Collaboration, Data Sharing, and the Research Network-As-System

by

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TABLE OF CONTENTS

LIST OF TABLES

ABSTRACT

The research network-as-system operates by connecting researchers across large distances and from multiple disciplines via a web-based, technological system. Through this system, researchers collaborate simply by sharing data. The Integrated Ocean Observing System (IOOS) in the United States, and the Canadian Integrated Ocean Observing System (CIOOS), currently in development in Canada, are both examples of research networks-as-systems. By conducting semi-structured interviews with ten Canadian ocean researchers about their perception of CIOOS and their collaborative histories, this research discovered what helps and hinders in collaboration in the research network-as-system context, as well as how past and current collaboration experiences may influence researcher willingness to adapt to new network contexts. The findings of this study offer theoretical insight on researcher perception of collaboration in large, dispersed, and multidisciplinary groups, and in integrated online spaces. Further, this research provides practical direction regarding user preferences for system design in the research network-as-system context.

LIST OF ABBREVIATIONS USED

CARL – Canadian Association of Research Libraries

CHONe – Canadian Healthy Oceans Network

CIOOS – Canadian Integrated Ocean Observing System

CoP – Community of Practice

DFO – Fisheries and Oceans Canada

EMODnet – European Marine Observation and Data Network

IOOS – Integrated Ocean Observing System

MARUM – Center for Marine Environmental Sciences

MEOPAR – Marine Environmental Prediction and Response Network

ODM – Ocean Data Management

OOS – Ocean Observing System

OTN – Ocean Tracking Network

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CHAPTER 1: INTRODUCTION

1.1 Background

Recent research suggests that sea levels are rising more rapidly and dramatically than originally thought (Wall, 2017). While prior studies predicted that sea levels would rise by one to two feet by the end of the century, recurrent projections indicate that sea levels will rise more than eight feet by 2100 (Wall, 2017). This dramatic change in the world's oceans will have a significant impact on coastal communities, threatening human life due to extreme flooding and even eradicating some coastal towns and cities completely (Wall, 2017). Now more than ever, research on the world's oceans is needed to mitigate the effects of global warming and better understand the changing marine environments of our planet (Wilson, Smit, & Wallace, 2016).

According to Wilson, Smit, and Wallace (2016), ocean research today depends heavily on "access to accurate, rich, available, and integrated ocean data" (p. 1). *Integrated* is an important word to note here. Much of today's ocean research relies on the collaborative practice of integrating and sharing data on national or international scales (Liu, Kerkering, & Weisberg, 2015; Wilson et al., 2016). Large-scale scientific data sharing projects often take the form of web-based data sharing platforms (Liu et al., 2015). In the ocean sciences, these platforms and websites are often referred to as ocean observing systems (OOS) (Liu et al., 2015; Wilson et al., 2016).

Arguably, data sharing sites like OOS are a new form of research network. According to Mo, Hayat, and Wellman (2015), research networks bring together researchers whose projects and driving research questions relate to a shared objective, such as a broad theme, topic, or question. Data sharing platforms accomplish this same task by connecting people and data working towards answering important scientific questions (Liu et al., 2015). Throughout this thesis, I will refer to integrated data sharing networks as a new kind of network: the *research network-as-system*. This is a term I identified to describe research organizations that are both networks and systems.

While traditional research networks operate by connecting individuals to work on shared projects (Mo et al., 2015), the research network-as-system connects individuals for the primary purpose of sharing data (Liu et al., 2015). In this way, the research network-as-system represents a distinct context for collaboration in that individuals who participate in these networks collaborate simply by uploading and/or downloading data (Liu et al., 2015). Collaboration in the research network-as-system is a hands-off approach, requiring no direct interaction between network members.

An example of a research network-as-system is the Integrated Ocean Observing System (IOOS). IOOS integrates ocean data from across the United States into a single web-based platform, making data accessible on a national scale (IOOS, 2016). Scientists who contribute data to IOOS are members of a vast and complex network that is geographically-dispersed and multidisciplinary in character. Notably, prior studies on collaboration and research networks indicate that geographic dispersion (Wellman et al.,

2014; Yeon et al., 2015), a lack of face-to-face interaction (McLure Wasko & Faraj, 2000; Rathnappulige & Daniel, 2011), and multidisciplinarity (Caruso & Rhoten, 2001; Monteiro & Keating, 2009; Wellman et al., 2014) can impede collaboration by negatively impacting researcher willingness to collaborate.

The need for a system similar to IOOS was recently identified in the Canadian ocean research context (Wilson et al., 2016). In November 2015, "The Expert Forum on Ocean Data Management" was held in Montreal, Quebec (Wilson et al., 2016). This event assembled a diverse group of over fifty national and international stakeholders to discuss the future of ocean data management in Canada. This group included members from government, academia, and the private sector. Specifically, international representatives from IOOS, the Center for Marine Environmental Sciences (MARUM), and the European Marine Observation and Data Network (EMODnet) attended, as well as Canadian experts from Fisheries and Oceans Canada (DFO), Portage / Canadian Association of Research Libraries (CARL), Compute Canada, and the Canadian ocean data management community. Together, these participants discussed the future of ocean data management and data sharing in Canada.

Out of the forum emerged a clear vision: The Canadian Integrated Ocean Observing System (CIOOS) (Wilson et al., 2016). According to forum participants, CIOOS is necessary to ensure the Canadian scientific community is able to leverage "Canada's ocean data to best support scientific excellence, foster collaboration and innovation, and harness ocean data to inform decision-makers and other stakeholders" (Wilson et al.,

2016, p. 1). Participants suggested that the need to take action on this project is both great and time-sensitive. As a result, ocean data managers from across Canada have formed an Ocean Data Management Community of Practice (ODM CoP) that is committed to working together to make this research network-as-system happen (Wilson et al., 2016). The ODM CoP brings together representatives from the following Canadian ocean data centres and organizations: the Atlantic Coastal Zone Information Steering Committee (ACZISC), the Canadian Cryospheric Information Network/Polar Data Catalogue (PDC/CCIN), the Canadian Healthy Oceans Network (CHONe) II, Fisheries and Oceans Canada (DFO), L'Observatoire global du Saint-Laurent/St. Lawrence Global Observatory (OGSL/SLGO), the Marine Environmental Observation Prediction and Response (MEOPAR) Network, the Marine Institute of Memorial University of Newfoundland (MI), Ocean Networks Canada (ONC), and the Ocean Tracking Network (OTN).

Though still in development, CIOOS will function much like IOOS, integrating existing Canadian ocean observation data. This data will come from various regional and thematic OOS located across the country that currently collect and store ocean research data, as well as other ocean research groups and projects with valuable data to contribute (Wilson et al., 2016). CIOOS will operate using a web-based platform, providing "single-source discovery, search, and wide-ranging access to quality ocean data for all stakeholders" (Wilson et al., 2016, p. 2). Researcher interaction with CIOOS will therefore entirely happen in the online context.

While the results of the forum pointed to a promising sense of unity and shared vision, the ODM CoP and the Canadian ocean research community still has certain hurdles to overcome before CIOOS is realized. According to Wilson et al. (2016), one of the major hurdles is to create a "blueprint" for the system's architecture. The ODM CoP needs to figure out what CIOOS will actually look like and how it will function as cyberinfrastructure. In my mind, this hurdle, still being overcome, represented a unique opportunity. Why not talk to the researchers who will be contributing data and engaging with this system about their preferences for system design? What do researchers perceive as important? The ability to speak with Canadian ocean researchers about these topics now is invaluable as it has the potential to influence what CIOOS will eventually become.

Using CIOOS as an opportune context, this thesis works to develop an understanding of the research network-as-system from the researcher perspective. Specifically, this thesis provides data on what is at stake when one is asked to collaborate and participate in a research network-as-system. This study has two main research questions. First, to know what supports may be put in place at a national, institutional, and network level, it is important to understand what challenges exist in the research network-as-system context and how to mitigate them.

RQ1: What helps and hinders collaboration in a research network-as-system?

Secondly, if large, multidisciplinary, web-based research networks are the way forward in oceans research, it is important to understand what motivates researchers to get on board and participate.

RQ2: How do past and current collaboration experiences affect researcher willingness to adapt to new network contexts?

To answer these questions, I conducted semi-structured interviews with ten Canadian ocean researchers about their past and current collaboration experiences, as well their perception of future collaboration via CIOOS. While there are many ways to approach answering the above questions, I decided to focus my study design and data analysis using knowledge management (KM) framework. Specifically, I was inspired by Tan's (2016) framework of KM factors that are influential on collaboration (e.g., trust, organizational culture, face-to-face interactive communication, KM system infrastructure). The choice to utilize Tan was informed by my realization that Tan's framework very succinctly combined the various challenges and motivations for collaboration I had encountered in my review of relevant literature. Effectively, Tan's framework brought together many of the most important issues related to collaboration in one place. My study explored the relevancy of Tan's framework in the context of the research network-as-system, investigating how Tan's framework applies when collaboration involves data sharing. Tan's framework was also used to profile the past and current collaboration experiences of participants.

The findings of this study are directly and practically beneficial for individuals involved in the development and management of research networks-as-systems. In particular, this study will be useful for the ODM CoP as it navigates the planning, development, and design process for CIOOS. In terms of theoretical contributions, this study offers insight

on researcher perception of collaboration in large, dispersed, and multidisciplinary groups and in integrated online spaces.

1.2 Overview of Thesis

This thesis consists of six chapters. Following the introduction, Chapter 2 acts as a review of relevant literature, looking at prior research on collaboration in research networks, as well as the increasing importance of data sharing for scientific research communities and the consequent shift towards the research network-as-system model. Chapter 2 concludes by identifying gaps in the current literature that served to motivate this study. Chapter 3 details the research methods used in this project. In Chapter 4, the two research questions set out by this study are answered and the findings are explained in full. Chapter 5 discusses the main findings of this study in relation to prior research. Finally, Chapter 6 explores the significance of this study's findings, explaining the theoretical and practical contributions of this thesis, study limitations, as well as suggestions for future research.

CHAPTER 2: LITERATURE REVIEW

This chapter is a review of prior literature related to subjects at the heart of this thesis. In section 2.1, studies on contemporary research collaboration are explored, including discussion of the challenges posed by multidisciplinary and geographically-dispersed collaboration. Section 2.2 describes findings from prior research related to research network characteristics known to enable collaboration: trust, sense of community, open and informal interactivity, and organizational support. Section 2.3 covers literature on the rise of the research network-as-system in scientific research communities, specifically discussing the benefits and challenges associated with data sharing in these contexts. This chapter concludes by outlining gaps in prior research (section 2.4), providing important context for the two research questions driving this study.

2.1 Contemporary Research Collaboration

As Wellman, Dimitrova, Hayat, Ying Mo, and Smale (2014) state, "Effective scholars rarely talk only to themselves" (p. 481). Research is always, in some way, a collaborative practice. Whether the collaboration is explicit, through co-authorship, or less so, through reading and citing the work of others, talking through ideas with a colleague, or revising one's work in response to peer review, research requires a certain level of connection and knowledge exchange. While the collaborative nature of research has long been understood, expectations surrounding collaboration are becoming more refined. Increasingly, funding agencies are directing funding to large-scale, multidisciplinary

collaborations (Monteiro & Keating, 2009). The landscape of research collaboration is changing its focus, requiring individual researchers to connect in new, often formalized, ways.

Formal collaboration between researchers most often occurs in the context of research networks. Mo, Hayat, and Wellman (2015) define research networks as "networks of teams or work units progressing towards a common goal" (p. 108). More and more, research networks are created by external bodies (Wellman et al., 2014). Funding agencies fabricate "large and complex research enterprises," encouraging researchers from multiple disciplines and across large geographic distances to come together and share resources (Wellman et al., 2014, p. 483). The benefits of these networks are perhaps obvious. Bringing together a large and diverse group of researchers to further knowledge on a particular topic, or set of topics, will usually make for interesting and valuable results; however, this kind of research network also poses certain challenges to collaboration. In the following sections, challenges related to multidisciplinary and geographically dispersed collaboration are highlighted. Of course, multidisciplinary and geographically dispersed research networks do successfully inspire collaboration Discussion of how these challenges can be mitigated via the cultivation of certain network characteristics is therefore also included.

2.1.1 Challenges of Multidisciplinarity

While funding agencies are eager to support research collaborations that bring together researchers from multiple disciplines (Monteiro & Keating, 2009; Wellman et al., 2014),

the fact remains that multidisciplinary research is "extremely difficult to practice successfully" (Caruso & Rhoten, 2001, p. 4). According to Wellman et al. (2014), many researchers express interest in multidisciplinary collaboration, but actual practice is historically limited. Notably, membership in a multidisciplinary research network does not equal multidisciplinary collaboration. Mo et al.'s (2015) study on the Graphics, Animation and New Media Network of Centres of Excellence (GRAND) research network, which aimed to facilitate cross-disciplinary collaboration in Canada, discovered that, despite network members expressing interest in multidisciplinary collaboration, actual collaboration between disciplines was uncommon within the network and researchers tended to collaborate within their own disciplinary boundaries.

Prior research suggests that collaboration between researchers from multiple disciplines is rare partly because multidisciplinary collaboration requires a convergence of distinct research cultures (Caruso & Rhoten, 2001; Wellman et al., 2014). As Monteiro and Keating (2009) explain, individual disciplines collaborate and communicate in different ways. After observing and interviewing members of an interdisciplinary research team, Monteiro and Keating (2009) found that researchers from different disciplines can only ever have a partial understanding of each other's work. This means that both multi- and interdisciplinary collaboration is necessarily founded on certain misunderstandings. Researchers from different disciplines often have contrasting ideas about "the nature of knowledge, how it is obtained, and how it can be tested or confirmed" (Monteiro & Keating, 2009, p. 14), as well as dissimilar ideas about how to define research success (Caruso & Rhoten, 2001; Hislop, 2004). Coming together to collaborate therefore often

involves the challenging navigation of different disciplinary cultures and assumptions.

2.1.2 Challenges of Geographic Dispersion

In addition to investing in multidisciplinary collaborations, funding agencies are increasingly attracted to large-scale research enterprises that connect researchers across geographic distances. Due to the opportunities offered by our increasingly digital world, this is, of course, possible. Many research networks now function as large-scale and geographically-dispersed entities in which communication and collaboration occurs primarily online (Mo et al., 2015; Wellman et al., 2014; Yeon et al., 2015).

Prior research indicates, however, that geographic dispersion and virtual communication pose certain challenges to collaboration. Yeon et al.'s (2015) study surveyed 286 researchers from a completely virtual research community about their knowledge sharing behaviours. The findings from this study suggest that close relationships between researchers are important for facilitating collaboration; however, close relationships are difficult to foster when communication occurs completely in a virtual context (Yeon et al., 2015). Wellman et al.'s (2014) study on the GRAND network makes a similar suggestion, indicating that, despite the opportunity to collaborate with researchers on a national scale, many GRAND scholars chose only to collaborate with individuals located in close enough proximity to enable face-to-face interaction.

2.2 Research Networks: Characteristics to Cultivate

Research networks must mitigate the challenges posed by the multidisciplinarity and

geographic dispersion of contemporary research collaboration. According to prior research, such mitigation occurs through the cultivation of trust, sense of community, and interaction that is open and informal in nature via organizational support: Table 1 offers a breakdown of what prior research reviewed for this study has identified each of these characteristics.

Trust	Caruso & Rhoten, 2001; Das & Teng, 1998; Hislop, 2004; Jarvenpaa & Leidner, 1999; Rathnappulige & Daniel, 2011; Tan, 2016; Wenger, 2010; Yeon, Wong, Chang, & Park, 2015
Community	Caruso & Rhoten, 2001; Tan, 2016; Wenger, 2010; Yeon et al., 2015
Open and Informal Interactivity	Hislop, 2004; McLure Wasko & Faraj, 2000; Nistor, Daxecker, Stanciu, & Diekamp, 2015; Rathnappulige & Daniel, 2011; Tan, 2016
Organizational Support	Mo et al., 2015; Tan, 2016

Table 1: Prior Studies on the Characteristics of Research Networks

Trust, community, open and informal interactivity, and strong organizational support, discussed in more detail below, are therefore important characteristics of research networks.

2.2.1 Trust

Studies on research collaboration consistently cite trust as having a major effect on researcher willingness to collaborate (Caruso & Rhoten, 2001; Hislop, 2004; Jarvenpaa & Leidner, 1999; Rathnappulige & Daniel, 2011; Tan, 2016; Wenger, 2010; Yeon, Wong, Chang, & Park, 2015). Individuals are more inclined to cooperate and work together if they trust that others are reliable, non-opportunistic (Das & Teng, 1998), and will not exploit shared resources in ways that conflict with the original source's interests (Tan, 2016). Rathnappulige and Daniel's (2011) study, which involved interviews with medical researchers working in teams, found that individuals were only willing to share knowledge and collaborate at a high level if they felt safe within their teams. Successful collaboration between these researchers was therefore dependent on trust.

According to prior research, trust between individuals can be built over time through prolonged interaction (Das & Teng, 1998). Though this finding makes sense—given enough time, individuals are able to know each other better and establish confidence in each other's intentions and working styles—the reality of collaboration is that projects may need to get started quickly. If time is lacking, studies suggests that frequent interaction can also facilitate trust building (Jarvenpaa & Leidner, 1999; Yeon et al., 2015). Hoping to mitigate trust issues in a completely virtual research community, Yeon et al. (2015) suggested organizing frequent meetings between small groups of researchers so as to increase opportunities for researchers to be exposed to each other and hopefully build trust as quickly as possible. Research networks should therefore facilitate frequent and consistent interaction between members so as to cultivate trust and strong

collaborative relationships.

