenges that long-term monitoring programs seem to face is the rotation of personnel and their knowledge of and interest in the program. As Gulfwatch is a program that has been ongoing for over 20 years, many of the key players from the earlier years of the project have since retired and have not necessarily been replaced or have been replaced by individuals who don't have the time or the vested interest to maintain the program. However, there are some retired members that still volunteer with the program. The Gulfwatch program also seemed to have benefited from the sourcing of federal and provincial government staff into its committee. As is shown in the historic cataloguing of Gulfwatch use, persons involved in Gulfwatch would bring the information into their government jobs and make use of it. The retirement of individuals who did this meant that this practice was not carried forward and the use of

Gulfwatch information in government departments in Nova Scotia seemed to diminish or cease, despite involvement of other government staff in the Gulfwatch program. For this reason, the importance of discussing Gulfwatch findings and protocols should be communicated to all committee members to try and improve the general awareness and use of the program in their departments.

The Gulf of Maine Council asserts that talks have been given at one particular ENGOs meeting at least once. To protect the identity of the person contacted, the ENGO will not be named. An individual from this ENGO indicated no awareness and thus no use of the Gulfwatch information in his/her work. There are some possible reasons for this mismatch of distributing information and general awareness of potential end users. Firstly, it is possible that the particular individual contacted was not at the presentation(s) of Gulfwatch information. Secondly, it is equally possible that the individual has no recollection of the presentation. Thirdly, if the individual were to have joined the organization after the Gulfwatch presentations took place and was not informed of Gulfwatch upon arrival, there would be no reason to expect awareness of the project. This suggests a few possible recommendations. First, conference talks are perhaps not the best method of raising general awareness. Secondly, if conferences are going to be a method of communication, multiple talks over numerous years may achieve a higher level of awareness or maintain momentum within target end user organizations than a one-time presentation. Finally, the importance of Gulfwatch should be conveyed to target end user organizations and perhaps a briefing booklet or other documentation provided on how Gulfwatch could be of use to a particular organization (or type of organization) so as to provide organizations with the ability to have knowledge of the Gulfwatch program.

5.2.1. Lessons learned from Gulfwatch: Recommendations for any long-term project

This study has provided insights into the enablers and barriers of long-term monitoring information use, as well as provided particular suggestions for enhancing the use and influence of research information. The lessons learned from studying Gulfwatch in Nova Scotia are applicable in general terms to other long-term biomonitoring projects.

1. The relevance of the program to the needs of potential users must be maintained. Open dialogue is necessary with potential users to ensure that the information being supplied is the information that is needed for decision-making. This does not mean that users should dictate what information is collected. Rather, researchers and managers/decision-makers need to openly discuss the environmental and health issues and collectively decide what information is most relevant. This is the information that should be gathered by monitoring programs.
2. Programs must be adaptable. If new analytical tools become available to monitor a different suite of environmental contaminants, monitoring programs should seek to incorporate them into their methodologies. Similarly, if it becomes clear that there are no significant changes in a monitored contaminant over time, that particular contaminant does not need to be as much of a priority as emerging contaminants. That is not to say that monitoring should cease, but in order to release funding to be able to monitor different chemicals, contaminants that have a decreasing or stable trend should be monitored less frequently.
3. In order to improve use of biomonitoring project information products, approaches that target specific potential users are likely to be the most successful. This is best achieved using an information broker. For example, Gulfwatch information is incorporated into

ESIP fact sheets. Maintaining relationships with information brokers will be important in ensuring that information is communicated accurately and effectively.

4. Communicating findings of monitoring programs in creative ways will likely be more successful than traditional outreach approaches. Members of the monitoring program should actively communicate findings in informal ways. Jacobson *et al.* (2013) found that often the most effective and important means of information distribution is through personal networks and not through traditional published sources of information. Therefore, personal communication with colleagues should be emphasized.

5.3. Conclusions

This study served two purposes: to demonstrate a methodology to determine the overall use and influence of a long-term biomonitoring program and to apply the methodology to a case study (Nova Scotia) to determine the efficacy of the developed research methods. The methodology used was not perfect in design, but the implementation of the method on Nova Scotia as a case study suggested ways in which the study could be improved. Suggested improvements are outlined in detail in this study. This study showed that Gulfwatch data and information are not widely used in Nova Scotia and provided some insights as to why. Recommendations to improving awareness and use of Gulfwatch, as well as other monitoring programs, are made. A robust method of determining the breadth of data distribution and the degree of data uptake helps to inform the monitoring group as to how to improve their communication to ensure that the valuable information is distributed to and used by those who need it most, to help prevent serious environmental or human health disasters.

