CONTEXTS, CONDITIONS, AND METHODS CONDUCIVE TO KNOWLEDGE CO-PRODUCTION: THREE CASE STUDIES INVOLVING SCIENTIFIC AND COMMUNITY PERSPECTIVES IN ARCTIC WILDLIFE RESEARCH

Paul McCarney

A DISSERTATION SUBMITTED TO THE FACULTY OF GRADUATE STUDIES IN PARTIAL FULFILLMENT OF THE REQUIREMENTS FOR THE DEGREE OF DOCTOR OF PHILOSOPHY

Graduate Program in Environmental Studies
York University
Toronto, Ontario

July 2018

Abstract

Decision-makers require current and robust information to address the effects of social-ecological changes facing ecosystems, wildlife, and humans; however, research defined by single disciplines and knowledge systems is often challenged in fully representing the complexity of such problems. There is a recognized need to include the perspectives of academic and local knowledge holders in research as evidence argues this can produce more robust knowledge and lead to greater public acceptance of policy. Knowledge co-production has been proposed as a research approach that can include academic and non-academic actors in addressing complex problems that transcend disciplinary and epistemological boundaries and have societal and scientific significance. While knowledge co-production has gained attention in environmental research in many regions, its application has not been extensively explored in the Arctic.

This research used a case study approach to examine the contexts, conditions, and methods that support knowledge co-production on wildlife issues with Canadian Arctic communities. Three cases were selected to examine knowledge co-production in the context of a past research study, an ongoing study, and to consider the pre-conditions necessary for knowledge co-production to benefit future research. Data collection included semi-structured interviews, workshops, and participant observation with scientists and Inuit community members involved in ringed seal research in Kugaaruk and Iqaluit and fisheries research in Pangnirtung, Nunavut.

Results indicate that Arctic wildlife research can benefit from knowledge co-production. There are particular structural and process conditions that help facilitate successful knowledge co-production and establishing these conditions requires deliberate work on the part of researchers and community members involved. Establishing shared goals and problem definitions, creating the space to identify and share positionalities and perspectives on issues, and clarifying roles of academic and community actors all emerged as important conditions in the cases. Further, results suggest that semi-structured interviews and purposefully designed and facilitated thematic workshops provide the flexibility to create the time and space needed for participants to learn about and engage with one another's values, perspectives, and priorities. This research shows that when effort is made to establish the necessary conditions for knowledge co-production early on in the research process, projects can produce knowledge that is perceived as more credible, salient, and legitimate by all involved.

Acknowledgements

This is really the one place out of these many thousands of words where I have the opportunity to be as unapologetically personal as I wish without the pressure for brevity, so bear with me. This project has been a fun and engaging process. I have had the opportunity to meet many wonderful, interesting, and inspiring people, to see parts of the country that are indescribably beautiful, and participate in some incredible activities and adventures. I am infinitely grateful. While this project consistently inspired and motivated me, it's also a humbling fact that I would not have been able to complete it without the support of a great number of people, some of whom I would like to identify and thank directly.

My supervisory committee members have been mentors to me in the deepest sense of the word. They have challenged me, fascinated me, and given me advice at every stage of this project. The value I have gained from surrounding myself with them is tremendous and I want to thank them for everything. As I try to figure out how to thank my family, what I have known to be true in the background suddenly becomes real: there simply aren't words to express my gratitude. Those immediately close to me have constantly expressed and provided their unwavering support and I am deeply appreciative. In particular, I am so grateful for my parents and my amazing partner, Kristeen. I have enjoyed this project but it is also true that I wouldn't have been able to complete it without their encouragement and support. I have a group of friends who probably couldn't provide a coherent summary of what I have spent years doing but who have also provided an ear for my stress and company to celebrate whenever I have asked for it.

In some ways, it is difficult to thank the individuals I have met and worked with throughout Inuit Nunangat here, because the thanks I owe in this regard are difficult to express in this space. In particular, there are individuals in Kugaaruk and Pangnirtung who showed me their communities and the landscapes of those places in a way I would not have ever had the opportunity to experience without them. More than anything, I have enjoyed working with these individuals and getting to know them personally over the years. Thank you.

Table of Contents

List of Tables

List of Figures

Chapter One: Introduction

1. Background

Various community-based and academic bodies of thought have called for research to include the perspectives of both academic and non-academic actors and contribute knowledge to solving issues relevant to local communities (e.g. Brunet, Hickey, & Humphries, 2014a; Brunet, Hickey, & Humphries, 2014b; Gearheard & Shirley, 2007; Hirsch Hadorn, Hoffmann-Riem, et al., 2008; Simon, 2017; Stevenson, 1996). The inclusion of local actors in research can also produce more robust knowledge about questions that scientists may be challenged in answering, due to disciplinary constraints or limited resources (Max-Neef, 2005). For instance, "citizen science" research has been used in environmental monitoring and its potential usefulness in other conservation research has been noted (Franzoni & Sauermann, 2014; Tregidgo, West, & Ashmore, 2013; Tulloch, Possingham, Joseph, Szabo, & Martin, 2013). The importance of including both scientific and local knowledge has been particularly noted in discussions around environmental and wildlife conservation. Research has demonstrated strong connections between cultural and biological diversity, indicating the importance of linking the health and well-being of local communities with conservation initiatives (Cormier-Salem, 2014; Maffi, 2005). In addition, the connections between cultural and biological diversity point to the importance of considering and integrating social-political factors in conservation initiatives; however, current worldwide declines in biodiversity (e.g. Bellard, Bertelsmeier, Leadley, Thuiller, & Courchamp, 2012; Cheung et al., 2009; Pereira et al., 2010; Pimm et al., 2014) and the projected impacts of these declines on human well-being indicate the need to explore new ways to integrate social and ecological dimensions in management and conservation that achieve the needs of both human and ecological communities.

Arctic regions are undergoing rapid environmental changes and face increasingly complex social and environmental threats, including from climate change that is occurring more rapidly than anticipated, increased pressure for natural resource development, legacy and new forms of environmental contaminant deposition, significant changes in wildlife populations

including some iconic and important species, and the effects of these issues on human health (Avila, Kaschner, & Dormann, 2018; de March, de Wit, & Muir, 1998; Huntington, 2009). Reductions in sea ice extent and timing have led to expanded development of commercial fisheries in the Arctic, including targeting new species, as a result of increased access to formerly inaccessible regions. There is a need for ongoing assessment of ecological aspects of fisheries development and informed fisheries management decisions that consider emerging and increasingly articulated legal rights of Indigenous communities, particularly within the context of settled land claims in Arctic regions. Reductions in sea ice also have implications for marine species such as polar bears (*Ursus maritimus*) and ringed seals (*Pusa hispida*), which rely on ice platforms for critical feeding and breeding habitat. As harvested species, changes in polar bear and ringed seal populations will affect Inuit communities that continue to rely on these species as important food, economic, and socio-cultural resources.

Decision-makers require current and robust information to address the potential effects of complex social and environmental changes facing Arctic ecosystems, wildlife, and humans (Huntington, 2009). There has been a shift in environmental decision-making from a strict focus on resource management to a governance model that acknowledges and appreciates the connections between local practices, conservation, and sustainable management, a shift that has been apparent in recent approaches to marine protection (Cormier-Salem, 2014). There is also increasing awareness of the need for research to produce knowledge that is directly useful to decision-makers and to identify effective ways to translate knowledge from science to policy (Lynch et al., 2015; C. Pohl, 2008). Knowledge production processes therefore need to be capable of capturing and integrating both the ecological and human dimensions of environmental and wildlife issues in a way that can inform effective decision-making (Heberlein, 2012). Species at risk conservation in Canada explicitly considers socioeconomic issues in decisions about whether to list species, and there is some evidence in this are that existing models that aim to balance human and ecological priorities are not entirely effective in achieving management outcomes (Favaro et al., 2014).

Research involving active participation of local actors can produce results that are more likely to be trusted and applied by actors at various scales (Brunet et al., 2014b). It has also

been found that policy and management decisions are more likely to be understood and accepted when informed by research that has involved active participation of local actors (Jones et al., 2008). The area of marine protection has demonstrated success in achieving environmental conservation priorities more effectively when including local actors (e.g. Cormier-Salem, 2014). At the same time, there is a need to critically reflect on what constitutes "meaningful participation" in research, particularly when that research claims and intends to produce more robust research knowledge (De Weger, Van Vooren, Luijkx, Baan, & Drewes, 2018; Elzinga, 2008; Samaddar, Okada, Choi, & Tatano, 2016). The task for researchers when planning and conducting research is not simply to increase participation in a quantitative sense. Rather, the value is in enhancing opportunities for participation by individuals who hold the knowledge that will ultimately contribute to solving problems.

Transdisciplinary knowledge co-production has been proposed as a research approach that is particularly effective at addressing complex problems that involve the intersection of both academic and non-academic perspectives (Hirsch Hadorn, Biber-Klemm, et al., 2008; Hirsch Hadorn, Hoffmann-Riem, et al., 2008). Knowledge co-production is defined by knowledge that is produced collectively by multiple actors who represent a plurality of perspectives for the purpose of solving locally relevant, real-world problems (D. Armitage, Berkes, Dale, Kocho-Schellenberg, & Patton, 2011; Berkes, 2009; Dale & Armitage, 2011; Godemann, 2008; Christian Pohl et al., 2010). While the central principles of transdisciplinary research and knowledge co-production have been clearly articulated, it has been noted that there are gaps in understanding related to the practice and evaluation of knowledge co-production, including what constitutes "good" transdisciplinary research (Carew & Wickson, 2010; Jahn & Keil, 2015; Klein, 2006). Klein (2006) notes that "in the context of innovation and creativity", the nature of transdisciplinary research means that a "strict set of criteria" or "uniform yardstick" for evaluating good research "may be counterproductive" (p. 78). At the same time, Wickson, Carew, and Russell (2006) argue that there is a need to explore appropriate evaluation frameworks but that these will likely be tied to the research context rather than based on criteria that are rooted in a particular discipline.

The Canadian Arctic represents one research context that lends itself to an examination of knowledge co-production. It is a context that involves complex problems, academic and non-academic perspectives, and requires knowledge that can contribute to decision-making about socially relevant problems. Arctic wildlife and Inuit communities will face increasingly complex challenges as a result of environmental, social, political, and economic changes. At times, the interaction of local communities, researchers, and managers in Arctic research has generated conflicts about the knowledge produced and uncertainties over how to proceed in decision-making processes that are acceptable to all involved. More generally, however, decision-making requires knowledge that is current, rigorous, and capable of capturing the full range of interests involved in Arctic wildlife management. I argue that the successful integration of the knowledge of stakeholders cannot occur at the level of decision-making (i.e. government management bodies and policy-making), but must occur at the level of knowledge production (i.e. research), to ensure that the information used by decision-makers and other users is representative of the perspectives of all stakeholders. Transdisciplinary research has the potential to produce knowledge that more fully represents the diverse interests and considerations of all the actors involved.

Developing strategies to address the human and ecological dimensions of environmental changes on Arctic wildlife and human communities requires a research approach capable of examining and integrating various perspectives – including those rooted in the social and natural sciences and articulated by local communities – into the production of new knowledge. Strategies to address large-scale environmental changes will require conservation and decision-making approaches that can take into account both the human and ecological dimensions (Heberlein, 2012). Inuit communities are situated at an important point between wildlife species in their environment and the knowledge gained about them from ongoing scientific research. It is therefore important to consider the ways in which knowledge production about wildlife could be enhanced by collaboration between communities and scientists. Indeed, results from a recent report examining the priorities of Arctic leadership and communities across the North emphasized that, “the next step in the evolution of scientific practice in the Arctic is linking community-driven Arctic research priorities with national policy

development to ensure scientific investments benefit communities and answer key questions facing the Arctic" (Simon, 2017).

2. Research Question

My research seeks to better understand the factors and conditions that contribute to successful and effective research involving a plurality of perspectives and knowledge systems. The objective is to better understand the utility and effectiveness of transdisciplinary research, in particular knowledge co-production. It examines a context in which knowledge co-production has not seen widespread application and contributes to collective understanding of knowledge co-production and suggests ways in which Arctic wildlife research can benefit from knowledge co-production. Specifically, it examines the contexts, conditions, and methods that support knowledge co-production and considers whether knowledge co-production can benefit Arctic wildlife research. I work with researchers in existing research projects to consider whether they can or could have benefitted from knowledge co-production. In addition, I consider whether a project that is in its initial stages could benefit from adopting a knowledge co-production approach and if so, how it could do so. Therefore, this research answers the primary question: **what are the contexts and conditions that support knowledge co-production and what methods are effective in creating these conditions and engaging actors?**

3. Research Context: Arctic Marine Wildlife Research

3.1. Complex Problems in Arctic Research

The Arctic is experiencing some of the most drastic effects of climate change, warming at an estimated two to three times the global rate (IPCC, 2014; Wassmann, Duarte, Agusti, & Sejr, 2011). There have been increasingly longer ice-free periods throughout the year and reductions in ice extent and thickness, with 2012 having the lowest recorded extent of Arctic sea ice, surpassing the previous record in 2007 (NSIDC, 2014; Perovich et al., 2014). Changing

environmental conditions will create the need for new factors to be considered in management and decision-making. Changes in the populations of harvested species will also affect Inuit communities. In addition, reductions in ice have opened areas that were previously restricted by thick, multi-year ice, creating opportunities for an expansion of commercial fishing opportunities and an expanded interest in industrial development in the Arctic. Oil and gas exploration, and the associated expansion in shipping traffic and infrastructure development, have increased particularly since the 1970s, and have the potential to disrupt habitat and behavior of marine species (Huntington, 2009). Arctic regions are also at risk from the transport and accumulation of environmental contaminants, many of which are a result of human activity taking place outside Arctic regions (de March et al., 1998). Contaminants and pollutants, such as metals and persistent organic pollutants (POPs), accumulate in food webs and impact both ecosystems and human health (Huntington, 2009). Decision-makers will continue to require current and robust information to develop strategies to address the potential effects of these changes and other complex concerns facing Arctic ecosystems, wildlife, and humans (Huntington, 2009).

Issues surrounding polar bears in Canada provide an example of the need to explore improved methods for integrating multiple perspectives in research and decision-making. A recent report by the Joint Secretariat for the Inuvialuit Settlement Region (2015) notes that polar bear research has been inconsistent in its documentation of the knowledge of Inuvialuit guides, field assistants and co-researchers. The report argues that the "systematic documentation of PBTK is essential no matter what the research context is, and new documentation protocols are required that make use of best social science practices" (Joint Seretariat, 2015, p. 216). Inuvialuit community members also expressed concerns related to research methods that disturb bears. In particular, community members were concerned about the effects of tranquilizers on bear behavior and food safety. It may be that shortcomings related to methods used to document and include both scientific and Inuit Knowledge in research have contributed to a lack of acceptance of research results.

There have been attempts to characterize the reasons for disagreements over polar bear research and management processes. Dowsley and Wenzel (2008) suggest that

disagreements over management is a factor of poor understandings of Inuit Knowledge, which has led to an undervaluing of Inuit perspectives in co-management processes. In addition to factors related to scientific and Inuit Knowledge, both the Joint Secretariat report (2015) and the Nunavut Wildlife Management Board's (NWMB) *Draft Nunavut Polar Bear Co-Management Plan* (2015) suggest that public perception and opinion about the status of polar bears influence management decisions. The NWMB report states that "[p]ressure from national and international environmental and non- governmental organizations, climate change advocates, and the general public at large to conserve and protect polar bears has created contention about whether polar bear populations still need to increase" (Nunavut Wildlife Management Board, 2015, p. 5). When the decision was made to reduce Baffin Bay quotas in 2010, Nunavut Environment Minister acknowledged the concern that continuing with what was perceived as an unsustainable hunt could result in international sanctions preventing the export of polar bear products (TheStar.com, 2010). Continuing disagreements over polar bear research and management, and lack of clear processes to overcome these disagreements, demonstrate the need for alternative methods of knowledge production and integration.

3.2. Knowledge Interaction in Arctic Research

The literature on transdisciplinarity positions it as an approach that is well suited to research problems that involve multiple knowledges and perspectives. This research is concerned with examining the interaction of local/community and academic knowledges and perspectives and, therefore, contains certain assumptions about the nature and definition of knowledge, knowledge systems, and the value of multiple knowledge systems interacting (the latter is discussed in more detail in Section 4.1). I begin from the premise that there are multiple ways of knowing the world, or knowledge systems (Rathwell, Armitage, & Berkes, 2015; Reid, Berkes, Wilbanks, & Capistrano, 2006). I focus specifically on local/community and academic knowledge systems but recognize that people have diverse identities and that the concepts of "community" and "academic" should not be taken for granted as a dichotomy. For instance, individuals can be both community members and academics and can be situated in

and informed by multiple knowledge systems. Nevertheless, as this research is concerned with the co-production of knowledge and the contributions of different actors and their knowledge in this process, some generalizations are useful to distinguish between the knowledge systems involved while also recognizing that presenting knowledge systems as a binary can be problematic.

As the academic actors involved in this research are primarily situated within Canadian universities, it is fair to suggest that the academic perspectives that contributed to this research are informed predominantly by Western knowledge traditions and scientific thought. Throughout the case studies, I frame community participants as local experts and knowledge holders in order to acknowledge that the contributions of these actors may be informed by a range of experiences and knowledges. Further, while Elders and recognized Traditional Knowledge holders participated in this research, the roles, knowledge, and contributions of other participants who may not consider themselves Traditional Knowledge holders was valuable in this research. While this is not a study of Traditional Knowledge and a full critical treatment of the literature on the nature of knowledge and Indigenous Knowledge is beyond the scope of this dissertation, I also recognize that Inuit community perspectives are situated within the larger context of an Inuit Knowledge epistemology and address it briefly here.

For the purposes of this dissertation, it was not critical that I develop and adhere to a single term and unified definition for Traditional Knowledge, including distinguishing between terms used and preferred by a variety of scholars, including Indigenous Knowledge, Traditional Ecological Knowledge, or Local Ecological Knowledge. For my purposes, it was more important to focus on understanding key conceptual foundations of Traditional Knowledge, rather than grasping for a concrete definition. To that end, I focus more specifically on Inuit Knowledge as recognition of the culturally specific form of knowledge with which I interacted in this research. Attempts to define *Inuit Qaujimajatuqangit* (IQ), the Inuktitut term for Inuit Knowledge in Nunavut, have been criticized for being overly narrow, often focusing on IQ as "either useful to a more nuanced management and development of resources or important to cultural survival and resistance to dominant Western ideology" (Tester & Irniq, 2008, p. 49). The Government of Nunavut has worked to develop a unified understanding of IQ and the role of Inuit culture in

government operations. A meeting on Traditional Knowledge in Igloolik, Nunavut in 1998 convened by the Nunavut Social Development Council brought together Elders from all Nunavut communities to address this need. Wenzel (2004) quotes an anonymous meeting participant who conceptualized IQ as a way of knowing that encompasses "all aspects of traditional Inuit culture including values, world-view, language, social organization, knowledge, life skills, perceptions, and expectations". In Tester & Irniq's (2008) discussion about the foundations of Inuit Knowledge, they refer to IQ as a "seamless" knowledge system that does not have easily distinguishable or compartmentalized constituent parts. In using the idea of a "seamless" body of knowledge, Tester & Irniq (2008) adopt Bell's (2002) definition of IQ as "the Inuit way of doing things: the past, present, and future knowledge of Inuit Society" (p. 3). Similarly, Wenzel (2004) documents three primary sources that give more clarity to the meaning of IQ. These sources together describe the essence of IQ as a "living technology" that, while derived from "the ancient knowledge of the Inuit", includes and applies to "all aspects of Inuit life" (Wenzel, 2004, pp. 241-242). Therefore, Indigenous Knowledge in general, and IQ in the current context, shouldn't be defined in such a way that its meaning is restricted to the environmental aspects of the knowledge, but within an understanding that encompasses all aspects of life (Huntington, 2005; Tester & Irniq, 2008; Wenzel, 2004). This research is not examining IQ as a knowledge system, but rather is concerned with the inclusion of Inuit community perspectives in knowledge co-production processes and therefore recognizes the role of IQ in framing these perspectives.

The role of Inuit community knowledge holders in scientific research has often been limited to providing traditional ecological knowledge (TEK) about a research problem that has been defined prior to community engagement, followed by a process of integrating the TEK with scientific knowledge during analysis. A transdisciplinary approach seeks to restructure the engagement of perspectives. Rather than simply integrate multiple perspectives at one instant in the research process, a transdisciplinary approach seeks to involve the actors and stakeholders who hold those perspectives from the beginning (Klein, 2004; Wickson et al., 2006). Further, transdisciplinary research goes beyond merely including stakeholders, which may still reinforce hierarchical relationships between actors, but attempts to "provisionally

blur" the boundaries between academia and society (Godemann, 2008; Hirsch Hadorn, Hoffmann-Riem, et al., 2008; Christian Pohl et al., 2010). Godemann (2008) emphasizes the mutual involvement of actors, stating that transdisciplinary research addresses problems "which can only be solved through cooperation between academics and practitioners" (p. 628). In this way, Godemann (2008) positions transdisciplinary research as the only approach capable of addressing certain societal problems.

There has been increasing recognition at academic, community, and institutional levels that Indigenous communities need to be more meaningfully included in all stages of research and decision-making that affect them (Inuit Tapiriit Kanatami, 2018; Simon, 2017). At the academic level, P. Armitage and Kilburn (2015) have noted the inconsistent nature of research standards that guide the inclusion of Inuit perspectives, the need for research involving multiple knowledges to be rigorous and maintain quality standards, and the increasing scrutiny Traditional Knowledge studies receive, as evidence for the need to identify a clear approach to research that includes Indigenous communities and their knowledge.

The need for meaningful inclusion of Inuit in research has been operationalized by the establishment of guidelines related to research conduct, the creation of research approval and licensing processes controlled by Inuit organizations, and in research funding opportunities that explicitly require the inclusion of community interests and benefits (Inuit Tapiriit Kanatami, 2018; van den Scott, 2012). Methods to include Inuit communities and participants must be consistent with the values and processes contained in their ways of knowing. Tester and Irniq (2008) discuss the epistemological conflict when "attempts are made to avoid the complexities and challenges posed by linking factual with spiritual or cosmological aspects of IQ" (p. 49). As alluded to above, efforts to integrate TEK into research and management risk losing important spiritual components of the knowledge that Indigenous Peoples consider inseparable from the factual information sought by researchers and decision-makers. Rather than seeking a one-size-fits-all approach, research engaging with Indigenous Knowledge needs to be suited to the particular context and use for which knowledge is being sought (Huntington, 2005). Huntington (2005) suggests that rather than identifying a classification of knowledge sought by the

research (TEK, IK, etc.), researchers instead qualify their studies, such as “an ecological study of traditional knowledge” (Huntington, 2005, p. 32).

Knowledge co-production eventually involves a process of integrating the perspectives contributing to research. Integrating knowledges has been identified as a key challenge of transdisciplinary research and is a common point of critique of research that includes Indigenous Knowledge (Fernandez-Gimenez, Huntington, & Frost, 2006; Christian Pohl, van Kerkhoff, Hirsch Hadorn, & Bammer, 2008; Stevenson, 1996; Wickson et al., 2006). Part of this critique has centered on what is perceived as a focus on combining elements of knowledge systems towards creating an objective knowledge product. Rather than focusing on an end-product, researchers have emphasized the need to focus on the dialogue of Indigenous Knowledge and science as a process (Berkes, 2009). In a knowledge co-production approach, the goal is not to create a synthesized knowledge product by combining discernible and decontextualized elements of Indigenous Knowledge and science. Instead, knowledge co-production seeks to produce knowledge through an iterative process of reshaping groups’ perceptions, behaviours, and agendas through interaction with each other’s knowledges (Christian Pohl et al., 2010).

In terms of achieving knowledge integration, Berkes (2009) says that this process should take place within the context of a relationship between actors defined by a set of values to ensure respect for the integrity of the different epistemologies involved. Wickson et al. (2006) suggest that researchers should seek “the development of a single unified ‘truth’ but rather, can seek to integrate the different knowledges by looking for coherence, correspondences and ‘ridges’ across the differences, generating knowledge by finding, identifying and communicating patterns across diverse disciplines and discourses” (p. 1053). Rathwell et al. (2015) refer to the process of “bridging knowledge systems”, which they define as a process that maintains “the integrity of each knowledge system while creating settings for two-way exchange of understanding for mutual learning. This definition acknowledges the role of both a parallel approach to knowledge systems, as well as mutual learning and evolution/innovation of the shared knowledge base” (p. 853). Ultimately, the goal of knowledge integration is the generation of knowledge that is accepted by all involved, a more complex task than simply

producing universal facts: “If research does not match with the cognitive features of a paradigm…peers are unable to recognise and value the respective results” (Hirsh Hadorn et al., 2008, p. 413). Rather than privileging particular perspectives involved in research, the value in transdisciplinary research is its focus on an interactional process of knowledge co-production that leads to a better knowledge outcome.