2.2.2 Community

Sense of trust is closely linked with another key condition that affects collaboration within research networks: sense of belonging. Multiple studies indicate that the degree to which individuals feel that their research network is a community with a shared vision has a prominent influence on researcher willingness to collaborate (Caruso & Rhoten, 2001; Tan, 2016; Wenger, 2010; Yeon et al., 2015). Wenger (2010) is careful to distinguish between networks and communities and in his discussion of Communities of Practice (CoPs). According to Wenger, communities emphasize "identity," whereas networks emphasize "connectivity" (p. 191). Networks and communities can coexist; however, coexistence is not a given (Wenger, 2010). A network can exist without being a true community.

How does one foster community? A shared vision, or "common goal" (Mo et al., 2015, p. 108), serves to bind individuals together, helping to form closer bonds and foster trust. As Yeon et al. (2015) assert, if a network's shared vision is explicitly tied to endorsing and practicing collaboration, individuals will be even more willing to work with others within their network. Research networks looking to cultivate collaboration should therefore first focus on fostering community identity as a productive way forward.

2.2.3 Open and Informal Interactivity

Nature of interactivity also affects the success of a research network. Literature on

research collaboration consistently confirms that *how* collaborative interactions occur is important to researchers, and the more social and informal the exchanges, the better (Hislop, 2004; McLure Wasko & Faraj, 2000; Nistor, Daxecker, Stanciu, & Diekamp, 2015; Rathnappulige & Daniel, 2011; Tan, 2016). Studies suggest that open, informal discussion and face-to-face interaction within networks positively affect researcher willingness to collaborate (McLure Wasko & Faraj, 2000; Rathnappulige & Daniel, 2011). Nistor et al.'s (2015) study on academic CoPs, which involved surveying 136 scholars about their sense of community and interaction with other scholars, found that to share formal (professional) knowledge, members of a community have to first share informal (personal) knowledge. As mentioned previously, many research networks are now geographically dispersed, limiting opportunities for face-to-face interaction; however, research networks that encourage social and informal interaction between researchers, whenever and however possible, will be most successful at enabling collaboration (McLure Wasko & Faraj, 2000).

2.2.4 Organizational Support

Perhaps unsurprisingly, prior research indicates that the ability of a research network to facilitate collaboration is heavily reliant on organizational support (Mo et al., 2015; Tan, 2016). Ensuring that trust, sense of community, and nature of interactivity are all conducive to collaboration is the responsibility of a research network's management team. For example, Tan's (2016) study on how different knowledge management (KM) factors affect collaboration involved distributing a survey questionnaire to 421 Malaysian researchers. The findings of Tan's study indicated that an organization's culture can

greatly affect its success in facilitating knowledge sharing and collaboration. A research network or community with a culture that celebrates and encourages collaboration, perhaps via trust- and community-building exercises or opportunities for social interaction, is more likely to be highly collaborative (Tan, 2016). In large part, it is the responsibility of organizational management to foster this kind of culture. Furthermore, it is also important for those at the helm of research networks to be aware and attentive to researcher needs and preferences regarding collaboration (Tan, 2016).

2.3 Data Sharing and The Research Network-As-System

Prior studies on research collaboration and research network characteristics are helpful for understanding what can motivate individuals to work together and share knowledge (trust, sense of community, open and informal interaction, and organizational support), as well as what can hold them back (disciplinary differences and geographic dispersion). The research network-as-system, however, poses unique challenges to collaboration not covered by the literature discussed above. This new type of research network is typically large in scale (national, or even international), bringing together multiple research disciplines related to a broad topic, and consisting of completely virtual interactions (uploading and downloading data). While multidisciplinarity and geographic dispersion are not uncommon in contemporary research networks, the research network-as-system poses the same challenges as other networks, without much opportunity for mitigation. As a research network that facilitates collaboration only via impersonal data sharing, opportunities for trust-building, community cultivation, and open and informal interaction are limited, if even possible.

So how did we get here? If studies and experience show that research networks should ideally be close-knit and highly personal, why are we increasingly moving towards a highly impersonal research network model? To help understand this shift as well as the stakes involved in research networks-as-systems, the next section of this literature review will explore the benefits and challenges associated with collaboration as data sharing.

2.3.1 The Rise of Data Sharing: Benefits

The development of the research network-as-system is directly linked to the increasing focus on data by the scientific community. Pryor (2012) defines data as "the primary building block of all information" (p. 3). According to Pryor, data constitutes the "lowest level of abstraction in any field of knowledge" and can be identified as "collections of numbers, characters, images or other symbols that when contextualized in a certain way represent facts, figures or ideas as communicable information" (p. 3). While the collection and analysis of data have long formed the backbone of scientific discovery, innovations in computer technology have revolutionized how we acquire and use data to further scientific knowledge (Simons & Richardson, 2013; Tenopir et al., 2011).

Developments such as "computational simulation and modeling, automated data acquisition, and communication technologies" allow scientists to collect huge amounts of data at ever-increasing rates (Tenopir et al., 2011, p. 1). Resulting from this revolution is a "data deluge" or "data tsunami" (Simons & Richardson, 2013, p. 116). Scientists are currently collecting more data than they ever have before, and in many cases, more data

than they know what to do with. As a result, mass amounts of important data go unanalyzed and unused.

One method of coping with this data deluge, is to share data among scientists. At its core, data sharing means "providing access" to data for the sake of "use and reuse" (Tenopir et al., 2011, p. 1). Historically, the scientific community has shared knowledge and information via scholarly publications and conference presentations. In the face of a data deluge, however, the scientific community has recognized the value of sharing raw data so as to ensure that resources are not wasted. This shift creates opportunities for other scientists to work with data that one person alone cannot process (Tenopir et al., 2011). Preventing the waste of valuable data is an acknowledged benefit of data sharing.

Other benefits of data sharing include creating opportunity for researcher exposure to various methodological approaches, engaging in study replication and verification (Teixeira da Silva & Dobranszki, 2015), and even changing the kinds of questions scientists are asking (Candela, Castelli, Manghi & Tani, 2015). With mass amounts of data now at the fingertips of scientists, scientific inquiry is moving towards uncovering research patterns on larger scales and in new ways (Candela, Castelli, Manghi & Tani, 2015).

Of course, this shift in research norms is in part due to pressure from research funding agencies. Large sums of money are invested in research and data is a "valuable product" of that research (Simons & Richardson, 2013, p. 117). Logically, funders are interested in

having their money go as far as possible. If data collected through a funded project can be shared with other scientists, it can potentially further the initial investment, which is another major benefit of data sharing (Simons & Richardson, 2013).

Furthermore, many would argue that data from funded research projects does not belong to any one scientist. Rather, data is a public good produced by "public money" (Sveinsdottir et al., 2014, p. 333). Data should therefore be shared among the scientific community but also be publicly accessible (Sveinsdottir et al., 2014). Teixeira da Silva and Dobranszki (2015) suggest that making data open and available to the public increases transparency in science and, as a result, increases societal trust in the value of funding scientific research. To facilitate data sharing and foster transparency, funders are starting to ask for data management plans from researchers and research councils are outlining clear policies regarding required data management practices (Simons & Richardson, 2013).

2.3.2 The Rise of Data Sharing: Challenges

Clearly, data sharing is increasingly encouraged and becoming more of a common practice for scientific researchers. Despite the obvious benefits of sharing data, outlined above, in some cases, researchers remain resistant to the idea of data sharing (Candela et al., 2015; Edwards, Mayernik, Batcheller, Bowker, & Borgman, 2011; Tenopir et al., 2011). Teixeira da Silva and Dobranszki (2015) point to a fear of data theft as a major cause of researcher unwillingness to share data. If data is openly accessible, it can be downloaded, changed slightly, and used without attribution in another scientist's research.

The original scientist (and funding agency) are not given due recognition, and in some cases, the research published by the data thief is invalid or faulty due to manipulation of the original dataset (Teixeira da Silva & Dobranszki, 2015).

Another aspect of data sharing that cultivates researcher hesitancy is the increasing complexity of "research data itself" (Simons & Richardson, 2013, p. 122). Research data exists in a variety of formats and represents discipline-specific approaches to science. To ensure data is not misinterpreted or misused when shared, researchers must provide metadata to facilitate understanding and interoperability (Edwards et al., 2011). This challenge is reminiscent of the disciplinary cultures of collaboration observed in traditional research networks (Mo et al., 2015; Wellman et al., 2014).

Unfortunately, scientists often experience the need to ready data for mass consumption and provide metadata as "an additional burden on top of their primary work" (Edwards et al., 2011, p. 673). Edwards et al. (2011) refer to this burden as "data friction," suggesting that the uploading and movement of data to and through a system (such as a research network-as-system) costs valuable "time, energy, and human attention" (p. 669). Hence, the resistance. Tenopir et al. (2011) suggest that providing "flexible cyberinfrastructure" (p. 19) and guidance regarding proper metadata usage is the key to nurturing positive attitudes regarding data sharing within research networks. Research networks-as-systems that exist for the sake of data sharing should bear this responsibility in mind.

Though not related to researcher resistance, another challenge posed by data sharing is

lack of awareness. Most commonly, data sharing occurs in two ways: 1) an individual scientist will directly ask another scientist to share a dataset, and 2) datasets will be made available online via digital data repositories/catalogues (in some cases, research networks-as-systems). Both methods pose a similar challenge. In the first instance, the individual scientist needs to know the data exists to actually request access. Similarly, in the second instance, scientists need to go looking for the data online to find it. Awareness is essential. For datasets to be found and used, scientists need to be made aware of their existence (Candela, Castelli, Manghi & Tani, 2015).

While exposure to research through scholarly publications and conference presentations can foster awareness of available data, these outlets tend to offer polished end-products, focusing solely on the data used for a particular study (and not the data that was collected but remains unused). Data journals, a relatively new genre of scholarly publication, are a partial solution to the challenge that is of data awareness (Candela et al., 2015). Data journals publish data-focused papers, which describe datasets that are available online (Candela et al., 2015). Candela et al.'s (2015) study on data journals surveyed more than 100 publications, suggesting that the genre of data journals is substantial and there is demand for the information they provide.

2.4 Gaps in the Literature

Prior research on collaboration is helpful for understanding what makes a strong and highly collaborative research network. The assertion that a trusting, close-knit, and cohesive network community is best suited for facilitating collaboration makes logical

sense; however, it also suggests that research networks should have clear boundaries, indicating an inside (those who belong to a network community) and an outside (those who do not). Cultivating a clear sense of community within a research network therefore also means cultivating an understanding of the network's boundaries.

But what if a research network cannot establish clear boundaries? For example, due to their large size, multidisciplinarity, and impersonal interactivity, research networks-as-systems often have vague and shifting boundaries. Who logs on and downloads data? How do they use that data? Where are members geographically located? What research disciplines do they represent? Most important: *Who actually belongs?* The answers to these questions at any given moment are not obvious to the average contributor or participant of a research network-as-system. He or she may understand that his or her network functions on a national scale, but understanding who contributes and accesses data from across the nation is likely hazy and uncertain. Thus, my primary research question is: What helps and hinders collaboration within a research network-as-system?

Furthermore, beyond specific consideration of the research network-as-system model, the literature discussed above also ignores the fact that research networks (in general) are impermanent and shifting in nature. Whether due to funding or a need for increased resources, the boundaries of research networks often expand. Studies on research collaboration emphasize the need for research networks to cultivate strong communities, personal relations between researchers, and guidance regarding data management and interoperability. These studies fail to acknowledge, however, that the same variables that

make a research network close-knit and highly collaborative may possibly hinder future network expansion. If individuals are accustomed to collaborating in certain ways, transitioning to a new network context (with new collaborators, collaboration methods, and data management requirements) may be difficult. In an attempt fill this gap in the literature, my thesis poses a second research question: How do past and current collaboration experiences affect researcher willingness to adapt to new research network contexts?

CHAPTER 3: METHODOLOGY

This chapter details the qualitative research methods employed by this study. Semi-structured interviews with 10 participants were conducted to better understand what helps and hinders collaboration in research networks-as-systems, as well as how past and current collaboration experiences affect researcher willingness to adapt to new network contexts. Qualitative data was collected for this purpose. Demographics data was also collected to understand and describe the participant sample.

Section 3.1 of this chapter describes the participant sample and methods employed to recruit participants. In Section 3.2, the research design is explained, including justification for the use of Tan's (2016) framework of KM factors as partial inspiration for this study. Section 3.3 describes the interview protocol, including explanation of the two research instruments: an interview script and a demographics questionnaire. In Section 3.4, details regarding how the study unfolded via data collection and data analysis procedures are provided. Finally, Section 3.5 explains how this study complies with research ethics.

3.1 Participants and Recruitment

3.1.1 Participants

The participant sample consisted of 10 ocean researchers currently working in Canada. The sample included four females and six males. In terms of age, two participants identified with the age range 32-38 years old, three identified as being 39-45 years old,

four identified as being 46-52 years old, and one participant identified as being 60-66 years old. All 10 participants possess PhDs. In terms of research discipline, five participants described themselves as working in Oceanography, three described themselves as working in Biology, and two described themselves as working in Geography. The participant sample included researchers working at various levels of academia: five participants hold the academic position of Professor, two hold the position of Associate Professor, two hold the position of Assistant Professor, and one is an adjunct faculty member.

I anticipated that this study would require 10-15 interview participants to enable an understanding of what helps and hinders collaboration in research networks-as-systems, as well as how past and current collaboration experiences affect researcher willingness to adapt to new network contexts. Martin and Quan-Haase (2013) describe data saturation in qualitative research as occurring "when no additional insights are gained from additional data" (p. 1021). Using this definition as my guide, I continued to complete interviews until no new themes emerged from the data and data saturation was reached. As with Martin and Quan-Haase's (2013) research on historians' use of e-books, data saturation occurred in the current study after 10 interviews.

The study population consisted of *all* ocean researchers working at Canadian institutions and collecting scientific data. A total number for this population is not available. While the character of this study population may seem quite large and general in nature, all Canadian ocean researchers collecting scientific data have the potential to contribute to

CIOOS and could therefore offer insight on the issues under investigation. Particular attention was paid, however, to recruiting participants who contribute research to any of the regional/thematic Ocean Observing Systems (OOS) in Canada currently working towards integration as CIOOS, as their future involvement with the system is likely a more pressing reality.

3.1.2 Recruitment

Potential participants were contacted and invited to take part in the study via email (Appendix A: Email Invitation). Contact information for researchers (i.e., email addresses) were readily available on the Internet through institutional websites. Additionally, key informants (Canadian ocean data managers) were consulted to recommend researchers as potential participants. In total, 97 ocean researchers were sent email invitations. The email invitation was also sent to the listservs of the following Canadian OOS: Marine Environmental Ocean Prediction and Response Network (MEOPAR), Ocean Tracking Network (OTN), COINAtlantic, and Canadian Healthy Oceans Network (CHONe). 10 participants responded and agreed to be interviewed. No honorarium or compensation was offered during the recruitment process.

3.2 Research Design

The ultimate goals of this study were to better understand the researcher perspective in research network-as-systems, as well as how past collaboration experiences may affect researcher willingness to adapt to new network contexts. While there are many ways to approach these goals, the research design was largely inspired by Tan's (2016)

framework of knowledge management (KM) factors that affect collaboration. Tan divides up KM factors into four contexts: *individual, organizational, technological*, and *communication*. According to Tan, each context and its corresponding factors have the potential to affect successful collaboration between researchers.

Individual KM factors: Trust, Knowledge Self-Efficacy, Reciprocal Benefits

Organizational KM factors: Organizational Culture, Organizational Rewards, Top Management Support

Technological KM factors: KM System Infrastructure, KM System Quality

Communication KM factors: Openness in Communication, Face-to-Face Interactive Communication

These factors are defined in detail in Section 3.3 – Interview Protocol. I chose Tan's (2016) framework as inspiration for my research design because of how it very succinctly combines the main challenges and motivations related to collaboration. In Table 1 of this thesis (see: Chapter 2 – Literature Review), Tan (2016) is the only study that is common among the four main research network characteristics discussed. In many ways, Tan's framework serves to bring together all the issues that have the potential to influence collaboration in a single model. Tan's framework was therefore an effective and comprehensive tool for investigating collaboration in this research.

In designing this study, I furthered Tan's (2016) line of inquiry by applying her framework in a new context: the research network-as-system. The proposed development of CIOOS, which will require ocean researchers across Canada to share data and

collaborate on a national scale (Wilson et al., 2016), provided an opportune case for tackling this topic. While this study could have focused on IOOS, a research network-as-system already in operation, I wanted to explore a research community in a state of flux. A national, integrated oceans research network like CIOOS is a new development for Canada. Anticipation and various expectations are therefore circulating amongst researchers. I wanted to capitalize on this sense of newness and expectation to ensure that Canadian ocean researchers have a voice in the creation and design of CIOOS. It is my hope that the findings of this research will inform and influence the development of CIOOS, a research network-as-system.

I utilized Tan's framework to answer RQ1 "What helps and hinders collaboration within a research network-as-system?" by exploring the KM factors that researchers identified as potentially helping and/or hindering future collaboration in CIOOS. Further, in order to answer RQ2 "How do past and current collaboration experiences affect researcher willingness to adapt to new research network contexts?" I used Tan's framework to understand and profile the past and current collaboration experiences of participants.

While Tan (2016) approached her investigation of KM and research collaboration by distributing a survey questionnaire to researchers (quantitative in nature), I went a different route, choosing instead to conduct semi-structured interviews with ocean researchers across Canada. My choice to depart from Tan's quantitative approach and conduct a qualitative study was motivated by my desire to develop a deeper understanding of the issues explored by Tan. I sought to carve out a space for Canadian

ocean researchers to give voice to their thoughts, opinions, and perceptions regarding research collaboration, the research network-as-system model, and the development of CIOOS.

This study aimed to create opportunity for participants to engage in in-depth reflection on past and current collaboration experiences, as well as consideration of future collaboration via a research network-as-system. Semi-structured interviews as a data collection method facilitated this aim because they gave me, the interviewer, freedom to a) slightly alter the pre-determined questions from the interview script to accommodate the unique flow and interaction of each interview and b) ask probing questions to ensure all pertinent themes were explored (Luo & Wildemuth, 2009). The semi-structured nature of this study's interviews also allowed for flexibility in follow-up questions (Luo & Wildemuth, 2009).