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Appendices

Appendix A: Anecdotal Instances of Use and Influence of Gulfwatch Data

1. Bellevue Cove Seafood Processing Facility, Nova Scotia. (Peter Wells, personal communication, June 2014)
    - use the Gulfwatch data to assure buyers and others that the seafood is not contaminated and is safe for human consumption
2. There have been previous attempts to determine the use of Gulfwatch information in policy and decision making. (GOMC (n.d.) *References to Contaminants from Gulf of Maine Council User Needs Assessments: Conference Call*. Gulf of Maine Council on the Marine Environment ESIP Program. Internal document available from: http://www.gulfofmaine.org/2/wp-content/uploads/2014/03/References-to-Contaminants-from-Gulf-of-Maine-Council-User-Needs-Assessments.doc.)

   "From recent user needs assessment of how Gulfwatch is being used (Gulfwatch contaminant monitoring undertaken by the Council) (2007) - these are per e-mail responses or phone interviews.
    - "We incorporate review of Gulfwatch data in our shellfish area classification work (sanitary surveys, triennial updates of sanitary surveys, etc.). This is especially true if our shoreline surveys indicate potential contamination from poisonous/deleterious substances. I expect to continue to use the data in this way, esp. to identify trends that may be of concern."
    - "I use Gulfwatch data to track trends in toxic contaminants in NH's estuaries. To a lesser extent, I use the data to evaluate whether shellfish harvesting should be

allowed in an area. I anticipate using the data in much the same way in the future. It would be helpful if we could translate the mussel tissue data into toxic contaminant concentrations in ambient water, which could be evaluated by state water quality standards."

3. According to the BoFEP Gulfwatch webpage there are many instancs of use. (BoFEP. (1999) Fundy Issues 12: Results at Work. Retrieved from: http://www.bofep.org/gulfwach.htm)

- "Pointing out the practical applications of their program, Gulfwatch organisers note that government agencies in the US and Canada use Gulfwatch data to develop environmental management plans and policies, and to meet federal reporting requirements. State agencies have used the data in drafting pollution reports required by the US Congress under the Clean Water Act. Government agencies in Canada and the US have used them in making sanitary survey reports to determine whether it is safe to harvest and eat shellfish; developing licensing requirements for industrial discharges; developing nonpoint source pollution controls; and issuing dredge disposal permits and assessing disposal sites.
- Gulfwatch also plays a role in assessing the effects of specific activities on water quality, such as discharges from sewage treatment plants and paper mills, and environmental accidents such as oil and chemical spills. Samples collected after spills and compared with baseline data can show how a spill has affected water quality. Samples taken after cleanup efforts are under way help track the environmental recovery taking place and help with the development of wildlife protection guidelines.

- Amar Menon of EC's shellfish section said his office has used Gulfwatch data for the last five years in evaluating whether Fundy shellfish beds are suitable for harvesting. "We do our own bacteriological analysis [and] use their information to get an idea of the chemical contamination in some of the shellfish areas," he said
- Canadian Wildlife Service researchers are using the data to study the effects of contaminants on sea ducks that eat blue mussels, as well as in a program that monitors wildlife for the presence of the chlorinated pesticide DDT in their tissues.
- Researchers in Canada are also using the data to assess rising concerns about endocrine disrupters, substances known to affect the endocrine organs, such as the thyroid, pituitary, and adrenal glands, which regulate the body's functions.
- Gulfwatch has also found a place in natural resources assessment and management. Data from the program were used in "finding what problems we have," said New Hampshire Estuary Project Director Chris Nash. And, he said, "It probably will be used if toxics monitoring becomes part of our monitoring plan." Also in New Hampshire, as part of a new partnership to protect water quality in the Great Bay Estuary, that state is funding increased Gulfwatch monitoring in the Great Bay and in Hampton Harbour.
- Growers of shellfish, finfish, and sea vegetables in Nova Scotia and Maine have used Gulfwatch data to find clean sites for hatcheries and growout facilities. And, according to the Gulfwatch five-year report, "In general, the entire fishing industry (oceanic and aquaculture) has relied on Gulfwatch data to assure the public that monitoring of marine environmental quality is being performed."