4. Methodology

4.1. Transdisciplinary Research and Knowledge Co-Production

This research does not specifically intend to achieve transdisciplinary research or knowledge co-production; rather, it is a study of various aspects and factors surrounding the process of knowledge co-production. However, the theoretical foundations of transdisciplinarity motivated the purpose of this project and guided the development of the various evaluative frameworks used, so it is relevant to review its underlying principles. Transdisciplinarity shows potential in responding to the particular social and environmental context of Arctic research. Transdisciplinary research emerged as a distinct research approach in the 1970s, with growing recognition of the need to include both academic and non-academic stakeholders in knowledge production (Horlick-Jones & Sime, 2004). The emergence of transdisciplinarity was part of a paradigm shift in scientific practice marked by a move from research focused solely on matters of disciplinary importance to a recognition of the need for research to address problems of importance to society (Balsiger, 2004; Hirsch Hadorn, Hoffmann-Riem, et al., 2008; Klein, 2014). Klein (2014) describes one of the key features in the development of transdisciplinarity as an expansion in the scope of scientific inquiry from a focus only on the production of “‘reliable scientific knowledge’ to the inclusion of ‘socially robust knowledge’” (p. 72). In part, the emergence of transdisciplinary research responded to lines of thinking that problematized traditional, discipline-based knowledge production models characterized by “specialization in isolation” (Max-Neef, 2005). At the same time, there was growing recognition that traditional research approaches were often challenged in capturing

the full complexity of problems from within the methodological and intellectual boundaries of individual academic disciplines.

The shift in the focus of knowledge production has been described as an expansion of traditional forms of scientific knowledge production, Mode 1 knowledge, to applied, participatory forms of knowledge production, Mode 2 knowledge (Brunet et al., 2014a; Gibbons et al., 1994; Nowotny, 2003). Within this characterization of knowledge, Mode 2 knowledge and its associated methods of production are considered more compatible with the focus of transdisciplinarity. Mode 2 knowledge, according to Gibbons et al. (1994), "is intended to be useful to someone whether in industry or government, or society more generally and this imperative is present from the beginning" (p. 4). Further, the parameters of the knowledge production process is not contained within the discipline of one set of actors or considered a linear process, but rather "is always produced under an aspect of continuous negotiation and it will not be produced unless and until the interests of the various actors are included" (Gibbons et al., 1994, p. 4).

One specific approach to transdisciplinary research has been articulated as the "co-production" of knowledge (D. Armitage et al., 2011; Berkes, 2009; Dale & Armitage, 2011; Godemann, 2008; Christian Pohl et al., 2010). In knowledge co-production, actors represent what Fleck (1981) refers to as diverse "thought styles". Participants interact to co-produce knowledge that, according to Gibbons et al. (1994), "will be different from any of the constituent frameworks, yet could not have been developed without them" (p. 30). Knowledge co-production seeks to "[transgress] the expert/lay dichotomy while fostering new partnerships between the academy and society" (Klein, 2014, p. 72). The approach to knowledge co-production adopted for this project combines elements of the principles that underpin transdisciplinarity with the focus on the resulting knowledge that is produced through the process of co-production (a form of Mode 2 knowledge). Therefore, the definition of knowledge co-production used throughout this project is research that: 1) takes into account the full complexity of problems and considers all factors that together comprise the nature of an issue; 2) considers multiple perspectives of an issue, including both scientific (academic) and societal (non-academic) views; 3) aims to produce practically relevant knowledge driven by the need to

solve a real world problem; and, 4) is aimed at improving conditions in society for the common good (Godemann, 2008; Hirsch Hadorn, Hoffmann-Riem, et al., 2008; Christian Pohl, 2005).

Speaking broadly about knowledge co-production involving natural resource management and Indigenous communities, Davidson-Hunt and Michael O'Flaherty (2007) suggest that knowledge co-production "is vital to indigenous community-based natural resource management, given that planners and indigenous peoples rarely have a common understanding of the issues at hand and tend to speak past one another" (p. 293). Further, with this approach, researchers are more likely to participate in producing knowledge needed by community actors,

> Working from the premise that knowledge is a dynamic process—that knowledge is contingent upon being formed, validated, and adapted to changing circumstances—opens up the possibility for researchers to establish relationships with indigenous peoples as coproducers of locally relevant knowledge: to recognize the role of the researcher in the process of knowledge production through their forming of questions, documentation, and analysis (Davidson-Hunt & Michael O'Flaherty, 2007).

Russell, Wickson, and Carew (2008) recognize that environmental problems require knowledge production processes "able to deal with complexity and uncertainty and able to integrate and communicate knowledge among many actors and between fields of knowledge" (p. 464). Complexity in research has been conceptualized as problems which are interdependent and not limited in the scope of their effects to the interests of individual disciplines. Complex problems are characterized by interactions of value frameworks held by actors rather than strictly gaps in factual or scientific information (Head & Alford, 2013; Klein, 2014). Berkes (2017) specifically notes the complex nature of global environmental problems, which "do not occur in isolation but tend to be interconnected, sometimes in unexpected ways. Thus, it is useful to conceptualize the global environmental system as a complex adaptive system" (p. 1). The nature and significance of complex problems is framed by a wide range of perspectives, each one being valid and important, or as Berkes (2017) states, "in a complex system, there is no single "correct" perspective" (p. 2). As such, addressing complex problems requires that actors engage with each other's value frameworks and knowledge systems. Given the nature of issues facing Arctic communities and environments, and the interactions between

local communities, researchers, and decision-makers that are vital to address these issues, knowledge co-production shows potential as a useful research approach.

Certain conditions can facilitate or inhibit successful knowledge co-production. D. Armitage (2005) discusses the "institutional, organizational, and socio-political conditions that have encouraged more collaborative forms of environmental assessment practice" (p. 240) in the Northwest Territories. While D. Armitage (2005) examined the context around environmental assessment (EA), his focus on identifying the conditions that support collaboration and 'double-loop' learning (Diduck, Bankes, Clark, & Armitage, 2005) share characteristics with knowledge co-production. In particular, a researcher's ability to identify and generate the appropriate conditions can promote the production of accurate and rigorous information, engagement of multiple actor perspectives, and critical reflection on the assumptions embedded in existing knowledge production processes. In EA, and other circumstances involving knowledge production about complex problems, the role of emergent institutions and organizations at multiple vertical levels; enhanced communication strategies and effective participation; common goals and shared visions; bridging knowledge systems; and building adaptive capacity among actors are key factors of enhanced collaboration and learning (D. Armitage, 2005).

4.2. Research Design

Much of the methodological development of transdisciplinary research depends on exploring lessons from case studies from a variety of research contexts (Hoffmann-Riem et al., 2008). Though a few examples do exist (e.g. D. Armitage et al., 2011; Dale & Armitage, 2011; Idrobo & Berkes, 2012; Vlasova & Volkov, 2016), the Arctic is a research context in which few transdisciplinary research cases are available for reflection and learning. I use a case study approach (Kohlbacher, 2006; Yin, 2014) to examine research projects at various stages of completion and in different communities to better understand transdisciplinary research and particularly its potential application in the Canadian Arctic.

While not included as a formal chapter in the dissertation, I conducted a systematic literature review to examine trends in scientific Arctic marine mammal research over the past 100 years. A systematic review is a methodical way to search for literature through a carefully planned and detailed search protocol. This approach ensures the methods for searching and reviewing the literature are clearly described, rigorous, and reproducible (Victor, 2008). Systematic literature reviews have been used in the health literature in particular as a method to review trends and changes in literature over time, determine research priorities, examine the state of knowledge on a specific issue at a particular point in time, and contribute to policy and practice guidelines (Furgal, Garvin, & Jardine, 2010; Lichtenstein, Yetley, & Lau, 2008; Moher, Liberati, Tetzlaff, & Altman, 2009). A number of documents have elaborated guidelines for conducting and reporting the results of systematic literature reviews to ensure rigor in methods and comparability in results across studies (Higgins & Green, 2011; Moher et al., 2015; Victor, 2008). Recently, the value of synthesis studies, including systematic reviews, in the field of ecology has been acknowledged, with systematic reviews becoming increasingly popular (Doerr, Dorrough, Davies, Doerr, & McIntyre, 2015; Lortie, 2014). The literature review process was integral to my own understanding of the wider research context and the specific research projects I examined for this research, particularly the ringed seal and polar bear case studies. The literature review gave me a higher level perspective of trends within the scientific marine mammal literature across both spatial and temporal scales. Part of the research design was based on working closely with natural science projects and the literature review helped to establish my own knowledge of the field and ensure I could effectively be part of the conversation around Arctic wildlife science.

I use a multiple-case design (Yin, 2014) to examine knowledge co-production, as a process within a transdisciplinary research approach, in the context of a past research Arctic wildlife study, an ongoing study, and in one, to consider the conditions necessary for knowledge co-production to benefit future Arctic wildlife research. In arguing for the adoption of “replication, not sampling logic, for multiple-case studies”, Yin (2014) suggests that each case is selected either to predict similar results (literal replication) or contrasting results but for predictable reasons (theoretical replication). I partnered with researchers who focus on marine

wildlife in Nunavut to select three cases that each fulfilled a literal replication role in the overall study. Each case was selected to address a different aspect of the research questions; however, the cases were connected in the purpose of demonstrating the potential usefulness of knowledge co-production.

Specific methods are presented in each chapter of the dissertation. I use qualitative data collection and analysis throughout the case studies. Data collection methods include semi-structured interviews (Bryman & Teevan, 2005; Creswell & Creswell, 2018; Creswell & Poth, 2018; Huntington, 1998), purposefully designed and facilitated thematic workshops (Huntington et al., 2002), participant observation (Creswell & Poth, 2018; DeWalt & DeWalt, 2002), and document review (Creswell & Creswell, 2018; Creswell & Poth, 2018). Throughout the case studies, I used thematic coding with NVivo (QSR International Pty Ltd. Version 11, 2017) to follow an analytic approach based on qualitative content analysis (Bryman & Teevan, 2005; Hsieh & Shannon, 2005; Kohlbacher, 2006). I selected methods for each case study based on both the specific objectives of the case and to fit an overall design in which there was cohesion and logic across cases. I used participant observation in each of the case studies as a way to continuously and systematically document and include my own observations and experiences with the research topic. In addition, particular interview and workshop questions were used in multiple cases to create a sense of replication and allow a comparison between cases and contexts.

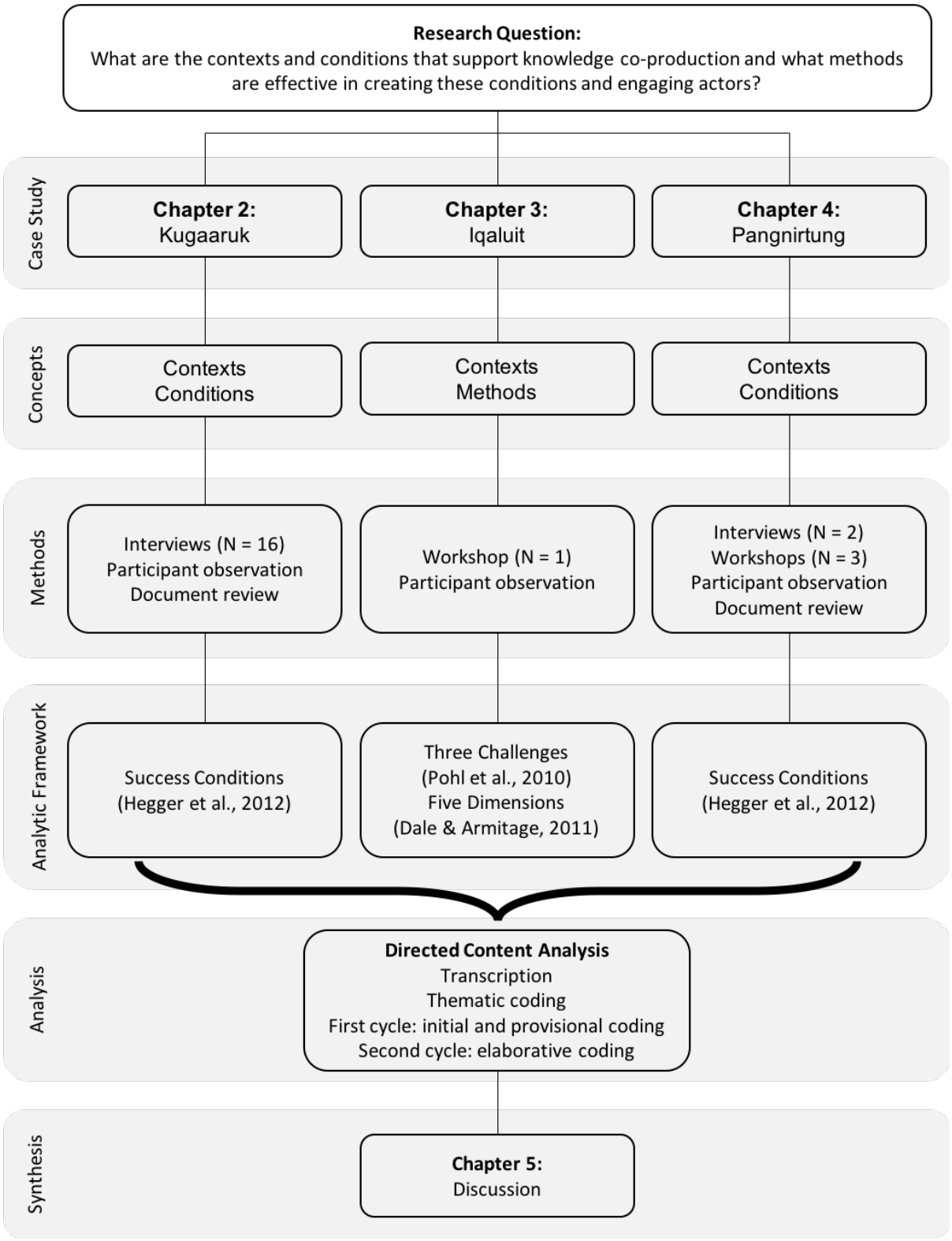

Figure 1: Research design included three case studies and specific analytic frameworks to examine the three concepts of the research question (contexts, conditions, and methods).

4.3. Conceptual Framework

Case studies were selected and structured to examine three components of knowledge co-production: the research contexts that contain criteria which makes them suitable cases for knowledge co-production; structural and process conditions at the social-political, organizational, and institutional levels that support knowledge co-production; and research methods that are suitable to knowledge co-production practice. Each case fulfilled a different analytical role based on the stage of research of the projects: one case study retrospectively examined a research project that was already underway, one represented a current examination of the state of one particular field of research, and the third represented a prospective examination of research that was just entering the planning stages. A set of evaluative frameworks connect the cases to an overall examination of knowledge co-production. The temporal nature of the design (past, present, future) provides unique insight into both the effectiveness of the evaluative frameworks and the ability to isolate each of the three components of knowledge co-production to examine each one in more detail.

I used an overarching conceptual framework to examine the different aspects of the research question within and across the three case studies (Fig. 1). Drawing from existing literature, I adapted and applied different approaches to analyzing knowledge co-production into a cohesive analytic framework that cut across the case studies. In terms of considering the contexts to which knowledge co-production is potentially suited, I considered how the four components of my definition of knowledge co-production applied to each case study (Godemann, 2008; Hirsch Hadorn, Hoffmann-Riem, et al., 2008; Christian Pohl, 2005).

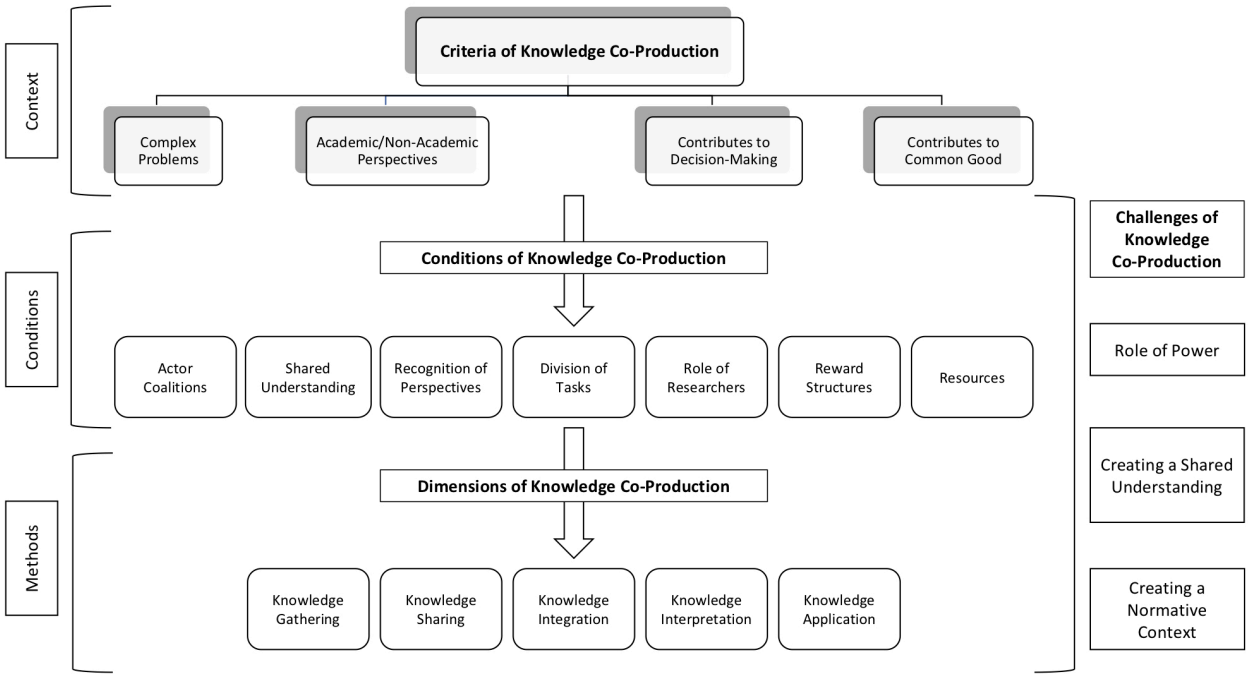

Figure 2: Conceptual framework for the organization of the research and the evaluative frameworks used to examine each component of the research question.

To examine the conditions conducive to knowledge co-production, I used a framework developed by Hegger, Lamers, Van Zeijl-Rozema, and Dieperink (2012) and what they refer to as seven Success Conditions for effective "joint knowledge production" between science and policy actors (Fig. 1). Hegger et al.'s (2012) use of Success Conditions to analyze policy situations can be extended to understand the conditions conducive to knowledge co-production research involving scientific and community actors. In their model, Hegger et al. (2012) conceptualize joint knowledge production as an interaction between the actors involved in producing knowledge and the structural context in which they operate, including the rules that determine interactions and responsibilities between actors and the resources available. Hegger et al. (2012) summarize the seven Success Conditions as the broadest possible actor coalition within the limits present; a shared understanding of goals and problem definitions; recognition of stakeholder perspectives; organized reflection on division of tasks by participating actors; a clear role of researchers and their knowledge; the presence of

innovations in reward structures; and the presence of specific resources (such as boundary objects, facilities, organizational forms and competencies).

For the purposes of examining methods to achieve knowledge co-production in research, I adapted an analytic framework used by Dale and Armitage (2011) and D. Armitage et al. (2011), who looked at knowledge co-production in Arctic co-management systems. In their framework, Dale and Armitage (2011) describe five dimensions of knowledge co-production (Fig. 1). The first dimension, knowledge gathering, refers to the specific activities and methods used to collect information about a question. Second, knowledge sharing refers to the interaction among knowledge holders through which they communicate their perspectives on an issue. Third, knowledge integration is the stage at which different knowledges are related to each other. Fourth, knowledge interpretation is the process of assigning meaning to informational knowledge. Finally, knowledge application "involves the translation of evolving knowledge into specific [decisions]" (Dale & Armitage, 2011, p. 7).

The final part of the overarching conceptual framework identifies three challenges to knowledge co-production that I considered when examining both the conditions and the methods of knowledge co-production (Fig. 1). First, the role of power dynamics is a critical and ongoing consideration in interactions between academic and local actors and is particularly relevant in the context of research involving Indigenous communities and Arctic research more specifically (Agrawal, 1995; Nadasdy, 2003; Tester & Irniq, 2008; White, 2006). There is a rich body of knowledge/power literature and while I carefully considered and worked to address power relations at various scales throughout this research, a thorough review of this literature is beyond the scope of this dissertation. Nevertheless, the history of colonialism in Canada and the ways in which colonial relations have been enacted through academic research were a consistent and ongoing consideration throughout this project. For instance, Fernandez-Gimenez et al. (2006) note the "underlying power dynamics of native involvement in research and co-management", where experiences have been that scientific information often holds "power over the credibility of TEK" (p. 312).

Christian Pohl et al. (2010) refer to the second challenge as the need to "interrelate the perspectives of the different thought collectives" to create a shared understanding of an issue

(p. 271). The goal is to "achieve a more comprehensive, or — in terms of power and thought styles — more balanced and adoptable understanding of an issue and corresponding solutions" (Christian Pohl et al., 2010, p. 272). The significance of this challenge is that the shared understanding must not be imposed by researchers or other actors external to the process, it needs to emerge through the interactions of participants.

The third challenge involves creating a "normative orientation" (Christian Pohl et al., 2010) with regards to the main concepts and issues of the problem. D. Armitage et al. (2011, p. 997) describe the goal of this task as the "[s]hared desire to use knowledge co-production to achieve mutually agreed outcomes". In an analysis of knowledge co-production in four cases of sustainability research, Christian Pohl et al. (2010) examine researchers' definition of the concept of sustainable development and suggest that the "normative and contested character of sustainable development was crucial, both as a starting point and a key motor of the co-production process" (p. 272). Christian Pohl et al. (2010) argue that creating a shared understanding of the underlying presuppositions of sustainability among actors is critical for knowledge co-production. At the same time, while researchers should promote the shared orientation, they should also maintain an awareness of the contested nature of the concept and therefore an openness to the possibility that the meaning of the term may change. While their analysis was particularly concerned with sustainability research, a corresponding foundational concept can be identified in other knowledge co-production efforts – for instance, environmental and wildlife conservation – and establishing a shared normative orientation among actors is critical.

4.4. Positionality Statement

As a researcher, I bring a set of experiences and assumptions to this research. First and foremost, I embrace the notion that my own background and identity affect the knowledge I am involved in producing. Second, it is important to identify the ways in which my identity creates a particular lens through which I see the world and to understand how this lens influences my interaction with this research. Finally, I don't suggest that the subjectivities I

bring to this research can or should be compartmentalized from my role as a researcher in the pursuit of an ideal of objectivity; rather, I work to understand and account for the ways in which my identity influences my role. It has been important for me to recognize my own positionality and the associated power that I have brought to this research.

My own background is of mixed European ancestry. Having been educated in Euro-Canadian school systems, I bring a perspective informed by Western knowledge. While my own worldview has been formed by a range of experiences, specific factors have brought me to this research and continue to inform my perspective. I completed an undergraduate degree at Trent University in Peterborough, Ontario with a joint major in Indigenous Studies and International Development Studies. While at Trent, I had the opportunity to learn about issues related to Indigenous rights and decolonization movements in Canada. As part of my degree, I spent a year abroad studying in Chiang Mai, Thailand and while there had the opportunity to work with a number of Burmese Indigenous refugee non-governmental organizations. While working with these organizations, I focused on a number of projects concerned with the impacts of resource development and extraction on the human rights of Indigenous communities in Burma. When I returned to Trent, I was particularly interested in continuing to explore issues related to Indigenous rights and resource development and Indigenous communities' jurisdiction in their territories. I had the opportunity to learn about Indigenous communities' own expressions of their sovereignty and jurisdiction and the role that non-Indigenous Canadians can fulfill as allies and parties to the original treaties that were agreed upon with Indigenous communities. I valued the need to uphold treaty and other responsibilities that European and Canadian governments agreed to with Indigenous Peoples in Canada and I was interested in understanding how these responsibilities could be upheld in the environmental field.

In 2008, I began a Master of Arts in Canadian Studies and Indigenous Studies at Trent University. My research examined a case study involving the Ardoch Algonquin First Nation and their opposition to a uranium exploration project on their traditional territory in eastern Ontario. This project enhanced my own understanding of the importance of Indigenous communities' relationships in their territories and the need to more meaningfully recognize Indigenous jurisdiction and include Indigenous Knowledge in decision-making. I also completed

an Ecosystem Management Technology diploma at Fleming College in Lindsay, Ontario, which was an important experience in developing my own understanding of ecological processes and skills. My academic experiences throughout my Master's research and my time at Fleming College solidified my personal perspectives and interests related to working with Indigenous communities and environmental decision-making.