3.3 Interview Protocol

This study utilized two research instruments: 1) an interview script (see Appendix B: Interview Script), and 2) a demographics questionnaire (see Appendix C: Demographics Questionnaire). To ensure the research instruments were sound and valid, I consulted and received feedback regarding both instruments from a member of the Ocean Data Management Community of Practice (ODM-CoP) working to develop CIOOS. This individual has expert knowledge of the topics involved in this thesis.

3.3.1 Interview Script

The interview script consists of 20 original questions written by me; however, the first 15 questions were adapted from Tan's (2016) survey instrument (Appendix B). These questions do not attempt to be a direct replication of Tan's survey. Rather, they were designed to cover the KM contexts and corresponding factors identified and explored by Tan, while allowing for deeper and customized probing of the relevant issues. Specifically, I was able to customize questions to suit the unique organizational and research contexts of participants.

The first 15 questions in the interview script were devised to better understand the past and current collaboration experiences of participants. Through these questions, I asked participants about their past and current collaboration experiences within their employing institutions, with other researchers in Canada, and within any other research communities to which participants described themselves as belonging. Overall, responses to these questions helped to paint a picture of participants' past and current collaboration experiences, setting me up well to answer RQ2 "How do past and current collaboration experiences affect researcher willingness to adapt to new research network contexts?" Adapted from Tan's (2016) survey, questions about past and current collaboration experiences covered all KM factors in Tan's framework. These factors and their relationship to specific interview questions are discussed in more detail below.

Individual Factors

Trust. Tan (2016) suggests that trust is a "central" influence on knowledge sharing and collaboration (p. 528). According to Tan, if trust is lacking, individuals are held back from collaborating due to a fear that others will "exploit" shared knowledge (p. 528). Interview questions eight, nine, twelve, and thirteen serve to question researchers about their sense of trust in past and current collaborations, and in the Canadian ocean research community.

Knowledge Self-Efficacy. Tan (2016) identifies knowledge self-efficacy as a KM factor that is influential on research collaboration. At its core, knowledge self-efficacy is an individual's belief that his or her knowledge is useful and valuable to others (Tan, 2016). According to Tan, knowledge self-efficacy can motivate collaboration, as individuals with a strong sense of this KM factor understand that they have important knowledge to offer in collaborative relationships and interactions. Interview question nine serves to question researchers about their sense of knowledge self-efficacy in past and current collaborations.

Reciprocal Benefits. Tan (2016) identifies an individual's understanding of the reciprocal benefits resulting from collaboration as having a positive influence on his or her willingness to collaborate. A sense of reciprocity results when individuals collaborate and share knowledge with others and "expect to receive useful knowledge in return" (Tan, 2016, p. 528). Interview questions eight and nine serve to question researchers about their sense of reciprocal benefits in past and current collaborations.

Organizational Factors

Organizational Culture. According to Tan (2016), being immersed in an organizational culture that celebrates and encourages collaboration as "part of its practice" can have a positive impact on researcher willingness to collaborate (p. 529). With this mind, interview questions three, five, six, and seven serve to question researchers about the organizational cultures of their employing institutions.

Organizational Rewards. Tan (2016) suggests that organizational rewards are a useful tool for stimulating successful collaboration. Organizational rewards range from "financial motivation such as better stimulus and bonuses to non-monetary benefits such as promotion incentives and career security" (Tan, 2016, p. 529). Interview question ten serves to question researchers about the presence and possible impact of organizational rewards in past and current collaborations.

Top Management Support. Tan (2016) suggests that collaboration is more likely to be common and successful if members of top management at a given institution celebrate its importance and offer active encouragement. Interview question ten serves to question researchers about the presence and possible influence of top management support in past and current collaborations.

Communication Factors

Face-to-Face Interactive Communication. According to Tan (2016), "Face-to-face interactive communication in KM refers to personal communication by means of

verbalized dialogues and body language while conversing" (p. 531). Face-to-face interactive communication has a positive influence on collaboration and researcher willingness to share resources and knowledge with others (Tan, 2016). Interview questions five and fourteen serve to question researchers about face-to-face interactive communication in past and current collaborations.

Openness in Communication. Openness in communication is the "extent to which individuals are keen to exchange their opinions with each other" (Tan, 2016, p. 530). Interview questions eight and nine serve to question researchers about a sense of openness in communication in past and current collaboration experiences.

Technological Factors

KM System Infrastructure. Tan (2016) defines knowledge management system infrastructure as the

> information technologies that allow KM-related activities, such as web-based storage, virtual communities, Internet, intranet, groupware, video conferencing, group support systems, distance education tools, online group discussion, portal technology, instant messaging (i.e., Blackboard, WebCT), and e-mail. (p. 530)

KM system infrastructure can facilitate the virtual sharing of knowledge, information, and data, enabling convenient and productive collaboration between researchers (Tan, 2016). Interview question eleven serves to question participants about the use and potential influence of KM system infrastructure in past and current collaborations.

KM System Quality. According to Tan (2016), "knowledge management system quality refers to the quality of knowledge offered by the KM system" (p. 530). Is the knowledge/information/data presented in the system easily accessible, dependable, precise, and of value to researchers? If so, the KM system will be deemed higher in quality and more likely to encourage collaboration (Tan, 2016). Interview question eleven serves to question participants about the potential impact of KM system quality in past and current collaborations.

The final five questions in the interview script relate specifically to CIOOS, the research network-as-system that is the focus of this study. These five questions are quite open ended, asking participants about their awareness of the system, and their perception of any benefits (for themselves and for others), risks, and challenges associated with participation in the system. While these questions are not adapted from Tan (2016), I correctly suspected that some of Tan's KM factors would emerge as benefits, risks, and challenges in participant responses. This set of questions shed light on RQ1 "What helps and hinders collaboration in research networks-as-systems?" Further, this set of questions allowed me to gage participant willingness to participate in CIOOS, a new research network, therefore enabling me to fully answer RQ2.

3.3.2 Demographics Questionnaire

With the demographics questionnaire (Appendix C), I collected demographic data about my participants for the purposes of understanding and describing my participant sample.

The demographics questionnaire consisted of five questions related to gender, age, level of education, research discipline, and academic position.

3.4 Procedure

3.4.1 Data Collection

Data collection for this study occurred between November 15, 2016 and January 20, 2017. All semi-structured interviews occurred via telephone, were audio-recorded, and took approximately 30 to 45 minutes. While all participants were asked a standard list of pre-scripted questions (see Appendix B: Interview Script), probing and follow-up questions varied among participants.

To ensure informed consent, all study participants were sent an electronic copy of the consent form via email (see Appendix D: Consent Form) prior to the interview. At the time of each interview, I confirmed participants had read and understood the consent form. If participants had not yet read the consent form, I read the form aloud over the phone and asked them to follow along with their electronic copy. After answering any questions about the study and/or the consent form, I asked participants to provide verbal consent for participation in the study and verbal consent for audio-recording of the interview. Verbal confirmation of consent was recorded in my personal notes. I then turned on the audio recorder.

Next, I reminded participants that they could stop the interview at any time to ask questions or withdraw their participation. I also reminded them that they were able to

withdraw their participation and data for any reason up to one week after the interview, as described in the consent form. The reason for this one-week limitation was that their interviews may have been transcribed and data analysis begun by that time, making it difficult to withdraw data. Before continuing on to the interview questions and demographic questionnaire, I gave participants an opportunity to ask any additional questions they may have had, or leave the study if they so desired. We then proceeded with the official interview, guided by the Interview Script (see Appendix B).

At the end of each interview, participants were asked a series of demographic questions (see Appendix C). Finally, participants were asked if they had any closing questions about the study. Before ending the phone call, participants were asked whether they would like to receive a copy of the final research results in the form of an electronic thesis. If yes, I confirmed contact information for this future exchange.

3.4.2 Data Analysis

To protect the identities of participants, audio recordings of interviews were all stored on my personal laptop computer, which is password protected. Further, in all interview transcriptions, collected demographic data, and research notes indicating verbal confirmation of consent from participants, participant names were replaced with pseudonyms and any features that might identify either a participant or his/her organization were redacted. These anonymized transcriptions, data, and notes were kept on a password protected server at Dalhousie University as well as on my own laptop

computer (in a separate location than the original interview recordings), which is password protected.

Data from the demographics questionnaire was recorded and analyzed in Microsoft Excel using descriptive statistics. This data provided a basic understanding of the composition of the study sample. Demographics data included the gender, age, research discipline, and academic position of all participants.

Interview data was carefully transcribed into Microsoft Word using the audio-recordings. Initial data analysis occurred in Microsoft Word. Data was analyzed using thematic analysis. Due to the qualitative, semi-structured nature of my data collection, thematic analysis was chosen to ensure the nuance and complexity of my findings could be fully and accurately communicated. Braun and Clarke (2006) define thematic analysis as "a method for identifying, analyzing, and reporting patterns (themes) within [qualitative] data" (p. 79). According to Braun and Clarke, thematic analysis involves six major steps: 1) familiarize yourself with the data, 2) generate initial codes, 3) collate codes into themes, 4) review themes to ensure they fit the data, 5) define and name themes, 6) produce the final report of analysis.

Familiarization with the data occurred during transcription. Identification of initial codes was informed by Tan's (2016) framework of key KM contexts and corresponding factors: *individual* (trust, knowledge self-efficacy, reciprocal benefits), *organizational* (top management support, organizational rewards, organizational culture), *technological*

(knowledge management system infrastructure, knowledge management system quality), and *communication* (openness in communication, face-to-face interactive communication). I applied these contexts and factors as higher level codes when completing a first reading of all interview transcripts in Microsoft Word.

Interview transcripts were next uploaded to Nvivo11 software for further development of lower level thematic codes and analysis of data. In total, 57 codes were created (see Appendix E: Coding Scheme). Creation and collation of these codes allowed for thematic exploration of participant reflection on past and current collaboration experiences, as well as their consideration of future collaboration in a research network-as-system (CIOOS). Themes and codes were reviewed to ensure they accurately fit the data. Chapter 4 - Findings of this thesis acts as the final report of the data analysis.

3.5 Research Ethics

The methods used in this study were developed to comply with the *Tri-Council Policy Statement: Ethical Conduct for Research Involving Humans* (CIHR, NSERC & SSHRC, 2014). An application for ethics approval was submitted to Dalhousie University's Social Sciences & Humanities Research Ethics Board in September 2016. On October 19, 2016, final ethics approval was received (see Appendix F). The application submitted for ethics approval is included as an appendix to this thesis (Appendix G: Application for Ethics Approval).

3.6 Validity and Reliability

To ensure validity and reliability in qualitative research, this study employed methods for verifying academic rigour recommended by Seale and Silverman (1997). Every effort was taken to carefully and objectively record and transcribe interview data (Seale & Silverman, 1997). Interviews were audio recorded using technology that was pre-tested for sound quality and these recordings served as the basis for transcription. Further, generalizations made in this research were supported by “counts of events” and “deviant case analysis" to avoid unrepresentative anecdotalism (p. 380). Lastly, qualitative data analysis was assisted by the use of Nvivo11 software to ensure analysis was as thorough and systematic as possible (Seale & Silverman, 1997).

3.7 Participant IDs

In the chapters to follow, participants will be identified in two ways:

1. By research discipline, in a broad sense (Biology, Oceanography, or Geography).
2. By academic position, in a broad sense (Professor, Associate Professor, Assistant Professor, or Adjunct Faculty).

This two-part identification is the basis of the participant IDs used throughout this thesis. The ten participant IDs are as follows:

Professor Biology1

Professor Biology2

Professor Geography1

Professor Geography2

Professor Oceanography1

Associate Professor Oceanography1

Associate Professor Oceanography2

Assistant Professor Biology1

Assistant Professor Oceanography1

Adjunct Faculty Oceanography1

Further, any identifying information directly present in quotations (place of employment, number of co-workers, details regarding specific research projects, etc.) is not reported.

CHAPTER 4: FINDINGS

In this chapter, the findings from semi-structured interviews with participants—10 ocean researchers working at Canadian universities—are described. Based on analysis of the interview data, this chapter responds directly to the two research questions driving this study:

> **RQ1: What helps and hinders collaboration in research networks-as-systems?**
>
> **RQ2: How do past and current collaboration experiences affect researcher willingness to adapt to new network contexts?**

To respond to RQ1, Section 4.1 explores the forces that participants identified as helping or hindering collaboration in the research network-as-system context. Answering RQ2, Section 4.2 paints a picture of participants' collaborative histories so as to investigate the relationship between those histories and participants' overall willingness to adapt to a new network context (in this case, the research network-as-system CIOOS). Throughout both sections, the relevancy of Tan's (2016) framework of KM factors that are influential on collaboration is discussed. In Section 4.3, a summary of the major findings is provided.

4.1 RQ1: What helps and hinders collaboration in research networks-as-systems?

This section answers the first research question posed by this study "What helps and hinders collaboration in research networks-as-systems?" by outlining the relevant findings from participant interviews. In terms of helping forces, conversations with participants revealed that participants commonly exhibited a positive attitude towards

collaboration that has the potential to help collaboration in the research network-as-system context. In terms of hindering forces, participants indicated that risks related to data sharing, the burden of additional labour required of the research network-as-system model, potential exclusion of disciplines and experimental research data from the system, and overall system quality all have the potential to hinder collaboration in the research network-as-system model. Drawing on participant responses, helping and hindering forces are discussed in more detail throughout this section.

4.1.1 What Helps?

Participant responses to interview questions and resulting conversation revealed that participants possess an overall positive attitude towards collaboration that will help collaboration in the research network-as-system context. In this study, I define attitude as one's outlook, preferences, strategies, and general beliefs regarding a topic (in this case, collaboration in a research network-as-system). Discussed in more detail below, three themes relating to positive attitudes towards collaboration were identified: 1) knowledge self-efficacy, 2) reciprocal benefits, and 3) nature of research. Knowledge self-efficacy and reciprocal benefits are KM factors originally described in Tan's (2016) study. Participants understand that their data is valuable to others and that others' data is valuable to them, contributing to their shared positive attitude towards collaboration and motivating them to collaborate. In addition, one individual KM factor not identified by Tan was revealed as helpful for collaboration in the research network-as-system context: nature of research. The ways in which participants' research necessitates collaboration, the kind of research they do, emerged as an important factor that contributes to

participants' positive attitudes towards collaboration in general and motivates participation in research networks-as-systems, such as CIOOS.

Positive Attitude towards Collaboration. When asked to consider participation in CIOOS, all participants demonstrated a generally positive attitude regarding the prospect of sharing data with others on a national scale. This positive attitude persisted despite the acknowledgment of risks related to trust and technological challenges associated with data sharing (discussed in more detail in section 4.1.2 Hindering Factors). For example, reflecting on data sharing via CIOOS, Assistant Professor Biology1 declared, "Sure, there are risks, but they do not outweigh the benefits." Though participants acknowledged specific risks and challenges, their general attitude towards data sharing via CIOOS was enthusiastic and supportive.

Knowledge self-efficacy is directly related to the positive attitudes participants exhibited towards collaboration. When questioned about potential collaboration and data sharing via CIOOS, nine out of ten participants indicated that they strongly believe their data will be beneficial to other researchers if shared through CIOOS. For example, when reflecting on the relevancy of his data to others, Associate Professor Oceanography1 exclaimed, "I hope so. Otherwise, why am I collecting it? I mean, I'm not just collecting it for myself, so yes, I hope so. I know it would be." Multiple participants actually seemed baffled by my question (Question 17 – Appendix B: Interview Script), as if the value of their data to other researchers should be obvious, indicating a strong sense of knowledge self-efficacy.

Also informing participants' shared positive attitude towards collaboration is their strong sense of reciprocal benefits. Participants described reciprocal benefits as a clear and major motivation for future participation in CIOOS. For example, Professor Oceanography1 stated,

> The thing about sharing data is, you're putting data in, but you're also getting data out. That's the thing people are worried about. "I'm going give up my data." But you don't really. Because you get access to a much bigger data set. And so yes, I think it [participation in CIOOS] would be tremendously beneficial.

When asked to consider contributing data to CIOOS, all ten participants acknowledged that sharing data with others would be beneficial because, in turn, the participants would be given access to data collected by others.

A third KM factor that was shown to impact participants' positive attitudes towards collaboration was the actual nature of their research. Nature of research was not identified as an influential KM factor in Tan's (2016) study but emerged again and again throughout my conversations with participants. Participants indicated that their research demands collaboration, and specifically, data sharing. They therefore have an open and supportive perspective on research networks-as-systems such as CIOOS. Many participants acknowledged that networks like CIOOS are essential for furthering knowledge in their respective fields. For instance, Professor Geography2 explained that CIOOS would be beneficial "to avoid duplication, to delve in and answer more complex questions, to allow different areas of expertise to be able to look at data from different viewpoints, and to apply different methods of analysis." Furthermore, Professor Biology2 referenced IOOS,

the American data repository that CIOOS will be modelled after, as having "tremendous value" and "all kinds of unintended uses" for ocean research. The nature of research undertaken by participants in this study benefits from sharing and accessing data collected by wide variety of researchers.

Notably, my discussions of data sharing with participants revealed one alternative attitude. Though very supportive of collaboration and data sharing in general, Associate Professor Oceanography1 took issue with the way I referred to data as belonging to a single researcher. For example, when I asked the participant about "his data," he responded, "There's a distinction between my data, which would suggest ownership, and the data I collect." Quite poetically, Associate Professor Oceanography1 clarified his statement with this reflection: "A beach has many wonderful pebbles on it. You can go and collect them and take them home, put them in a jar or something, but they're not really your property. They're part of the earth." In this instance, the participant exhibited a unique attitude towards data sharing, describing his belief that data does not belong to any one researcher and is therefore meant to be shared.