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- Maine has used Gulfwatch information in the following ways:
    - describing toxic contamination
    - Review new industrial discharge applications
    - Developed criteria for impairment
    - Sanitary surves for classification of shellfish growing waters
    - Identify watersheds that need special management for storm water rules in light of new developments
    - Studying contaminatn relationships between different ecological compartments
    - Aquaculture industry uses Gulfwatch to set leases in clean sites
    - Organic certification for aquaculture products
- New Hampshire has used Gulfwatch information in the following ways
    - Bienniel Water Quality Report to Congress
    - Sanitary surveys for classification of Shellfish growing waters
    - Key database of toxic contaminants
- Massachusetts has used Gulfwatch in the following ways:

    - Massachusetts Bay Program, coordinated sampling
    - Assessing receiving waters near marine sewage discharges
- Canadian organizations and districts have used Gulfwatch information in the following ways:
    - Environment Canada: Ocean disposal program
    - Canadian Council of Ministers of the Environment: development of reference points of DDT for wildlife protection
    - Shellfish growing area classification
    - DFO: set restrictions on harvesting areas based on contamination information
    - The Canadian Wildlife Service: develop screening criteria for contaminant levels in mussel-consuming sea ducks.
    - Are being used to asses recent concerns about endocrine disruptors, Canadian Wildlife Service
    - DFO: Effects of contaminants on fish habitats
    - Canadian mussel watch program compared Gulfwatch data
    - Shellfish Sanitation Program
    - Issuance of aquaculture leases in Nova Scotia and New Brunswick
    - Toxic Chemicals Programme of Environment Canada

Appendix B: Gulfwatch Output Bibliography

Journal Articles

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- Bigelow Laboratories Winter Seminar Series
- Bowdoin College
- Casco Bay Estuary Project Technical Advisory Committee
- Casco Bay Estuary Project Management Committee
- Clean Annapolis River Project
- Gulf of Maine Symposium
- Coastal Zone Canada
- Friends of Casco Bay
- Great Bay Coast Watch
- Gulf of Maine Council "Bridging the Gulf" Conference
- A variety of other GOMC fora
- Island Institute
- Maine Legislature
- Maine Volunteer Water Quality Fairs
- Marine Environmental Research Institute
- Marine Benthic Conference
- New Hampshire Estuaries Project
- New Hampshire Department of Environmental Service
- Penobscot Bay Coalition
- RARGOM Workshops

- Southern Maine Technical College
- Submerged Land Management Conference
- University of Maine Orono
- University of New Hampshire undergraduate classes and seminars
- University of New Hampshire / University of Maine Marine Docents
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Appendix C: Coding Rubrics

C1 Bibliography Codes

Gulfwatch publications and other outputs were classified using the following definitions (in order of appearance in Appendix B: Bibliography):

Journal Articles: defined as those publications that were authored by a member of the Gulfwatch committee or team member and were published in a recognized academic journal

Technical Reports: defined as those publications that were authored by a member of the Gulfwatch committee or team member and were published as grey literature, or literature that is not published by a recognized publishing agent (i.e. an academic journal, a commercial publisher). These documents also pertain specifically to Gulfwatch data or analysis

Book Chapters: defined as those publications that were authored by a member of the Gulfwatch committee or a team member and made use of Gulfwatch information. They are single chapters in volumes usually consisting of several chapters form different authors centering around a common theme.

Conference Proceedings: defined as papers that were authored by a member of the Gulfwatch committee or team member who presented a paper at a conference or seminar and had the paper published as part of the overall conference proceedings.

Theses: defined as those publications authored by a graduate student regarding Gulfwatch

Abstracts of Talks (Published): defined as conference talks instigated by a member of the Gulfwatch committee or other team member where there is an abstract of the talk is available and/or published for consumption by the public; in this case, an entire article or paper is not published as in "Conference Proceedings".