When I began my PhD research, I was driven by a belief in the need to advance environmental and wildlife conservation and continue to improve relationships between Indigenous communities and non-Indigenous Canadians that have been defined by colonial histories in Canada. Being personally situated in and informed by a Western knowledge system, one of the assumptions I bring to this research is a belief in the utility of decision-making that is based on knowledge generated from both social and natural science research, as well as a personal belief in the value of the concept of wildlife management that has developed in North America. At the same time, I have had the opportunity to spend time with Indigenous Knowledge holders and to develop respect for Indigenous concepts of relationships with wildlife and environments. My own intellectual assumptions, therefore, are that effective conservation will depend on, and be enhanced by, meaningful exchange and use of both Western and Indigenous Knowledge. These assumptions and the values that underpin them led me to explore the field of knowledge co-production, which claims to be able to achieve exchange of information and to generate robust knowledge from a plurality of worldviews.

5. Organization of the Dissertation

The dissertation is structured around two organizational lines: the temporal nature of the case studies and the components of knowledge co-production examined throughout the entire study. Each of the case studies represents a different set of experiences related to interactions between community members and researchers, which offers insights into the range of contexts to which knowledge co-production may be appropriate. One case study represents a context in which there have not been any outward disagreements between researchers and community interests. A second case study represents a context with a longer

history of research and in which there has been tension between researchers and community organizations. Finally, the third case study represents a type of middle ground in which participants represent a range of perspectives and experiences across different communities and projects.

Chapter Two presents a retrospective examination of a community-based seal sampling project in Kugaaruk, Nunavut. The purpose of the Kugaaruk case study is to understand how an existing project might have benefitted from knowledge co-production. The Kugaaruk case study focuses on understanding the extent to which the context of Arctic marine mammal research is suited to knowledge co-production and whether ongoing research projects have independently established conditions that support knowledge co-production. The sampling program in Kugaaruk was underway for two years prior to my involvement as part of this research. The Kugaaruk case study asks whether the research could have had a knowledge co-production approach from the initial stages, and if so, in what ways would the research have been different and could knowledge co-production have benefitted the research?

Chapter Three focuses on the process of knowledge co-production in the context of current and ongoing ringed seal research and management in Nunavut. In Chapter Three, the goal was to use knowledge co-production to examine ringed seal research in Nunavut and consider the potential of workshops to facilitate knowledge co-production in practice. The Iqaluit case study offers a broad picture of the nature of research on one species across Nunavut. It is useful as an examination of methods for knowledge co-production and as an indicator of issues and topics that may be present in more specific research contexts, including the other two case studies. The Iqaluit case study focuses on a different temporal context and component of knowledge co-production but took place simultaneously with the Kugaaruk case study. The results of the Iqaluit case study informed part of the examination of conditions in Kugaaruk and contributed to the methods used in the Pangnirtung case study.

Chapter Four looks at a prospective research project and considers the pre-conditions that researchers and local actors need to establish prior to engaging in knowledge co-production. The research context in Chapter Four is related to fisheries research in Pangnirtung, Nunavut. The purpose of Chapter Four is to consider methods that can establish the pre-

conditions that are needed to support future knowledge co-production and to reflect on the nature of these pre-conditions. Using the same evaluative framework that was used to examine the conditions of knowledge co-production in Kugaaruk and applying lessons learned from the Iqaluit case study related to methods, this case study explores a process to engage actors in activities intended to establish the pre-conditions that could support future knowledge co-production.

Chapter Five provides an integrated discussion of the case studies. The purpose of Chapter Five is to consider lessons learned related to the application of knowledge co-production in a relatively unexplored research context, better understand the conditions that are more likely to support successful knowledge co-production, and reflect on the effectiveness of the methods examined throughout the research. It comments on the limitations of this research and suggests considerations for future studies. Finally, Chapter Five outlines specific contributions to relevant literature and wider contributions to decision-making that I hope this research provides.

Chapter Two: A Retrospective Examination of Ongoing Research Demonstrates Potential Benefits of Knowledge Co-Production in the Arctic

1. Introduction

Arctic regions face a range of pressing social and environmental issues. The effects of climate change and other anthropogenic activities, and their interactions with the needs and health of human communities have emerged as drivers of Arctic research and policy (de March et al., 1998; Huntington, 2009). Addressing the impacts of large-scale environmental changes on both Arctic marine mammals and human communities will require approaches to conservation and decision-making that take into account both the human and ecological dimensions of these issues (Heberlein, 2012). Generating knowledge that can effectively inform decision-makers requires research approaches capable of integrating various perspectives that offer a more rigorous representation of the full complexity of environmental issues – including those rooted in the social and natural sciences and held by local communities.

Reductions in sea ice extent and timing will have implications for marine mammals, such as ringed seals (*Pusa hispida*), which rely on ice platforms as critical feeding and breeding habitat. As harvested species, changes in marine mammal populations will also affect the nutritional, social, and economic well-being of Inuit communities. The traditional importance of marine mammals in Inuit communities means that these communities will be affected not only by the health of marine mammals and their environment but also by the knowledge gained about these species through ongoing scientific research. It is therefore important to consider the ways in which knowledge production about marine mammals could be enhanced by collaboration between academic and local communities.

Knowledge co-production has been proposed as a research approach that is well suited to complex problems defined by the intersection of multiple perspectives, both academic and non-academic, for the purpose of producing knowledge about scientifically and socially relevant problems (Hirsch Hadorn, Biber-Klemm, et al., 2008; Hirsch Hadorn, Hoffmann-Riem, et al., 2008). As a research context that involves complex problems, academic and non-academic

perspectives, and requires knowledge that can contribute to decision-making, Arctic marine mammal research lends itself to a consideration of the potential benefits of knowledge co-production. There is also wider political recognition of the importance in connecting scientific and local community priorities for the purpose of answering real-world questions. In a 2017 report examining the priorities of Arctic leadership and communities across the North, Mary Simon emphasized that "the next step in the evolution of scientific practice in the Arctic is linking community-driven Arctic research priorities with national policy development to ensure scientific investments benefit communities and answer key questions facing the Arctic" (Simon, 2017).

It has been acknowledged that learning from case studies is an important way to advance collective understanding of the benefits and application of knowledge co-production (Hoffmann-Riem et al., 2008). Few projects have explicitly used knowledge co-production in the Arctic. Dale and Armitage (2011) discussed their use of knowledge co-production in the context of narwhal co-management in Nunavut but there is a gap in discussions of knowledge co-production specifically in Arctic research; however, a number of ongoing scientific research projects in the Arctic fit the criteria for research contexts that are well suited to knowledge co-production. One way to learn about the potential contribution of knowledge co-production to the unique social-ecological context of the Arctic is to retrospectively examine ongoing research projects through the lens of knowledge co-production. These retrospective analyses allow us to consider whether knowledge co-production might have benefitted the specific objectives and processes of existing research and offer insights into the potential benefits of knowledge co-production for future research. Conversely, examining existing projects might offer lessons to future knowledge co-production about successful methods that have been used to enhance collaboration and bridge knowledge systems between social and natural sciences and between academic and non-academic actors.

I examined an ongoing harvest-based ringed seal sampling project in Kugaaruk, Nunavut to consider the potential for successful knowledge co-production in Arctic marine mammal research. I used qualitative data collection and analysis to examine three main questions. First, was the research in Kugaaruk a suitable case for knowledge co-production? Second, did the

project contain any aspects of knowledge co-production already? Third, based on the strengths and challenges that arose throughout the project, could knowledge co-production have benefitted the project? On the latter question, I wanted to understand whether knowledge co-production might have enhanced the project's strengths and helped avoid or address challenges encountered throughout the research. Results indicated that knowledge co-production could have benefitted the Kugaaruk research by identifying additional actors to contribute to framing and structuring the research problem, helping to ensure actors were clear about their roles, and establishing more reliable structures for communication and feedback throughout the project. These results also indicate that it is worthwhile to explore the potential application of knowledge co-production in other research throughout the Arctic.

2. Background

2.1. Transdisciplinary Research and Knowledge Co-Production

Transdisciplinarity emerged in the 1970s out of a growing recognition that knowledge production processes needed to include both academic and non-academic actors and perspectives (Horlick-Jones & Sime, 2004) and an appreciation for scientific inquiry to expand from a focus only on the production of "'reliable scientific knowledge' to the inclusion of 'socially robust knowledge'" (Klein, 2014, p. 72). There was also increasing recognition that individual disciplines were often challenged in capturing the full complexity of research problems. Transdisciplinary research has been further articulated as a research approach defined by the "co-production" of knowledge (D. Armitage et al., 2011; Berkes, 2009; Dale & Armitage, 2011; Godemann, 2008; Christian Pohl et al., 2010). The definition of knowledge co-production used in this project is research that: 1) takes into account the full complexity of problems and considers all factors that together comprise the nature of an issue; 2) involves multiple actors who represent a plurality of perspectives on an issue, including both scientific (academic) and local community (non-academic) views; 3) aims to produce practically relevant knowledge driven by the need to solve a real-world problem; and, 4) is aimed at improving

conditions in society for the common good (Godemann, 2008; Hirsch Hadorn, Hoffmann-Riem, et al., 2008; Christian Pohl, 2005).

Knowledge co-production shows potential as a research approach well suited to the particular social, political, and environmental context of the Arctic (Davidson-Hunt & Michael O'Flaherty, 2007). Russell et al. (2008) recognize that environmental problems require knowledge production processes "able to deal with complexity and uncertainty and able to integrate and communicate knowledge among many actors and between fields of knowledge" (p. 464). Complexity has been conceptualized as problems which are interdependent in their social and natural contexts, involve an element of uncertainty and unpredictability, and therefore are not limited in the scope of their effects to the interests of individual disciplines (Klein, 2014; Russell et al., 2008). Complex problems are characterized by interactions of value frameworks held by different actors rather than strictly gaps in factual or scientific information (Head & Alford, 2013; Klein, 2014). Addressing complex problems, therefore, requires the participation of multiple actors who engage with a plurality of value frameworks and knowledge systems.

Various bodies of thought recognize the need for research to include the participation and perspectives of multiple groups of actors and for research to produce knowledge that contributes to issues relevant to both academic and non-academic communities. Knowledge co-production addresses this need by attempting to "[transgress] the expert/lay dichotomy while fostering new partnerships between the academy and society" (Klein, 2014, p. 72). Among other benefits, research involving more meaningful local participation can produce results that are more likely to be trusted and applied by actors at various scales (Brunet et al., 2014b). It has also been found that policy and management decisions are more likely to be understood and accepted when informed by research that has involved the active participation of local actors (Jones et al., 2008).

At the same time, there is a need to critically reflect on research that claims to be participatory and to articulate effective methods to ensure participation is meaningful (Elzinga, 2008). The task for researchers is not simply to increase participation in a quantitative sense. Rather, the value is to create the conditions that enhance opportunities for participation by

individuals who hold the knowledge that will ultimately contribute to effective problem-solving and to ensure that knowledge generated through participatory processes is accurate and used effectively (Irvin & Stansbury, 2004).

2.2. Ringed Seals

Ringed seals have a circumpolar distribution and are the most abundant Arctic marine mammal. They are specifically adapted to ice-covered seas, relying on first-year sea ice as critical habitat where they haul-out in the spring during the annual moult and on which pregnant females construct subnivean birth lairs to protect pups from both predators and weather (Furgal, Kovacs, & Innes, 1996; Harwood, Smith, Melling, Alikamik, & Kingsley, 2012). Ringed seals are sensitive to environmental conditions, such as ice extent and thickness, snowfall, and abundance of other marine species (Derocher, Lunn, & Stirling, 2004; Stirling & Parkinson, 2006). As the main prey of polar bears, changes in ringed seal health and abundance will also have implications for other species (Derocher et al., 2004).

Changes in ringed seal health will also affect Inuit communities. Ringed seals are an important traditional subsistence and economic marine resource for many Nunavut communities (Kingsley, 1990). Ringed seal skins are used to make clothing and other products, providing communities with both personal needs and commercial economic opportunities. It is estimated that CAD $40 million is generated annually through the harvest-based economy in Nunavut, which includes roughly 40 000 seals harvested each year at a food value of approximately CAD $5 million (Government of Nunavut, n.d.).

Previous studies have suggested that ringed seal populations could be an appropriate indicator of environmental change in the Arctic (Kingsley, Stirling, & Calvert, 1985; Laidre et al., 2008; Stirling, 1997). There has been collective recognition among scientists and Arctic communities of the importance in monitoring Arctic marine mammals and ringed seals in particular (Gill et al., 2011). Ringed seal monitoring projects are ongoing across Canada and include harvest-based sampling, satellite telemetry, spring aerial surveys, and acoustic monitoring. Many ringed seal research programs rely on working closely with Inuit

communities, including Hunters and Trappers Organizations (HTOs), hunters who collect samples, and community members who contribute local and Traditional Knowledge through interviews. As a species of significance for both human and ecological communities and of interest to both scientific and local actors, ringed seals represent a potentially useful research context for knowledge co-production.

3. Methods

3.1. Case Study Context

The Hamlet of Kugaaruk is located on the coast of Pelly Bay, near the Gulf of Boothia within the Kitikmeot Region of Nunavut. A harvest-based seal sampling program began in 2011, working with local hunters to collect biological tissues and morphometric data from ringed (and to a lesser extent bearded seals (*Erignathus barbatus*)) taken in the annual subsistence harvest. The research aimed to examine the diet, reproduction, health and body condition, and distribution, movement, and abundance of seals in the region. From 2012-2016, 191 ringed seal and 12 bearded seal samples were collected by hunters and submitted to the HTO for shipment to southern research partners. The research also included a social science component to interview hunters and other resource users about seal and polar bear ecology in the region. Seal samples also contribute data to a study examining feeding ecology and diet composition of polar bears in the Gulf of Boothia.

At times, the interaction of local communities, researchers, and managers in wildlife research have generated conflicts about the knowledge produced and uncertainties over how to proceed in decision-making processes that are acceptable to all involved. Conflicts between actors are often highlighted in popular media or suggested as representative of Arctic scientific research more broadly. In contrast, the Kugaaruk case allowed an examination of knowledge co-production as a research approach under generally optimal social-political conditions with regards to the nature of the research questions and the relationships between academic and non-academic actors. Kugaaruk has had relatively few research projects and I am not aware of

any conflicts between researchers and community members or organizations. Ringed seals are a widely abundant species without immediate conservation or management concerns. At the same time, they are a species of importance to Arctic communities and ecosystems, positioning seals as a research context without overly contentious social-political factors.

The seal sampling project in Kugaaruk was not designed as a knowledge co-production project; however, the intersection of multiple value frameworks, including those of scientists and local community members, and the presence of both scientific and local interests positioned the project as one that may have been well-suited to knowledge co-production. It is also possible that research projects unintentionally adopt certain aspects of knowledge co-production and identifying these aspects and the strengths they bring to research could be useful for future work. Therefore, this case study was well-suited to examine the potential benefits of knowledge co-production in Arctic marine mammal research.

3.2. Data Collection

I used qualitative data from participant observation, interviews, and document review (Bryman & Teevan, 2005; Creswell & Creswell, 2018; Creswell & Poth, 2018) to consider how knowledge co-production might have impacted the Kugaaruk research. Data collection involved 16 one-on-one, semi-structured interviews with community members, including hunters who participated in the sampling program (N = 11) and hunters or other community members who did not participate in the sampling program (N = 5). Interview participants ranged in age between 31 and 84 years old and included 15 men and one woman. Document review included project funding proposals and project reports (N = 6).

Participant observation is a form of qualitative data collection based on a researcher's own observations and participation of activities, enabling researchers to observe the natural occurrences of events and the interactions and behaviours of others (Creswell & Poth, 2018; DeWalt & DeWalt, 2002). Johnson and Christensen (2008) discuss four forms of participant observation that occur along a continuum ranging from complete participant, participant-as-observer, observer-as-participant, and complete observer. Participant observation in this case

would be classified as participant-as-observer, where participants were informed that my participation was part of research. According to Creswell and Poth (2018), as a participant-as-observer, the researcher participates in activities at the site which helps the researcher gain an insider perspective and develop subjective data. Participant observation data was based on informal interactions with both researchers and community partners (namely the HTO Secretary Managers and a community research assistant/liaison), informal interactions with other community members, reflections from community research presentations, and interactions with two hunters while travelling on the land to observe the seal sampling.

Interviews took place in February-March 2015 and February 2017 and ranged from 20 minutes to approximately one hour 45 minutes each. Interviews were semi-structured and designed to cover key topics while also being flexible to allow conversations to emerge and direct the interview (Bryman & Teevan, 2005; Creswell & Poth, 2018). Interview participants were recruited with the help of a community liaison who worked with the Kurtairojuark Hunters and Trappers Organization and through radio announcements using a combination of snowball and purposeful sampling (Creswell & Poth, 2018). The community liaison arranged interviews with Elders and others who were known to be knowledgeable about seals and polar bears and were trusted as key informants. In other cases, interview participants recommended particular people in the community as additional participants.

The interview protocol was informed by themes identified in existing knowledge co-production literature and a workshop on ringed seals that took place in Iqaluit, Nunavut in 2014 (McCarney, Thiemann, Furgal, & Ferguson, 2014). A portion of the interviews focused on community perceptions about research more broadly and did not require participants to be directly involved with the sampling program; however, I made effort to recruit participants who had participated in the seal sampling program and could speak to all sections of the interview guide. If participants did not actively hunt themselves, they were not asked the questions about seal and polar bear ecology.

The first section of the interview asked a series of questions about seal and polar bear feeding ecology, life history, habitat use, and health. The second section of the interview focused on assessing the degree to which aspects of knowledge co-production had been

present in Kugaaruk by asking questions related to community engagement in the process of problem identification and problem structuring; participants' knowledge of the results of the sampling program as an indication of communication at the community level more broadly; desired changes to research methods and processes; and interest in seeing the sampling project continue. All research methods were reviewed and approved by the Human Participants Review Committee at York University.

3.3. Data Analysis

3.3.1. Analytic Framework

I used an analytic framework adapted from Hegger et al. (2012), who discuss what they refer to as "Success Conditions" for effective joint knowledge production between science and policy actors. In their framework, Hegger et al. (2012) conceptualize joint knowledge production as an interaction between the actors involved in producing knowledge and the structural context in which they operate. The structural context that impacts the success of knowledge co-production is defined by four dimensions: the actors themselves, the discourses that frame the problem, the rules that determine interactions and responsibilities between actors, and the resources available (including the power relations and resource dependencies between actors). Together, these four dimensions contain seven Success Conditions that impact the "perceived credibility, salience and legitimacy of the knowledge produced" (Table 1; Hegger et al., 2012, p. 61). I extended the framework developed by Hegger et al. (2012) as a tool to conceptualize conditions that are conducive to successful knowledge co-production involving scientific and community actors.

Table 1: Success Conditions of joint knowledge production from Hegger et al. (2012), plus one additional Success Condition based on a review of wider Arctic research literature, used as an adapted assessment framework to develop the coding scheme for analysis of the Kugaaruk case.

Dimensions of Knowledge Co-Production	**Success Conditions for Knowledge Co-Production**
Actors	1. Broadest possible actor coalition within limits present
Discourses	2. Shared understanding of goals and problem definitions
	3. Recognition of differences in actor perspectives
Rules	4. Organized reflection on division of tasks by actors
	5. Role of researchers and research-based knowledge is clear
	6. Presence of reward structures
Resources	7. Presence of specific resources (such as boundary objects, facilities, organizational forms, and competences)
Additional Success Condition	A. Engagement with emerging legal / institutional frameworks

The framework developed by Hegger et al. (2012) was useful for my purposes because it focuses on knowledge as an interactive and dynamic process and presents the Success Conditions as conditions that, when present, are likely to increase the potential that research efforts will produce knowledge that is perceived as credible, salient, and legitimate by various audiences and users of the knowledge. The Success Conditions are not presented as guarantees of success but rather as a lens through which to consider the likelihood that the outcomes of knowledge co-production will be successful. Using their framework provided a lens through which to examine the specific processes and actors involved in Kugaaruk. One of the advantages of the framework from Hegger et al. (2012) is that it creates the analytic space to consider that knowledge co-production does not need to be an all-or-nothing endeavour defined as a dichotomy of success or failure, but rather that research may include particular

elements of knowledge co-production while having missed others. This type of analysis is consistent with the suggestion by Hirsch Hadorn, Hoffmann-Riem, et al. (2008) and others that knowledge co-production is an iterative rather than a linear process. In this understanding of knowledge co-production, the processes and interactions in research, framed here by the Success Conditions, are dynamic and can change throughout research projects and therefore, while related, can be considered somewhat independently in their presence, absence, and influence on research.

3.3.2. Qualitative Content Analysis

Interviews were audio recorded and transcribed for thematic qualitative analysis in NVivo (QSR International Pty Ltd. Version 11, 2017). Document review data were also imported into NVivo for analysis. Participant observation notes were coded manually and used as references to add context (confirmation or contradiction) to understandings developed from analysis of interview and document review data. I took a qualitative content analysis approach, a methodological extension of standard quantitative content analysis that “comprises a search for underlying themes in the materials” (Bryman & Teevan, 2005, p. 337). Qualitative content analysis maintains focus on the social context in which the material was generated and considers both the manifest content and the latent content of the data (Kohlbacher, 2006). In particular, I used directed content analysis, an approach based on an existing theory that is used to "validate or extend conceptually a theoretical framework" (Hsieh & Shannon, 2005, p. 1281).

For thematic coding, I followed a process described by Ryan and Bernard (2016) as “cutting and sorting” to look for similarities and differences among textual data. First cycle coding involved a round of open coding to become familiar with the interviews and understand what coding categories might emerge from the content itself, followed by what Saldana (2009) refers to as provisional coding to apply *a priori* codes that were developed in advance of data collection. A deductive (*a priori*) category application technique (Kohlbacher, 2006) used codes based on the Success Conditions described in Hegger et al. (2012). In order to ensure that the

Success Conditions captured the range of factors regarded as important for successful research, I reviewed existing literature to identify a list of elements that are considered important for successful research. I then considered whether the seven Success Conditions encompassed this broader list of elements. One element important to research in the Arctic that was not specifically captured by the Success Conditions was concerned with the need for research to engage with emerging legal, institutional, and ethical frameworks in Arctic research (e.g. Association of Canadian Universities for Northern Studies, 2003; van den Scott, 2012). I added this element to the existing list, giving a final framework of eight Success Conditions (Table 1).

To provide direction to the analysis, second cycle coding used an elaborative coding technique, a top-down approach that applies existing constructs to a new study to better understand a preconceived theoretical framework (Auerbach & Silverstein, 2003; Saldana, 2009). During the second cycle coding stage, sections of coded data were organized to look for evidence indicating the presence or absence of the Success Conditions in Kugaaruk. Interviews were also coded to understand successes and challenges experienced throughout the research. Some degree of interpretation was necessary, particularly in the analysis of the interview transcripts, which were often translated, to assess whether the data was indicating the presence or absence or simply acknowledging an awareness of some aspect of research that is related to a Success Condition. To deal with this, I also coded data for instances where it indicated an awareness of Success Conditions more broadly but did not make clear statements about their presence or absence in Kugaaruk. Instances where interview participants discuss aspects of research that relate to the Success Conditions can provide context to the ways in which the deliberate use of knowledge co-production may have affected the experiences of different actors in the research.

3.3.3. Assessment Framework

I analyzed data for evidence of the presence or absence of each Success Condition within and across data sources. I used a value framework adapted from Buckham (2013) to determine the presence or absence of each Success Condition. First, I coded the interview and

document review data for instances where they indicated the presence or absence of a Success Condition and assigned a value to each Success Condition (Table 2). Data were treated differently between cases where there was simply a lack of indication as to the presence of a Success Condition and those that clearly indicated the absence of a condition. If data indicated clearly the presence of a Success Condition, it was assigned a + value; if data was conflicted as to the presence or absence of a Success Condition, it was assigned a 0 value; if data clearly indicated the absence of a Success Condition, it was assigned a - value; and if there was insufficient evidence among data to assess the presence or absence of a condition, it was assigned an INSF value (Table 2). Typically, there needed to be evidence across both interview and document review data indicating the presence or absence of a condition for it to be assigned a + or - value. Participant observation data were not used in the initial application of the value assignment but used to add context to confirm or contradict the value framework results.

Table 2: Value framework adapted from Buckham (2013) used to evaluate the presence and absence of the Success Conditions of knowledge co-production.

Meaning	Value
All or majority of evidence suggests presence of Success Condition	+
Conflicting evidence across sources as to the presence of Success Condition	0
All or majority of evidence suggests absence of Success Condition	-
Insufficient evidence to determine presence/absence	INSF

Second, I developed a process to systematize, to the best of my ability, an assessment of confidence in the presence or absence of each condition within each data source. This confidence assessment enabled me to discuss the potential strength of the influence of the Success Conditions on the research. Conditions for which there was conflicting or insufficient evidence as to the presence or absence of a Success Condition were not considered in the confidence score assessment. Each of the interview (IN), document review (DR) and participant observation (PO) data was assigned a low, medium, or high confidence score based on the percentage of examples within each data source that indicated the presence or absence of a

Success Condition (1-25%=LOW, 26-50%=MED, 51-100%=HIGH). If there was a case of conflicting evidence between data sources, participant observation data was used to add context and possibly move the results to a presence or absence.