Interviews with participants revealed that knowledge self-efficacy, reciprocal benefits, and nature of research are all individual KM factors that create an overall positive attitude towards collaboration. This positive attitude helps collaboration in the research network-as-system context because it cultivates a sense of commitment and enthusiasm in relation to data sharing within dispersed groups and in online spaces. Notably, while nature of research did not emerge as a KM factor in Tan's (2016) study, participants' strong sense

of the fact that their research requires collaboration and data sharing was shown to play a significant role in fostering positive attitudes towards collaboration and the research network-as-system, and is therefore an important factor to consider.

4.1.2 What Hinders?

While participants exhibited a shared positive outlook on CIOOS as a future research network-as-system, certain forces were still identified as potentially hindering collaboration in the research network-as-system context. These forces include: 1) risks related to data sharing; 2) the burden of additional labour required of the research network-as-system model; 3) potential exclusion of disciplines and experimental research data from the system; and 4) overall system quality. Risk, burden, exclusion, and quality are discussed in more detail below.

Risk. Reflecting on potential data sharing via CIOOS, two participants described feeling hesitant about data sharing due to the risk that they would not be given proper credit for their data. In both cases, this perception of risk was due to trust being violated in past experiences. Professor Geography2 remarked, "I've had experience where data has been provided to others and has been published without me having any authorship." Having shared data in the past with negative consequences, two participants in this study indicated that they would be wary of sharing data in the future because they do not trust that others would accurately indicate original authorship. For two participants, trust as a KM factor poses certain risks that hinder their willingness to collaborate in the research network-as-system context.

The risk of one's data being used by others without due acknowledgment is related to a larger culture of dishonest science described by many participants. This culture is one in which "nefarious scientists" (Professor Biology2) are known to steal data, failing to cite the original author, manipulate numbers, and publish flawed findings. While multiple participants acknowledged that this culture exists, a majority stated that it poses a minimal risk. Adjunct Faculty Oceanography1 explained, "I think there are people who will misappropriate and misuse other people's data, but it's extremely rare." In most cases, the nominal risk posed by dishonest science did not inhibit participant willingness to share data.

Risk as a hindering factor on collaboration in the research network-as-system further emerged with regards to data sharing when one participant expressed fear about protecting marine species. Professor Biology1 stated that sharing data with "detailed distribution information on endangered species or exploitable species" was a cause for concern as it could "give anybody with nefarious intentions the ability to go out and illegally exploit things that we don't want them to exploit." Professor Biology1 indicated distrust regarding the uncertainty inherent in data sharing: who will use my data and how? Controlling the answer to this question is not a simple or, in some cases, possible task.

Burden. Risks, however, are different than costs. Multiple participants recognized that the research network-as-system model often requires additional labour on the part of researchers that is experienced as a burden. This burden involves prepping data to share

with others. As Associate Professor Oceanography1 remarked, “There’s the rub … The cost is ridiculous. It’s so painful to get all the metadata organized.” Further, Assistant Professor Oceanography1 reflected, “The biggest challenge, I think, is finding the person power, giving researchers more work to do, to make their data fit … How do you find the time or the personnel to do that?” Participants identified the burden of extra work that the research network-as-system requires as a deterring force that can hinder collaboration.

Exclusion. Participants also indicated that exclusion of specific disciplines or data types may hinder collaboration in the research network-as-system that is CIOOS. For example, one participant expressed feeling discriminated and left out of the Canadian ocean research community due to her disciplinary background. Professor Geography2 commented,

> There are definitely clubs, cliques, and silos within the oceanographic and coastal community within Canada ... There are also disciplinary assumptions. For example, though my training is very similar to someone in Oceanography, because I am in a Geography department, there are incorrect assumptions that the type of analyses that I do, even if they are very similar to individuals in Oceanography, are different … You’re not as accepted to the group and it’s a lot harder to actually be invited into collaborative activities or participate.

As an ocean researcher working in a Geography department, Professor Geography2 suggested that she is often passed over or not included in collaborative activities. If this trend of exclusion continues, complex and multidisciplinary collaboration could be hindered in CIOOS.

Further, Professor Biology1 expressed uncertainty with regards to whether or not his data would fit in the context of CIOOS, explaining that his data is experimental, rather than observational, in nature. Professor Biology1 indicated that be believes much of the data that will be stored and shared in CIOOS is monitoring and survey data (observation-based). Consequently, he suggested that experimental data like his own "doesn't fit" well in research networks like CIOOS. The findings of this study indicate that the exclusion of certain data types from a system may further hinder possibilities for collaboration in the research network-as-system context.

Quality. All ten participants expressed the importance of system quality, one of Tan's (2016) KM factors, for CIOOS to be successful. Associate Professor Oceanography1 suggested that, to be successful and meaningful to researchers, the CIOOS project must "maintain a database that captures the unique diversity of our ocean ecosystems." Specifically, when considering system quality, participants described two major technological challenges that they perceive as potentially hindering the quality of the CIOOS research network-as-system: data standardization, and provision of metadata. These challenges, which have the potential to hinder collaboration, are outlined in more detail below.

A common challenge related to system quality and described by participants was regarding standardization. Participants reflected that a national research network-as-system like CIOOS will need to accommodate a wide variety of data. Will all data have a

place in CIOOS? And if so, how does one standardize the offerings of the database? For example, Professor Biology1 stated, "Trying to fit it into a standardized database, that's what's really difficult and that's where I see there being a lot of frustration with the community and my students. They end up sharing only part of the data because it's not set up to the accept all of it." Participants expressed fear that valuable data may not fit well in CIOOS and, as a result, research will suffer. In this way, system quality is identified as potentially hindering collaboration.

Another common challenge to system quality that was important to participants was regarding the inappropriate provision of metadata. Multiple participants expressed worry that CIOOS will not furnish shared data with sufficient metadata. For instance, Professor Geography1 remarked,

> There is a fear that people will misuse the data. So, you collected data, but the way you collected it is important to understand what to do with it, and some people will not understand that. And that's why properly documenting the data and having access to the person who put the data on the site is important.

Participants suggested that the failure to provide accurate and comprehensive metadata would lead to potential data misinterpretation or misuse, and therefore may hinder successful collaboration.

Interviews with participants revealed that risks related to data sharing, the burden of additional labour required of research networks-as-systems, potential exclusion of researchers or research data based on discipline or approach, and the overall quality of the

system itself are all perceived as hindering forces in the research network-as-system context. Though participants maintain a positive attitude towards collaboration despite these hindering forces, the importance of risk, burden, exclusion, and quality should not be underestimated. These hindering forces all have the potential to impede successful collaboration and, if not addressed, may possibly erode the positive attitude shared by participants over time.

4.2 RQ2: How do past and current collaboration experiences affect researcher willingness to adapt to new network contexts?

When reflecting on past and current collaboration experiences, all participants revealed themselves to be highly collaborative individuals who have engaged in a wide variety of past collaborative interactions and relationships. As discussed in response to RQ1, participants also indicated that they are supportive and enthusiastic about CIOOS, demonstrating a high level of willingness towards adapting to the future research network-as-system. To answer RQ2, this section paints a picture of participants' collaborative histories in order to better understand the relationship between past and current collaboration experiences and the strong sense of willingness demonstrated by participants. Participants' collaborative histories are detailed according to four main themes: The Individual as Collaborator (Section 4.2.1), Organizational Affiliations (Section 4.2.2), and Technology (Section 4.2.3), and Communication (Section 4.2.4). In Section 4.2.5, I draw on these themes to answer RQ2.

4.2.1 The Individual as Collaborator

Participants in this study describe themselves as highly collaborative individuals with specific preferences and motivations related to collaboration. These preferences and motivations are described below in relation to past and current collaboration experiences. Taken together, these preferences and motivations shed light on how participants view themselves as professional collaborators, wherein collaboration is an essential component of their working lives.

When asked about preferred working style (solitary or collaborative) for research, the majority of participants described preferring a balance of solitary and collaborative work. Professor Biology1 remarked,

> My projects are all collaborative but I also believe, for example, you can't write by committee. The reason, I'm productive is because I actually don't come to work two days a week. So, yes, I'm highly collaborative, and collaborate with tons and tons of people, but at the same time I believe the reason that I'm successful is that I also make sure I save time for me, both intellectually and otherwise.

In many cases, participants suggested that such a balance is not just preferred but necessary for success in the discipline of scientific ocean research.

While most participants described preferring a balance of solitary and collaborative work, a minority described a preference for collaborative work. Professor Geography2 stated, "Collaborating is definitely a more positive environment than being in isolation." No participants indicated a preference for solitary work.

Again and again, participants indicated that the very nature of their research demands collaboration, and specifically, data sharing. For example, Professor Oceanography1 remarked, “The problems are really big and complex, so the more data we have access to, the more likely it is we’re going to actually answer some of those complex questions that we’re asking.” In many cases, participants indicated that ocean research relies on access to large amounts of diverse data.

Regarding past and current collaboration experiences, all ten participants demonstrated a strong sense of knowledge self-efficacy. This KM factor was described in relation to two main practices: a) providing insight and advice to others, and b) initiating collaboration with others. All ten participants indicated that they are very willing to provide insight, advice, and feedback to their colleagues and collaborative partners. For example, when questioned about providing feedback and advice to others, Professor Geography1 stated, “That’s very common. In the last little while, I would say half of my department came to me for advice for things related to my expertise.” Participants’ willingness to offer guidance to others suggests a high degree of self-confidence and knowledge self-efficacy.

All participants also referenced past experiences of reaching out to researchers to initiate collaboration. For example, Professor Oceanography1 explained how a typical collaboration begins: “You see a possibility for a project so you contact somebody at another institution who may be interested.” Participants’ eagerness to propose collaboration to others points to an understanding of how their knowledge would add

value to collaborative relationships.

All ten participants also described reciprocal benefits as being a major motivation for collaboration and data sharing in the ocean research context. Speaking about collaboration in general, Professor Oceanography1 explained that the relatively small character of the Canadian ocean research community necessitates an exchange of knowledge and resources in which individuals benefit from the work and expertise of others: "The field is big, the community is small, so we have to collaborate. There is no way to do what we do on our own. It sort of forces you, if you will." Specifically, participants consistently referenced how the reciprocal benefits of collaboration increase research efficiency and productivity. Professor Geography2 described being part of a Community of Practice aimed at learning a new technology: "Because there's a learning curve, we found that establishing a Community of Practice allows everyone to be a lot more productive and someone new doesn't have the same pitfalls that others have experienced." In this instance, individuals shared the burden of the learning curve, grasping the new technology quicker and more efficiently by avoiding mistakes made by others.

4.2.2 Organizational Affiliations

This section details the organizational affiliations that have, in the past, created opportunity for participants to collaborate. While Tan's (2016) study described the organizational context as a researcher's employing institution, conversations with participants in this study revealed that participants have multiple organizational

affiliations, all with collaborative opportunity, including employing universities, formal research networks, and informal research communities. This section details the collaborative cultures of these organizations. Additionally, this section presents participant reflection on how organizational rewards and top management support are a) uncommon in Canadian universities and b) unnecessary for motivating collaboration in the organizational context.

Employing Institutions. When asked if collaboration between internal colleagues at participants' employing institutions was common, four of ten participants answered positively. For example, Professor Geography1 stated, "Every department and people have their own dynamics. I'm fortunate though, my colleagues and I have a good relationship, it's very functional, so people work together and chat and all of that." The six other participants expressed that internal collaboration with colleagues is less common than with researchers outside of their employing institutions. Associate Professor Oceanography2 explained,

> There is only one of me at my institution—only one person doing the kind of work I do. If I want to collaborate with someone doing work related to my own, I have to look elsewhere, outside of my university. I think this is very common in Canada.

Participants indicated that, in many cases, researchers working on similar questions and projects are located at other institutions. Branching outside of one's employing university to find collaborators is therefore common.

When questioned about a specific aspect of collaboration—data sharing—half of the

participants in this study indicated that they have shared data with internal colleagues at their employing institutions in the past. Three of these participants specified that data sharing usually only happens with internal colleagues when individuals are working on a grant application together. For instance, Assistant Professor Biology1 declared, “Sharing data and more formal knowledge usually only happens if we’re working on a funding proposal together and have a specific project in mind we’re hoping to do.” In this way, data sharing is a strategic practice aimed at a shared goal: securing research funding for a mutual project.

All ten participants described collaboration with students, from undergraduate to doctoral students, as being a common and important aspect of the organizational cultures of their employing institutions. Professor Biology1 noted, “Students are the core of everything.” Multiple participants also noted that collaboration with students can create opportunities for collaboration between colleagues, such as co-supervision.

Formal Research Networks. All but one participant in this study described belonging to a formal research network. In all cases, the formal research networks discussed in this study were ocean observing systems (OOS) or ocean research networks, such as the Marine Environmental Observation Prediction and Response Network (MEOPAR), based in Canada. Participants consistently described the organizational cultures of these networks as highly collaborative. According to participants, data sharing is a common practice in these networks and multiple individuals indicated that membership to these networks creates valuable opportunities for connecting with other researchers. For example,

speaking about the Ocean Tracking Network (OTN), an ocean research organization and data repository, Assistant Professor Biology1 expressed, "OTN has been a great way to be exposed to people and form meaningful working relationships with other researchers." Notably, the one participant who did not describe belonging to a formal research network, expressed that she maintains and benefits from connections within an informal community of researchers (discussed in more detail below).

Informal Research Communities. When reflecting on past and current collaboration experiences, participants also identified informal research communities as having organizational cultures that celebrate and encourage collaboration. While an informal research community is not an organization in the typical sense, participants consistently described working with others towards common research goals in an informal capacity as an important component of their research processes. Participants described these communities as being both national and international in character.

Organizational Rewards. Tan (2016) suggests that organizational rewards are a useful tool for stimulating successful collaboration. Organizational rewards range from "financial motivation such as better stimulus and bonuses to non-monetary benefits such as promotion incentives and career security" (Tan, 2016, p. 529). In the context of this study, discussion about organizational rewards was limited to reflection on participants' current employing institutions. Overall, according to participants, organizational rewards do not seem to be commonly used by Canadian universities to motivate collaboration among colleagues.

Two of the ten participants interviewed for this study described feeling recognized for collaboration in a non-tangible fashion. For example, Professor Associate Oceanography1 remarked,

> There's no financial bonus or something. I think there's a tendency by my superiors to highlight projects that involve more than one faculty member and can show people standing together ... I think the goal generally at those levels is to promote the university to its community and examples of faculty working together is a good thing. But, in terms of, do I know that there's a higher probability of getting research money or a new truck or something if I do it in collaboration with someone else? I don't think that's the case.

Though two participants discussed the presence of organizational recognition for collaboration, neither seemed particularly inspired or encouraged by such recognition.

Additionally, two other participants described receiving financial rewards from their institutions for collaborative projects. For instance, Professor Biology 1 stated, "There are pots of money that you can access to do things in groups that bring people together." Both participants discussed financial rewards as being a motivator for collaboration within their institutions due to the fact that increased funding is always beneficial for their research.

Top Management Support. Tan (2016) suggests that collaboration is more likely to be common and successful if members of top management at a given institution celebrate its

importance and offer active encouragement. In the context of this study, discussion about top management support was limited to reflection on participants' current employing institutions. Only two of the ten participants interviewed for this study indicated that they feel actively supported by top management to engage in collaboration. One of these participants (Professor Geography 2) identified as being employed by a "smaller institution" and suggested that collaboration is encouraged by management because the university relies on faculty sharing resources.

The other eight participants responded in strikingly similar ways when asked about top management support. Is collaboration facilitated or encouraged by management? Consistently, participants stated that a) collaboration is not facilitated by management, and b) it is neither encouraged nor discouraged by management. For example, Assistant Professor Biology1 reflected,

> I think it is assumed, not encouraged. Science today tends to be quite collaborative and so my Dean and my Vice President-Research [members of top management] – they all just assume we're collaborating. There is no specific encouragement or facilitation I can think of.

Many participants qualified their responses by suggesting that, in today's scientific research culture, collaboration is assumed and therefore does not require active encouragement.

4.2.3 Technology

When describing past and current collaboration experiences, participants consistently

cited technology as playing an important role in the collaboration process. Notably, participants displayed independent and flexible relationships with using technology to collaborate. Participants do not rely on KM system infrastructure provided by their employing institutions, but rather, seek out alternative technology to facilitate collaboration.

While participants were asked specifically about KM system infrastructure provided by their employing institutions to facilitate collaboration, only two individuals could identify systems that have played or do play a positive role in their collaborations with others. Associate Professor Biology1 described the email service provided by his institution as being essential for collaboration, while Assistant Professor Biology1 described sharing data with others by directing individuals to her institutional repository. Notably, four participants who could not identify KM systems provided by their employing institutions indicated that they were not certain such systems did not exist but rather lacked awareness of them. For example, when asked if there are technological systems in place at his employing university that facilitate collaboration, Associate Professor Oceanography1 replied, "Not that I can think of," suggesting that KM system infrastructure may exist that the participant does not currently use.

Thinking beyond the systems provided (or not provided) by their organizations, seven participants described using alternative systems for sharing data and facilitating collaboration. Systems described by participants included Dropbox, Google Drive, Apple's iCloud, desktop sharing software, personal email, and USB sticks. Dropbox, a

cloud-based file hosting service that allows for storing and sharing files, was by far the most popular system cited. All seven participants who described using systems not provided by their institutions admitted that they use Dropbox for sharing files. For example, Assistant Professor Oceanography1 stated, "We're sharing data over Dropbox, but as far as I know there's not a university system to do that. I kind of feel like there should be, but there isn't." To compensate for a lack of institution-provided KM system infrastructure, participants look elsewhere to meet their file storing and sharing needs.

4.2.4 Communication

Participants demonstrated a strong sense of flexibility with regards to communication in past and current collaboration experiences. Overall, participants exhibited a high level of openness in communication with regards to collaborators. Participants are very willing to provide advice and insight to others, and, in turn, participants are very willing received advice and insight from others. Furthermore, participants revealed that face-to-face communication, though beneficial, has not historically been necessary for collaboration to be successful. Rather, participants are willing to collaborate even if communication is restricted to online communication.