Paper/Poster Presentations: defined as presentations or posters given by members of the Gulfwatch committee or team where no paper or abstract is published and/or readily available for consumption by the public

Fact Sheets: defined as those outputs either authored by a member of the Gulfwatch committee or other team member or a publication that specifically addresses the mandate of Gulfwatch and its monitoring. Can be available as hard copy only or as an online resource

Briefing Note: defined as a specific briefing outside of a conference or symposium context where information about Gulfwatch is relayed by a member of the Gulfwatch committee or other team member

GOMC Internal Document: defined as those documents that are written and made available for the specific use of the Gulf of Maine Council on the Marine Environment and any planning or management that is associated with the mandate of the Council. Can

be authored by a Gulfwatch committee or team member or a Gulf of Maine Council member

Other (Items that have utilized Gulfwatch data): defined as those outputs that make use of Gulfwatch data or other information but are not authored by a member of the Gulfwatch committee or other team member. These outputs may fall under other categories as listed above, but are listed together to show indication of use of Gulfwatch data rather than outputs designed to raise awareness of Gulfwatch information.

C2 Web Analysis Codes

The list of files downloaded from the Gulfwatch website were classified using the following definitions:

Metals: those file types that contained raw heavy metals data from any year or any type of file. All years of data available were amalgamated. Likewise, all file types (.html, .xls, .txt) were collected into the same category

PAHs: those file types that contained raw PAH data from any year or any type of file. All years of data available were amalgamated. Likewise, all file types (.html, .xls, .txt) were collected into the same category

PCBs: those file types that contained raw PCB data from any year or any type of file. All years of data available were amalgamated. Likewise, all file types (.xls and .txt) were collected into the same category.

Sample Site Information: any file that contained the geographical information about the sampling sites monitored by Gulfwatch. Several different web locations were available that resulted in a download of the same information, so these were all collected under a common label.

Data Reports/Publications: any file that was a data summary report (e.g. the "Five Year Review of Gulfwatch") or any other publication that was produced by the Gulfwatch Committee and available for download through the website.

Fact Sheet: the Gulfwatch factsheet was a prevalent enough download to warrant a category on its own to capture the popularity. This category refers only to those file downloads from various website locations that allow the user to access the Gulfwatch Fact Sheet.

Others: There were several file types that had very few downloads. Examples of these were a PowerPoint file that was used to describe Gulfwatch findings to the working group. This category captures all files not included in the previous definitions and serves to simplify data analysis.

The list of webpages visited by users of the Gulfwatch website were classified using the following definitions:

Raw Data: there is a way to access raw Metal, PAH, PCB, and Pesticide data without downloading a file. This method uses a webpage (.html) to display the same raw data that was captured in the previous set of definitions for heavy metals, etcetera. All webpages that showed Metal, PAH, PCB, and pesticide data in .html format are included in this definition.

Gulfwatch Interactive map: includes all webpages that allow a user to access the interactive map depicting the heavy metals data gathered by the Gulfwatch Committee.

Publications: defined as any webpage that led to the ability to download a publication file, either a data report, the fact sheet, meeting minutes, or other related documents.

Sampling Data-Related: defined as any webpage that led to the ability to download a data file, or access the .html data webpage, or other Gulfwatch data-related pages

Sampling Site Information: defined as any page that either provided information about the sites that Gulfwatch collects samples from or any page that led to the ability to download the sampling site files.

Gulfwatch Information: defined as pages designed to provide the web-user with more information about the Gulfwatch program. Examples include the committee member

contact information page, the home page, the "Mussels as Biomonitors" page, or any other similar page.

C3 Interviews Codes

Table C1: Codes and categories used to analyze data, fitted to the "Continuum of Use" spectrum described by Nutley *et al.* (2012). Codes are also subdivided into those related to indications of use, barriers or enablers to use, or suggestions for improving use of Gulfwatch information.