4. Results

4.1. Kugaaruk as a Case for Knowledge Co-Production

I first considered the relevance of knowledge co-production to the local and scientific context of the Kugaaruk research. I focused on the four main components that constitute the definition of knowledge co-production used here and examined evidence that the Kugaaruk context is one that would have potentially been suited to the use of knowledge co-production.

4.1.1. Involves complex problems

The nature of environmental pressures facing Arctic ecosystems and species reinforces the complex nature of the research project in Kugaaruk. The environmental changes occurring in the Arctic necessitate an integrated understanding of the impacts of these changes on both natural and social systems. As a research problem that focused on seals and polar bears and their ecology in the context of changing environments, the Kugaaruk research involved an issue defined by complexity and future uncertainty. In Kugaaruk, the intersection of community value frameworks with the scientific priorities of researchers was expressed by interview participants and evident through document review data.

4.1.2. Involves scientific and local community perspectives

The Kugaaruk research was specifically designed to engage both scientific and local community perspectives and actors by including scientific data collection and social science research methods. Research ethics guidelines, particularly those concerned with research in the

Arctic, specifically identify the need for research to engage local communities and create opportunities for their meaningful involvement (Inuit Tapiriit Kanatami, 2018). Research projects vary greatly between communities and disciplinary contexts, so there is no universally applicable or accepted way to engage local communities. The research in Kugaaruk, however, exists within the context of increased calls for meaningful engagement of Arctic communities in research, including within the NLCA. Document review data directly identified an engagement with these issues and ethical frameworks. Informal interactions with the research scientists also provided evidence that there was an awareness that the research issue was important to local actors and that there was an effort to include both scientific and local perspectives in the research.

4.1.3. Produces knowledge to contribute to decision-making

Since ringed and bearded seals are not actively managed as biological resources (e.g., via hunting quotas), there was no immediate element of decision-making in the project's outcomes. Therefore, the seal sampling component of the project is intended more towards ongoing monitoring than active decision-making; however, marine mammals worldwide continue to facing increased risk from a variety of anthropogenic and other threats (Avila et al., 2018). The knowledge produced through the Kugaaruk research was intended to contribute to broader understanding of the health and status of marine mammals in the Gulf of Boothia, which is ultimately important for future conservation and management efforts. Research documents discussed the contribution that the project will make to providing information to support the integrated resource management systems established under the NLCA. One of the goals identified in the funding proposal for the Kugaaruk project was to generate knowledge that would assist in conservation and maintaining healthy and abundant seal populations that can continue to support ongoing harvest.

Though this element of knowledge co-production was not immediately apparent in the Kugaaruk research, it is important to consider the temporal nature of the research's contribution to decision-making. At least part of the impetus for the project was an

acknowledgement that environmental changes will continue to impact marine mammals and Arctic communities, thus potentially requiring more active management in the future. In this respect, the Kugaaruk research does have an intentionality to it with regards to its potential to contribute to future decision-making for the benefit of both ecological conservation and the needs of human communities.

4.1.4. Aims to improve conditions in society for the common good

As noted above, the Kugaaruk seal project was not immediately intending to contribute to decision-making; however, considerations of conservation more broadly were at the forefront of the project. The Kugaaruk research, together with related marine mammal monitoring throughout the Arctic, aimed to contribute important data about the health of Arctic marine ecosystems and species to conservation efforts. The project proposal and reporting documents also explicitly highlight the intention of the project to help ensure that conservation decisions support the ongoing sustainable harvest of seals by Inuit. Interview participants did not discuss the importance of ringed seals in a global conservation context; however, it was clear that seals are an important food and cultural resource for community members in Kugaaruk, so their sustainability is a factor in community food and economic security. To those ends, the project does fit the criteria that it aims to contribute to the common good in society, at both local and global scales.

4.2. Framework Results

I applied the framework to assess the presence or absence of the Success Conditions of knowledge co-production in Kugaaruk. Results of the framework application and the confidence scores are presented in Table 3.

4.2.1. There is evidence to suggest the presence of five Success Conditions of knowledge co-production in Kugaaruk

The framework results indicated that five Success Conditions were present in Kugaaruk: *broadest possible actor coalition, role of researchers and research-based knowledge is clear, presence of reward structures, presence of specific resources, engagement with emerging legal/institutional frameworks* (Table 3).

Table 3: Results of the value framework and confidence scoring on interview (IN), document review (DR), and participant observation (PO) data from Kugaaruk. Data sources were assigned a confidence score based on the percentage of examples within each source that indicated the presence or absence of a Success Condition (1-25%=LOW, 26-50%=MED, 51-100%=HIGH).

Success Condition	Value	Confidence Scores
1. Broadest possible actor coalition within limits present	+	DR (MED), IN (MED), PO (MED)
2. Shared understanding of goals and problem definitions	-	IN (HIGH), PO (HIGH)
3. Recognition of differences in actor perspectives	0	
4. Organized reflection on division of tasks by actors	-	DR (LOW), IN (MED), PO (MED)
5. Role of researchers and research-based knowledge is clear	+	DR (MED), IN (HIGH), PO (HIGH)
6. Presence of reward structures	+	DR (HIGH), IN (HIGH), PO (HIGH)
7. Presence of specific resources	+	DR (MED), IN (HIGH), PO (HIGH)
A. Engagement with emerging legal / institutional frameworks	+	DR (MED)

The actor coalition in Kugaaruk consisted primarily of the scientific researchers and the HTO. The actor coalition was primarily framed by the scientific researchers who proposed the study and was informed by guidance from the HTO. Seven out of 16 interviews and two document review examples provided evidence that indicated the presence of this Success Condition (Table 4). Document review and interview data indicated that there was a successful working relationship between the researchers and the HTO (Table 5); however, one of the challenges experienced throughout the research was that regular communication between the

researchers and the HTO was sometimes difficult and inconsistent which may also indicate a weakness in the actor coalition. Overall, there was medium confidence in the presence of this Success Condition across all data sources (Table 3).

Table 4: The number of interview (IN) and document review (DR) sources indicating the presence, absence, and awareness of each Success Condition.

	Presence			**Absence**			**Indication of Awareness**		
Success Condition	IN	DR	*Total*	IN	DR	*Total*	IN	DR	*Total*
1. Broadest possible actor coalition within limits present	7	2	*9*	3	0	*3*	11	2	*13*
2. Shared understanding of goals and problem definitions	1	1	*2*	16	0	*16*	2	1	*3*
3. Recognition of differences in actor perspectives	3	3	*6*	5	0	*5*	8	3	*11*
4. Organized reflection on division of tasks by actors	2	2	*4*	8	1	*9*	5	0	*5*
5. Role of researchers and research-based knowledge is clear	10	3	*13*	8	0	*8*	13	0	*13*
6. Presence of reward structures	11	4	*15*	1	0	*1*	1	0	*1*
7. Presence of specific resources	11	2	*13*	2	0	*2*	0	0	*0*
A. Engagement with legal / institutional frameworks	/	3	*3*	/	0	*0*	/	0	*0*

Table 5: Selected quotes from the interview and document review data for Success Conditions that the value framework indicated were present in Kugaaruk.

	Presence	
Success Condition	**IN**	**DR**
1. Broadest possible actor coalition within limits present	"They got a letter from you guys, I guess, and they asked us if we're interested and we said yeah, the community said yeah, and that's how it started." "I was told that HTO had the seal sampling project and one of my sons told me and we went to go pick up some sample bags." "For the past few years I noticed everything is going really smooth with the researchers."	"We have initiated a research partnership with the community of Kugaaruk via collaboration with the Kurtairojuark Hunters and Trappers Association. During our previous NGMP project, we corresponded regularly with the HTA manager. Members of our research team from York University have visited the community regularly over the past 3 years. Our harvest-based sampling and data collection research has received the support of the HTA Board since 2012. Members of the community have been enthusiastically supportive of our recent research…" "The Board of the Kurtairojuark Hunters and Trappers Association (HTA) has been an active collaborator on this ongoing community-based research project…"
5. Role of researchers and research-based knowledge is clear	"I think it will be best thing for the researchers to come here again to explain all the details because if there's a third party involved, there will be miscommunication, some information left out." "Most important thing is to report back, show us what you guys did, and people did, and that's making people going to be happy to see it." "The way you guys do with hunters, sampling…that's the best way, so they could find, even if they – what do you call it – they could figure it out how the seals are	"We will plan to visit the community and hold public meetings every year. We have designed a full-colour poster that describes some of the sampling requirements for the study. We will request that a message goes out over local community radio inviting hunters to participate in the research." "Members of our research team have visited the community regularly over the past 3 years. Under the proposed research, we will continue to visit the community to describe the importance of the research and present results as they emerge. In addition to

	Presence	
Success Condition	**IN**	**DR**
	now or not only seals, any animals, they could figure it out by the computer…To me, it's okay by the hunter sampling. The hunter, where they're in communities like not only here, where there are communities, the hunters knows the animal; they know more or less."	scientific peer-reviewed publications, we will distribute research results to the community via printed materials and in-person meetings."
6. Presence of reward structures	"I think there's a benefit for that type of research for the community –more input what's available in our area. The marine wildlife or the wildlife in the area so the community can know more in order to keep that habitat, the animals up and going." "Yeah I believe that it's going to be a good benefit for the community so that they could know what they … How the seals are distributed or how they are feeding and what's the population…it's a good economic benefit for the community too as well." "I think it'll help the community a bit like for some hunters that are not working, you know, doing the samples, they get paid for it and can buy their gas and whatever." "I choose to participate because I like to have the seals too as well, just to feed myself and my family and on top of that it brings some income."	"In addition to providing the community with information that will support meaningful involvement in the integrated resource management systems established under the NLCA, this project will collect, analyze and report information on the state of the Gulf of Boothia ecosystem." "The ultimate goal of the work is to build true capacity by establishing a long-term, sustainable monitoring program that is run by northerners for northerners. Such a program would complement Inuit harvesting rights and directly inform wildlife management and conservation by helping maintain healthy populations capable of sustaining harvesting."
7. Presence of specific resources	"I think the radio show will be the best way to go, just to inform the public."	"Building on past successes, we will use a range of strategies and techniques to communicate research results and promote community involvement, including oral presentations by the project leaders, print and

	Presence	
Success Condition	**IN**	**DR**
	"Really the HTO, use to the HTO office to get the information…Probably the HTO will go on radio, let the public know, local radio." "Seems like the local radio because the community hears local radio most of the time. And everybody wants to hear what's going on and all that, what the people are coming here for. [The HTO Manager] always goes on local radio before you guys come here."	video material, community workshops and meetings, and web-based interactive multimedia." "We will coordinate with the HTA manager to make an announcement on local radio in the spring, and each month following to inform hunters of the collections."
A. Engagement with emerging legal / institutional frameworks	N/A	"Any and all IQ/TEK components of this research will be conducted under appropriate licensing from the Nunavut Research Institute and approval of the York University Human Participants Review Committee." Nunavut Research Institute Scientific Research License York University Office of Research Ethics Human Participants Review Sub-Committee Approval

Table 6: Selected quotes from the interview and document review data for Success Conditions that the value framework indicated were absent in Kugaaruk.

	Absence	
Success Condition	**IN**	**DR**
2. Shared understanding of goals and problem definitions	"I have no complaints, I'm pretty happy with the [sampling research]…I'll get a call saying that there's some samples and I'll bring them. That's all I know about. I'm not too sure why they had that sampling." "Not just one way where the researcher comes and explain to the communities and just do what they do. For myself it would be better if we could communicate back to the researchers and get all the information before they actually start the research." "But we don't hear after that. Most of the time they don't talk to you. Probably they report to Nunavut Wildlife Management Board, maybe to ministers, but we don't hear from them - most of the time we don't hear it. It would be nice to hear that this has happened, this is around here, we've got polar bear or seal around there - it would be nice."	N/A

	Absence	
Success Condition	**IN**	**DR**
4. Organized reflection on division of tasks by actors	"…the locals should get more involved with the researchers because the locals have all the knowledge within the land and they know the wildlife very well within the land. And good communication between the researchers and the Inuit would be nicer too." "I was just told that they had to bring some samples and I was not told why. I was not informed how they distribute the sampling, all I was told is that I would get paid just to bring some samples in."	"Every year, some sample kits are submitted with missing or incomplete data sheets. We have communicated with the HTO to emphasize the importance of hunters completing and submitting the sample data sheet included in each sampling kit we provide. As of 2016, the accurate measurement of seal body weights and length remains an ongoing challenge. Unfortunately, the samples collected in 2016 were misplaced in the community, presumably due to staff turnover at the HTO office. The samples were eventually located during our visit to the community in March 2017 and were shipped to our lab, but they appeared to be badly degraded. Whether these samples yield any useful data remains to be seen."

Table 7: Selected quotes from the interview and document review data for the Success Condition for which there was conflicting evidence as to the presence or absence as a result of the value framework.

	Insufficient Evidence	
Success Condition	**IN**	**DR**
3. Recognition of differences in actor perspectives	**Presence:** "It's good because they come in and talk to you in person. Sometimes there's some people that enquire on the telephone and ask questions, you know, I don't do telephone interviews. You know, it's better to go in person and you see us and we see you and, you know, it's a lot better that way." **Absence:** "I think it would be better to have – post a public meeting, to get all the input from the community because each individual has a different opinion. So it would be a lot better if we had different opinions from the whole community." "If they have both trust and respect for the researchers and the locals, I believe that's going to work very well. But since my lifetime I noticed that the researchers tend to miss out some information and the community that doesn't receive that information thinks the researchers are doing something else and then they can lose their trust in them. When they lose their trust in them, they lose their respect as well. So best for myself is to get all the information to the community so the community can understand what the researchers are doing and they're actually following up."	**Presence:** "Since 2015, we have been working with local hunters and community members to collect IQ and Traditional Knowledge on seals, polar bears, harvesting patterns, and perceptions of scientific research." "The collection and documentation of TEK and *Inuit Qaujimajatuqangit* should continue, with a focus on ringed seals, to monitor changes in seal populations and the broader marine ecosystem." **Absence:** N/A

Table 8: Selected quotes from the interview and document review data that indicated an awareness of the importance of Success Conditions in research.

	Awareness of Success Conditions	
Success Condition	**IN**	**DR**
1. Broadest possible actor coalition within limits present	"The best thing would be cooperation for both researchers and the community. I'm not too sure what the exact steps would be, but the main thing is just to cooperate with the community and the researchers." "The HTO for sure, because I got to have all the information regarding the land, the hamlet as well, to get the whole community involved." "That one, what I could tell to that one is if the research people want to do research if they come to the community and go out with the hunters, that way they'll learn…Not only what they're doing in the, with all your instrument and all that, but out on the land what they're doing."	"We propose a collaborative partnership with the community of Kugaaruk to carry out a community-based monitoring program to collect biological information and samples from seals harvested in the Gulf of Boothia."
2. Shared understanding of goals and problem definitions	"The best thing is for the researchers and the community to help each other, get all the information and to agree upon what the research is."	"Regular (i.e., at least annual) meetings should be held between researchers and local hunters to communicate research plans, objectives, and results."
3. Recognition of differences in actor perspectives	"A public meeting would be the best way to go…in our tradition we have just oral and we're not too familiar with the written… orally would be the best way to go, either to have a radio show or have a public meeting." "Best thing to do is like, come in and have a meeting with HTO and the public, and that way they know, if they have questions they could ask."	"Local hunters will contribute *Inuit Qaujimajatuqangit* (IQ) and Traditional Knowledge about the animals they harvest and see while on the land. IQ and Traditional Knowledge on the abundance, distribution, health, and body condition of seals and polar bears will be integrated with the scientific findings."

	Awareness of Success Conditions	
Success Condition	**IN**	**DR**
4. Organized reflection on division of tasks by actors	"It would be better if the Inuit gets more involved with any type of researchers because a lot of researchers get misinformation and they've allowed a lot of information out. They think they have all the information, but the Inuit has knowledge of the land, they know the land, they know all the wildlife within the area." "If they've done, if they could report to a community or HTO committees or whatever - we finished this, here we've got so much - it would be perfect."	No data
5. Role of researchers and research-based knowledge is clear	"I think twice a year would be a good time to have the radio show. Fall and winter. And the researcher, if they can come here personally to do – help the radio show, just get one of the locals to translate and give all the information." "I think it would be more better if the researchers come, because they would have all the information, whereas they will just give out a letter stating that what your explanation … What you're doing. There might be some information left out within there, so it would be a lot better if the researchers come personally to go on the radio show. So if the local has any questions, they would get a direct answer from the researcher."	No data
6. Presence of reward structures	"I'm not too sure what the role of this project. But I know that if it's going to help the community, then I would like to get involved more…but only if it's going to help the community."	No data

	Awareness of Success Conditions	
Success Condition	**IN**	**DR**
7. Presence of specific resources	No data	No data
A. Engagement with emerging legal / institutional frameworks	No data	No data

Eleven interview participants expressed an awareness of ideas related to an actor coalition, indicating that this is an important aspect of research to community members and that there are groups of people within the community that are important to include in research. For instance, interview participants identified the importance of including Elders in research from the beginning of projects. For these participants, including Elders was important based on the role of Elders as community representatives and knowledge holders. Therefore, the actor coalition in knowledge co-production projects serves both logistic and cultural roles. On one hand, the actor coalition ensures that necessary knowledge holders are included; it also serves a legitimizing role to help ensure that local actors feel represented and that local protocols are being followed.

Our results found that 10 interview participants indicated the presence of clarity around the *role of researchers and research-based knowledge* (Table 4). Two main themes emerged in this area. Interview participants discussed their perceptions of researchers' direct *roles* in the project (e.g. sample collection coordination, data analysis) and researchers' *responsibilities* to the community (e.g. communicate information and results, visit the community). For instance, in terms of researchers' *roles*, interview participants were aware that researchers send seal sample kits to the HTO each year and that the kits are sent down south for analysis after hunters return them. In terms of researchers' *responsibilities*, interview participants also focused on what they expected of researchers in terms of reporting results back to the community and expressed a desire to see more communication of results and findings (Table 5). The document review data also indicated that researchers were aware of and committed to the need for ongoing and regular communication with the community (Table 5), indicating that this is an area that could be strengthened through the use of knowledge co-production principles.

In addition to clarity around the role of researchers in the seal research specifically, 13 interview participants discussed the role of researchers and research projects more broadly, including their preferences for how research should be done and the roles they wish to see researchers play (Table 4). For example, one participant expressed concerns with aerial surveys, saying that "surveying is not done properly…the population might be higher or

lower...Sometimes they will fly over and miss a few caribou or any kind of animals…the numbers are not accurate". In some cases, participants expressed a desire to see additional research to answer questions they had about wildlife. For example, one interview participant expressed that he would like to see more research, "because some animals, their meat are changing. I never seen them before and I don't know how come they're there and like, as soon as I see something inside the meat, I always don't know what is it until I go home and tell the old people what's that. And they'll tell us, you mustn't eat that because sick or something". One participant discussed his hope to see researchers advocate in the south for greater understanding of Inuit culture. These results indicate that participants are aware of the importance of the role of researchers and the need for deliberate conversations around these roles to take place openly.

Eleven interviews and all four of the document review data sources indicated the *presence of reward structures* (Table 4). In particular, 82% of interview participants who identified some aspect of reward structures from the research discussed the economic benefits of participating in the seal sampling (Table 5). Hunters were paid for each sample kit they returned to the HTO, and many interview participants, both those who directly participated in the sampling and those who did not, commented on the benefit that this payment brought to hunters. It allowed hunters to buy gas and ammunition needed to go hunting, meaning that the program makes it more financially feasible for hunters to go out on the land and hunt seals that are consumed as wild foods. From 2012-2016, there was a strong return rate of the sample kits, with 197 kits returned to the HTO, which supports the finding that community hunters saw a benefit in participating in the research. Other interview participants discussed benefits that they expect will come from increased knowledge about seals related to their importance as a food source (Table 5). The only potential challenge I identified related to the need for reward structures was the request among community members that a greater number of sample kits be made available so that additional people in the community could participate. In that regard, the number of sample kits provided is limited by available research funding.

In the case of *engagement with emerging legal/institutional frameworks*, I only considered document review data in determining its presence or absence as it related more to

processes involving researchers at their own institutional level. In particular, the Kugaaruk research acquired the necessary research licensing from the Nunavut Research Institute and Fisheries and Oceans Canada and three of the document review sources directly addressed the importance of this process, so data indicated that this Success Condition was present in Kugaaruk (Tables 4 & 5).

4.2.2. There is evidence to suggest the absence of two Success Conditions of knowledge co-production in Kugaaruk

The framework results indicated that two Success Conditions were absent in Kugaaruk*: shared understanding of goals and problem definitions* and *organized reflection on division of tasks by actors* (Table 3). A single data source was used to indicate the absence of *shared understanding of goals and problem definitions*; however, all 16 interview participants expressed an absence of this condition (Table 4) which, combined with participant observation data that added useful context, was considered sufficient evidence to indicate the absence of the condition. In the case of *organized reflection on division of tasks by actors*, document review data was given a low confidence score, meaning that I would not have immediately classified this condition as absent; however, participant observation data provided additional context that was considered sufficient to consider this condition absent (Table 3).

Hegger et al. (2012) discuss the need for actors to arrive at shared problem definitions. While actors in Kugaaruk shared the broad long-term goal to maintain the health of seal populations and the sustainability of the seal hunt, my results indicate that there was a lack of a clear *understanding of goals and problem definitions* in terms of the immediate objectives of the research. It was not that actors differed drastically on their perceptions of problem definitions; rather, all 16 interview participants expressed a lack of thorough understanding of the specific goals of the seal research, a finding also supported by participant observation. Interview participants knew what they were supposed to do with the seal sampling kits but were not aware why the research was taking place and its specific objectives (Table 6). While some participants had some general knowledge about some of the goals of the research, they

also expressed that they were not directly informed about the specific questions being answered by the research (Table 6). The absence of this Success Condition is also potentially connected to some of the challenges experienced throughout the research related to the desire among community members to see more communication from researchers and confusion about the differences between research that has taken place in Kugaaruk (discussed below).

Although the framework results indicated the presence of clarity around the *role of researchers and research-based knowledge*, results found that broader *reflection on division of tasks by actors* was absent in Kugaaruk. The interview and participant observation data were each given a medium confidence score related to this Success Condition (Table 3). Our results found that interview participants were aware of the potential contribution that researchers and their knowledge might make but were less aware of who was fulfilling specific roles in the project, particularly when it came to community actors and who was responsible for decision-making about the research (Table 6). As noted above, interview participants expressed a general lack of certainty about the goals of the research while also expressing a desire to hear more about the results and this may have been improved if, for instance, roles and responsibilities related to communication between the HTO and the community had been more firmly established at the outset of the research. In addition, there were some challenges throughout the project related to the sampling data sheets not being fully and consistently completed by hunters and one year where samples were misplaced in the community (Table 6). As noted above, the HTO expressed its commitment to the project each year and the working relationship between the researchers and different individuals at the HTO was consistently positive; however, more careful and conscious clarification of the division of tasks among actors may have helped address some of these challenges experienced in Kugaaruk.

4.2.3. There is conflicting evidence for the presence or absence of one Success Condition of knowledge co-production in Kugaaruk

There was conflicting evidence in determining whether the *recognition of differences in actor perspectives* was present or absent in Kugaaruk (Table 3). Results from the qualitative

analysis demonstrated that there was both interview and document review data that indicated the presence of this Success Condition; however, a greater number of interviews indicated its absence (Table 4). Between both the interview and document review data, there were medium confidence scores for both the absence and presence of the condition, respectively. Participant observation data was not compelling enough to influence the overall framework value. Therefore, though there was evidence indicating the lack of presence of this Success Condition, there was not enough evidence that specifically indicated its absence.

Recognition of differences in actor perspectives in knowledge co-production is related to the need to create a shared understanding of goals and problem definitions. While the latter deals with the particular framing of the problem and the normative orientation of the research, *recognizing differences in actor perspectives* is related to engaging with the knowledge systems that enable actors to understand "the diverging and implicit perspectives on the world around them" (Hegger et al., 2012, p. 58). This aspect of knowledge co-production goes beyond merely recognizing the preferences of different actors and attempts to understand the ways in which actors' perspectives about the world shape their understanding of the research. Importantly, recognition of perspectives needs to be a two-way process, with both academic and non-academic actors recognizing and engaging in one another's perspectives.

In Kugaaruk, the different actor perspectives were shaped by the different forms of local and scientific knowledge held by participants. The conflicting data in the framework results about the presence or absence of this Success Condition was likely due in part to insufficient data. Interview questions did not focus on this aspect of knowledge co-production in enough depth to provide sufficiently strong evidence to determine presence or absence. Document review data stated that considering different forms of knowledge about seals in the Gulf of Boothia was an explicit goal of the research (Table 7) and therefore provided a medium confidence in the presence of this Success Condition. In addition, interview questions asked about community members' values around seals and other components of marine ecosystems. Interview participants expressed that researchers considered their needs with regards to research processes but also that there are some issues related to research processes (Table 7), which resulted in a medium confidence score for the absence of this Success Condition among

interview data. Overall, there was not enough data to confidently assess whether and how the project truly engaged with the differences in actor perspectives from the outset of the research. Therefore, although I am not able to conclude that this Success Condition was absent in Kugaaruk, there was not enough evidence to clearly indicate its presence.