Openness in communication is the "extent to which individuals are keen to exchange their opinions with each other" (Tan, 2016, p. 530). All participants demonstrated a high level of openness in communicating opinions with colleagues and collaborators. When asked about their willingness to provide advice, insight, and feedback to colleagues about their research, all ten participants expressed that they are very willing.

When asked about their willingness to ask for advice, insight, and feedback from colleagues about their research, eight of ten participants expressed that they are very willing. For example, Professor Biology2 asserted,

> If I don't have it, I will go look for the knowledge because there's no point trying to reinvent the wheel. If there's somebody down the hall who already knows all the ins and outs of it, you might as well ask them and get them involved.

These eight participants did not demonstrate any insecurity regarding asking others for input on their research and work, suggesting a strong sense of openness in communications.

The two remaining participants suggested they are somewhat willing to ask for research advice, insight, and feedback from colleagues, but only if they believe the individual in question has meaningful insight to offer. For example, Professor Biology1 explained,

> I'll ask whoever I think is the best in the world. And if that person is not at my institution, I will ask whoever the right person is, whether it's part of my broader mentoring family or whether it's a collaborator or colleague or someone I've never met before but I think has something to offer.

Both participants explained that, often, internal colleagues do not have the appropriate knowledge and experience to provide insight and so asking these individuals for advice is not useful.

All ten participants described face-to-face interactive communication as being a common

and important component of their interactions with colleagues internal to their employing institutions. Face-to-face interactive communication with internal colleagues was described as being both informal and formal in nature. For example, speaking about informal face-to-face interaction, Professor Geography1 referenced "grabbing a coffee and chatting about something – a seminar coming up or a paper I read" with colleagues in his department. Though this interaction was not necessarily related to a specific research project, it belongs to a more general collaborative culture of knowledge sharing that exists within this individual's institution. Having coffee and discussing work with colleagues was cited by multiple participants as common practice at their employing institutions.

In terms of formal face-to-face interaction with internal colleagues, multiple participants discussed scheduling official meetings to discuss collaborative research projects in person. In particular, participants cited co-supervising students as a common cause for face-to-face interaction with internal colleagues. For example, Associate Professor Oceanography2 stated, "If we're co-supervising a student, then we meet up with them and talk about their project – that's something that happens quite often." Participants suggested that student projects often bring together individuals who would otherwise rarely meet up face-to-face.

One participant remarked that face-to-face interactive communication is most important for multidisciplinary collaborations. Assistant Professor Oceanography1 explained,

> One of the projects I'm working on, I collaborate with someone from the Faculty of Law. We've had one or two meetings where we've sat down and talked about

> research results. Specifically, she was getting some of her students to explain to the Physical Sciences people about the work that they've done and what's possible in future work.

According to Assistant Professor Oceanography1, sitting down and talking with someone face-to-face enables individuals from different disciplines to explain their work, and ask and answer questions to alleviate disciplinary misunderstanding

All participants explained that face-to-face interaction with internal colleagues is always paired with email correspondence. Many admitted that email communication is more common than face-to-face communication, even with individuals working in very close proximity. For example, Assistant Professor Oceanography1 remarked,

> The person I work with who is in a different department, his building is just across the street from me, so it's not very far, but I tend not to see him too often. We usually talk by email or even meet at conferences.

Assistant Professor Oceanography1 actually laughed when realizing that email has become his dominant form of communication, even with those he has the potential to interact with in a face-to-face capacity, suggesting that his realization was somewhat surprising.

When discussing collaboration with individuals who are external to their employing institutions, multiple participants described communicating primarily via email. These individuals suggested that face-to-face interaction usually only occurs if the collaborating individuals find themselves in the same geographic location, such as for a meeting or

conference. Professor Geography1 explained, “I know people in 20 or 30 countries and we exchange emails and every time there is a conference we circulate the news and we see each other in those meetings.” Participants indicated that they take opportunities for face-to-face interaction with external colleagues as they arise; however, face-to-face interaction is not necessary for productive collaboration.

4.2.5 Answering RQ2

Participant reflection on past and current collaboration experiences revealed that participants are highly collaborative individuals for whom collaboration is an integral component of their professional identities and research. Further, participants indicated that they have collaborated in multiple research communities and organizations, including their employing universities, formal research networks, and informal research communities. Participants do not require organizational rewards or top management support to feel motivated to collaborate; rather, motivation to collaborate comes from the work itself. Notably, participants demonstrated a high level of flexibility and openness with regards to a) the use of technology to facilitate collaboration and b) collaborative communication in general. Taken all together, participants described having rich and complex collaborative histories. As a result, participants have become experienced, committed, and flexible collaborators, and consequently exhibit a high level of willingness with regards to adapting to new network contexts.

4.3 Summary of Findings

In this chapter, the findings from semi-structured interviews with 10 Canadian ocean researchers were described. Based on analysis of the interview data, this chapter answers the two research questions posed by this study.

RQ1: What helps and hinders collaboration in research networks-as-systems?

Findings suggested several forces that potentially help or hinder collaboration in the research network-as-system context. Specifically, participants' overall positive attitudes towards collaboration was revealed as a force that could help collaboration in a research network-as-system such as CIOOS. Further, participants indicated specific forces with the potential to hinder collaboration in the research network-as-system context: namely, risks related to data sharing, the burden of additional labour required of research networks-as-systems, potential exclusion of researchers or research data based on discipline or approach, and the overall quality of the system itself.

RQ2: How do past and current collaboration experiences affect researcher willingness to adapt to new network contexts?

This research explored participants' collaborative histories and the relationship between those histories and participants' overall willingness to adapt to a new network context, such as CIOOS. Overall, participant reflection on past and current collaboration experiences revealed that participants are highly collaborative individuals who have experience collaborating in multiple collaborative communities and organizations. Participants demonstrated a high level of flexibility and openness with regards to a) the

use of technology to facilitate collaboration and b) collaborative communication in general. As a result, participants are enthusiastic and experienced collaborators who are very willing to adapt to new network contexts.

CHAPTER 5: DISCUSSION

This chapter discusses the findings of this study in relation to prior research. In Section 5.1, findings related to RQ1 "What helps and hinders collaboration in the research network-as-system?" are situated within prior literature, highlighting important considerations for facilitating collaboration in the research network-as-system context. In Section 5.2, findings related to RQ2 "How do past and current collaboration experiences affect researcher willingness to adapt to new network contexts?" are shown to complicate prior research, and the theory of networked individualism is used to explain this complication (Rainie & Wellman, 2012). Finally, Section 5.3 details departures between this research and Tan's (2016) framework, and Section 5.4 provides a summary of the major points of discussion.

5.1 Considerations for the Research Network-As-System

This section highlights important considerations for facilitating collaboration in the research network-as-system context by drawing on prior research. Specifically, Section 5.1.2 explores how researchers' attitudes towards collaboration can either inhibit or motivate collaboration, describing why it is important to cultivate an attitude wherein knowledge and data are conceived of as public goods (McLure Wasko & Faraj, 2000). In Section 5.1.3, the four key issues this study identifies as potentially hindering collaboration in the research network-as-system context are discussed: risk, burden, exclusion, and quality. In particular, this section uses prior literature to show how these

issues are interrelated and how the challenges posed by risk, burden, and exclusion can and should be mitigated through system quality.

5.1.1 An Attitude to Cultivate

Through this research, one major issue was identified as potentially helping collaboration in the research network-as-system context: a positive attitude on the part of network members towards the idea of collaboration. The findings of this study suggest that a shared positive attitude has the potential to foster a committed and enthusiastic body of network members who actively collaborate and share data, despite perceived risks and challenges. The notion of attitude as a motivator for collaboration is not unique to this study. Rather, McLure Wasko and Faraj's (2000) study on knowledge sharing in communities of practice shed light on how two differing attitudes can have opposing effects on collaboration.

The two attitudes explored by McLure Wasko and Faraj (2000) were 1) the attitude of conceiving knowledge as a private good and 2) the attitude of conceiving knowledge as a public good. Perhaps unsurprisingly, McLure Wasko and Faraj discovered that the attitude of conceiving knowledge as a private good inhibited collaboration, while the attitude of conceiving knowledge as a public good motivated and facilitated collaboration. According to McLure Wasko and Faraj, the reason for these opposing effects is that conceiving knowledge as a private good encourages competition and "hoarding behaviour," (p. 162), while conceiving knowledge as a public good encourages knowledge sharing and collaboration for the overall benefit of the community.

Supporting McLure Wasko and Faraj's (2000) findings, this research suggests that a positive attitude towards collaboration, in which knowledge and data are not conceived of as private goods, but rather, as worth sharing with others, motivates Canadian ocean researchers to collaborate for the general benefit of their research community. In many ways, the shared positive attitude towards collaboration exhibited by ocean researchers speaks to a pre-existing Community of Practice (CoP) that exists throughout the Canadian ocean research community (Wenger, 2010). While researchers may always be somewhat divided by their disciplinary differences, their shared commitment to the intrinsic value of collaboration will help to bind them together as they move forward with participation in CIOOS.

Overall, the findings of this research indicate that research networks-as-systems should take note of the power of attitude for facilitating successful collaboration. Specifically, research networks-as-systems like CIOOS should be careful not to institute any sort of reward system or financial incentive to collaborate. These forms of recognition can cultivate an attitude in which knowledge and data are conceived of as private goods, inhibiting collaboration (McLure Wasko & Faraj, 2000).

5.1.2 Issues to Mitigate

Through this research, four key issues were identified in relation to what hinders collaboration in the research network-as-system context:

1) *Risk*. Risks associated with data sharing and a culture of dishonest science, such as the misuse and/or misappropriation of shared data;
2) *Burden*. The burden of additional labour placed on participants to ready data for sharing with others;
3) *Exclusion*. Failure to include all relevant disciplines and research data in the network;
4) *Quality*. The quality of the system itself.

All four issues are potential hindrances to successful collaboration in the research network-as-system context and, on reflection, are interrelated. Specifically, issue number four—the quality of system at the core of the network—has the potential to mitigate the risks and challenges posed by the other three issues: risk, burden, and exclusion. By drawing on prior research, this section will describe how such mitigation is possible and provide insight on ocean researcher understanding of how, in the research network-as-system context, a quality (i.e., flexible and robust) KM system is crucial for facilitating successful collaboration.

Risk. As Edwards et al. (2011) explained, to prevent misinterpretation or misuse of shared data by others, researchers must provide metadata to facilitate understanding and interoperability. This research suggests that Canadian ocean researchers possess a keen understanding of this notion: accurate and sufficient metadata has the potential to mitigate risks related to dishonest science. Notably, in the research network-as-system context, it is the responsibility of the system itself to ask for the right information of members via required metadata fields. Risk, therefore, can be mitigated by a high quality system. In

multidisciplinary networks and systems like CIOOS, this issue is particularly important, as disciplinary differences may create discrepancies in terms of needs and expectations regarding data interpretation and use.

But what is the "right information" to ask for? Answering this question is a daunting task, especially given the diversity of data a research network-as-system like CIOOS will store and make accessible. The ODM CoP in charge of designing and developing CIOOS will likely not have the expertise to understand the nuance and complexity of all research data that is relevant to the research network-as-system. To ensure metadata fields are comprehensive and truly multidisciplinary, community involvement in the development of metadata forms is essential. Asking ocean researchers from a wide variety of research disciplines what metadata is most useful and what should be required would be incredibly beneficial and likely make researchers feel even more trusting of the system's ability to mitigate risk.

Burden. This research confirms Edwards et al.'s (2011) findings, which indicated that scientists often experience the need to ready data for mass consumption as undesirable additional labour and a burden. Notably, Tenopir et al. (2011) suggest that providing guidance regarding proper metadata usage and provision can alleviate negative attitudes towards data sharing, and presumably, this sense of burden. In this way, burden, as a challenge identified by this study as potentially hindering collaboration in the research network-as-system context, can be alleviated by the system itself being of high quality and guiding members through the metadata process. To alleviate this sense of burden,

research networks-as-systems should consider budgeting resources to either a) provide comprehensive instructional materials to researchers or b) possibly employ data assistants to help with the prepping of data.

Exclusion. The findings of this research indicate that the exclusion of certain disciplines or types of research data from a research network-as-system can have a hindering impact on collaboration. Specifically, research networks-as-systems like CIOOS may potentially fail to accommodate or include researchers or research data or because they do not easily fit typical KM system infrastructure. Whether related to discipline or data format, ocean researchers may wonder: will I have a place in this system? If the system fails to be inclusive, collaboration is hindered.

How does a system become inclusive? Promoting and communicating a culture of openness to all researchers with relevant research interests, no matter their disciplinary affiliation, will ensure the networks brings together a diverse group of individuals and a complex catalogue of valuable data. Of course, for a complex catalogue to be successful, the catalogue must, indeed, be complex. Tenopir et al. (2011) suggest that building and maintaining "flexible cyberinfrastructure" is the key to nurturing positive attitudes regarding data sharing within research networks (p. 19). Similarly, this study indicates that designing a flexible system that can accommodate a wide variety of research data will ensure optimal inclusivity and opportunity for collaboration via CIOOS. The challenge posed by exclusion can therefore be mitigated in by the quality of the system itself.

Quality. As discussed above, concerns related to risk, burden, and exclusion in the research network-as-system context can all be alleviated by the design of the system itself. This finding places new importance on Tan's (2016) factor KM system quality, as it suggests that a high quality system can resolve pressing issues in the research network-as-system context. Notably, this study indicates that ocean researchers possess a keen awareness regarding the importance and nuance of system quality. These are researchers who have a deep understanding of what works and what does not work when utilizing web-based, data sharing systems. Individuals involved in developing research networks-as-systems should take note of this finding. Employing participatory, user-centred design processes, such as usability studies, have been successful in the past for ensuring optimal design of cyberinfrastructure for scientific research purposes (Michener et al., 2012). Involving members of a research network-as-system in any design, re-design, or assessment work related to the system in question would therefore likely be beneficial. Specifically, including network members in decisions regarding what metadata to include in the system, such as what metadata should be required and what metadata should be optional to include, would be valuable.

5.2 Collaboration, Adaptation, and Networked Individualism

According to the findings of this research, the diverse and varied collaborative histories of ocean researchers has enabled a high level of comfort with regards to navigating a complex world of different collaborative communities, interactions, and technologies. Consequently, when faced with a new network context, ocean researchers appear unfazed

by the prospect of adapting. Rather, the notion of adjusting to new collaborative norms, processes, and relationships seems to be a matter of course when it comes to collaboration.

This lack of concern with regards to adaptation complicates the findings of prior research. While past studies pointed to the need to cultivate close-knit ties and strong community identities in order to make researchers feel comfortable and motivated to collaborate (Caruso & Rhoten, 2001; Wenger, 2010; Yeon et al., 2015), this study suggests that such cultivation is unnecessary. Rather, in the Canadian ocean research community, collaboration is assumed and important; researchers therefore do not need to be externally motivated to collaborate. Canadian ocean researchers appear to deeply understand the necessity and benefits of collaboration, and that is motivation enough.

Have researchers evolved beyond the need for community cultivation? The findings from this study suggest yes, at least in the ocean sciences sector. One way of reading researchers' lack of concern and strong sense of flexibility related to collaboration is to label them as networked individuals (Rainie & Wellman, 2012). The term networked individualism, coined by Rainie and Wellman (2012), speaks to how, increasingly, we are "networked as individuals, rather than embedded in groups" (p. 6). Just as the participants in this study operate as individuals, freely and willingly moving through different research communities based on need or interest, networked individuals "have partial membership in multiple networks and rely less on permanent memberships in settled

groups" (Rainie & Wellman, 2012, p. 12). As networked individuals, Canadian ocean researchers appear to be unbound by the borders of any one network.

Of course, the findings of this study cannot fully answer how past and current collaboration experiences affect researcher willingness to adapt to new network contexts, the second research question posed by this study. Rather, this research suggests a relationship between past and current collaborative experiences and researcher willingness in this particular context, but more research is needed to fully understand this relationship.

5.3 Departures from Tan

While Tan (2016) served as a useful tool for this study's research design and data analysis, there are two major points of departure between this research and Tan's study that are important to highlight. First, throughout this study, a new individual KM factor emerged as influential on collaboration: nature of research. In this way, this research calls for an expansion of Tan's framework to incorporate the finding that the nature of one's research (the kinds of questions being asked, the needs of a project, etc.) has the potential to motivate collaboration.

Second, while Tan's (2016) study positions the organizational KM context as representing the employing institutions of researchers, this study revealed that, in the Canadian context, ocean researchers belong to multiple collaborative organizations, including formal research networks and informal research communities, which exist

outside of their employing institutions. In this way, this research signals a need to redefine the organizational context when applying Tan's framework in a Canadian context. This redefinition will ensure that the cultures and norms of all relevant organizations are explored when studying the collaboration behaviours and realities of Canadian researchers. Notably, Tan's study explored collaboration and knowledge sharing in the context of Malaysian universities, and therefore, differences in research cultures observed by Tan's study and this research are expected.

5.4 Summary of Discussion

This chapter has discussed the findings of this research in relation to prior literature. First, important considerations for the research network-as-system were presented. By showing how findings related to RQ1 "What helps and hinders collaboration in the research network-as-system?" support prior literature, this chapter points to conceiving of data as a public good as an important attitude to cultivate for facilitating collaboration in the research network-as-system context. Further, drawing on prior research, issues to mitigate in the research network-as-system context were discussed. Specifically, this chapter has shown how the issues of risk, burden, exclusion, and system quality are interrelated, and how system quality actually has the ability to mitigate the other three risks.

By discussing the findings related to RQ2 "How do past and current collaboration experiences affect researcher willingness to adapt to new network contexts?", this chapter has demonstrated how this research complicates the findings of prior literature, specifically with regards to the need to cultivate strong community ties to facilitate

collaboration. Differently, this research shows that ocean researchers operate as networked individuals (Rainie & Wellman, 2012), moving freely between and within multiple collaborative communities due to intrinsic motivation rather than community cultivation.