	Awareness	**Knowledge/ Understanding**	**Attitudes/ Perceptions/ Ideas**	**Policy/ Practice Change**
Indication	• Awareness (Yes/No) • Others who are aware	• Awareness (Unsure of program goals) • Who should use?	• Particular examples of use (e.g. GOMC State of the Gulf Report; ESIP Fact Sheets; Musquash Estuary; BoFEP programs)	• Use (Yes/No)
Enablers/ Barriers	• Information overload	• Timeliness of data	• Jurisdictional mandates • Interest in Chemicals • Reliance on other organizations	

Improvement	• Improving use:
	  ○ Targeted approach
	  ○ Broad distribution
	  ○ Emerging contaminants
			• Potential uses
			  ○ Baseline data
			  ○ trends	

Interviews were also coded for the occupation of the various participants. Codes included:

- CFIA
- DFO
- Environment Canada
- Gulfwatch Committee Member
- Health Canada
- Industry
- Nova Scotia Department of Fisheries and Aquaculture
- Nova Scotia Department of the Environment

Appendix D: Ethics Approval Documentation

DALHOUSIE UNIVERSITY
Inspiring Minds

FACULTY OF MANAGEMENT
DALHOUSIE UNIVERSITY

Graduate Student Ethics Approval for a Course-based Project

August 27, 2014

Sarah Chamberlain,

I am pleased to inform you that I have reviewed your project "**Developing and implementing a research framework to determine the overall use and influence of a long-term environmental monitoring program: A Case Study on Gulfwatch in Nova Scotia",** for the course MARA 5002: Graduate Project, under the supervision of Bertrum MacDonald and Peter Wells, and have found the proposed research involving human participants to be in accordance with the *Faculty of Management Ethics Review Policy and Procedures for Course-based Projects* and the *Tri-Council Policy Statement on Ethical Conduct for Research Involving Humans (TCPS2).* This project has received ethics approval.

This approval will be in effect until and not exceeding December 16, 2014 (fourteen days from the final date of classes for the 2014 Dalhousie Fall Semester). It is your responsibility to immediately report any adverse events involving participants. Please note that any significant changes to the research methodology, consent form or recruitment materials must be resubmitted to the Ethics Review Assistant for review and approval prior to their use.

Congratulations on your successful Faculty of Management Graduate Student Ethics Approval for your Course-based Project. I wish you all the best as you begin this next phase of your research. Should you have any questions regarding ethical issues at any point during your project, please do not hesitate to contact me.

Sincerely,

Ashley Doyle
Ethics Review Assistant, Faculty of Management
Dalhousie University
PO Box 15000
Halifax, NS B3H 4R2
a.doyle@dal.ca

Appendix E: Interview Recruitment and Procedure Materials

E1 Interview Scripts

"Before we begin, I want to clarify my use of the word "information" throughout this interview. When I discuss Gulfwatch information, I am referring to all outputs of Gulfwatch, whether it is through publications directly by the Gulfwatch Committee, conferences, fact sheets, publications by individuals associated with Gulfwatch but not necessarily mandated by the Gulfwatch Committee or the GOMC. In short, my use of the word "information" encompasses all the outputs either by or about Gulfwatch, its data collection, methods, etcetera.

I am going to ask you questions about your role in your organization, your awareness and use of Gulfwatch information, whether and in what way Gulfwatch information has influenced you or your organization's decision making, as well as questions about access to information you need."

E2 Interview Type 1: Past and Present Gulfwatch Committee Members:

Biography Questions

1. What organization do you work for and what is your current role in that organization?

   Follow-up questions:

   - **For current members**: how long have you been a member of the Gulfwatch committee?
   - **For past members**: When were you a member of the Gulfwatch committee? Have you had any other roles in the Gulf of Maine Council or Gulfwatch?

Awareness

2. Do you know if there is an intended audience for Gulfwatch information?

   Follow-up questions:

   - **If yes:** Who is the intended audience?
   - **If yes**: In your view, how aware of Gulfwatch data and publications are the target audience?
   - **If yes**: In your view, how aware of Gulfwatch data and publications are potential users?

Distribution/Accessibility

3. Do you distribute Gulfwatch information to the target audience?

Follow-up questions:

- To whom? How long have you done this for?
- How often do you do this?

4. Do you think the ways data and other information are distributed and communicated by the Gulfwatch Committee and committee members are sufficient?

   Follow-up questions:

   - **If yes**: why?
   - **If no**: why not?

5. If not: what could be done to facilitate better distribution or communication of data or reports?
6. In your opinion, are the data and publications up-to-date enough to be of use to current and potential users?

Use

7. Who are the users of Gulfwatch information?

   Follow-up questions:

   - Can you describe how potential users might be or are using Gulfwatch information.
   - Does your organization use Gulfwatch information? In what way? **Or:** Why not?