4.2.4. Data indicates an awareness of six Success Conditions of knowledge co-production

In some cases, data sources indicated an identification and awareness of the importance of the Success Conditions in research or of interview participants' preferences for how Success Conditions should be implemented (Table 8). Among the 16 interviews, participants expressed an awareness of six Success Conditions. Document review data indicated an awareness of three Success Conditions (Table 4). While this data was not necessarily strong enough to determine the presence or absence of Success Conditions in Kugaaruk, the awareness of aspects of research that relate directly to the Success Conditions of knowledge co-production – among interview participants, in particular – supports the hypothesis that knowledge co-production may have helped strengthen aspects of the research that actors care about and could have enhanced the success of the research.

5. Discussion

I retrospectively examined an ongoing harvest-based seal sampling project in Kugaaruk, Nunavut to consider the potential benefits of knowledge co-production in the context of Arctic marine mammal research. I used qualitative content analysis to review semi-structured interviews and existing documents to examine three main questions: 1) whether the Kugaaruk research was a potential match for knowledge co-production; 2) whether any aspects of knowledge co-production had been used in the research; and, 3) whether having used knowledge co-production might have enhanced the project's strengths and helped avoid or address challenges encountered throughout the research. Our results indicated that knowledge

co-production could have benefitted the Kugaaruk research by identifying additional actors to contribute to framing and structuring the nature of the research problem, helping to ensure actors were clear about their roles, and establishing more reliable structures for communication and feedback throughout the project.

The Kugaaruk seal research did not intentionally use a knowledge co-production approach; however, the framework results provided evidence to suggest that five Success Conditions of knowledge co-production were present in Kugaaruk. The framework further indicated that two Success Conditions were absent in Kugaaruk. Considered alongside successes and challenges experienced throughout the research, I suggest that knowledge co-production could have enhanced the successes of the project and helped avoid or address certain challenges. These overall results suggest that knowledge co-production can benefit Arctic marine mammal research. The results also contribute to understandings of knowledge co-production and the aspects of research it can benefit. Finally, the approach taken here to retrospectively examine the Kugaaruk research has particular strengths and limitations that can be considered for future research.

Hegger et al. (2012) suggest that the presence of their seven Success Conditions is likely to increase the perceived credibility, salience, and legitimacy of knowledge produced through research. They suggest that identifying and including the broadest possible coalition of actors is more likely to lead to socially robust knowledge by having the validity of the knowledge tested at both the academic and societal levels and by involving both scientific and local experts. According to Hegger et al. (2012), four principles need to be considered when forming an actor coalition. First, the coalition should include those with specific knowledge to contribute. Second, actors need to be prepared to participate in at least portions of the knowledge production processes. Third, some actors may be a source of opposition if they are not included and therefore may represent an important part of the coalition to maintain local social-cultural acceptance and cohesion. Fourth, consideration needs to be given to maintaining a manageable number of actors to ensure the process is effective. Our experiences suggest that it is also important to give specific consideration to who is responsible for identifying the actors to be included. It is possible that failure to include some actors might occur because they were not

known or were not identified as necessary. In creating the "broadest possible actor coalition" it is also important to ensure that multiple actors are involved in identifying those who should be included in the coalition.

One of the challenges experienced throughout the Kugaaruk research related to communication between actors and there is evidence to suggest that some of these challenges could have been avoided if additional actors had been identified and included from the outset. Although there was an actor coalition established in Kugaaruk, some of the communication challenges indicate that a broader actor coalition may have been beneficial. Participant observation data indicated that some of the communication difficulties were the result of unavoidable factors at the community level, such as personnel changes at the HTO (Table 6), but I do not feel that these challenges were related to the commitment of the HTO to the research itself or to the specific interpersonal relationship between the researchers and the HTO. In addition, communication and logistical obstacles were overcome far more effectively as researchers personally spent time in Kugaaruk, lending support to interview and other data (e.g. McCarney et al., 2014) that suggest in-person communication is preferred by community members and more effective at maintaining actor coalitions (Table 5). Some of the communication and logistical challenges might have been overcome by involving additional people at the community level who could have taken over responsibilities related to communication with the researchers as needed. In addition, hunters or other community actors who participated in the seal sampling could have been engaged to fulfil additional roles related to communication with the broader community, which might have helped address challenges related to lack of awareness about the goals and results of the research.

This case study offers some insights into understanding the *role of researchers and research-based knowledge* in knowledge co-production. Hegger et al. (2012) describe four potential roles that researchers can play in knowledge production processes, two of which are more suited to cases of "value agreement and low uncertainties" and two of which are suited to cases defined by "value pluralities and high uncertainties", with the latter category more appropriately describing the Kugaaruk case. With an intended focus on achieving both scientific priorities and community benefits, the seal research was also concerned with what Hegger et

al. (2012) describe as “tacit knowledge, beliefs and values, of non-scientific stakeholders” (p. 59). In this respect, the role of researchers in the Kugaaruk case could be characterized as that of “honest brokers” or “issue advocates” (Hegger et al., 2012, p. 59).

An interesting aspect of the *role of researchers and research-based knowledge* arose in Kugaaruk related to uncertainty among interview participants over the differences between research projects and the researchers involved. The observation that community members were unclear about the distinctions between different research projects was also noted in Chapter 4 and this can cause misunderstandings between researchers and communities. In discussing this observation, some caution should be taken. There is often an expectation and goal among researchers that communities be aware of our research, including who is involved and the objectives of the study. Although certainly an admirable goal, this risks homogenizing local communities as a singular voice with one set of interests; it further risks overestimating the importance of the research in the lives of local people. It is perhaps not realistic to expect all individuals in a community to be aware of every research project taking place. In Kugaaruk, I also wanted to understand whether interview participants were aware of different projects and the fact that they were run by different researchers. It should perhaps be more important to ensure that community members are more broadly aware of the diversity of research taking place in their communities, the institutions and local organizations involved, and where to find information if they want it. Overall, while results indicate that the Kugaaruk research was somewhat effective in making clear the role of researchers and their knowledge, some additional clarity in this regard was possible and could potentially have been achieved with a more deliberate focus on this Success Condition. In addition, as noted above, community members expressed particular roles and responsibilities they wanted researchers to fulfil and these might have been identified earlier in the research process if this Success Condition had been more fully addressed.

The Kugaaruk case study adds some understanding to considerations over the need for *reward structures* in knowledge co-production. Hegger et al. (2012) suggest that those facilitating knowledge co-production should consider the rewards for researchers, policymakers, and other societal actors in participating because the perception by actors of

novel reward structures is likely to enhance the success of knowledge co-production. Hegger et al. (2012) note that "[i]n many cases, researchers have a strong incentive for promising highly contextualised research, while the reward for fulfilling these promises is absent" because professional recognition for academics is still tied to traditional career incentives such as publishing in academic journals (p. 60). However, local actors "are likely interested in perceived useful knowledge. They may also have a personal interest in the issues at hand" (Hegger et al., 2012, p. 60). Further to the discussion provided by Hegger et al. (2012), the nature of what constitutes reward structures for the various actors involved in knowledge co-production needs to be considered in light of the local context and the lived realities of local and other non-academic actors. In Kugaaruk, the primary benefit identified by interview participants was related to the income provided by the research (Table 5). While it is noble to wish for all actors to identify intellectual benefits from research, in the context of a harvest-based economy, the ability to purchase fuel, ammunition, and to defray other hunting costs is an important factor in people's daily lives so financial reward structures for local participants should not be minimized. Future knowledge co-production projects should give particular attention to considering the reward structures that derive from research projects and in ensuring that these rewards are suited to both the academic and local context.

The process of developing a *shared understanding of goals and problem definitions* deals directly with the research problem itself and is, therefore, a fundamental condition of successful knowledge co-production. Hegger et al. (2012) review four types of policy problems (unstructured, badly-, moderately-, and well-structured) that can be adapted for the purpose of understanding the range of problems that can be addressed in knowledge co-production research. Differentiated based on the degree to which solutions can be clearly framed and defined, the broader context of the research problem in Kugaaruk reflects what Hegger et al. (2012) describe as a "global change problem" and therefore is most appropriately described as a moderately-structured problem. In moderately-structured problems, actors generally agree on the goal of the problem, and "[r]esearch-based knowledge can then be used to identify and backup arguments" for policy action (p. 56). In the context of Kugaaruk, the purpose of the research was not to immediately identify policy solutions; however, the typology of policy

problems can be adapted here to refer to long-term conservation goals for the Gulf of Boothia ecosystem and the associated social-cultural benefits of maintaining healthy marine mammal populations.

Hegger et al. (2012) review various ways of structuring the *division of tasks* in knowledge co-production, with one end of a spectrum defined by the clear separation between the roles of knowledge producers and users contrasted with what they refer to as "intensive collaboration" in which researchers might also act as mediators or facilitators. They acknowledge that there is not one ideal way to organize the division of tasks and roles in knowledge co-production, but rather it is "more likely that different role divisions are conducive in different contexts…What literature convincingly shows, however, is that openness of actors regarding what their intentions and expectations are, is crucially important" (p. 58). Actors need to choose "consciously and reflexively" which roles to pursue in a project and this is certainly true in an Arctic context that is usually defined by a large geographical separation between researchers and communities and relatively infrequent in-person meetings due to the high costs of Arctic travel. In these contexts, having clearly established roles among actors is critical to ensuring there is trust and that responsibilities and tasks are carried out throughout the research.

There are two points to be made on potential limitations to this paper. One concerns the expectations placed on interview data. Interview participants were well positioned to speak to their own perceptions about research and these perceptions served as indicators about the presence or absence of Success Conditions; however, it could reasonably be argued that only those individuals who were part of the actor coalition could be expected to have firm knowledge of certain aspects of the Success Conditions. For instance, my results indicated the absence of *organized reflection on division of tasks by actors*, and some caution is warranted with this conclusion. Interview participants indicated that they were unaware of the roles filled by the researchers and the HTO, which suggested the absence of such organized reflection; however, this may not necessarily indicate that there wasn't any organized reflection on the division of tasks but rather that this was not communicated or visibly apparent in a way that community members were broadly aware of it. At the same time, if the division of tasks had

been more firmly established in Kugaaruk, challenges related to communication (such as the misplacement of seal samples) likely would have been avoided, which provides additional evidence that this Success Condition could have been strengthened. Nevertheless, in evaluating research for successful knowledge co-production, care should be given to the weight placed on particular data sources. This caveat also points to the strength of my analysis in having used multiple data sources and suggests that the role of researchers in maintaining detailed notes and participant observation records is important for reflection and future analyses.

Finally, there is a note to be made on the extent of the claims made here. Knowledge co-production does not claim to address every aspect of what constitutes successful research in every context. As with any methodological approach, knowledge co-production is potentially well positioned to produce successful research in particular contexts; however, there may be other elements of research considered important for success that are not specifically taken up in the knowledge co-production literature. Similarly, there may be challenges to research that knowledge co-production does not claim to address. As such, my objective was not to claim that knowledge co-production is the only research design that could have enhanced the project's successes and addressed its challenges. In considering whether knowledge co-production could have benefitted the Kugaaruk research, I also considered whether there were other factors responsible for the strengths of the project that would have been lost if the project had pursued a knowledge co-production approach. In terms of challenges encountered, it is possible that there are multiple alternative research approaches that could have avoided or addressed these challenges; this study offers insight into the potential benefits of one particular research approach. Other studies could examine the same case from the perspective of an alternative research approach and find promising results. Our goal was to identify a method to retrospectively examine a research project in order to consider whether knowledge co-production might have been beneficial and to then offer modest claims about this question.

6. Conclusions

There are a number of examples that provide evidence for the need to explore improved methods for integrating multiple perspectives in wildlife research and decision-making. Addressing the human and ecological dimensions of wildlife research and management is complex and therefore requires knowledge production processes "able to deal with complexity and uncertainty and able to integrate and communicate knowledge among many actors and between fields of knowledge" (Russell et al., 2008, p. 464). I used a framework adapted from Hegger et al. (2012) that examines the social and institutional Success Conditions around knowledge co-production research to retrospectively consider a harvest-based seal sampling project in Kugaaruk. I applied a framework adapted from Buckham (2013) to assess whether Success Conditions of knowledge co-production were present or absent in Kugaaruk. I then considered whether these conditions strengthened or enhanced the successes experienced in Kugaaruk and the potential that challenges might have been mitigated or addressed if the research had deliberately taken a knowledge co-production approach.

The seal sampling research in Kugaaruk provided an opportunity to explore knowledge co-production in the Arctic under generally optimal social-political conditions. Kugaaruk has had relatively few research projects and I are not aware of any conflicts between researchers and community organizations. Ringed seals are a widely abundant species with no immediate conservation or management needs, but are a species of importance to Arctic communities and one that will be affected by broad-scale climatic changes, positioning seals as a complex research problem without overly contentious political factors to navigate.

Results from this study provide insights into potential benefits knowledge co-production might have for other research problems in the Arctic. For instance, polar bear management in the Canadian Arctic provides an example of a wildlife context in which social and political conflicts demonstrate the need for new methods and processes. A report by the Joint Secretariat for the Inuvialuit Settlement Region (2015) notes that polar bear research has been inconsistent in its documentation of the knowledge of Inuvialuit guides, field assistants and co-researchers and argues that "new documentation protocols are required that make use of best social science practices" (Joint Seretariat, 2015, p. 216). Inuvialuit community members also expressed concerns related to particular research methods. It is possible that a lack of mutually

agreed upon methods to document and include both scientific and Traditional Knowledge in research have contributed to a lack of acceptance of research results. Continuing disagreements over polar bear research and management in Nunavut (e.g. Dowsley & Wenzel, 2008; George, 2009), and lack of clear processes to overcome these disagreements also point to the need for alternative methods of knowledge production and integration.

Our results indicate that knowledge co-production is a research approach that can benefit Arctic wildlife research that involves both scientific and local actors and perspectives. In Kugaaruk, some of the experiences that contributed to the success of the project are aspects of research that knowledge co-production directly addresses, suggesting that these successes might have been enhanced if knowledge co-production had been deliberately adopted from the beginning. In addition, the knowledge co-production literature directly addresses particular processes and elements of research that might have helped reduce some of the challenges experienced in Kugaaruk. Equally important, I did not find any evidence that adopting a knowledge co-production approach more deliberately from the outset of the research would have reduced any of the successes achieved in Kugaaruk.

The evaluative framework proposed by Hegger et al. (2012) is useful in retrospectively examining research to consider the degree to which knowledge co-production may have benefitted the project. Organized reflection on the key elements of knowledge co-production and how to effectively implement them will be useful for future projects that wish to benefit from the processes that knowledge co-production can bring to Arctic research. The Success Conditions proposed by Hegger et al. (2012) and used here can serve as a guide to researchers in considering important elements at the outset of research to ensure that the institutional, organizational, and social-political conditions that are conducive to successful knowledge co-production are established and monitored throughout research projects. It will also be useful to continue to consider the ways in which existing understandings of Success Conditions of knowledge co-production apply specifically in the context of Arctic research and any potential additional conditions that can be identified.

Chapter Three: Knowledge Co-Production by Inuit Community Members and Scientists: A Case Study of a Ringed Seal Workshop in Nunavut

1. Introduction

Various community-based and academic bodies of thought have recognized the need for research to include the perspectives of both academic and non-academic actors and for research to contribute to issues relevant to local communities (e.g. Brunet et al., 2014a; Brunet et al., 2014b; Gearheard & Shirley, 2007; Hirsch Hadorn, Hoffmann-Riem, et al., 2008; Simon, 2017; Stevenson, 1996). Including local, non-academic knowledge in research has the potential to produce more robust knowledge about complex problems where academic researchers may be challenged by limited disciplinary scope or resources (Max-Neef, 2005). For instance, citizen science approaches have been used in environmental monitoring and its potential usefulness in other conservation research has been noted (Franzoni & Sauermann, 2014; Tregidgo et al., 2013; Tulloch et al., 2013). There is also a need for research to produce knowledge that is useful to decision-makers and to identify effective ways to translate knowledge from science to policy (Lynch et al., 2015; C. Pohl, 2008). Stakeholders are more likely to trust and apply research-based knowledge when that research has meaningfully involved local actors (Brunet et al., 2014b); and policy and management decisions are also more likely to be understood and accepted (Jones et al., 2008). At the same time, there is a need to critically reflect on research that claims to be participatory and to articulate effective methods to ensure participation is meaningful (Elzinga, 2008).

A research approach developed in response to the needs identified above, in addition to pressures and movements internal to academic institutions, is described as knowledge co-production. Knowledge co-production is an approach in which knowledge is produced collectively by multiple actors who represent a plurality of perspectives for the purpose of solving locally relevant, real-world problems (D. Armitage et al., 2011; Berkes, 2009; Dale & Armitage, 2011; Godemann, 2008; Christian Pohl et al., 2010).

Arctic regions face a range of pressing social and environmental issues. The effects of climate change and other anthropogenic activities, and their interactions with the needs and health of human communities have emerged as drivers of Arctic research and policy (de March et al., 1998; Huntington, 2009). The Arctic has experienced and will continue to experience the most drastic effects of global climate change, warming at an estimated two to three times the global rate (Wassmann et al., 2011). In a 2017 report examining the priorities of Arctic leadership and communities across the North, Mary Simon emphasized that "the next step in the evolution of scientific practice in the Arctic is linking community-driven Arctic research priorities with national policy development to ensure scientific investments benefit communities and answer key questions facing the Arctic" (Simon, 2017). Decision-makers require current and robust information to address the potential effects of complex social and environmental changes facing Arctic ecosystems, wildlife, and humans (Huntington, 2009).

Table 9: Intended applied and theoretical contributions of the analysis of the ringed seal workshop to knowledge co-production.

	Applied Knowledge		**Theoretical Knowledge**
Workshop Objectives	Identify knowledge gaps and priorities related to ringed seal research among researchers, communities, and managers.	Identify questions, strengths, and concerns about current research and ways for participants to address these in their respective roles.	Reflect on the use of a workshop in facilitating knowledge co-production about ringed seal research in Nunavut.

In this paper, I report on a workshop that took place in Iqaluit, Nunavut intended to facilitate knowledge co-production about community, scientific, and management priorities for ringed seals (*Pusa hispida*), a socially and ecologically important species in the Arctic. While there were multiple objectives for the workshop (Table 9; McCarney et al., 2014), here I reflect on and evaluate the outcomes of the two-day workshop and argue that it was effective in facilitating knowledge co-production about ringed seal research in Nunavut. I conclude by offering insights into the effectiveness of workshops as a method to facilitate knowledge co-production.

1.1. Transdisciplinary Research and Knowledge Co-Production

Transdisciplinary research emerged as a distinct approach in the 1970s, with growing recognition of the need to include both academic and non-academic stakeholders in the production of knowledge about complex societal problems (Horlick-Jones & Sime, 2004). Traditional research disciplines were often challenged in capturing the full complexity of research problems from within their individual methodological and intellectual boundaries. The emergence of transdisciplinarity was part of a paradigm shift in scientific practice marked by a move from research focused solely on matters of disciplinary importance to a recognition of the need for research to address unsolved problems of importance to society (Balsiger, 2004; Hirsch Hadorn, Hoffmann-Riem, et al., 2008; Klein, 2014). One of the key features in the development of transdisciplinarity was what Klein (2014, p. 72) describes as an expansion in the scope of scientific research from a focus only on the production of "'reliable scientific knowledge' to the inclusion of 'socially robust knowledge'". Transdisciplinary research has been further defined by the co-production of knowledge (D. Armitage et al., 2011; Berkes, 2009; Dale & Armitage, 2011; Godemann, 2008; Christian Pohl et al., 2010). In knowledge co-production processes, actors represent what Fleck (1981) refers to as diverse "thought styles". Participants interact to generate knowledge that, according to Gibbons et al. (1994, p. 30), "will be different from any of the constituent frameworks, yet could not have been developed without them". Knowledge co-production seeks to "[transgress] the expert/lay dichotomy while fostering new partnerships between the academy and society" (Klein, 2014, p. 72).

The definition of knowledge co-production used in this paper is research that: 1) takes into account the full complexity of problems and considers all factors that together comprise an issue; 2) considers multiple perspectives, including both scientific and societal views; 3) aims to produce practically relevant knowledge driven by the need to solve a real-world problem; and, 4) is aimed at improving conditions in society for the common good (Godemann, 2008; Hirsch Hadorn, Hoffmann-Riem, et al., 2008; Christian Pohl, 2005).

1.2. Knowledge Co-Production in the Canadian Arctic

Inuit communities in the Canadian Arctic, and the wildlife they depend upon face increasingly complex challenges as a result of environmental, social, political, and economic changes at regional and global scales. The management of Arctic wildlife requires knowledge that is current, rigorous, and capable of capturing the full range of the interests involved. The interaction of local communities, scientific researchers, and managers can result in conflicts about the knowledge produced and uncertainties over decisions (e.g. Dowsley & Wenzel, 2008). There have been different approaches to facilitating collaboration between academic and local knowledge systems. A knowledge integration approach is often used to bring together scientific and Indigenous perspectives in knowledge generation processes (Fernandez-Gimenez et al., 2006; Nadasdy, 2003; Raymond et al., 2010), but it has garnered criticism for being inconsistent with Indigenous epistemologies. Knowledge co-production shows promise in contributing to conflict resolution, however, there is a need for increased clarity and reporting on research methods that attempt to facilitate knowledge co-production.

Knowledge integration has a tendency to be overly focused on separating knowledge systems into discrete units of data that can be plugged into a final knowledge product (Nadasdy, 2003; Raymond et al., 2010; Tester & Irniq, 2008). Tester and Irniq (2008, p. 49) suggest the conflicts arise when "attempts are made to avoid the complexities and challenges posed by linking factual with spiritual or cosmological aspects of [*Inuit Qaujimajatuqangit* (IQ)]". Uncertainty exists around the best practices of knowledge integration and thus there is disagreement over its success (Stevenson, 1996; Usher, 2000). Instead, other approaches emphasize the need to focus on the dialogue of Indigenous Knowledge and science as a process (Berkes, 2009).

Knowledge co-production differs from a knowledge integration approach in that each knowledge system remains whole in its original social context and complexities (Berkes, 2009). This feature is a key component of knowledge production and diversity of views is critical in the field of futures studies (Sardar, 2010). Sardar (2010, p. 183) emphasizes that the "full preservation of our humanity requires that this diversity is assured, that it not only survives but thrives in any desired future". While integration remains one component of the full knowledge

co-production process, the approach is characterized by five dimensions: knowledge gathering, sharing, integration, interpretation, and application (D. Armitage et al., 2011; Dale & Armitage, 2011).

1.2.1. Three Challenges of Knowledge Co-Production

The knowledge co-production literature identifies a number of process and conceptual challenges involved in co-producing knowledge between academic and local actors. Together, these challenges can be categorized into three main themes. First, the role of power dynamics is a critical and ongoing consideration in interactions between academic and local actors and is particularly relevant in the context of Arctic research (Agrawal, 1995; Nadasdy, 2003; Tester & Irniq, 2008; White, 2006). In the context of the Alaska Beluga Whale Committee (ABWC) co-management organization, Fernandez-Gimenez et al. (2006) noted "the awareness, particularly acute on the native side, of the underlying power dynamics of native involvement in research and co-management", where experiences have been that scientific information often holds "power over the credibility of TEK" (p. 312). Of particular relevance to the current case, Hirsch (2002) discusses the ways in which power relations can affect the outcomes of workshops by changing the nature of interactions between participants. Hirsch (2002) explains that authority in group settings is affected by historical power relations and can be reinforced by interactions between speakers. It also cannot be taken for granted that participatory activities, such as workshops, necessarily deconstruct power relations (Pettit, 2012).

Christian Pohl et al. (2010) describe the second challenge as the need to "interrelate the perspectives of the different thought collectives" to create a shared understanding of an issue (p. 271). The goal is to "achieve a more comprehensive, or — in terms of power and thought styles — more balanced and adoptable understanding of an issue and corresponding solutions" (Christian Pohl et al., 2010, p. 272). The significance of this challenge is that the shared understanding must not be imposed by the facilitators, it needs to emerge through the interactions of participants. For evaluation purposes, I would add that there needs to be a way to test or confirm in real time whether participants' perceptions and interpretations truly do

reflect a shared understanding of an issue across the different thought styles engaged in co-producing knowledge.

The third challenge involves creating a "normative orientation" (Christian Pohl et al., 2010) with regards to the main concepts and issues of the problem. D. Armitage et al. (2011, p. 997) describe the goal of this task as the "[s]hared desire to use knowledge co-production to achieve mutually agreed outcomes". In an analysis of knowledge co-production in four cases of sustainability research, Christian Pohl et al. (2010) examine researchers' definition of the concept of sustainable development and suggest that the "normative and contested character of sustainable development was crucial, both as a starting point and a key motor of the co-production process" (p. 272). Christian Pohl et al. (2010) argue that creating a shared understanding of the underlying presuppositions of sustainability among actors is critical for knowledge co-production. At the same time, while researchers should promote the shared orientation, they should also maintain an awareness of the contested nature of the concept and therefore an openness to the possibility that the meaning of the term may change. While their analysis was particularly concerned with sustainability research, a corresponding foundational concept can be identified in other knowledge co-production efforts – for instance, environmental and wildlife conservation – and researchers should take the time to establish a shared normative orientation among actors.