Finally, this chapter has revealed important departures between Tan's (2016) framework and this research. In particular, the need to expand Tan's framework of KM factors that are influential on collaboration to include nature of research was noted. Further, this research indicates that Tan's definition of the organizational context as representing the employing institutions of researchers does not fit well in the Canadian research context. Rather, this study shows that Canadian ocean researchers belong to multiple collaborative organizations, all with distinct cultures. Any future study looking to explore the collaboration behaviours of Canadian researchers will therefore need to redefine the organizational context before utilizing or adapting Tan's survey instrument so as to ensure all relevant organizational cultures are considered.

CHAPTER 6: CONCLUSION

The research network-as-system is an important innovation for Canadian ocean research (Wilson et al., 2016). This unique model of research network operates by connecting researchers across large distances and from multiple disciplines via a web-based, technological system (Liu et al., 2015). Through this system, researchers collaborate simply by sharing data. IOOS, in the United States, and CIOOS, currently in development in Canada, are both examples of research networks-as-systems.

By conducting semi-structured interviews with ten Canadian ocean researchers about their perception of CIOOS and their collaborative histories, this study has found what helps and hinders in collaboration in the research network-as-system context, as well as how past and current collaboration experiences may influence researcher willingness to adapt to new network contexts. Tan's (2016) framework of KM factors that are influential on collaboration was used for study design and data analysis. Uniquely, this study applied Tan's framework in a new context—the research network-as-system. Tan's framework was also employed to profile the past and current collaboration experiences of participants. The theoretical and practical contributions of this research are discussed in detail in the following two sections.

6.1 Theoretical Contributions

Confirming the findings of McLure Wasko and Faraj (2000), this research has shown that cultivating and/or exhibiting a positive attitude, in which data and knowledge are

conceived of as public goods, can have a facilitating and helping effect on collaboration in the research network-as-system context. Specifically, this research points to the existence of a Community of Practice (CoP) (Wenger, 2010) that binds researchers from different disciplines together based on their shared commitment to collaboration. Further, supporting the findings of prior research, this research has identified data sharing risks related to dishonest science (Edwards et al., 2011), the burden of additional labour associated with data sharing (Edwards et al., 2011; Tenopir et al., 2011), and a low quality KM system (Tan, 2016) as hindering forces to collaboration in the research network-as-system context.

Uniquely, this study identified an additional force with the potential to hinder collaboration not explored in prior research: exclusion of researchers based on discipline or type of research data. This discovery is an important contribution because it suggests that, despite network commitment to integrating and connecting research from multiple disciplines, pre-existing assumptions regarding who and what has a place in a given network may foster researcher resistance to participation. It is important to debunk assumptions related to exclusion in order to ensure all relevant research and researchers are included.

Further, this research has also uniquely shown how the challenges posed by risk, burden, and exclusion as hindering forces can actually be mitigated via considerations related to system quality. This contribution is particularly valuable for scientific research communities as they move towards the research network-as-system model. Understanding

how system infrastructure can work to a given network's favour will help new and evolving networks to incorporate the mitigation of challenges related to risk, burden, and exclusion in the very design of a given system.

Thinking about researcher willingness to adapt to new research network contexts, this study has complicated the findings of prior literature, which suggest that cultivating strong community ties is necessary and important for facilitating collaboration (Caruso & Rhoten, 2001; Yeon et al., 2015). Differently, this research has shown that ocean researchers operate as networked individuals (Rainie & Wellman, 2012). They move freely between and within multiple collaborative communities due to their intrinsic motivation to collaborate, rather than association with or loyalty to a strong community identity. In this way, this research provides support for the theory of networked individualism, particularly with regards to the way in which individuals are networked in their professional lives (Rainie & Wellman, 2012).

Finally, this research has identified two ways to expand Tan's (2016) framework regarding KM factors that influence collaboration. Specifically, this research has shown a need to expand Tan's framework to include nature of research as an individual KM factor. This finding is important because it indicates that the nature of one's research (the kinds of questions being asked, the needs of a project, etc.) has the potential to motivate collaboration. Further, this research indicated that Tan's definition of the organizational context as representing the employing institutions of researchers does not fit well in the Canadian research context. Rather, this study has shown that Canadian ocean researchers

belong to multiple collaborative organizations, all with distinct cultures, and a redefinition of Tan's organizational KM context is necessary to incorporate and recognize this reality.

6.2 Practical Contributions

The findings of this study are directly and practically beneficial for individuals involved in the development and management of research networks-as-systems. This study has offered insight on what is important to ocean researchers when utilizing a KM system for collaboration and data sharing. Specifically, ocean researchers are concerned with the accurate and sufficient provision of metadata, as well as finding a place for their data in an inclusive and complex system. This insight is beneficial to those designing and managing research networks-as-systems because they can use this information to inform their design process, understand where they need to direct their efforts and funding, and how they should market the network to members.

Overall, this research has found that ocean researchers are very much concerned with the quality of the systems they are using to share data and collaborate with others. As observed in this study, this concern manifests as complex and strong opinions about system design, indicating that ocean researchers are very much aware of what they want and need from a data sharing system. Those involved in designing and developing research networks-as-systems can benefit from this awareness if they choose to employ user-centred design methods. Specially, this research recommends that the design process for research networks-as-systems should be iterative in nature, asking for input from users

from a variety of disciplines regarding what metadata should be required, and testing multiple prototypes on users. For CIOOS in particular—still in development—there is a real opportunity to "get it right." Those involved in its organization should therefore take the time to ensure the system is representative and inclusive of the diverse needs of its multidisciplinary user population. Only then will the data and researchers who make up the network be fully integrated as a cohesive and functional whole.

Ocean researcher concern related to readying data for sharing also suggests that research networks-as-systems would benefit from implementing training related to the provision of metadata. A training program would serve two main purposes. First, training would equip researchers with the skills they need to provide accurate and sufficient metadata for others. Second, the very existence of a training program would help alleviate researcher concerns about risks related to dishonest science, as researchers would be assured that actions were being taken to protect against data misuse and misinterpretation. Training related to providing proper attribution for data would also help alleviate these concerns.

Further, the issue of exclusion identified by this study indicates that those involved in the organization of research networks-as-systems should not only be open to the inclusion of unlikely disciplines and unconventional research data, but they should actively communicate that openness. Specifically, promotional materials should clearly convey a sense of inclusivity and willingness to accommodate researchers and research projects that are on the periphery. As well, it may be worthwhile to target and invite researchers

from non-traditional disciplines to contribute their data and participate in the network so as to demonstrate a commitment to inclusivity.

The overall positive attitude towards collaboration and openness with regards to providing insight and feedback to others demonstrated by ocean researchers in this study suggests that oceans-focused research networks-as-systems may wish to consider developing mentorship programs as part of their operations. While the research network-as-system model is very much a hands-off approach to collaboration, the obvious willingness to work with others for the sake of research observed in this study suggests that ocean researchers are eager to connect and collaborate. Research networks-as-systems would benefit from capitalizing on this willingness, facilitating relationships between new and old network members about the use and benefits of the system.

6.3 Limitations of the Research

A major limitation of this study is its relatively small sample size. While data saturation was reached after 10 interviews, conducting additional interviews may have enhanced the findings of this study. Furthermore, it is possible that the individuals who agreed to participate in this study represent a portion of the ocean research community who are particularly interested in the study's topics (research collaboration, data sharing, the development of CIOOS). Individuals who view these topics as unimportant may have been less likely to participate and their insights are therefore not represented in this study. However, the findings of this study are still significant as they shed light on the thoughts and opinions of researchers who appear to be keenly committed to collaboration in the

research network-as-system context.

Last, the interview questions required participants to reflect on their current collaboration behaviours, the collaboration cultures of their organizations, their preferences with regards to collaboration, and their thoughts and opinions regarding the development of CIOOS. The findings of this study are therefore based on how the participants view themselves, their organizations, and the ocean research community. This fact represents a potential limitation as the way in which individuals view and talk about themselves and their experiences may not always directly reflect their realities. However, this research was designed to capture attitudes and perceptions, which are very important given their influence on researchers' current and future behaviours.

6.4 Suggestions for Future Research

While this study has focused on the ocean sciences, future research could explore how collaboration in research networks-as-systems functions for other scientific research fields. Nature of research emerged as an important KM factor in the findings of this study; ocean researchers appear to believe that their research requires them to collaborate and share data. Is this true of all scientific disciplines? Investigating the broad topics of this thesis in another academic field would be a worthy line of inquiry. Additionally, conducting a study similar to this one with ocean researchers in other countries would reveal whether nature of research is a motivating force for collaboration in other geographic contexts.

Further, issues related to data ownership that emerged in this study offer opportunity for future research. One participant's suggestion that he does not feel he owns the data he collects, and is therefore very motivated to share that data, is an interesting topic that begs for further investigation. Is this sentiment shared by others? Is yes, why do some researchers feel this way and not others? How does perception of data ownership impact approach to collaboration? Exploring the nuance of data ownership poses interesting questions for future research.

Finally, this research suggests a relationship between past and current collaborative experiences and researcher willingness in this particular context, but more research is needed to fully understand this relationship. Does a diverse collaborative history always lead to a willing attitude? Do all researchers operate as networked individuals? Do specific negative experiences with collaboration inhibit willingness to adapt? In future research, it would be worthwhile to target a group that is known to be particularly unwilling to adapt to new networks and probe how their past collaboration experiences may have created such unwillingness.

REFERENCES

Braun, V., & Clarke, V. (2006). Using thematic analysis in psychology. *Qualitative Research in Psychology, 3*(2), 77-101.

Candela, L., Castelli, D., Manghi, P., & Tani, A. (2015). Data journals: A survey. *Journal of the Association for Information Science and Technology, 66*(9), 1747–1762. doi: 10.1002/asi.23358

Caruso, D., & Rhoten, D. The Hybrid Vigor Institute. (2001). *Lead, follow, get out of the way: Sidestepping the barriers to effective practice of interdisciplinarity.* Retrieved from http://www.hybridvigor.net/interdis/pubs/hv_pub_interdis-2001.04.30.pdf

CIHR, NSERC & SSHRC (Canadian Institutes of Health Research, Natural Sciences and Engineering Research Council of Canada, and Social Sciences and Humanities Research Council of Canada). (2014). *Tri-Council Policy Statement: Ethical Conduct for Research Involving Humans*. Retrieved from http://www.pre.ethics.gc.ca/pdf/eng/tcps2-2014/TCPS_2_FINAL_Web.pdf

Das, T. K., & Teng, B. (1998). Between trust and control: Developing confidence in partner cooperation in alliances. *Academy of Management Review, 23*(3), 491-512. doi:10.5465/AMR.1998.926623

Edwards, P. N., Mayernik, M. S., Batcheller, A. L., Bowker, G. C., & Borgman, C. L. (2011). Science friction: Data, metadata, and collaboration. *Social Studies of Science*, *41*(5), 667–690. doi: 10.1177/0306312711413314

Hislop, D. (2004). The paradox of communities of practice: Knowledge sharing between communities. In P. M. Hildreth, & C. Kimble (Eds.), *Knowledge networks: Innovation through communities of practice* (pp. 36-45). Hershey, PA: Idea Group Publishing.

IOOS. (2016). About us. Retrieved from https://ioos.noaa.gov/about/about-us/

Jarvenpaa, S. L. & Leidner, D. E. (1999). Communication and trust in global virtual teams. *Organization Science, 10*(6), 791-815. Retrieved from http://www.jstor.org/stable/2640242

Kim, Y. & Stanton, J. M. (2012). Institutional and individual factors affecting scientists' data-sharing behaviours: A multilevel analysis. *Journal of Computational Science Education, 3*(1), 47-56.

Kim, Y., & Zhang, P. (2015). Understanding data sharing behaviors of STEM researchers: The roles of attitudes, norms, and data repositories. *Library & Information Science Research, 37*(3), 189-200. doi:10.1016/j.lisr.2015.04.006

Liu, Y., Kerkering, H., & Weisberg, R. H. (2015). Introduction to coastal ocean observing systems. In Y. Liu, H. Kerkering, & R. H. Weisberg (Eds.), *Coastal Ocean Observing Systems* (pp 1-10). London: Academic Press.

Luo, L. & Wildemuth, B. M. (2009). Semistructured interviews. In B. M. Wildemuth (Ed.), *Applications of Social Science Research Methods to Questions in Information and Library Science* (pp 232-241). Westport: Libraries Unlimited.

Martin, K., & Quan-Hasse, A. (2013). Are e-books replacing print books? Tradition, serendipity, and opportunity in the adoption and use of e-books for historical research and teaching. Journal for the American Society for Information Science and Technology, 64(5), 1016-1028. doi: 10.1002/asi.22801

McLure Wasko, M., & Faraj, S. (2000). "It is what one does": Why people participate and help others in electronic communities of practice. *The Journal of Strategic Information Systems, 9*(2–3), 155-173. doi:10.1016/S0963-8687(00)00045-7

Michener, W. K., Allard, S., Budden, A., Cook, R.B., Douglass, K. Frame, M.,…Vieglais, D. A. (2012). Participatory design of DataONE—Enabling cyberinfrastructure for the biological and environmental sciences. *Ecological Informatics, 11*, 5-15. doi: 10.1016/j.ecoinf.2011.08.007

Mo, G. Y., Hayat, Z., & Wellman, B. (2015). How far can scholarly networks go? examining the relationships between distance, disciplines, motivations, and clusters. *Studies in media and communications 9: Communication and information technologies annual* (pp. 107-133) Emerald Group Publishing Limited. doi:10.1108/S2050-206020150000009005

Monteiro, M., & Keating, E. (2009). Managing misunderstandings: The role of language in interdisciplinary scientific collaboration. *Science Communication, 31*(1), 6-28. doi:10.1177/1075547008330922

Nistor, N., Daxecker, I., Stanciu, D., & Diekamp, O. (2015). Sense of community in academic communities of practice: Predictors and effects. *Higher Education, 69*, 257-273. doi:10.1007/s10734-014-9773-6

Pryor, G. (2012). *Managing research data*. London: Facet Publishing.

Rainie, H., & Wellman, B. (2012). *Networked: the new social operating system*. Cambridge, MA: MIT Press.

Rathnappulige, S., & Daniel, L. (2013). Creating value through social processes: An exploration of knowledge dynamics in expert communities of practice. *International Journal of Technology Management, 63*(3-4), 169-184. doi:10.1504/IJTM.2013.056897

Sayogo, D. S., & Pardo, T. A. (2013). Exploring the determinants of scientific data sharing: Understanding the motivation to publish research data. *Government Information Quarterly, 30*, Supplement 1, 19-31. doi:10.1016/j.giq.2012.06.011

Seale, C. & Silverman, D. (1997). Ensuring rigour in qualitative research. *European Journal of Public Health, 7*(4), 379-384. doi: 10.1093/eurpub/7.4.379

Simons, N., & Richardson, J. (2013). Research data: the new gold. In *New Content in Digital Repositories* (pp. 115–146). Chandos Publishing. Retrieved from http://www.sciencedirect.com/science/article/pii/B9781843347439500067

Sveinsdottir, T., Wessels, B. A., Smallwood, R., Linde, P., Kala, V., Tsoukala, V., & Sondervan, J. (2014). Policy recommendations for open access to research data in europe -- stakeholder values and ecosystems. *Information Services & Use, 34*(3), 331-333. doi:10.3233/ISU-140756

Tan, C. N. L. (2016). Enhancing knowledge sharing and research collaboration among academics: the role of knowledge management. *Higher Education, 71*(4), 525-556. doi:10.1007/s10734-015-9922-6

Tenopir, C., Allard, S., Douglass, K., Aydinoglu, A. U., Wu, L., Read, E., … Frame, M. (2011). Data Sharing by Scientists: Practices and Perceptions. *PLOS ONE, 6*(6), e21101. doi: 10.1371/journal.pone.0021101

Teixeira da Silva, J. A., & Dobranszki, J. (2015). Potential dangers with open access data files in the expanding open data movement. *Publishing Research Quarterly, 31*, 298-305. doi: 10.1007/s12109-015-9420-9

Wall, L. (2017, Feb 5). Sea level rise means 'complete rethinking' of coastal living in N.L., says researcher. *CBC News*. Retrieved from http://www.cbc.ca/news/canada/newfoundland-labrador/sea-level-rise-means-complete-rethinking-1.3967588

Wellman, B., Dimitrova, D., Hayat, Z., Ying Mo, G., & Smale, L. (2014). Networking scholars in a networked organization. *Research in the sociology of organizations 40: Contemporary perspectives on organizational social networks* (pp. 479-497) Emerald Group Publishing Limited. doi:10.1108/S0733-558X(2014)0000040024

Wenger, E. (2010). Communities of practice and social learning systems: The career of a concept. In C. Blackmore (Ed.), *Social learning systems and communities of practice* (pp. 179-198). London: Springer.

Wilson, L., Smit, M., & Wallace, D. W. R. Marine Environmental Observation Prediction & Response Network. (2016). *Towards a unified vision for ocean data management in Canada: Results of an expert forum.* Retrieved from http://meopar.ca/uploads/ODM_whitepaper_-_English.pdf

Yeon, K., Wong, S. F., Chang, Y., & Park, M. (2015). Knowledge sharing behavior among community members in professional research information centers. *Information Development, 32*(3), 655-672. doi:10.1177/026666691456651

APPENDIX A: EMAIL INVITATION

Subject: Invitation to participate in a study on ocean research collaboration

Dear participant name,

My name is Deborah Hemming. I'm a Master's student in the Faculty of Management at Dalhousie University**. I'm currently completing a research project called "Research Networks in Transition: Exploring Collaboration within Shifting Boundaries" for the Master of Library and Information Studies program and I was wondering if you would be interested in participating in an interview about collaboration.** I am seeking ocean researchers working in Canada to participate in this study.