8. Can you identify **potential** users of Gulfwatch data or information?

   Follow-up questions:

   - Are there individuals or organizations who could use Gulfwatch information?
   - Are there individuals or organizations who, in your opinion, should be using Gulfwatch information?

9. To your knowledge, what are the expected uses of Gulfwatch information?

Influence

10. How has the use of Gulfwatch information influenced actions taken by users? (E.g. by government, industry, other organizations?)
11. Do you have any examples where you know Gulfwatch information has directly influenced policy (either government or organizational policy)?

Other

12. Have you had any other thoughts or comments over the course of the interview about the awareness, use and influence of Gulfwatch information that you want to mention?

End of Interview *

*** At the end of each interview, thank the interviewee and remind them that they may receive a summary of the report when it is completed in December.**

E3 Interview Type 2: Potential End-Users of Gulfwatch Information

Biography Questions

1. What organization do you work for?

   Follow-up question:

   - What are your responsibilities?

Awareness

2. Are you aware of the Gulfwatch program and its publications?

If Yes:

- How did you find out about Gulfwatch?

  Follow-up questions:

  - Was there someone or some publication or conference that made you aware of Gulfwatch?
  - When did you discover Gulfwatch information?

- Are other members of your organization aware of Gulfwatch? Which members?

Note: If the Interviewee indicates "yes" to the question of awareness, skip the following 'if no" section and continue to question 3 (Fig. 1).

If No:

- Do you need and/or use water quality information for your job?
- What specifically do you need information about?

  Potential probe questions:

  - Contaminants? Trends in water quality? A particular geographic location?

- Do you find it easy to access the information you need for your work?

  Follow-up questions:

  - How do you access information for your needs?

  - What sorts of questions do you try to answer by using water quality information?

Note: If the interviewee answers "no" to questions of awareness, then Interviewees will be

asked questions 10, 11, and 19 and the interview will be concluded (Fig. 1).

Use Questions

3. Do you or your organization use the Gulfwatch data?

If Yes:

- How many people within your organization or just yourself?
- When you use Gulfwatch data or publications, what do you look for in this data/publications, i.e., what are you interested in finding?

Potential probe and follow-up questions:

- Raw data? Summaries of trends or changes in water quality? Information on particular toxins? All of these? Any others I haven't mentioned?
- What else would you like to see in the data or publications? Is there anything that you need that is not provided currently?

4. Is the data or information sufficient for your needs?
5. When was the last time you used Gulfwatch information?
6.

Note: If the interviewee indicates "yes" to the question of use, skip questions 6-8 inclusive and continue to ask questions 9-18 (Fig. 1).

If No:

6. Do you look at the Gulfwatch information but not use it for your work?
7. Have you used Gulfwatch information in the past? When did you last use Gulfwatch information?

Follow- up questions:

- **If no:** Why do you no longer use Gulfwatch information?

  Was it an issue of access to data? Or the timeliness of data delivery? Are there other reasons?

8. What kind of data or other information from Gulfwatch would be most informative to you?

Note: If the Interviewee indicates "no" to questions of use, then only the following questions will be asked: 9, 10, and 18 (Fig. 1).

All interviewees (regardless of awareness or use)

9. Do you access water quality data and information from sources other than

Gulfwatch?

Follow-up question:

- Are you or your organization doing your own water quality information?
- Are these other data sources different than Gulfwatch? I.e. different contaminants monitored, different time scales, different methodology of measurement?
- What questions are you trying to address with your own monitoring information?
- For information that is sourced rather than internally collected: How do you access the water quality information you need?

Influence

10. What questions or problems are you trying to address in your work?
11. Is Gulfwatch information helpful in addressing those questions?

Follow up questions:

- **If yes:** How so?

  What do you mostly use Gulfwatch information for?
- **If no:** Why not?

12. Has Gulfwatch information been helpful in any other way to you or to your organization?

Distribution/Accessibility

13. How do you access information about Gulfwatch and the results of the long-term biomonitoring project?

Potential probe questions:

- The website? Your own searches for publications?

14. Are data or data reports distributed to you? By whom?
15. Were you able to find what you are looking for?

Follow-up questions:

- Why or why not?
- Could there be improvements in data distribution or delivery? What other formats could be used to communicate data?