1.2.2. Five Dimensions of Knowledge Co-Production

In their framework, Dale and Armitage (2011) describe five dimensions of knowledge co-production. The first dimension, knowledge gathering, refers to the specific activities and methods used to collect information about a question. Second, knowledge sharing refers to the interaction among knowledge holders through which they communicate their perspectives on an issue. Third, knowledge integration is the stage at which different knowledges are related to each other. Fourth, knowledge interpretation is the process of assigning meaning to informational knowledge. Finally, knowledge application "involves the translation of evolving knowledge into specific [decisions]" (Dale & Armitage, 2011, p. 7).

The progression from knowledge integration to the subsequent phases is a key aspect that defines knowledge co-production. In more conventional approaches to knowledge production, including other approaches that attempt to be participatory, the interactions between different thought styles often end at the stage of knowledge sharing, with researchers or other coordinators integrating and interpreting knowledge in isolation, disconnected from the knowledge holders themselves. In knowledge co-production, on the other hand, a central principle is to ensure that participants are engaged in meaning-making processes about their knowledge and priorities through their active involvement in the full range of knowledge production, interpretation, and application.

2. Case Context: Ringed Seal Research in Nunavut

2.1. Ringed Seals in Nunavut

Ringed seals are the most abundant Arctic marine mammal (Reeves, 1998). They are specially adapted to survive in environments with periods of ice cover (Harwood et al., 2012). Ringed seals rely on first-year sea ice as critical over-winter habitat where they haul-out in the spring during the annual moult, and on which pregnant females construct subnivean birth lairs for protection of pups against both predators and weather (Furgal et al., 1996; Harwood et al., 2012). Ringed seals are therefore vulnerable to changes in environmental conditions, such as seasonal changes in ice extent and thickness, snowfall, and abundance of other marine species.

Changes in ringed seal health will also affect Inuit communities. Ringed seals are an important traditional marine resource and almost all Nunavut communities hunt seals for economic, cultural and nutritional subsistence (Kingsley, 1990). Seal skins are used to make clothing and other products, providing communities with both personal needs and commercial economic opportunities. It is estimated that CAD $40 million is generated annually through the harvest-based economy in Nunavut, which includes roughly 40 000 seals each year at a food value of approximately CAD $5 million (Government of Nunavut, n.d.).

Ringed seal monitoring is ongoing across Canada and includes harvest-based sampling, satellite telemetry, spring aerial surveys, and acoustic monitoring (Stirling, 1973; van Parijs, Lydersen, & Kovacs, 2003). Many ringed seal research programs work closely with Inuit communities, including Hunter and Trappers Organizations (HTOs), hunters who gather samples, guides, and community members who contribute local and traditional knowledge through interviews. There has been collective recognition among scientists and Arctic communities of the importance of monitoring Arctic marine mammals and ringed seals in particular (Gill et al., 2011).

In 2009, the European Union (EU) banned trade in seal products based on animal welfare concerns related to hunting methods ("Regulation (EC) No 1007/2009 of the European Parliament and of the Council of 16 September 2009 on trade in seal products," 2009). In the summer of 2015, the Government of Nunavut successfully applied to the EU to become a Recognized Body under the Indigenous Communities Exemption of the EU Seal Regime, allowing seal products to be imported to Europe from Nunavut ("Commision Decision C(2015) 5253 of 30 July 2015," 2015; Department of Executive and Intergovernmental Affairs, 2015).

A 2007 workshop in Valencia, Spain brought together Arctic scientists and representatives from Indigenous communities to develop a monitoring strategy for Arctic marine mammals, focusing on ringed seals and belugas (*Delphinapterus leucas*) as case studies (Simpkins, Kovacs, Laidre, & Lowry, 2009). Kovacs (2013) noted that following the 2007 workshop, “a lack of international co-ordination and in particular a lack of committed funding has left scientists in each country working in isolation with annual time horizons” (p. 5). In 2012, a workshop of ringed seal scientists was organized in Tromsø, Norway to plan an internationally co-ordinated effort for ringed seal research and monitoring (Kovacs, 2013). Following the 2007 and 2012 workshops, there has been interest in Canada in continuing to co-ordinate ringed seal monitoring, in addition to increased efforts to include communities in identifying research priorities and opportunities.

2.2. Institutional Frameworks Influencing Arctic Research and Management

The intersection of human needs, ecological pressures, and political influences makes ringed seal management a complex task, requiring consideration of multiple priorities. Inuit communities are situated at perhaps the most important point between ringed seals in their environment and the knowledge gained about ringed seals from ongoing research, so it is important that knowledge holders in communities, researchers, and resource managers engage in knowledge production and decision-making processes. In addition, there is increasing recognition at community and institutional levels that Inuit communities need to be more meaningfully included in all stages of research and decision-making that affect their lives.

The Nunavut Land Claims Agreement (NLCA) established the Nunavut Wildlife Management Board (NWMB) in 1994, with the responsibility of wildlife co-management in Nunavut (Section 5.2.1). The NLCA recognized the "need for an effective system of wildlife management, and to be effective, the system of management requires an efficient, co-ordinated research effort" (Section 5.2.37). In facilitating the advancement of research, it is the responsibility of the NWMB to "promote and encourage training for Inuit in the various fields of wildlife research and management" (Section 5.2.38[b]). Therefore, there is a clear recognition that it is vital for Nunavut communities to be included in both decisions about wildlife and the production of knowledge that leads to decision-making.

These changes are reflected in research ethics guidelines specifically designed to include Indigenous community interests in research design. The Association of Canadian Universities for Northern Studies (ACUNS) refers to a "new partnership ethic" which "emphasizes the need to create meaningful relationships with the people and communities affected by research" (ACUNS, 2003). The Tri-Council Policy Statement (TCPS) on the Ethical Conduct for Research Involving Humans has developed a specific ethics framework to ensure that Indigenous communities are included in all stages of research, which arose out of a recognition that research has historically failed to appropriately involve and respect Indigenous Knowledge and community interests (Canadian Institutes of Health Research, Natural Sciences and Engineering Research Council of Canada, and Social Sciences and Humanities Research Council of Canada, 2010). These policies, in addition to various ethics approval processes in individual

communities, have begun moving research in a direction that seeks to ensure that research is accountable to the priorities of communities and provides local benefits.

3. Methods

3.1. Workshops as a Method of Knowledge Co-Production

With effective facilitation, workshops can foster discussion and engage multiple perspectives in open dialogue (Vogt, Brown, & Isaacs, 2003). Workshop settings are commonly used as tools for planning, training, or public engagement (e.g. Einsiedel, Boyd, Medlock, & Ashworth, 2013) or as exercises to identify research or decision-making priorities (e.g. Fernandez-Gimenez et al., 2006). What they have in common is the goal to engage different perspectives to foster collective learning between participants (Huntington et al., 2002). In an analysis of three workshops focused on co-management in the Arctic, Huntington et al. (2002, p. 788) describe the dynamic nature of workshops that makes them particularly useful, noting that by having discussions "on a specific species or topic, the workshops provided a practical and concrete basis upon which to build a shared understanding or at least greater insight into the reasons behind divergent views". Thus, workshops may be well-suited to the context of wildlife research and management in the Canadian Arctic, a field that involves complex interconnections between social and ecological needs.

3.2. Workshop Design

The two-day workshop evaluated in this paper brought together researchers, Inuit knowledge holders from communities throughout Nunavut, staff from the federal, territorial, and regional governments, representatives from wildlife management organizations, and students from Nunavut Arctic College. The workshop focused on identifying both broad questions and concerns about ringed seal research and management in Nunavut and more specific information needs that could guide future research. The goal of the workshop was to

co-produce knowledge about ringed seal research in Nunavut. The workshop activities were designed to create an opportunity for participants to engage in dialogue about the reasons for their priorities and perspectives (Mößner, 2011; Christian Pohl et al., 2010).

The workshop organization involved four breakout sessions and collective sessions. During the breakout sessions, participants were divided into five smaller groups to discuss particular topics and answer questions that had been provided to them. Following each breakout session, participants reassembled to report the main points of their discussions to the full group. Throughout the first day, there were also six plenary presentations to the whole group by individual participants: one by a representative from Nunavut Tunngavik Inc. (NTI) on the Nunavut Land Claims Agreement and Inuit rights, and five providing updates on scientific seal research programs. Participants had opportunities to ask questions after each presentation.

The breakout sessions had two groups of community members, two groups of seal researchers, and a group of participants representing seal management interests. Community members attended from all three Nunavut regions (Kitikmeot, Kivalliq, and Qikiqtaaluk), but due to weather delays, participants from the Kitikmeot region were underrepresented and as a result participants from the Kitikmeot and Kivalliq regions combined their groups. The two groups of seal researchers were grouped based on general research fields: 1) contaminants, seal pathology, and other health-related areas, and 2) seal ecology and biology. Representatives from the Government of Nunavut and the Nunavut Wildlife Management Board were in the management group. Students from Nunavut communities attending the Environmental Technology Program (ETP) at Nunavut Arctic College were invited to join the groups of their choice and as a result, mixed with all five groups. These students offered a perspective to the discussions that created important linkages between the other groups of participants.

3.3. Data Collection

Data collection included the content and results from the workshop and participant observation by the organizers including notes taken during the workshop planning and throughout the sessions. During breakout sessions, each group was asked to take notes on large chart paper to present the results of their discussions to the entire group. These chart paper presentation notes were kept for later analysis. In addition, the workshop presentations and whole group sessions were audio recorded and transcribed for thematic coding in NVivo qualitative data analysis software (QSR International Pty Ltd. Version 11, 2015).

Participant observation notes throughout the workshop planning and sessions were also treated as data, documenting, in particular, the methodology that informed the workshop design and structure. Participant observation is a form of qualitative data collection based on a researcher's own observations and participation of activities, enabling researchers to observe the natural occurrences of events and the interactions and behaviours of others (Creswell & Poth, 2018; DeWalt & DeWalt, 2002). Johnson and Christensen (2008) discuss four forms of participant observation that occur along a continuum ranging from complete participant, participant-as-observer, observer-as-participant, and complete observer. Our role in the workshop planning would be classified as participant-as-observer, where other participants were informed that the workshop was also being used as research. Decisions on the planning, design, and structure of the workshop were made with the purpose of systematically and strategically organizing the workshop to lead to knowledge co-production. Reflections on the design of the workshop were used to inform the analysis of the three challenges of knowledge co-production. Notes taken throughout the workshop were used to make decisions about subsequent breakout sessions and later to reflect on the workshop's success in facilitating knowledge co-production based on the five dimensions of knowledge co-production.

3.4. Analytic Approach

Although the theory and practice of transdisciplinarity are almost five decades old, creating a widely applicable evaluation approach has been a consistent challenge (Carew & Wickson, 2010; Jahn & Keil, 2015; Klein, 2006; Wickson et al., 2006). I used an adapted

evaluative framework based on D. Armitage et al. (2011) to examine the success of the workshop and evaluate whether it facilitated knowledge co-production. Our evaluation had two prongs.

First, I reflected on the design and structure of the workshop. In their examination of wildlife co-management in the Canadian Arctic, D. Armitage et al. (2011) refer to the challenges of the *role of power*, *creating a shared understanding*, and *establishing a normative context* (Table 10; see also Christian Pohl et al., 2010). Participant observation notes were used to reflect on components of the workshop organization addressed the three challenges discussed by Christian Pohl et al. (2010). In particular, the physical structure and organization of the room, the discussion and presentation processes throughout the workshop, the planning around the questions presented during the breakout sessions were examined as participant observation data.

Table 10: Three challenges of knowledge co-production outlined in Armitage et al. (2011), requirements of activities and participants to address each challenge in knowledge co-production more broadly, the workshop breakout sessions that addressed each challenge, and the criteria of knowledge co-production addressed.

Challenges	Requirement of Activity/Participants	How the Workshop Addressed the Challenges	Criteria of Knowledge Co-production Addressed
Role of power	Recognize and accept existence of different systems of understanding and practices; address power relationships between actors.	Used the structure and process of the workshop design to reorient historical power relations and ensure community participants given access to time and space.	1
Creating a shared understanding	Interrelate different thought styles and perspectives in complex and uncertain decision contexts.	B1 and B2 allowed time for broad discussion of priorities around ringed seals. B3 focused on common priorities identified and created time for more nuanced clarification of needs.	1, 2
Establishing a normative context	Use knowledge co-production to achieve mutually agreed outcomes that serve a shared normative orientation.	B1 clarified a shared long-term goal for ringed seals among the range of participants. B4 asked groups to generate concrete ideas for action to address common priorities.	3, 4

Table 11: Five dimensions of knowledge co-production developed by Dale and Armitage (2011) used as an evaluative framework for the workshop and how the workshop addressed each dimension.

Dimensions	Key Elements, Challenges, and Characteristics	Application of the Dimension at the Workshop
Knowledge gathering	Local knowledge often incorporated during data collection phase of research Often accomplished through conventional research methods Participation in data collection/gathering phases is necessary but not sufficient Knowledge integration can be done by those not qualified in social science methodologies Captures conclusions but not reason or logic of knowledge	Breakout and plenary sessions Knowledge gathering was discussion based Participants given time to discuss topics with other members of their groups Scientists and community members participated in breakout discussions and plenary presentations Focused on priorities for ringed seal research and the outcomes of the workshop
Knowledge sharing	Impacted by language issues and how knowledge is documented Knowledge embedded in language, making translation difficult and incomplete Challenges related to differences between oral and written knowledge systems	Simultaneous translation provided to all participants Workshop participants free to speak in language of their choice In-person nature of workshop allowed participants to seek clarification, adjust speed of discussions Both oral and written methods used
Knowledge integration	Difficulties rooted in essential epistemological differences between actors Challenges related to differences in how knowledge systems integrate or separate values and beliefs from the knowledge itself Differences in temporal scales of knowledge and qualitative/quantitative characteristics presents challenges	Opportunities created for participants to articulate and explain preconceptions about other participants' roles and worldviews Opportunities to express values and beliefs in addition to informational knowledge Session themes focused on common and overlapping knowledge
Knowledge interpretation	Even when knowledge gathering and sharing is collaborative, interpretation often not Informational knowledge is given meaning and application through interpretation	Session specifically focused on participants responding to questions of other participants to clarify roles and perspectives All groups given equal opportunity to explain interpretations and perspectives

Dimensions	Key Elements, Challenges, and Characteristics	Application of the Dimension at the Workshop
	May be shared goals and observations, but divergent interpretations of phenomena Interpretations sometimes dismissed by privileged actors or knowledge systems	Workshop focused on articulating why priorities were important
Knowledge application	Translation of evolving knowledge into decision-making Involves decision-making and collaborative process about how to apply knowledge Sometimes a need to apply contested knowledge and interpretations Conflict management can be culturally specific and lead to specific challenges Not an endpoint, but leads to ongoing knowledge co-production as a cycle	Session focused on identifying key steps for different groups of actors to take following workshop Workshop actions developed based on previous discussions Actions prioritized shared goals between different groups of actors Workshop identified as a starting point to continue to address longer-term priorities

Second, I examined the workshop using five dimensions of knowledge co-production: *knowledge gathering, knowledge sharing, knowledge integration, knowledge interpretation,* and *knowledge application* (Table 11; Dale & Armitage, 2011). Transcripts from the workshop presentation and plenary sessions were thematically coded based on these five dimensions to identify the extent to which the workshop achieved each aspect of knowledge co-production.

4. Results and Discussion

4.1. The Role of Power

It was important to create an atmosphere in which participants were comfortable exploring and expressing their thoughts about a range of topics, and critical that community knowledge was treated as expert knowledge. The importance of workshop structure and process in achieving these goals have been noted in other cases (Fernandez-Gimenez et al., 2006). In particular, there were three main components of the workshop design that were planned in advance to create this setting: the formation of breakout groups, the physical organization of the room, and the structure of breakout and plenary sessions.

The decision to structure groups based on participant identity/role was in the interest of creating a setting where participants felt comfortable speaking openly in their groups. It was important for breakout session discussions to be as detailed and honest as possible and this was more likely if participants were discussing with their peers with whom they had shared experiences and common points of reference.

The physical organization of the room was intended to contribute to "blurring" the boundaries between participants (Christian Pohl et al., 2010). The workshop was held in a large hotel meeting room, with a projection screen at the front of the room along with a table for the workshop co-chairs. Each breakout group sat at a round table, and the tables were arranged around the room randomly to avoid the appearance of hierarchical rows. During the breakout sessions, the two groups of researchers met outside the main room for their discussions, while the two groups of community participants and the management group were given the main

room for their discussions. This decision was intended to reorient what might typically be perceived as preferential access to time and space by scientific knowledge holders.

During plenary sessions, the community groups reported first, followed by the research and management groups. The purpose of this was to acknowledge the importance of hearing from community participants by ensuring that community groups had the time needed to present their ideas. There was also time to ask questions after each breakout group presentation. This structure helped create a tone of two-way communication, rather than a unidirectional transfer of knowledge from scientists to community members.

4.2. Creating a Shared Understanding

The face-to-face nature of workshop settings, having multiple days available and a flexible schedule, and the ability for the schedule to be responsive to the discussions that emerged contributed to creating a shared understanding of the most important issues. Fernandez-Gimenez et al. (2006, p. 313) identified "the importance of face-to-face interactions between biologists and native community members for the success of co-management", further noting that the contributions of community members' knowledge "could not have arisen from [TEK] documentation studies alone. They required the dialogue between hunters and scientists, the active exchange of knowledge and ideas". Similarly, Dale and Armitage (2011) note the different methods participants use to document and transmit knowledge – written or oral – is particularly relevant in knowledge co-production exercises. The opportunity for participants to ask questions, draw attention to points of interest, and ask for further explanation and interpretation of information was vital to generating shared understandings at the ringed seal workshop.

It is also important to consider differences in cultural understandings of time and the ways in which time regulation has been used by states to exert power (Halpern & Christie, 1990). In the context of knowledge co-production processes, constraints on the time available to participants can limit the success of knowledge interaction (Huntington, 1998). Having two days available for the workshop ensured I had ample time for participants to meaningfully

engage in discussions and collectively move through the dimensions of knowledge co-production.

I also ensured that I had flexibility in the schedule so that successive sessions could continue to address themes that emerged. The breakout session topics on the second day were not planned until after the first day's discussions, allowing participants to respond to themes raised on the first day. In this way, groups were better able to articulate their own thought styles by contextualizing them around an interpretation of the first day's material, and they were motivated to continue talking about issues they had identified as important. Without first ensuring that groups understood one another's perspectives, ideas for application and action would not work towards the same end goal.

4.3. Establishing a Normative Context

In the workshop, I established a general normative orientation with regards to ringed seals in the first session (D. Armitage et al., 2011; Christian Pohl et al., 2010). Establishing the normative context at the outset of the workshop allowed participants to frame their discussions based on a shared understanding of a common long-term goal for ringed seals. In this case, the normative orientation had to do with the overall goals for ringed seals in the Arctic and the ways in which local communities interact with seals. There aren't any immediate conservation concerns with ringed seals, so the workshop wasn't focused on identifying specific management policies; however, the history of wildlife management in the Canadian Arctic is bound up with the political control of northern communities (Kulchyski & Tester, 2007). Therefore, it was important that the workshop provided the discursive space to acknowledge and address this history if participants felt it necessary as a part of addressing power relations, both historic and contemporary. In addition, the workshop was focused on the wider context of ringed seals, which includes the social and political factors involved in the broader wildlife research and management regime in Canada. It was important that establishing a normative context focused on all relevant considerations with regards to seals and not strictly the biological or ecological factors. For both community members and scientists, the long-term goal

was to maintain healthy populations of ringed seals that could continue to be hunted by communities. Breakout groups readily acknowledged both the ecological and human dimensions of a normative context with regards to ringed seals and expressed a need to focus on the health of seal populations and the well-being of human communities.

4.4. Knowledge Gathering

Knowledge gathering at the ringed seal workshop took place through the breakout discussions and plenary presentations and included both scientific and community perspectives. Knowledge gathering activities initially had a broad focus, asking participants to identify any number of priorities related to both ringed seals and the outcomes of the workshop. The first breakout session also provided insight into participants' perspectives and perceptions around the way research programs operate and their respective roles in those programs (Table 12).

Table 12: Breakout session questions presented to each group throughout the workshop.

Breakout Session	Questions
Day 1: Breakout Session 1	B1.1: What are your priorities for the workshop? What do you hope is achieved?[1] B1.2: What do you want or need to know about ringed seals or ringed seal research or management from this workshop? Who do you think has this information?[1] B1.3: What are your long-term priorities for hunting / researching ringed seals?[1]
Day 1: Breakout Session 2	B2.1: How do you get knowledge about ringed seals? Where does your knowledge or information come from?[2] B2.2: How do you want to hear about research results (what type of medium, from where, from whom)?[2] B2.3: What challenges do you currently face in communicating about ringed seals in Nunavut as a researcher?[3] B2.4: How could these challenges be overcome? Do you know of any solutions?[3]

Breakout Session	Questions
Day 2: Breakout Session 3	B3.1: How would *you* like to see communications on ringed seal research get better? What about communications do you want to see improved (E.g. How it is communicated? When/how often? Who is communicating it?)?[2] B3.2: Why do you want a research centre in Nunavut? What kind of research would it focus on? Who would do this research? Where should it be located?[2] B3.3: What are your main food safety/health concerns with ringed seals that you need answers for?[2] B3.4: What are the obstacles to returning/communicating research results back to communities faster? Why does it take so long?[3] B3.5: Can you begin to include Inuit students and youth in research projects? Are there any challenges to doing this? Will you do this?[3] B3.6: Is it possible to have more face to face meetings to discuss research results? What are the specific obstacles and steps that would be required to make this possible?[3] B3.7: Based on your knowledge and research, what are the main food safety concerns related to consuming ringed seal in Nunavut? Who has this information and should be communicating it with communities?[3]
Day 2: Breakout Session 4	B4.1: Did the information you heard change what you do or will do in the future? How?[1] B4.2: What 3 actions would you like to see happen from this meeting and who should do them? (In your list, please try to identify at least 1 thing that you will do to make improvements in the issues raised at this workshop.)[1]
	[1] Questions for all groups *[2] Questions for community groups* *[3] Questions for researcher groups*

In response to the first breakout session, community groups expressed a desire to see more involvement from a range of community members in research and identified a need to improve communication, particularly between researchers and communities. One group commented,

> [W]hen they are going to do studies they should consult with the communities…and include Inuit in their studies. And it's continuously repeated that they need to inform the communities of their results. All the information that they record are distributed widely internationally, when Inuit are not informed of what they found out from their studies. And a lot of the communities do not like that because being better informed is much more preferred by the communities (Community Group 1, Pers. Comm., 2014).

The importance placed on effective communication was also shared by the research groups,

> [F]irst and foremost, the priorities we identified were similar to a number of ideas already mentioned, communication, facilitating, improving, promoting communication among communities, among researchers and between researchers and communities, better understanding of what researchers are doing, communicating those results back to the communities and a better understanding of the information that communities want and how can we get that to researchers and apply their tools to those priorities (Research Group 1, Pers. Comm., 2014).

Community and research groups also expressed an interest in seeing an expansion of ringed seal research, both in topical scope and geographical coverage. In particular, community groups identified an interest in studies related to food safety and contaminants and expressed a desire to be more involved in this research.

4.5. Knowledge Sharing

Knowledge sharing at the workshop was intended to take place through breakout sessions 1 and 2 (Table 12) and the six individual research update presentations. Dale and Armitage (2011) identify two main challenges that shape knowledge sharing: the method used to transmit knowledge, such as documented or oral knowledge transmission, and the difficulties in translating meanings across languages. Although simultaneous translation allowed participants to present in their own languages, there was still a concern that the context embedded in some of the original dialogue would be lost across the translation. I hoped that the in-person nature of the workshop, with opportunities to ask for clarification throughout the sessions, helped facilitate deeper understandings. Having opportunities for questions also allowed groups to understand where knowledge gaps existed for other participants based on the questions that were asked.

The topic of communication arose multiple times in the first breakout session, so breakout session 2 focused on engaging participants in knowledge sharing about this topic (Table 12). Effective communication is critical to engaging non-academic actors in the knowledge produced through research, so this was an important opportunity for participants to clarify their own positions and priorities about this theme. Question B2.1 asked community participants how they pass on knowledge about seals,

> [H]ow do you know knowledge about ringed seals. From our parents, from personal experience, through harvesting and all the past knowledges are passed on from generation to generation (Community Group 1, Pers. Comm., 2014).

> I got my knowledge from my mother, from our parents, our ancestors because they did not give up to survive. And they shared their learning, what they learned, passed it on to us through local hunting, trappers group. (Community Group 2, Per. Comm., 2014).