The study started October 20, 2016 and will continue through to January 15, 2017 (or sooner, if the goal of 10 to 15 respondents is met). The goal of my research is to gain a better understanding of what motivates/challenges individual researchers to join new research networks and if/how collaboration behaviours are changed in the process. I understand that the landscape of ocean research in Canada is currently changing and many individual data centres are hoping to integrate and share data on a national scale. **Would you be willing to answer a series of questions related to your experience with collaboration and your knowledge of this potential integration?**

The interview, consisting of a series of short questions relating to collaboration, will occur via telephone and shouldn't take more than 45-60 minutes. With your consent, the interview will be audio recorded. Your participation in this study is voluntary and will be kept confidential. The names of all participants and associated organizations will be anonymized with pseudonyms to protect their identities in reports, presentations, and publications emanating from this research.

I look forward to receiving your response and thank you in advance for your consideration. Please don't hesitate to contact me with any questions you may have.

All the best,
Deborah

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APPENDIX B: INTERVIEW SCRIPT

Thank-you very much for agreeing to participant in my study. I emailed you the consent form prior to this interview, did you have the opportunity to read it?
[if yes, continue, if no, read consent form to the participant]

Do you have any questions or would like any additional details? *[Answer questions.]*

Do you agree to participate in this study?
[If yes, record response in notes and continue.]
[If no, thank the participant for his/her time.]
Do you agree to that your interview may be audio-recorded? You can choose not to have this interview audio-recorded and instead I will take detailed notes.
[record response in notes and continue]
We have scheduled approximately 45-60 minutes together so I will keep a close eye on the time so that we have a chance to discuss all questions. At any time please feel free to ask any questions, ask to repeat the question, or ask for clarification if you are not sure of the question.

[If they agreed to audio-recording] I'm going to turn on the audio recorder now and we can get started.

1. How long have you worked at your institution/organization?

2. What is your position there?

3. Is your daily work more solitary or collaborative?

4. Do you prefer to work alone or with others?

5. How often do you interact with colleagues internal to your institution/organization?
    - In what ways do you interact? (email, phone, face-to-face)
    - In what ways are you most likely to interact?

6. Within your institution/organization, do you collaborate with individuals from multiple research disciplines?

7. What kinds of knowledge do you share with your internal colleagues?
        - Prompt: For example, data, research reports and publications, knowledge gained from conferences or workshops, knowledge gained from experience

8. How willing are you to ask an internal colleague for advice or insight on research?

9. How willing are you to provide advice or insight on research to internal colleagues?

10. Is collaboration with internal colleagues encouraged by management at your institution/organization?
    - In what ways is collaboration encouraged?

11. Are there technical systems in place to facilitate collaboration and knowledge sharing within your institution/organization?
    - What kinds of systems?
    - How valuable are these systems to your research?

12. Do you feel that you are a part of a research community?
    - Can you describe this community for me?
        - Prompt: Who belongs to this community? How do members of this community interact? Would you describe this community as multidisciplinary?

13. How familiar are you with ocean researchers from other institutions/organizations in Canada?
    - How have you become familiar with these individuals?
        - Prompt: Do you know them through their research? Have you met them at conferences or other meetings? Do you know them personally?

14. Do you communicate with ocean researchers from other institutions/organizations in Canada?
    - How do you communicate (email, phone, face-to-face, social media)?
    - Do you share data or other research resources with any of these researchers?

15. Do you currently contribute data to any ocean observing systems or ocean data repositories?
    a. If yes: Please specify

16. Are you familiar with the proposed development of the Canadian Integrated Ocean Observing System (CIOOS)?
    a. If yes: How did you hear about the CIOOS?
    b. If no, provide brief explanation about the CIOOS to participant:

    The Canadian Integrated Ocean Observing System is a project currently in development. Various separate ocean data centres located throughout Canada, known as OOS, are hoping to join forces and share data on a national scale. The result would be a Canadian Integrated Ocean Observing System. If and when the CIOOS comes into being, ocean researchers across Canada will be encouraged to share their data with other researchers via this national data

repository.

17. Do you feel sharing your data through the CIOOS will be beneficial to other researchers?
    - How so?
    - If no: Why not?

18. Do you feel you will benefit from CIOOS access to other researchers' data?
    - How so?
    - If no: Why not?

19. Do you perceive any risks in sharing data through the CIOOS?

20. Do you perceive any challenges in sharing data through the CIOOS?

That's all of the questions I have. Do you have any questions for me?
Thank you for your participation. Is there anyone else you think I should speak to about this topic in your organization?

My research thesis will be available online in the Summer of 2017. Would you like me to share the research results with you? **[If yes]** Is it OK to send the results to your email address that we have used to communicate*?* **[if yes, confirm contact information and record name and email on a separate sheet]**

APPENDIX C: DEMOGRAPHICS QUESTIONNAIRE

Male/Female/Prefer not to say:

Age:
18 to 24
25 to 31
32 to 38
39 to 45
46 to 52
53 to 59
60 to 66
67 to 73
74+

Level of Education:

Research Discipline (e.g. Biology, Computer Science, Social Science):

Position (e.g. Professor, Associate Professor, Post-doctoral Fellow, Other):

If Other, please specify:

APPENDIX D: CONSENT FORM

CONSENT FORM

Project title: Research Networks in Transition: Exploring Collaboration within Shifting Boundaries

Lead researcher: Deborah Hemming, Masters student, School of Information Management, Dalhousie University
deborah.hemming@dal.ca

Other researchers: Dr. Lori McCay-Peet, Thesis Supervisor, Assistant Professor, School of Information Management, Dalhousie University
mccay@dal.ca / 902-494-6119

Funding provided by: Marine Environmental Observation Predication and Response Network (MEOPAR)

Introduction
We invite you to take part in a research study being conducted by me, Deborah Hemming, a Masters student at Dalhousie University, as part of my Masters of Library and Information Studies (MLIS) program. Choosing whether or not to take part in this research is entirely up to you. There will be no impact on your employment if you decide not to participate in the research. The information below tells you about what is involved in the research, what you will be asked to do and about any benefit, risk, inconvenience or discomfort that you might experience.

You should discuss any questions you have about this study with Deborah Hemming. Please ask as many questions as you like. If you have questions later, please contact the lead researcher, Deborah Hemming, or her supervisor, Dr. Lori McCay-Peet.

Purpose and Outline of the Research Study
The purpose of this study is to better understand research collaboration in the context of new or changing research networks. I will be interviewing 10-15 Canadian ocean researchers about their collaboration behaviours and attitudes, specifically as they relate to the proposed development of a Canadian Integrated Ocean Observing System (CIOOS).

Who Can Take Part in the Research Study
You may participate in this study if are an ocean researcher in Canada.

What You Will Be Asked to Do
Participation in this study consists of answering a series of interview questions about personal collaboration behaviours and attitudes as well as a brief demographics questionnaire via telephone at a date and time that is convenient for you. It is estimated that participation in this study will take a total of 30-45 minutes. With your consent, the interview will be audio-recorded.

Possible Benefits, Risks and Discomforts
This study poses a minimal level of risk to your social and professional standing because the questions are concerning your research collaboration habits and attitudes. To mitigate this risk, your identity will be kept confidential. In the final research report and publications emanating from this research, you may be quoted but your identity will not be disclosed. To ensure your identity is protected, neither your place of employment nor any specific information about the topic of your research will accompany your quotations. When quoted, you will only be identified in two ways:

1. By research discipline, in a broad sense (e.g. Biology, Oceanography, Computer Science, Social Science). Your specific research area (e.g. Mathematical Biology) will not be identified.
2. By research position, in a broad sense (e.g. Professor, University Lecturer, Post-doctorate Fellow).

Any identifying information directly present in your quotations (place of employment, number of co-workers, details regarding specific research projects, etc.) will not be included in the final results.

Participating in the study might not benefit you directly, but we might learn things about research collaboration that will benefit you and others.

Compensation / Reimbursement
Participants in this study will not be compensated. Participants will not incur any expenses therefore participants will not need to be reimbursed.

How your information will be protected:
All information you give me will be kept private. Only myself and my thesis supervisor will have access to this information. I will describe and share our findings in a thesis as well as publications and presentations. I will be very careful to only talk about group results so that no one will be identified. This means that ***you will not be identified in any way in my reports, publications, and presentations***. Also, I will use a participant number (not your name) in my written and computer records so that the information I have about you contains no names. All your identifying information will be securely stored. All electronic records will be kept secure on a password protected server at Dalhousie University or my password-protected computer.

I will retain the data for two years to give me time to complete the project and publish findings. After that time, I will dispose of it.

If You Decide to Stop Participating
You can make the decision to withdraw your participation from the research up to one week after your interview. After that time, it will not be possible to withdraw as your data will be anonymized and data analysis begun.

How to Obtain Results
My final thesis will be available electronically via DalSpace in summer 2017. If you would like me to send you a link to this document, please let me know at the end of the interview and I will confirm I have the correct contact information.

Questions
I am happy to talk with you about any questions or concerns you may have about your participation in this research study. Please contact Deborah Hemming (deborah.hemming@dal.ca) or Dr. Lori McCay-Peet (at 902 494-6119, mccay@dal.ca) at any time with questions, comments, or concerns about the research study (if you are calling long distance, please call collect). We will also tell you if any new information comes up that could affect your decision to participate.

If you have any ethical concerns about your participation in this research, you may also contact Research Ethics, Dalhousie University at (902) 494-1462, or email: ethics@dal.ca (and reference REB file #2016-3989).

Consent to Participate
Non-written (verbal) consent will be obtained at the start of the telephone interview. At that time, you can also indicate whether or not you consent to the audio recording of the interview.

APPENDIX E: CODING SCHEME

1.0 Individual
- 1.1 Trust
  - 1.1.1 Dishonest science
- 1.2 Knowledge Self-Efficacy
  - 1.2.1 CIOOS – Believes data will benefit others
  - 1.2.2 CIOOS – Believes data will not fit well in the system
- 1.3 Reciprocal Benefits
  - 1.3.1 CIOOS – Perceived Reciprocity
- 1.4 Attitude
  - 1.4.1 Attitude towards data sharing
  - 1.4.2 Prefers collaborative work
  - 1.4.3 Prefers a balance of collaborative and solitary work
- 1.5 Nature of Research
  - 1.5.1 Nature of research demands collaboration
  - 1.5.2 Nature of research demands data sharing

2.0 Organizational
- 2.1 Organizational Culture
  - 2.1.1 Multiple Organizational Affiliations
  - 2.1.2 Employing Institution
  - 2.1.3 Research Communities
    - 2.1.3.1 Canadian Ocean Research Community
    - 2.1.3.2 Formal Research Network
      - 2.1.3.2.1 OOS
    - 2.1.3.3 Informal Research Community
    - 2.1.3.4 Nested Communities
- 2.2 Organizational Rewards
  - 2.2.1 Financial Rewards
  - 2.2.2 Recognition
- 2.3 Top Management Support
  - 2.3.1 Active support
  - 2.3.2 No active support
  - 2.3.3 Neutrality

3.0 Communication
- 3.1 Openness in Communication
  - 3.1.1 Somewhat willing to ask for advice/feedback
  - 3.1.2 Somewhat willing to give advice/feedback
  - 3.1.3 Very willing to ask for advice/feedback
  - 3.1.4 Somewhat willing to ask for advice/feedback
- 3.2 Face-to-Face Interactive Communication
  - 3.2.1 Face-to-face plus email
  - 3.2.2 Knowledge sharing
  - 3.2.3 Meeting up for coffee
  - 3.2.4 Students

4.0 Technological
- 4.1 KM System Infrastructure
  - 4.1.1 Provided by employing institution
  - 4.1.2 Not provided by employing institution
  - 4.1.3 Use of alternative systems (not provided by employing institution)
- 4.2 KM System Quality
  - 4.2.1 Additional labour
  - 4.2.2 Metadata
  - 4.2.3 Standardization

5.0 CIOOS Awareness
- 5.1 Previously Aware
  - 5.1.1 Awareness via Colleagues
  - 5.1.2 Awareness via OOS
- 5.2 Previously Unaware

APPENDIX F: FINAL ETHICS APPROVAL

Social Sciences & Humanities Research Ethics Board
Letter of Approval

October 19, 2016

Deborah Hemming
Management\Information Management

Dear Deborah,

REB #: 2016-3989
Project Title: Research Networks in Transition: Exploring Collaboration within Shifting Boundaries

Effective Date: October 19, 2016
Expiry Date: October 19, 2017

The Social Sciences & Humanities Research Ethics Board has reviewed your application for research involving humans and found the proposed research to be in accordance with the Tri-Council Policy Statement on *Ethical Conduct for Research Involving Humans.* This approval will be in effect for 12 months as indicated above. This approval is subject to the conditions listed below which constitute your on-going responsibilities with respect to the ethical conduct of this research.

Sincerely,

Dr. Karen Beazley, Chair

Post REB Approval: On-going Responsibilities of Researchers

After receiving ethical approval for the conduct of research involving humans, there are several ongoing responsibilities that researchers must meet to remain in compliance with University and Tri-Council policies.

1. Additional Research Ethics approval

Prior to conducting any research, researchers must ensure that all required research ethics approvals are secured (in addition to this one). This includes, but is not limited to, securing appropriate research ethics approvals from: other institutions with whom the PI is affiliated; the research institutions of research team members; the institution at which participants may be recruited or from which data may be collected; organizations or groups (e.g. school boards, Aboriginal communities, correctional services, long-term care facilities,

service agencies and community groups) and from any other responsible review body or bodies at the research site

2. Reporting adverse events

Any significant adverse events experienced by research participants must be reported **in writing** to Research Ethics **within 24 hours** of their occurrence. Examples of what might be considered "significant" include: an emotional breakdown of a participant during an interview, a negative physical reaction by a participant (e.g. fainting, nausea, unexpected pain, allergic reaction), report by a participant of some sort of negative repercussion from their participation (e.g. reaction of spouse or employer) or complaint by a participant with respect to their participation. The above list is indicative but not all-inclusive. The written report must include details of the adverse event and actions taken by the researcher in response to the incident.

3. Seeking approval for protocol / consent form changes

Prior to implementing any changes to your research plan, whether to the protocol or consent form, researchers must submit a description of the proposed changes to the Research Ethics Board for review and approval. This is done by completing an Amendment Request (available on the website). Please note that no reviews are conducted in August.

4. Submitting annual reports

Ethics approvals are valid for up to 12 months. Prior to the end of the project's approval deadline, the researcher must complete an Annual Report (available on the website) and return it to Research Ethics for review and approval before the approval end date in order to prevent a lapse of ethics approval for the research. Researchers should note that no research involving humans may be conducted in the absence of a valid ethical approval and that allowing REB approval to lapse is a violation of University policy, inconsistent with the TCPS (article 6.14) and may result in suspension of research and research funding, as required by the funding agency.

5. Submitting final reports

When the researcher is confident that no further data collection or participant contact will be required, a Final Report (available on the website) must be submitted to Research Ethics. After review and approval of the Final Report, the Research Ethics file will be closed.

6. Retaining records in a secure manner

Researchers must ensure that both during and after the research project, data is securely retained and/or disposed of in such a manner as to comply with confidentiality provisions specified in the protocol and consent forms. This may involve destruction of the data, or continued arrangements for secure storage. Casual storage of old data is not acceptable.

It is the Principal Investigator's responsibility to keep a copy of the REB approval letters. This can be important to demonstrate that research was undertaken with Board approval, which can be a requirement to publish (and is required by the Faculty of Graduate Studies if you are using this research for your thesis).

Please note that the University will securely store your REB project file for 5 years after the study closure date at which point the file records may be permanently destroyed.

7. Current contact information and university affiliation
The Principal Investigator must inform the Research Ethics office of any changes to contact information for the PI (and supervisor, if appropriate), especially the electronic mail address, for the duration of the REB approval. The PI must inform Research Ethics if there is a termination or interruption of his or her affiliation with Dalhousie University.

8. Legal Counsel
The Principal Investigator agrees to comply with all legislative and regulatory requirements that apply to the project. The Principal Investigator agrees to notify the University Legal Counsel office in the event that he or she receives a notice of non-compliance, complaint or other proceeding relating to such requirements.

9. Supervision of students
Faculty must ensure that students conducting research under their supervision are aware of their responsibilities as described above, and have adequate support to conduct their research in a safe and ethical manner.

APPENDIX G: APPLICATION FOR ETHICS APPROVAL

DALHOUSIE UNIVERSITY
RESEARCH ETHICS BOARDS

APPLICATION FORM

Prospective Research

This form should only be used if new data will be collected. For research involving only secondary use of existing information (such as health records, student records, survey data or biological materials), use the *REB Application Form – Secondary Use of Information for Research.*
This form should be completed using the *Guidance for Submitting an Application for Research Ethics Review* available on the Research Ethics website (application instructions).

SECTION 1. ADMINISTRATIVE INFORMATION [File No: office only]

Indicate the preferred Research Ethics Board to review this research:
[ ] Health Sciences OR [X] Social Sciences and Humanities

Project Title: Research Networks in Transition: Exploring Collaboration within Shifting Boundaries

1.1 Research team information				
Dalhousie researcher name	**Deborah Hemming**			
Banner #	B00486714		Department	School of Information Management
Email (@dal)	deborah.hemming@dal.ca		Phone	(902) 292-3782
Study start date	Sep 10, 2016		Study end date	Apr 30, 2016
Co-investigator names and affiliations				
Contact person for this submission (if	Name			
	Email		Phone	

not lead researcher)				

1.2 For student submissions:			
Degree program	Master of Library and Information Studies		
Supervisor name and department	Dr. Lori McCay-Peet, School of Information Management		
Supervisor Email (@dal)	mccay@dal.ca	Phone	(902) 494-6119

Department/unit ethics review (if applicable). **Undergraduate minimal risk research only**.
Attestation: [ ] I am responsible for the unit-level research ethics review of this project and it has been approved. Authorizing name: Date:

1.3 Other reviews:			
Other ethics reviews (if any)		Where	Status
Funding, if any (list on consent form)	Agency	Marine Environmental Observation Prediction and Response Network	
	Award Number		
Peer review (if any)			

1.4 Attestation(s). The appropriate boxes *must* be checked for the submission to be accepted by the REB)
[X] I am the **lead researcher**. I agree to conduct this research following the principles of the Tri-Council Policy Statement *Ethical Conduct for Research Involving Humans* (TCPS) and consistent with the University *Policy on the Ethical Conduct of Research Involving Humans*. I have completed the TCPS Course on Research Ethics (CORE) online tutorial. **[X]** Yes [ ] No For Supervisors (of student / learner research projects): **[X]** I am the **supervisor** for this research named in section 1.2. I have reviewed this submission, including the scholarly merit of the research, and believe it is sound and appropriate. I take responsibility for ensuring this research is conducted following the principles of the TCPS and University Policy. I have completed the TCPS Course on Research Ethics (CORE) online tutorial.