16. Have you encountered difficulties in accessing data and information about Gulfwatch and the results of the long-term biomonitoring project?

Follow-up question:

- What could make it easier to access or understand?

17. In your opinion, are the data and/or publications provided current enough for your needs?
    Follow-up question:
    - Does the date of the data release matter for your information needs? **Other**
18. Have you had any other thoughts or comments over the course of the interview about this study that you want to mention?

End of Interview*

*** At the end of each interview, thank the interviewee and remind them that they may receive a summary of the report when it is completed in December.**

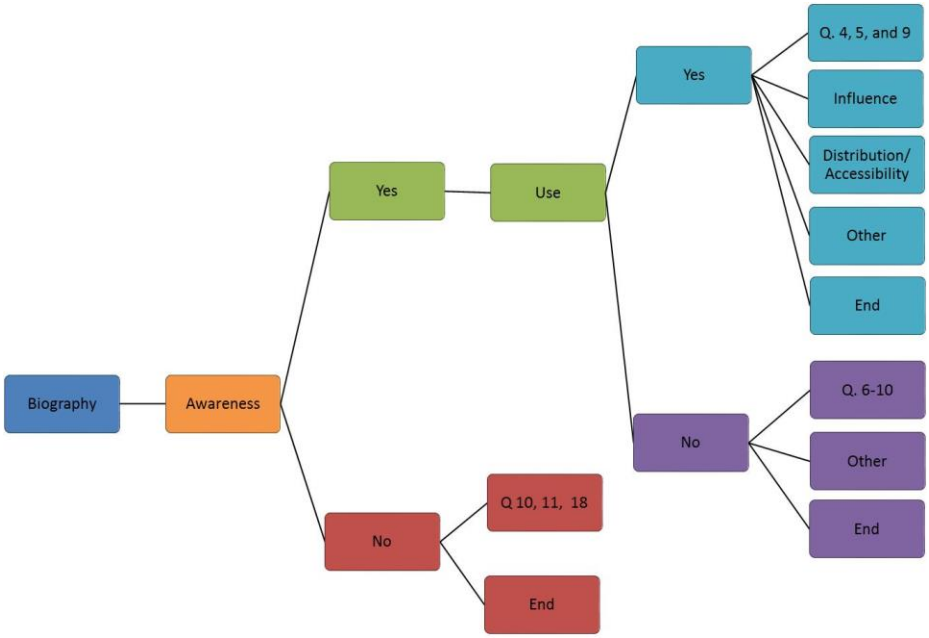

Figure E1: A chart indicating the flow of the interview questions, dependent upon the interviewee's response to a particular question. For example, if an interviewee answers "no" to a question of awareness of Gulfwatch, only the questions indicated in the pink boxes will be asked before the interview is concluded.

Recruitment Materials

Invitation Message

The following message was e-mailed to pontential interviewees to invite them to participate in the study:

My name is Sarah Chamberlain and I am a graduate student with the Marine Affairs Program at Dalhousie University. I am writing to invite you to participate in a research project being conducted as part of my degree requirements.

I am currently working with the Environmental Information: Use and Influence research team, based in the School of Information Management at Dalhousie University (www.eiui.ca) in partnership with the Nova Scotia Department of Fisheries and Aquaculture. The study I have developed is investigating how the data and information produced by Gulfwatch, a program of the Gulf of Maine Council on the Marine Environment has been used. My research is based on a variety of methods, including the interview you are invited to participate in.

This project is being co-supervised by Professor Bertrum MacDonald (Bertrum.macdonald@dal.ca / 902-494- 2472) and Professor Peter Wells (oceans2@ns.sympatico.net / 902-237-0600) at the Environmental Information: Use and Influence research initiative (eiui.ca).

You are invited to complete a 30-40 minute interview regarding your knowledge of Gulfwatch information, data, use, and influence. Your participation in this study is entirely voluntary.

Please let me know if you are willing to be interviewed and I will follow up with you to arrange the interview, which can be conducted by telephone or in person, whatever is most convenient for you. I have attached the consent form to this email which includes further details about the project. Please to not hesitate to contact myself or my supervisors about any questions you may have.