Question B2.2 focused on how community participants wished to receive information. The intention of this question was to help researchers understand the thought styles of community groups and begin to identify methods of results communication that could align with community preferences. Community groups expressed a range of preferences for results communication, which was perhaps surprising to researchers who may have been used to using particular methods in community and institutional settings. For example,

> And the regions should have a research centre, as we were saying earlier, here in our region we don't have a research centre. There should be a research centre where people can seek information (Community Group 1, Pers. Comm., 2014).

> [T]hrough radio, through internet, consultations…But if their project is recommended by HTO and it's approved they should not only report to the HTOs but also spread that information to the general public (Community Group 2, Pers. Comm., 2014).

> So our group thought public meetings were very important, it's not enough to just communicate the information to the HTO but to come back and have a meeting. Something in plain language that the majority can understand. This would especially be good for Elders and the general public. Also if a website could be created that would convey the information…Facebook, some communities have a community news page so this is another way to convey information (Management/Student Group, Per. Comm., 2014).

Question B2.3 allowed researchers to respond to some of the concerns about communication and preferences for communication among the community groups. The process

of results communication is often discussed in overly generic ways as a straightforward task, so this session allowed researchers to articulate the stages that are involved in preparing communications:

> There's also a challenge in making sure that the results are being communicated in a responsible way. And some researchers don't necessarily have all of the answers to the questions that might come up. And so it's important particularly when there are messages related to health that the information is coming from the right source. In the case of health, that the information is coming from the Department of Health and Social Services who have those expertise (Research Group 1, Pers. Comm., 2014).

> Much of what we do as scientific researchers is aimed at communicating with other scientific researchers and we're not necessarily very skilled at communicating back to communities, communicating to a general public overall. So we need to get better at that, we need support in our own institutions in terms of training. We're also not always certain of the best methods for communicating research results…is it best to communicate by email or by telephone, is it best to circulate posters, brochures, online resources, websites, social media, Facebook (Research Group 2, Pers. Comm., 2014).

4.6. Knowledge Integration

Knowledge integration in the context of the workshop involved the organizers identifying key opportunities for participants to cooperatively create meaning about the most important themes of the workshop and identify actions to address these themes. The task was not to find a direct overlap between the perspectives of each group, but rather, as Wickson et al. (2006) describe, to "integrate the different knowledges by looking for coherence, correspondences and 'ridges' across the differences" (p. 1053). Knowledge integration in this sense was therefore somewhat of an instrumental tool that facilitated the opportunity for participants to engage in meaningful knowledge interpretation in subsequent sessions. To achieve this, I identified common themes among the information that was shared by each of the groups in the first two breakout sessions and planned the second day's sessions to focus on these themes in more detail. This process involved reviewing flip chart and participant observation notes from the first day and grouping responses into themes. As has been noted,

knowledge integration, therefore, was not an endpoint of the process but rather was a key step that created opportunities for co-production the following day.

4.7. Knowledge Interpretation

Knowledge interpretation took place on the second day when the breakout session questions asked participants to respond directly to the ideas, questions, and concerns raised on the first day. Participants came to the workshop with existing interpretations of their own experiences with ringed seal research, including perceptions of the roles of other groups. Breakout session 3 focused on three main themes: communication, increased community training/participation in research, and food safety/health concerns.

The goal of this session was to move from sharing knowledge in an informational sense to begin to create a deeper understanding of why particular needs existed. Creating an understanding of the needs of other groups was a critical step in generating actions that would be accepted by all groups. For instance, throughout the workshop, community groups expressed the desire to see research centres established in Nunavut. I originally thought that this may have been an expression of a desire among communities to have more control over research. Breakout question B3.2 provided an opportunity to add clarification on this topic,

> …because of the lengthy waiting and sometimes the meat becomes old and not good enough to do any form of research and because of when an animal is being researched people don't eat it and it becomes old because they don't eat it if it's going to be a research product so they don't want to wait that long (Community Group 1, Pers. Comm., 2014).

> …because of the distance of the place where they have to send the samples it's also taking some time…so it's obvious that we really need the research centres in Nunavut. [A]nd these research centres should be working closely with the major researchers who work on health factors of wildlife as well as the human consumption (Community Group 2, Pers. Comm., 2014).

When community groups were given the chance to clarify in their own words why they wanted research centres in Nunavut, it became clear that the priority was more related to the distance

and time required for sending samples to southern laboratories and a concern over food safety with eating seals.

Breakout session question B3.5 asked research groups to address the topic of including more Inuit youth in research. This question was specifically raised by ETP students on the first day, and the researchers were able to explain why it is sometimes difficult for them to hire new community members to work on research projects. I believe this helped to clarify what was perhaps a misconception that there is a lack of effort among researchers to include and train community members beyond field assistant or guide roles. As one research group explained, there is certainly a willingness among researchers to include additional community members, but researchers are also limited in the time they have in communities to train new individuals,

> [C]an we begin to include Inuit students, the answer is an unequivocal yes…When it comes to having more youth and students participate, there is the trade-off between wanting experienced people and wanting to provide training for young people (Research Group 1, Pers. Comm., 2014).

There are also obstacles at the institutional level,

> Then there is the question of funding, specific money has to be set aside to support these students…they need to be paid, their travel needs to be paid and so identification of funding within the projects needs to be done in the early planning stages of those projects and programs like the one for the Northern Contaminants Program need to recognize the value of that in the project and we are doing that more and more, that is something that our program recognizes as needed (Research Group 2, Pers. Comm., 2014).

Both research groups also identified obstacles related to recruiting youth to work on research, such as uncertainty about how to identify specific individuals in communities who are interested in working with researchers. Research groups explained that they would like support from community organizations in recruiting interested youth.

4.8. Knowledge Application

The last breakout session focused on generating strategies to address issues raised throughout the workshop. Breakout session question B4.2 asked participants to identify key priorities for future action. Participants were asked to include one action that they would

personally take in their own work to make improvements on the issues raised, allowing them to focus specifically on areas for action in which they saw opportunities. In this way, participants could begin to integrate actions into their individual work towards achieving some of the broader needs related to interactions between communities and researchers. It was important that participants focused on realistic and achievable priorities. To accomplish this, I attempted to narrow the scope of discussion with each session to focus on the most prevalent themes discussed by participants. By the last session, therefore, the goal was that the actions proposed by participants would be concrete ideas to address the issues raised throughout the workshop.

The actions proposed by participants were focused around a number of general themes discussed throughout the workshop, namely: priorities for future research; communication; community capacity; workshop reporting; and student/community involvement in research. Table 13 outlines the actions identified by each of the breakout groups. While the priorities were concrete, the specific steps to achieve those priorities warranted more detailed discussion than I had time for at the workshop.

Table 13: Actions identified by each breakout group throughout the workshop that correspond to the main themes identified in the results.

Community Group 1	**Community Group 2**	**Research Group 1**	**Research Group 2**	**Management Group**
Research - Expand research to other communities - Develop plans for research centres in Nunavut to work on contaminants Communication - Develop more effective methods for communication, such as posters and media, and better direction for researchers so they know where to submit research information - Contact QIA liaison officers to help with communication	Research - Involve Inuit more in all stages of research, so that knowledge of hunting and Traditional Knowledge are included Communication - Inform HTOs of research results; HTOs inform Regional Wildlife Boards - Establish deadlines for returning results to communities - Create a group that can consult with researchers and direct communications in the communities - More meetings involving researchers, Elders, and students Community - Teach youth traditional skills around seal hunting	Reporting - Workshop summary report of workshop goals and achievements - Poster - Annual summary of research topics, results, and contact information Research - Expand sampling to additional communities	Reporting - Written report - Effective communication of the report to communities and to the people who can help achieve the goals identified at this workshop - Communicated to the broader public for wider awareness Research/Communication - Apply for funding to expand ringed seal monitoring networks in communities - Create a group to follow up on the progress of the goals identified at this workshop Students - Create job postings to hire students Community involvement - Invite hunters to community and regional meetings to share their knowledge	Students - Revamp the Fisheries and Sealing website to accommodate space that will provide contact information for researchers, communities, and students seeking jobs - Continue to invite students to workshops Research - Look into NTI lab space and capabilities, and how it can be expanded - Focus research on safety of seal meat for human consumption, and communicate to Nunavummiut - Ensure there is a way to get sick/contaminated animals to a research centre for testing Reporting - Produce report from workshop to document discussions Communication - Use the GN's Sealing Nunavut website to link researchers, students looking for work, and

Community Group 1	Community Group 2	Research Group 1	Research Group 2	Management Group
				communities looking for information - Establish community representatives to ensure information gets to community members - Ensure HTOs inform communities of research results

5. Conclusion

The ringed seal workshop was organized within a particular environmental, social, and political context that has created the need for new approaches to engaging a plurality of perspectives in research. Reflections on the ringed seal workshop offer useful insights into the potential for a knowledge co-production approach to successfully engage scientists and Inuit community members in research. Our experience with the workshop suggests that knowledge co-production is effective in generating knowledge about Arctic wildlife. By addressing each of the three challenges outlined by Pohl et al. (2010) and Armitage et al. (2011) (Table 10), and considering how the workshop activities progressed through Dale and Armitage's (2011) framework (Table 11), I conclude that the workshop did fulfill the central constructs of knowledge co-production and therefore was successful in co-producing knowledge about ringed seals.

Workshops have a particular flexibility that makes them a useful method for a knowledge co-production approach. I discussed three aspects of the workshop structure and process that helped address identified challenges to knowledge co-production and can be applied to other workshops. Workshops also offer the opportunity for face-to-face discussion, a reorganization of the time expectations placed on participants, and the ability to employ different discussion and presentation formats that can be responsive to the themes that emerge.

Consistent with the central constructs of knowledge co-production, the results from the workshop were intended to be the first steps in identifying real-world actions to guide future work on ringed seals. Future workshops should ensure that knowledge application is given sufficient time in discussions to generate detailed outlines for action and longer-term evaluation measures. This workshop was organized to focus on the research context in Nunavut specifically; however, it could be used as a model for similar activities with other regional focuses. At a more individual level, it was also the intention that participants would incorporate workshop results into their individual work with ringed seals. The degree to which the

workshop experiences have changed individual participants' perspectives and work is likely the strongest measure of the success of the workshop (Einsiedel et al., 2013). This level of evaluation has not yet been completed but would be a recommendation for future work.

The ringed seal workshop was successful in co-producing knowledge about ringed seals in Nunavut. The workshop was systematically designed to address three core challenges discussed by Pohl et al. (2010) and Armitage et al. (2011). In addition, the workshop's objectives and activities fulfilled the central constructs of knowledge co-production by taking into account the full complexity of the problems and providing space to consider all factors that comprise the issue; considering multiple perspectives, including both scientific and societal views; aiming to produce practically relevant knowledge; and focusing on identifying ways to address conditions for the common good.

Chapter Four: Conditions Conducive to Knowledge Co-Production: A Case Study of Community and Scientific Perspectives in Fisheries Research in the Arctic

1. Introduction

Arctic regions face a range of pressing social and environmental issues. The effects of these issues, in particular, climate change and anthropogenic activities, and their interactions with the needs and health of human communities have emerged as drivers of Arctic research and policy (de March et al., 1998; Huntington, 2009). The Arctic continues to experience the most drastic effects of global climate change, warming at an estimated two to three times the global average (Wassmann et al., 2011). Given this, decision-makers require current and robust information to address the effects of complex social and environmental changes facing Arctic ecosystems, wildlife, and humans (Huntington, 2009).

Reductions in sea ice extent and duration have resulted in expanding commercial fisheries in the Arctic, due to a combination of increased access to formerly inaccessible, ice-covered regions and a growing global demand for additional sources of protein (MacNeil et al., 2010). There is also increasing interest in the development of community-based and artisanal fisheries in a number of Arctic communities (MacNeil et al., 2010). Currently, there are established community-based commercial fisheries for Arctic char (*Salvelinus alpinus*), Greenland halibut (*Reinhardtius hippoglossoides*) (turbot), and shrimp (*Pandalus spp.*) in Nunavut, contributing an estimated $12-14 million annually to the territorial economy (Brubacher Development Strategies Inc., 2004). However, there is a need for ongoing assessment of ecological aspects of fisheries development and informed fisheries management decisions at the territorial and federal levels that take into consideration Indigenous community rights established through land claims agreements (Hussey et al., 2017).

Effective coordination among local communities, researchers, and managers will be vital to addressing the complex issues facing Arctic communities and environments. Knowledge co-

production is a research approach that can create a deeper understanding of the ecological and human dimensions of wildlife use and management. Knowledge co-production is characterized by knowledge that is produced collectively by multiple actors who represent a plurality of perspectives for the purpose of solving locally relevant, real-world problems (D. Armitage et al., 2011; Berkes, 2009; Dale & Armitage, 2011; Godemann, 2008; Christian Pohl et al., 2010). Speaking broadly about knowledge co-production involving natural resource management and Indigenous communities, Davidson-Hunt and Michael O'Flaherty (2007) suggest that knowledge co-production "is vital to indigenous community-based natural resource management, given that planners and indigenous peoples rarely have a common understanding of the issues at hand and tend to speak past one another" (p. 293). Further, "[w]orking from the premise that knowledge is a dynamic process… contingent upon being formed, validated, and adapted to changing circumstances", research is more likely to produce knowledge needed by community actors when researchers establish "relationships with indigenous peoples as co-producers" (Davidson-Hunt & Michael O'Flaherty, 2007). Notably, while focusing on the creation of locally relevant knowledge, knowledge co-production also maintains an emphasis on producing scientifically relevant and rigorous data.

Siew et al. (2016) have identified the importance of understanding the "specific cultural, social, and political conditions" (p. 813) that affect whether a knowledge co-production approach is appropriate for a given research context. The definition of knowledge co-production gives some indication of the types of socio-political and institutional conditions that are conducive to knowledge co-production. For instance, successful knowledge co-production depends on the interactions between academic and non-academic actors in the problem identification, analysis, and implementation stages of research (Hirsch Hadorn, Hoffmann-Riem, et al., 2008). Hirsch Hadorn, Hoffmann-Riem, et al. (2008) highlight the important role of a project manager or facilitator in creating the appropriate conditions to facilitate knowledge co-production, arguing that this individual "must try to create conditions in which participants may learn from each other and … establish common research problems and shared visions about appropriate problem solutions" (p. 390).

I report on a case study involving fisheries research to inform management in Pangnirtung, a community on Cumberland Sound, Baffin Island, Nunavut. My objective was to examine the institutional, organizational, and socio-political conditions of the research context and to identify whether these initial conditions were conducive to knowledge co-production. The complexity of the research context in Pangnirtung fit the criteria for using a knowledge co-production approach (Table 14). I asked if the pre-conditions conducive to knowledge co-production were present in Pangnirtung and if it was possible to create those conditions. I differentiate between the *initial conditions* as those that were present in the research context prior to this study and the *pre-conditions of knowledge co-production* as those that are needed and deliberately established to prepare for successful knowledge co-production. In understanding the nature of both the initial conditions and the pre-conditions of knowledge co-production, it is important to consider the interactions between actors and the institutional, organization, and socio-political context. I assessed the initial conditions in Pangnirtung and then designed and evaluated a process intended to engage actors in establishing the pre-conditions conducive to knowledge co-production.

Table 14: Components of a knowledge co-production approach to research, the criteria that define each component, and the application of each criteria in Pangnirtung.

Components of Knowledge Co-Production	**Defining Criteria of Each Component**	**Case Specific Conditions Related to Components**
Involves complex problems and considers the range of factors that comprise the nature of an issue	Knowledge about a societally relevant problem is uncertain, the concrete nature of the problem is disputed (by disciplines, actors, etc.), and there is much at stake for those affected by and involved in dealing with the problems (Hirsch Hadorn, Hoffmann-Riem, et al., 2008).	Case involves socioeconomic (community-based fishery; local economic development), political (Inuit rights and co-management aspects of NLCA; fisheries management issues), and scientific (fisheries ecology) factors. Activities were focused on understanding the combination of factors and the diversity of priorities in planning future research.
Considers both academic and societal perspectives	Research takes into account the life-world and scientific perspectives of a range of actors and their perceptions of the problem (Hirsch Hadorn, Hoffmann-Riem, et al., 2008).	Scientific researchers, community fishers, and HTO members involved in articulating meaning of activities based on respective priorities.

Components of Knowledge Co-Production	Defining Criteria of Each Component	Case Specific Conditions Related to Components
Aims to produce knowledge that will contribute to decision-making	Refers to the concept of 'socially robust' knowledge: validity of knowledge is tested both inside and outside scientific settings; includes knowledge extended network of experts and users; knowledge is tested and expanded through use by society (Nowotny, 2003).	Results from fisheries research can contribute to achieving community management priorities and will enhance understanding of fisheries management more broadly.
Aimed at improving conditions in society for the common good	An ethical principle that refers to social systems, institutions, and environments work towards the well-being of people. A difficult concept to define, but one that is addressed by transdisciplinary practice through the ability of the approach to engage participants in working towards consensus understanding about needed solutions to problems (Hirsch Hadorn, Hoffmann-Riem, et al., 2008).	Enhanced understanding and integration of economic and ecological activities related to the fishery could benefit community fishers in their goals and contribute to improved management structures to ensure a sustainable fishery.

2. Background

2.1. Transdisciplinarity and Knowledge Co-Production

Transdisciplinarity emerged as a distinct research approach in the 1970s, with growing recognition of the need to include both academic and non-academic stakeholders in knowledge production (Horlick-Jones & Sime, 2004). The development of transdisciplinary research was part of a paradigm shift in scientific practice marked by a move from research focused solely on matters of disciplinary importance to a recognition of the need to address problems of importance to society (Balsiger, 2004; Hirsch Hadorn, Hoffmann-Riem, et al., 2008; Klein, 2014). Klein (2014) described one of the key features in the development of transdisciplinarity as an expansion in the scope of scientific inquiry from a focus only on the production of "'reliable scientific knowledge' to the inclusion of 'socially robust knowledge'" (p. 72). At the same time,

there was increasing recognition that traditional research approaches were often challenged in capturing the full complexity of problems from within the methodological and intellectual boundaries of individual academic disciplines. Complex problems have been conceptualized as problems with interdependent effects (including ecological and social) that are not limited to the interests of individual disciplines (Head & Alford, 2013). In addition, complex problems are characterized by interactions of value frameworks held by both academic and non-academic communities rather than strictly gaps in factual or scientific information (Head & Alford, 2013; Klein, 2014).

Transdisciplinary research has been further defined by the co-production of knowledge (D. Armitage et al., 2011; Berkes, 2009; Dale & Armitage, 2011; Godemann, 2008; Christian Pohl et al., 2010). In knowledge co-production, actors represent different worldviews, or what Fleck (1981) refers to as diverse "thought styles". Participants interact to co-produce knowledge that, according to Gibbons et al. (1994), "will be different from any of the constituent [knowledge] frameworks, yet could not have been developed without them" (p. 30). Through this interaction of thought styles, knowledge co-production seeks to "[transgress] the expert/lay dichotomy while fostering new partnerships between the academy and society" (Klein, 2014, p. 72). Knowledge co-production can be defined as research that 1) attempts to take into account the full complexity of problems and considers all factors that together comprise the nature of an issue; 2) considers multiple perspectives of an issue, including both scientific (academic) and societal (non-academic) views; 3) aims to produce practically relevant knowledge driven by the need to solve a real-world problem; and, 4) is aimed at improving conditions in society for the common good (Table 14; Godemann, 2008; Hirsch Hadorn, Hoffmann-Riem, et al., 2008; Christian Pohl, 2005).

2.2. Pre-Conditions Conducive to Knowledge Co-Production

Certain pre-conditions can facilitate or inhibit successful knowledge co-production. D. Armitage (2005) discusses the "institutional, organizational, and socio-political conditions that have encouraged more collaborative forms of environmental assessment practice" (p. 240) in

the Northwest Territories. While D. Armitage (2005) examined the context around environmental assessment (EA), his focus on identifying the pre-conditions that support collaboration and 'double-loop' learning (Diduck et al., 2005) share characteristics with knowledge co-production. In particular, a researcher's ability to identify and generate the appropriate pre-conditions can promote the production of accurate and rigorous information, engagement of multiple actor perspectives, and critical reflection on the assumptions embedded in existing knowledge production processes. In EA, and other circumstances involving knowledge production about complex problems, the role of emergent institutions and organizations at multiple vertical levels; enhanced communication strategies and effective participation; common goals and shared visions; bridging knowledge systems; and building adaptive capacity among actors are key factors of enhanced collaboration and learning (D. Armitage, 2005).

Hegger et al. (2012) discuss what they refer to as "Success Conditions" for effective "joint knowledge production" between science and policy actors. These Success Conditions can be extended to understand the pre-conditions conducive to knowledge co-production involving scientific and community actors. In their model, Hegger et al. (2012) conceptualize joint knowledge production as an interaction between the actors involved in producing knowledge and the structural context in which they operate, including the rules that determine interactions and responsibilities between actors and the resources available. Together, these four dimensions contain seven Success Conditions for knowledge co-production (Table 15; Hegger et al., 2012).

Table 15: The four dimensions and seven associated propositions that comprise the Success Conditions for knowledge co-production developed by Hegger et al. (2012).

Dimensions of Knowledge Co-Production	**Success Conditions for Knowledge Co-Production**
Actors	1. Broadest possible actor coalition within limits present
Discourses	2. Shared understanding of goals and problem definitions

Dimensions of Knowledge Co-Production	Success Conditions for Knowledge Co-Production
	3. Recognition of stakeholder perspectives
Rules	4. Organized reflection on division of tasks by participating actors
	5. Role of researchers and their knowledge is clear
	6. Presence of innovations in reward structures
Resources	7. Presence of specific resources, such as boundary objects, facilities, organizational forms, and competences

3. Case Context

3.1. Cumberland Sound Fishery

The commercial Canadian fishery for Greenland halibut in the Cumberland Sound region began in 1981 and is co-managed in the Nunavut region by Fisheries and Oceans Canada (DFO) and, since the settlement of the Nunavut Land Claims Agreement (NLCA) in 1999, the Nunavut Wildlife Management Board (NWMB). The offshore and inshore fisheries have quotas of 5 500 t and 500 t, respectively (Fisheries and Oceans Canada, 2006). The NWMB and the Minister of Fisheries and Oceans share decision-making jurisdiction in the waters of the Nunavut Settlement Area (NSA) and extending to the 12-mile limit of Canada's Territorial Sea Boundary. In recognition that offshore fisheries decisions beyond the NSA may affect the harvesting rights and economic development of Nunavummiut, the NWMB also provides information and advice to the Minister about allocations to the east (Zone I) and south (Zone II) of NSA waters.

A management boundary divides the inshore Cumberland Sound Turbot Management Area (CSTMA) at the northern portion of Cumberland Sound, fished by artesian Pangnirtung fishers, from the offshore fishing zone that is fished by larger mobile and fixed gear vessels ("CSMB 2004" in Fig. 2). The CSTMA regulates the size of fishing vessels that are permitted to

fish inshore of the boundary line (total vessel length <25.57 m). The inshore quota, which was established in 2004 and includes a provision for a summer open water turbot fishery, is allocated to Inuit fishers by the NWMB. Based on Nunavut's allocation of offshore fisheries resources, the NWMB, Government of Nunavut, and Nunavut Tunngavik Inc., through the Fisheries Advisory Committee, determine the commercial allocations to individual Nunavummiut fishers. Through this process, the NWMB helps ensure the protection of Inuit harvesting rights and sustainable development of marine resources as established by the Nunavut Land Claim Agreement.

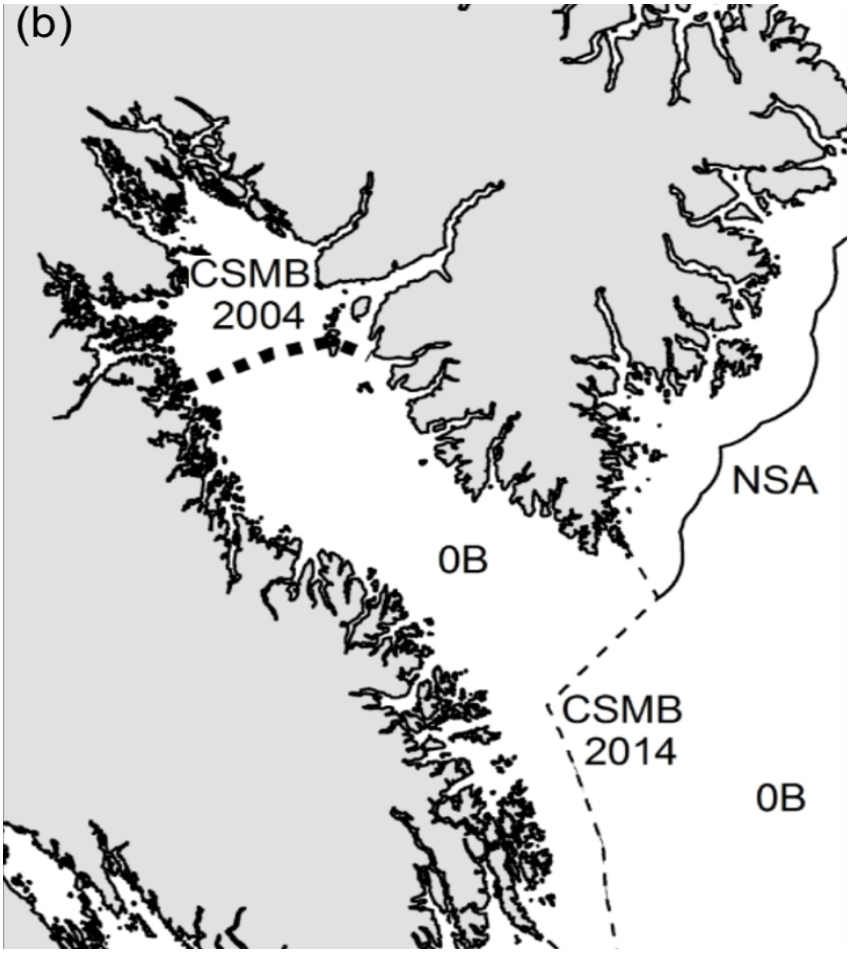

Figure 3: The current (CSMB 2004) and proposed (CSMB 2014) turbot management boundaries separating the inshore and offshore turbot management areas in Cumberland Sound, Nunavut.