[X] Yes [ ] No

SECTION 2. PROJECT DESCRIPTION

2.1 Lay summary

2.1.1 In lay language, describe the rationale, purpose, study population and methods. Include the background information or literature to contextualize the study. Mention what new knowledge is anticipated, and whether this is a pilot project or fully developed study. [500 words]

The sharing of data, information and knowledge is increasingly valued in all sectors and disciplines. When individuals come together to exchange and collaborate, they are able to build upon the experience and knowledge of their peers to develop innovative ideas and further discovery (Chen & Huang, 2007). The changing landscape of ocean research in Canada reflects this truth. Various separate Ocean Observing Systems (OOS) are currently in the process of uniting to share data through a national research network: the Canadian Integrated Ocean Observing System (CIOOS) (Wilson, Smit, & Wallace, 2016). As Wilson et al. (2016) state,

> Sound knowledge and understanding of the oceans is essential for mitigating human impacts on the global environment and for promoting sustainable economic use of the marine environment … Knowledge and understanding, in turn, depends on access to accurate, rich, available, and integrated ocean data. (p. 1)

Anecdotal evidence suggests that some ocean researchers are resistant to joining the CIOOS. This resistance is problematic because the network's success will rely on individual researcher willingness to collaborate. As Argote and Ingram explain, "The problem of knowledge transfer in organizations transcends the individual level to include transfer at higher levels of analysis, such as the group, product line, department, or division" (p. 151). Managing researcher attitudes and behaviours regarding collaboration within new, transitioning research networks is therefore an important issue for the network or governing organization as a whole.

Using the CIOOS as the context for my research, my thesis will investigate how and with whom researchers collaborate in research networks with shifting boundaries. I will interview researchers from each of the seven OOS in Canada to better understand what motivates researchers to join and participate in new networks, as well as what holds them back from participating.

While much has been written about how and with whom researchers collaborate within research networks, my thesis will fill an important gap in the research by exploring collaboration within research networks with shifting boundaries. Whether due to funding or a need for increased resources, the boundaries of research networks often expand. The CIOOS is a clear example of multiple research networks (separate OOS) expanding and integrating on a national scale (Wilson et al., 2016). It therefore provides an opportune context to investigate what motivates and challenges researchers to collaborate in the face of network expansion, offering new insight on how collaboration functions in situations marked by change and transition, and deepening understanding of research collaboration in general.

The results of my fully developed study will be useful for helping research networks to manage resistance and foster collaboration in the face of expansion. For example, the transition from separate OOS to a national CIOOS is spearheaded by an Ocean Data Management Community of

Practice (ODM CoP). The ODM CoP will directly benefit from the findings of my research. In a more general sense, any individuals leading a project of network expansion will benefit from my broader findings regarding the management of research networks with shifting boundaries.

References

Argote, L., & Ingram, P. (2000). Knowledge transfer: A basis for competitive advantage in firms. *Organizational Behavior and Human Decision Processes, 82*(1), 150-169. doi:10.1006/obhd.2000.2893

Chen, C., & Huang, J. (2007). How organizational climate and structure affect knowledge management—The social interaction perspective. *International Journal of Information Management, 27*(2), 104-118. doi:10.1016/j.ijinfomgt.2006.11.001

Wilson, L., Smit, M., & Wallace, D. W. R. Marine Environmental Observation Prediction & Response Network. (2016). *Towards a unified vision for ocean data management in Canada: Results of an expert forum.*

2.1.2 If a phased review is being requested, describe why this is appropriate for this study, and which phase(s) are included for approval in this application.

[X] Not applicable

2.2 Research question

State the hypotheses, the research questions or research objectives.

Research question: What considerations motivate and challenge collaboration within research networks with expanding boundaries?

2.3 Recruitment

2.3.1 Identify the study population. Describe how many participants are needed and how this was determined.

The study population is researchers from the following Ocean Observing Systems (OOS) in Canada: Atlantic Coastal Zone Information Steering Committee, Fisheries and Oceans Canada, L'Observatoire global du Saint-Laurent/ St. Lawrence Global Observatory, Marine Institute of Memorial University of Newfoundland, Ocean Networks Canada, Ocean Tracking Network, Polar Data Catalogue/Canadian Cryospheric Information Network.

I anticipate 10-15 participants will be needed to enable an understanding of how collaboration functions in situations marked by change and transition. This total will consist of one to two participants from each of the above OOS, ensuring a comprehensive investigation of individual researcher attitudes and behaviours related to collaboration in the context of the prospective Canadian Integrated Ocean Observing System (CIOOS) research network. Participant recruitment will stop based on data saturation. The participant number range of 10-15 was chosen based on Guest, Bunce, and Johnson's (2006) study, which found that data saturation occurred after 12 interviews. In keeping with the best practices of qualitative research, more may be interviewed if the examples are all novel (Guest, Bunce, & Johnson, 2006).

Guest, Bunce, & Johnson. (2006). "How many interviews are enough? An experiment with data saturation and variability." *Field Methods, 18*(1), 59-82. doi: 10.1177/1525822X05279903

2.3.2 Describe recruitment plans and append recruitment instruments. Describe who will be doing the recruitment and what actions they will take, including any screening procedures. Describe and justify any inclusion / exclusion criteria.

As sole investigator for this study, I will be in charge of all aspects of recruitment.
I will use criterion sampling to purposefully recruit individuals who occupy a variety of roles in their organizations. Key informants (e.g., Dalhousie University faculty) will be used to recommend potential participants in the CIOOS research network.
Potential participants will be recruited via email (see Appendix A - Email Invitation). Contact information for researchers (i.e., emails) will be readily available on the Internet through institution websites. The recruitment email will also be sent to the Marine Environmental Observation Prediction and Response Network listserv, which is associated with the CIOOS, as well as listservs for the various centres or institutions involved in MEOPAR.

2.3.3 Describe any community or organizational permissions needed to recruit your participants (attach support letters). Describe any other community consent or support needed to conduct this research. (If the research involves Aboriginal participants, please complete section 2.10).

[X] Not applicable

2.4 Informed consent process

2.4.1 Describe the informed consent process, including any plans for ongoing consent (how and when the research will be described to prospective participants, by whom, how the researcher will ensure prospective participants are fully informed). If non-written consent is proposed, describe the process. Address how any third party consent (with or without assent) will be managed. Append copies of all consent/assent documents, including oral consent scripts.

I will be sending the participants a consent form via email (see Appendix B – Follow-up Email to Participants and Appendix C – Consent Form). At the time of the interview, I will ensure they have read through the consent form and answer any questions they have before. I will then ask participants to provide verbal consent for participation. Before continuing on to the interview questions and demographics questionnaire, I will give participants an opportunity to ask any additional questions they may have, or leave the study if they so desire.

2.4.2 Discuss how participants will be given the opportunity to withdraw (their participation and/or their data) and any limitations on this.

Each interview will begin with an explanation of the study and a reminder that they can withdraw their participation and their data for any reason up to one week after their interview, as described in the consent form. The reason for this one-week limitation is that their interviews may be transcribed and data analysis begun by that time, making it difficult to withdraw data.

2.4.3 If an exception to the requirement to seek prior informed consent is sought, address the criteria in TCPS article 3.7A.

[X] Not applicable

2.5 Methods and analysis

2.5.1 Describe the study design, where the research will be conducted, what participants will be asked to do and the time commitment, what data will be recorded using what research instruments (append copies).

The proposed study method is semi-structured interviews via telephone and audio-recorded with consent. Participants will be asked to respond to a series of questions about personal collaboration behaviours and attitudes as well as a brief demographics questionnaire to ensure an understanding of the composition of the study sample.

Each interview will begin by asking participants if they had a chance to read the consent form which was previously sent via email (see Appendix C). If the participant has not, it will be read aloud. Participants will be given an opportunity to ask any questions they may have and will be asked for both their consent to continue with the interview and to audio record the interview. Verbal confirmation of consent will be recorded in the lead researchers' notes.

The researcher will tell the participant that the audio recording will begin (if participant has consented to audio-recording). Participants will be asked a series of 19 questions based on a semi-structured interview guide (see Appendix D). Follow up questions will be asked as necessary. Participants will then be asked to answer questions from a short demographics questionnaire (see Appendix E).

It is anticipated that it will take participants 10 minutes to read and ask questions about the consent form and up to 50 minutes to be interviewed and complete the demographics questionnaire, for a total of 60 minutes.

I, Deborah Hemming, will be conducting the interviews and will be the point of contact throughout the whole process.

[ ] This is a clinical trial (physical or mental health intervention) – ensure section 2.11 is completed

2.5.2 Describe plans for data analyses.

Data from the interviews and demographics questionnaires will be transcribed using Microsoft Word and then transferred to Microsoft Excel for analysis.

Due to the qualitative, semi-structured nature of my data collection, interview data will be analyzed using thematic analysis to ensure the nuance and complexity of my findings can be communicated. Identification of major patterns and themes will be informed by Tan's (2016) list of key knowledge management factors: individual (trust, knowledge self-efficacy, reciprocal benefits), organizational (top management support, organizational rewards, organizational culture), technological (knowledge management system infrastructure, knowledge management system quality), and communication (openness in communication, face-to-face interactive communication). I will use these factors to explore how different knowledge management contexts motivate and challenge collaboration within changing research networks.

Data from the demographics questionnaire will be used to gain a basic understanding of the composition of the study sample.

2.5.3 Describe any compensation that will be given to participants and how this will be handled for participants who do not complete the study. Discuss any expenses participants are likely to incur and whether/how these will be reimbursed.

Participants will not be compensated. Participation will not incur any expenses as the interviews will take place via telephone and I will be making the telephone call, therefore participants will not need to be reimbursed.

2.5.4 Describe and justify any use of deception or nondisclosure and explain how participants will be debriefed.

[X] Not applicable

2.5.5 Describe the role and duties of local researchers (including students and supervisors) in relation to the overall study. Identify any special qualifications represented on the team relevant to the proposed study (e.g. professional or clinical expertise, research methods, experience with the study population, statistics expertise, etc.).

As sole investigator for this study, I, Deborah Hemming, will be responsible for recruiting and contacting participants, collecting and analyzing data, and compiling findings in a final research thesis.

My thesis supervisor, Dr. Lori McCay-Peet, will provide guidance and assistance throughout this process, as necessary.

2.6 Privacy & confidentiality

2.6.1 Describe any provisions for ensuring privacy and confidentiality (or anonymity). Describe who will have access to data and why, how data will be stored and handled in a secure manner, how long data will be retained and where. Discuss any plans for data destruction and/or de-identification.

Participants will be sent the consent form via email prior to the interview to review and will be asked to provide non-written (verbal) consent over the telephone before the start of the interview. Consent forms and recordings of interviews will be stored on my personal laptop computer, which is password protected. Notes collected via pen and paper will be stored in a locked cabinet in the lead researcher's home until they have been transcribed at which time they will be securely disposed. Transcriptions of interviews and notes will replace names with pseudonyms, and redact any features that may identify either a participant or his/her organization. These anonymized transcriptions and notes will be kept on a password protected server at Dalhousie University as well as on my own laptop computer (in a separate location than the original interview recordings), which is password protected.

Only I, as the researcher, and Dr. Lori McCay-Peet, as my supervisor, will have access to the raw data. Any files sent to Dr. McCay-Peet will be sent via Dal email or Dalhousie's File Share Service. I will retain the data for two years to give me time to complete the project and publish findings. After that time, I will dispose of it.

[ ] This research involves personal health records (ensure section 2.12 is completed)

2.6.2 Describe how participant confidentiality will be protected when research results are shared. Discuss whether participants will be identified (by name or indirectly). If participants will be quoted address consent for this, including whether quotes will be identifiable or attributed.

Once my research is completed, I will compile my results in a research thesis and disseminate findings through publications and conference presentations. Participant identities will be anonymized and no participants will be directly or indirectly identified in the final results. Participants will be quoted, however their identities will be kept confidential. To ensure participant identities are protected, the place of employment of participants and any specific research projects they are involved in will not accompany quotations. When quoted, participants will only be identified in two ways:

1. By research discipline, in a broad sense (e.g. Biology, Oceanography, Computer Science, Social Science). Specific research areas within participants' disciplines (e.g. Mathematical Biology) will not be identified.
2. By research position, in a broad sense (e.g. Professor, Assistant Professor, Post-doctorate Fellow, Other).

Any identifying information directly present in quotations (place of employment, number of co-workers, details regarding specific research projects, etc.) will not be included in the final results.

The consent form alerts participants to the fact that they will quoted without being identified, and solicits their permission to do so.

2.6.3 Address any limits on confidentiality, such as a duty to disclose abuse or neglect of a child or adult in need of protection, and how these will be handled. Detail any such limits in consent documents.

[X] Not applicable

2.6.4 Will any information that may reasonably be expected to identify an individual (alone or in combination with other available information) be accessible outside Canada? This includes sharing information with team members, collecting data outside Canada, use of survey companies, use of software.

[X] No

[ ] Yes. If yes, describe how you comply with the University *Policy for the Protection of Personal Information from Access Outside Canada*, such as securing participant consent and/or securing approval from the Vice President Research.

2.7 Provision of results to participants

2.7.1 The TCPS encourages researchers to share study results with participants in appropriate formats. If you plan to share study results with participants, discuss the process and format.

The results of this study will be available online in Summer 2017 via DalSpace in the form of a research thesis (PDF). During interviews, participants will be asked if they would like me to send them a link to the thesis by email once it is available online. If yes, I will confirm contact information and send them the link once it is live.

[ ] Not applicable

2.7.2 If applicable, describe how participants will be informed of any incidental findings – unanticipated results (of screening or data collection) that have implications for participant welfare (health, psychological or social).

[X] Not applicable

2.8 Risk & benefit analysis

2.8.1 Discuss what risks or discomforts are anticipated for participants, how likely risks are and how risks will be mitigated. Address any particular ethical vulnerability of your study population. If applicable, address third party or community risk. Risks to privacy from use of identifying information should be addressed.

The questions asked in the interviews relate directly to participants' employment, as well as the practices and habits of their organizations. Because of this, participation might pose minimal risk to participants' professional and social standing. In order to mitigate that risk, all information gathered will be anonymized, and precautions will be taken to ensure that the findings of this study are not linked in any way to participants or their organizations.

2.8.2 Identify any direct benefits of participation to participants (other than compensation), and any indirect benefits of the study (e.g. contribution to new knowledge)

There will be no direct benefit for participation, however, as an indirect benefit, participants may be motivated to positively alter their collaboration practices within new research networks based on the research findings, which will be made available to participants.

2.9 Conflict of interest

Describe whether any dual role or conflict of interest exists for any member of the research team in relation to potential study participants (e.g. TA, fellow student, teaching or clinical relationship), and/or study sponsors, and how this will be handled.

[X] Not applicable

2.10 Research with Aboriginal peoples [X] Not applicable – go to 2.11
2.10.1 If the proposed research involves Aboriginal peoples, describe the plan for community engagement (per TCPS Articles 9.1 and 9.2). Attach supporting letters, research agreements and other relevant documents, if available. If community engagement is not sought, explain why the research does not require it, referencing article 9.2.
2.10.2 State whether ethical approval has been or will be sought from Mi'kmaw Ethics Watch or other Indigenous ethics review group(s), and if not, why the research does not fall under their purview.
2.10.3 Describe any plans for returning results to the community and any intellectual property rights agreements negotiated with the community, with regard to data ownership. If there are specific risks to the community involved, ensure these have been addressed in section 2.8.1.

2.11 Clinical trials [X] Not applicable – go to 2.12
2.11.1 Does the proposed research require clinical trial registration, in keeping with national and international regulations? [ ] No. Please explain why not. [ ] Yes. Please indicate where it was registered and provide the registration number.
2.11.2 If a novel intervention or treatment is being examined, describe standard treatment or intervention, to indicate a situation of clinical equipoise exists (TCPS Chapter 11). If placebo is used with a control group rather than standard treatment, please justify.

2.11.3 Clearly identify the known effects of any product or device under investigation, approved uses, safety information and possible contraindications. Indicate how the proposed study use differs from approved uses.
[ ] Not applicable

2.11.4 Discuss any plans for blinding/randomization.

2.11.5 What plans are in place for safety monitoring and reporting of new information to participants, the REB, other team members, sponsors, and the clinical trial registry? These should address plans for removing participants for safety reasons, and early stopping/unblinding/amendment of the trial. What risks may arise for participants through early trial closure, and how will these be addressed? Are there any options for continued access to interventions shown to be beneficial?

2.12 Use of personal health information
[X] Not applicable

2.12.1 Describe the personal health information required and the information sources, and explain why the research cannot reasonably be accomplished without the use of that information. Describe how the personal health information will be used, and in the most de-identified form possible.

2.12.2 Will personal health information be combined with information from other sources to form a composite record (data linkage)? Will the research create individually identifying health information by combining information from two or more databases without the consent of the individuals who are the subjects of the information (data matching)?
[ ] No.
[ ] Yes. Describe the other information and how linkage will be conducted, and/or why data matching is required.

2.12.3 Describe reasonably foreseeable risks to privacy and how these will be mitigated.