Thank you,

Sarah Chamberlain
902-818-5962
sarah.chamberlain@dal.ca

Consent Form

You are invited to take part in the project entitled "*The Use and Influence of a Long-Term Biomonitoring Project: A Case Study on Gulfwatch.*" My name is Sarah Chamberlain. I am a graduate student in the Marine Affairs Program at Dalhousie University in Halifax, Nova Scotia. I am conducting research for an independent project with the Environmental Information: Use and Influence research program in the School of Information Management at Dalhousie University (www.eiui.ca) under the supervision of Dr. Bertrum MacDonald and Dr. Peter Wells. My project is to be completed in partial fulfillment of the Master of Marine Management degree. Please see a brief description of the study below, as well as information about the risks and benefits to yourself.

Gulfwatch is a long-term program of the Gulf of Maine Council on the Marine Environment (GOMC). The GOMC is an international Canadian-American body that aims to improve collaboration on cross-border issues in the Gulf of Maine and Bay of Fundy region. Since 1991, Gulfwatch has been monitoring contaminants by using blue mussels as indicator species. Numerous publications, fact sheets, and other outputs have arisen due to this project, along with a large quantity of water quality data. Long-term spatial and temporal data on water quality is very valuable for baseline knowledge of environmental conditions, determining the sources of pollutants, including those that could be harmful to human health, and for making management and policy decisions for the marine environment. This project seeks to explore the overall awareness and use of Gulfwatch information in Nova Scotia.

Several methods will be employed in this study to understand the awareness and use of Gulfwatch and its information outputs. Interviews will help me to understand the distribution, awareness, use, influence of Gulfwatch information in Nova Scotia and help me to develop recommendations for improving the communication of data and relevant water quality information.

Your participation in the interviews is voluntary, and you can withdraw at any time or decide not to answer particular questions. All information received from you will be treated in confidence and will be anonymized to protect your identity, and no individual responses will be attributed to you but will merely aggregated into an overall report for the Marine Affairs Program at Dalhousie University, and presented to my classmates, professors, supervisors, and other interested parties and may be used in published reports. Participating in this study may not

benefit you directly, but the information and findings may be informative to organizations that produce large amounts of data and information and wish to improve their communication of that data. There will be no danger to you greater than what you experience in your daily life. Measures will be taken to change any quotations that could otherwise be attributed directly to you. A number will be assigned to all participants so anonymity is guaranteed.

If you agree to participate in this research study, please complete the consent form attached to this e-mail and return it to me via e-mail. I am happy to share a summary of my findings and recommendations with you upon the completion of the study in December 2014.

Please discuss any questions or concerns you have about this study with myself or my supervisors. If you have any questions contact me, Sarah Chamberlain (sarah.chamberlain@dal.ca or 902-828-5962). You may also contact my supervisors: Dr. Bertrum MacDonald (Bertrum.macdonald@dal.ca; 902-494-2488) or Dr. Peter Wells (oceans2@ns.sympatico.net; (902) 237-0600). I would like to interview you by telephone or in person in September, at your convenience. The interview will probably take about 45 minutes to complete.

If you have any difficulties with, or wish to voice concern about, any aspect of your participation in this study, you may contact Dr. Dominika Wranik, Assistant Dean (Research), Faculty of Management, Dalhousie University, for assistance at (902) 494-3764, or by e-mail: dwl@dal.ca.

Developing and implementing a research framework to determine the overall use and influence of a long-term environmental monitoring program: A Case Study on Gulfwatch in Nova Scotia

I have read the explanation about this study. I have been given the opportunity to discuss it and my questions have been answered to my satisfaction. I hereby consent to take part in this study. However, I understand that my participation is voluntary and that I may withdraw from the study at any time.

Please check each of the following conditions (as applicable)

- ☐ I agree to audio recording of the interview.

- ☐ I agree to use of substantial direct quotations from my interview in reports and publications arising from this research. I understand that these quotations will be treated anonymously and that a Participant Number will be applied to guarantee my anonymity.

- ☐ I would like to receive a summary of the reported results of this study upon its completion December 2014. I may be reached for this purpose at the following e-mail address:
  _____.

By signing this consent form, you are indicating that you fully understand the above information and agree to participate in this study.

_____ _____

Signature of Participant **Date**

_____ _____

Researcher's signature **Date**