In 1987, Pangnirtung became the first Nunavut community to develop a local exploratory winter fishery for Greenland halibut. Turbot fishers from Pangnirtung rely on landfast ice to access fishing areas that are typically concentrated within 70 km of Pangnirtung (Dennard, MacNeil, Treble, Campana, & Fisk, 2009). Winter fishing locations change depending on ice extent and quality and fisher preference, with fishers trying new areas both within and between years. The turbot fishery generally begins near the end of January and continues until ice break-up in the spring. In previous years, the fishing season lasted until later in May but in recent years has more typically ended towards the end of April or early May due to uncertain ice conditions. Turbot is a demersal flatfish, living in ocean depths up to 1 500 m; depths throughout Cumberland Sound vary, with central depths reaching >1 500 m (Dennard et al., 2009). Fishing locations are distributed throughout Cumberland Sound, with fishers setting lines at varying depths between locations and throughout the season but generally seeking the deepest water. The winter turbot fishery is based on Greenlandic longline fishing. A longline consists of a series of hooks (approximately 100) attached by short gangions at intervals of roughly 1-2 m to a long mainline. One end of the line is tied to a metal kite, which is deployed through a hole in the ice until the main line is pulled tight, and an anchor sets the line at the bottom of the ocean floor with a rope that extends up to the ice that is used to haul the line back up. The amount of time that lines remain set varies between fishers, but typically lines are hauled within four to twelve hours after being set. Fishing activity varies between individuals, with some fishers running lines on their own and others collaborating between a series of fishing holes and sets.

Pangnirtung opened a commercial fish plant in 1992, in partnership with the Nunavut Development Corporation to process fish caught in the longline turbot fishery and a smaller Arctic char fishery. Peak total turbot catches in 1992 were at 430 t, declining throughout the 1990s, and recovering in 2002-2003 (Canadian Science Advisory Secretariat, 2008; Dennard et al., 2009; Fisheries and Oceans Canada, 2006). Increasingly shorter ice seasons in the mid-2000s resulted in reduced total catch rates (Fisheries and Oceans Canada, 2006). For example, the total catch in 2007 was only 3 t, which is potentially attributable to a shorter ice season and less stable ice conditions (Dennard et al., 2009). Currently, the fish plant generates an estimated $3-

4 million annually in sales, with an estimated $390 000 paid to fishers and fish plant workers (Christie, 2012; Southcott, 2015).

3.2. Fisheries Research in Pangnirtung

Following presentations to the community and approval by the Pangnirtung Hunters and Trappers Organization (HTO), acoustic and satellite telemetry research to study the movement and behaviour of Greenland halibut in Cumberland Sound began in 2010 (Hussey et al., 2017; Peklova, Hussey, Hedges, Treble, & Fisk, 2012), generating fish movement data for two years (2010-2012). The acoustic telemetry involved surgically implanted tags and an array of deep-water (>500 m) receivers deployed on the ocean floor throughout Cumberland Sound (Figure 3). The tags produce a short ping that is recorded when a fish swims within the detection range of an acoustic receiver (~500-800 m), recording the identity of the fish and the date and time of the occurrence (Hussey et al., 2015). Satellite tags are deployed on fish during the winter fishery for up to one year and record high-resolution time series temperature and depth data. At a predetermined date, the tag releases from the fish, floats to the surface and transmits data to overhead satellites (Peklova et al., 2012).

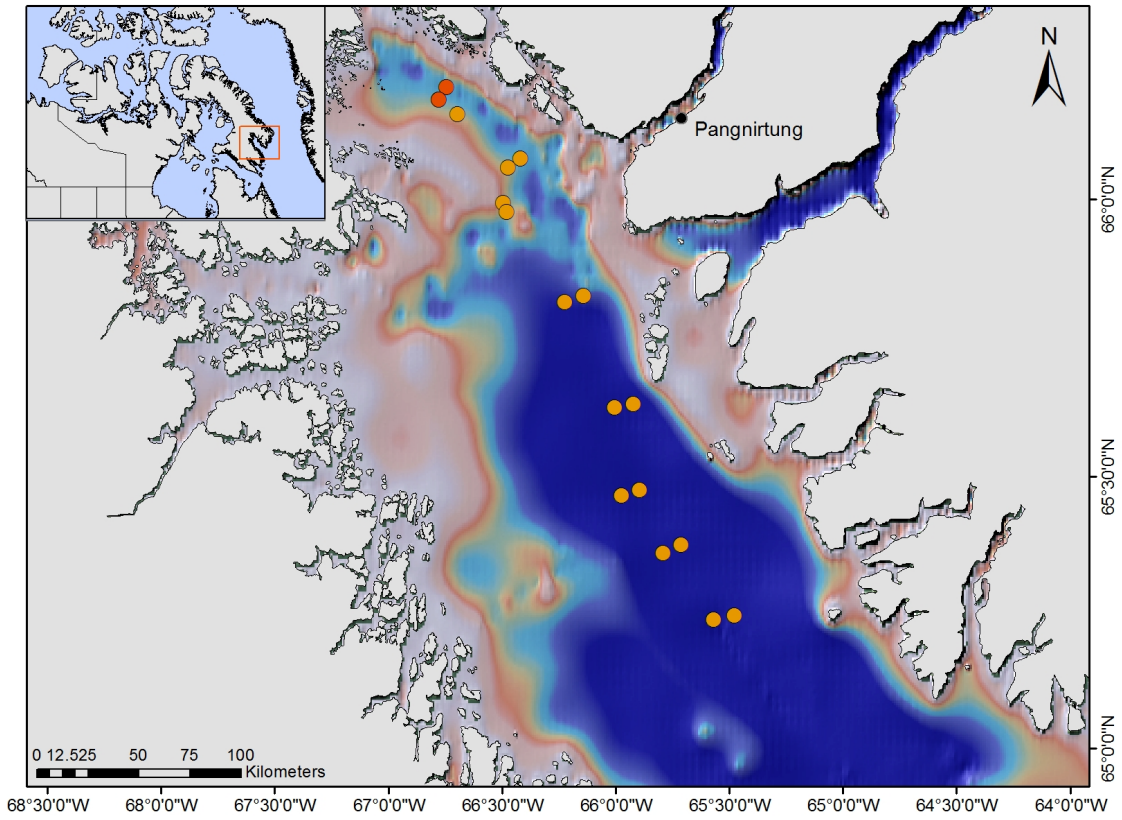

Figure 4: Locations of underwater acoustic receivers in Cumberland Sound from 2010-2016 to record turbot movements.

Following the 2010-2012 data collection, the Pangnirtung HTO denied the proposal to continue the acoustic telemetry research in Cumberland Sound due to concerns that the acoustic equipment was interfering with ringed seals (*Pusa hispida*), causing a reduction in harvests. While there is not a formal measure of ringed seal harvest effort or catch, it is an important food species for communities throughout Nunavut so it is safe to assume that many people in Pangnirtung, including commercial fishers, participate in ringed seal hunting. At a community meeting that involved the Government of Nunavut and DFO, scientists disagreed with the HTO that the acoustic receivers could impact ringed seals, explaining that the receivers themselves do not emit any sound and where well below the depths that ringed seals dive to.

The HTO and the scientists were unable to come to an agreement over potential impacts to seals and the research was suspended.

In May 2013, the HTO submitted a request to the NWMB to move the boundary of the Turbot Management Area to the Nunavut Settlement Area boundary at the mouth of Cumberland Sound (Fig. 2; Nunavut Wildlife Management Board, 2013). The basis for the request was local knowledge and scientific data, predominantly the acoustic telemetry data generated in 2010-2012, suggesting that, contrary to previous expectations, a single population of turbot moves in and out of the CSTMA seasonally, meaning that the same stock of fish had been targeted by both inshore and offshore fishers. Moving the line would have the effect of giving community fishing boats exclusive access to the turbot stock by restricting larger vessels from fishing in Cumberland Sound during the offshore fishery season which typically occurs from May to December.

In August 2013, the Minister of Fisheries and Oceans Canada denied the community's request to move the CSTMA boundary due to a lack of concurrent years of scientific data demonstrating that a single stock of turbot move in and out of the CSTMA seasonally (Kovic, 2014). In its 2013 decision not to move the CSTMA boundary, DFO indicated that if the Pangnirtung HTO developed a plan to collect additional scientific data, DFO would consider a provisional change to the boundary line until a more permanent request could be considered. In 2014, the HTO renewed the approval for the acoustic tracking research, with restrictions on the placement of telemetry receivers to reduce potential interference with ringed seal hunting locations (Fisk, 2015, personal correspondence). The new deployment of receivers would continue until summer 2016.

In March 2014, The Minister of Fisheries and Oceans Canada approved a provisional movement of the CSTMA boundary line to the mouth of Cumberland Sound ("CSMB 2014" in Fig. 2), while additional scientific data were being collected. The Canadian Science Advisory Secretariat (CSAS) was to review the data in March 2018 and advise the Minister as to whether the provisional boundary should be made permanent or moved back to the original location.

4. Methods

4.1. Data Collection

Data collection took place over four visits to the community between August 2015 and April 2017. The data used in the assessment of the initial conditions and in evaluating the success of the process used in Pangnirtung came from specific research activities and a series of community activities. Data collection, therefore, happened simultaneously with the process that was intended to create the pre-conditions that would facilitate knowledge co-production. Data collection included ongoing document review (e.g. funding proposals, community research presentations, HTO and NWMB meeting minutes); one-on-one semi-structured interviews with one of the scientific researchers and a preliminary meeting with community fishers; three facilitated workshops with one of the researchers and a group of community fishers; and participant observation during two winter turbot fishery seasons, an HTO board meeting, and informal interactions with community members and key informants. Data was used to assess the initial conditions in Pangnirtung, inform a process to establish the pre-conditions that would facilitate knowledge co-production, and assess the success of that process.

4.1.1. Interviews and Preliminary Meeting

A one-on-one interview with Aaron Fisk, the lead researcher for acoustic telemetry and satellite tagging in Cumberland Sound, and a preliminary meeting with a group of community fishers focused on understanding scientific and community perspectives and priorities about the Cumberland Sound fishery and were used to assess the initial conditions in Pangnirtung (Fig. 4). The interview and meeting were both semi-structured (Bryman & Teevan, 2005; Creswell & Creswell, 2018; Creswell & Poth, 2018) and contained many of the same questions to allow for a descriptive comparison between the perspectives and priorities of scientists and fishers. The preliminary interview and meeting both took place the day before the first community workshop, which involved the researcher and the same group of fishers. Organizing the preliminary data collection and the first workshop close together was intended to ensure

that participants' answers and thoughts were fresh in their minds when participants engaged with one another. The interview and meeting were both audio recorded and notes were taken by one of the researchers who acted as a facilitator. Results from the interview and meeting were used to inform the structure and facilitation of the first workshop.

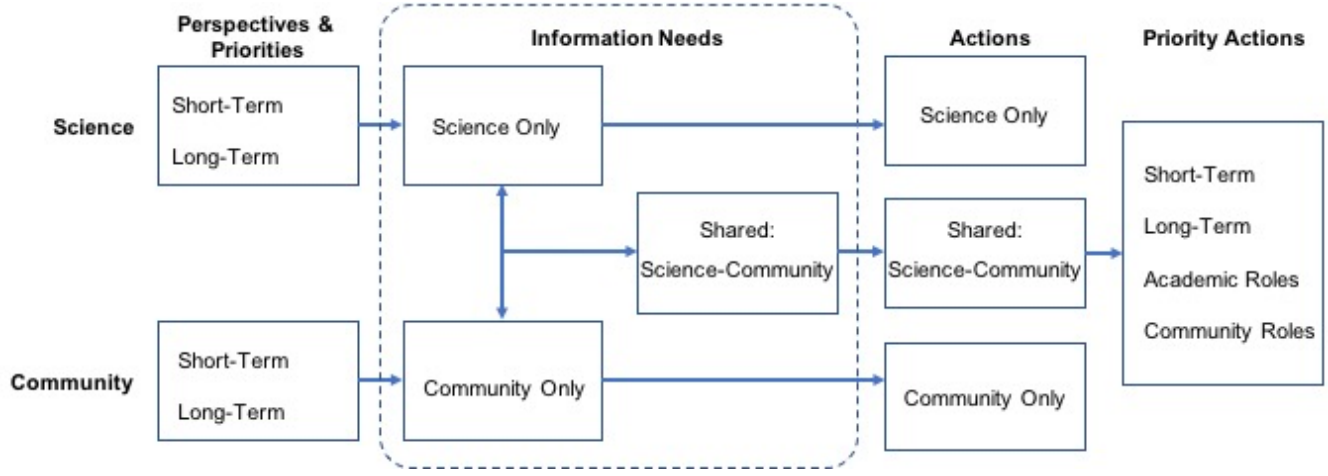

Figure 5: Conceptual framework that guided the organization and structure of the three workshop activities in Pangnirtung between August 2015 and August 2016.

To prepare for the second community workshop, a second one-on-one interview with the same researcher was structured around three broad questions, developed from the results of the discussions during the first workshop: 1) what types of information can be generated through the existing fisheries research? 2) what methods are available/required to generate this information? 3) what are the potential applications of this information to decision-making and how can this serve community needs? Having a clear understanding and description of the types of information the researchers are able to produce informed the development of the second workshop by focusing on identifying shared information needs that could be pursued within the roles and resources available to actors.

4.1.2. Facilitated Workshops

Three purposefully designed and facilitated workshops held in Pangnirtung were the primary methods used to engage scientists and community fishers in generating the pre-conditions that could facilitate knowledge co-production. The workshop designs were based on an analytical workshop method (Huntington, 2000). Workshops guides were designed to be flexible to create the space for participants to share their perspectives and priorities related to the fishery and provide opportunities for participants to discuss with one another in a neutral and informal setting. The workshops were designed to reveal both convergences and divergences in understandings between different actors and allow participants to clarify areas of different understanding and misunderstanding (Huntington et al., 2002; Christian Pohl et al., 2010). The overall process of the workshops was structured to follow the framework outlined in Figure 4. Each workshop was designed based on the discussions and insights about the Success Conditions that emerged through previous workshops. Finally, the issues of power dynamics between participants is a critical factor in research and knowledge production and was considered throughout the activities (Agrawal, 1995; D. Armitage et al., 2011; Nadasdy, 2003; Tester & Irniq, 2008; White, 2006).

To begin organizing the workshops, the actors that were critical for knowledge co-production about the fishery were defined and identified. The workshops were designed to address the seven Success Conditions in Hegger et al. (2012), particularly those that arose in the preliminary meeting and interview and through participant observation as requiring specific attention. The first workshop was intended to create clarity around discourses and problem definitions among participants (Hegger et al., 2012). The first workshop's questions and discussion sessions were designed based on the main themes identified in the preliminary interview with the researcher and meeting with the fishers. Activities at the first workshop were structured around full group discussions, breakout group discussions, and plenary-style reporting sessions. The discussion session topics and questions were designed to establish recognition and shared understandings of perspectives and priorities between scientists and fishers (Table 16). Data from the first workshop was also instrumental in continuing to understand the initial conditions in Pangnirtung. The second workshop's activities were focused on identifying the information needed by actors to pursue their priorities. The second workshop

involved a semi-structured full group discussion session. Questions were designed to reveal shared information needs that could address common priorities between actors and the roles that each group could fulfill in creating needed information. The third workshop focused on community participants identifying potential actions that could address the shared priorities that arose through the first two workshops, including the specific roles of actors, timelines for action, and what was needed by each group of actors to ensure the information would be useful to their individual priorities (Fig. 4).

Table 16: Workshop guide for the first Pangnirtung workshop in August 2015, including breakout session questions for community fishers and scientists.

Breakout Session	**Questions for Fishers and Scientist**	**Questions for Fishers**	**Questions for Scientist**
B1	1. What are your priorities for this meeting? Why did you choose to participate? What do you hope is achieved? 2. What are your priorities for the fishery in Pangnirtung/Cumberland Sound?		
B2	1. Why are these your priorities? Why are they important? 2. What questions do you have about these priorities? What do you need to pursue them (e.g. what information, technology, personnel, etc.)?	3. What questions do you have for the research scientists about these priorities?	3. What questions do you have for the fishermen about these priorities?
B3		1. Do you think the scientific questions are important for understanding the fishery? Why/why not? 2. Do you have any interest in being involved in	1. Can you help get equipment/money to help fishermen? How/why not? Will you do this? 2. What do you know about the status of sharks? Why is this the case? What is

Breakout Session	Questions for Fishers and Scientist	Questions for Fishers	Questions for Scientist
		research Why/why not? 3. What is the best way for researchers to communicate with you? How do you want to access information?	your role in this process? Why are sharks important?

Key to the success of my role as researcher-facilitator in Pangnirtung was creating the opportunity for exchange of perspectives and values between actors. The results of each workshop determined the direction of subsequent activities and discussions. Therefore, the workshops created the settings for participants to engage in conversation and express their own knowledge, beliefs, and values based on their particular perspectives. In analyzing the discussions from each of the workshops and planning future activities, the approach was to identify shared visions between actors and continue to narrow in on those visions to refine the focus of the discussions and eventually identify opportunities for collaborative action.

4.1.3. Participant Observation

Participant observation is a form of qualitative data collection based on a researcher's own observations and participation of activities, enabling researchers to observe the natural occurrences of events and the interactions and behaviours of others (Creswell & Poth, 2018; DeWalt & DeWalt, 2002). Johnson and Christensen (2008) discuss four forms of participant observation that occur along a continuum ranging from complete participant, participant-as-observer, observer-as-participant, and complete observer. My activities, in this case, would be classified as participant-as-observer, where participants were informed that my participation was part of research. According to Creswell and Poth (2018), as a participant-as-observer, the researcher participates in activities at the site which helps the researcher gain an insider perspective and develop subjective data.

Participant observation notes taken throughout the four trips to Pangnirtung recorded interactions with key informants in the community and informal conversations with community members. Data from these interactions revealed some of the perceptions that different actors held about the roles of other actors and were used to assess the presence or absence of the seven Success Conditions based on these perceptions. I also used participant observation during the 2016 and 2017 winter turbot fishing seasons, travelling with one of the participants to his fishing location. By directly observing fishing activity, these trips provided a more complete understanding of the perspectives, challenges, and questions expressed by fishers during the workshops and meetings.

4.2. Data Analysis

The interviews, meetings, and workshops were audio recorded and transcribed for analysis in NVivo qualitative data analysis software (QSR International Pty Ltd. Version 11, 2015). I used the dimensions and Success Conditions of knowledge co-production proposed by Hegger et al. (2012) as an adapted evaluative framework throughout the analysis. Data were descriptively coded using the seven Success Conditions discussed by Hegger et al. (2012) to develop the coding structure and categories. The data were analyzed to assess the presence or absence of the Success Conditions initially in Pangnirtung and the success of the research activities in addressing and creating the Success Conditions. I coded for the presence, absence, and expressions of the Success Conditions by participants during the preliminary interview and meeting and examined how expressions and observations of the Success Conditions changed throughout the workshop and participant observation activities.

4.3. Assessment Framework

Our study had two main components of the data collection and analysis. First, I conducted an assessment of the initial conditions in Pangnirtung to understand the degree to which they were potentially conducive to knowledge co-production. Second, I designed a

process to create the pre-conditions needed to facilitate knowledge co-production and assessed the success of this process.

I used the seven Success Conditions discussed by Hegger et al. (2012) to assess the initial institutional, organizational, and socio-political conditions in Pangnirtung (Table 15). The five pre-conditions for successful collaboration discussed by D. Armitage (2005) also provided insight into the assessment of initial conditions in Pangnirtung. This initial assessment considered the potential that knowledge co-production would be successful in Pangnirtung at the beginning of this study, prior to any community activities. The initial assessment revealed which particular Success Conditions needed to be addressed to establish the pre-conditions that would facilitate future knowledge co-production in Pangnirtung, helping to guide the design and development of activities. Although the assessment of initial conditions needed to take place before any activities were designed to ensure that activities focused on specific Success Conditions, the assessment of initial conditions was an ongoing process and new insights emerged throughout the study that were included in this assessment.

I also used the Hegger et al. (2012) framework to assess the success of the workshop activities as a process to engage participants in creating the pre-conditions conducive to knowledge co-production (Table 15). I compared the workshop and participant observation data to consider whether the activities addressed gaps in the Success Conditions that were present in the assessment of initial conditions in Pangnirtung.

5. Results

5.1. Initial Conditions in Pangnirtung

The initial conditions in Pangnirtung were largely shaped by the history of fisheries research in Cumberland Sound and the interactions between researchers and community organizations, leading to a situation where the initial conditions were not conducive to knowledge co-production. The interactions between community actors and scientists surrounding the acoustic telemetry work and its potential impacts on ringed seals created

tension between researchers and community members that persisted throughout the second phase of research that began in 2014. In terms of the framework used by Hegger et al. (2012), these tensions eroded the potential for an effective actor coalition to be established (Success Condition 1; Table 15).

There were conflicting understandings of the central discourses, particularly related to the motivations of actors and the processes involved in fisheries research (Table 15; Hegger et al., 2012). In this case, an important discourse was the relationship between researchers and local communities and the interactions between scientific and local knowledge. In terms of achieving the central principles of knowledge co-production (Table 14), while the academic and non-academic stakeholder perspectives may have been vocalized over a number of years, there was not a clear process to structure interactions and facilitate recognition and understanding of those perspectives towards creating a shared understanding of goals and problem definitions (Success Conditions 2 & 3; Table 15).

Interview data and document reviews (e.g. Hiscock, 2013; Nunavut Wildlife Management Board, 2013) revealed that an important community management priority was the permanent movement of the CSTMA boundary line. Data from the interviews and preliminary meeting revealed that there was some overlap in the priorities of community fishers and researchers (Table 17). There was a general lack of awareness among actors about the priorities of other actors and the underlying reasons for these priorities, which inhibited a shared understanding of the goals and problem definitions referred to by Hegger et al. (2012).

Table 17: Summary of community and scientific priorities about the Cumberland Sound fishery identified through interviews and meetings with fishers and researchers in Pangnirtung. This table represents a combination of the priorities identified by each group during the initial interview with the researcher, the pre-meeting with the fishers, and the first workshop in August 2015.

	Priorities about the fishery in Pangnirtung/Cumberland Sound		
Community Fishers	Increased number of workers in the plant to increase fish processing speed.	Longer winter fishing season.	Boats that are able to support a summer turbot fishery.
	Information about turbot migration and seasonal locations.	Better fishing gear to catch more fish.	Having a way to replace fishing

	Priorities about the fishery in Pangnirtung/Cumberland Sound		
			equipment when it is damaged or lost.
Scientific Researcher	Understanding turbot ecology in Cumberland Sound.	Understanding why turbot move throughout Cumberland Sound.	Sustainable management of the fishery.
	Contributing knowledge to broader understandings of Arctic marine ecosystems.	Understanding the priorities of community fishers.	Working with community members to study turbot.

Participant observation revealed persistent negative perceptions about researchers and a lack of trust among both community members and researchers in 2016. These negative perceptions were, at least in part, related to the perception among some community actors that researchers had not respected local knowledge about the potential effects of acoustic equipment on ringed seals and that researchers had not followed appropriate protocols to acquire HTO approval for the work. Some of the researchers involved at this time had also previously worked in Pangnirtung without conflict and reported having followed the procedures and protocols requested by the HTO related to approvals and reporting. Beyond the material interactions, these tensions among actors may indicate a lack of understanding of one another's worldviews and motivations. Overall, there were clear divergences in understandings around the central discourses between actors related to the relationships between scientific and local knowledge and priorities (Success Conditions 2 & 3; Table 15).

The division of responsibilities, the roles of the various actors, and the rules surrounding these roles were not entirely clear in Pangnirtung (Success Conditions 4 & 5; Table 15). Hegger et al. (2012) refer to a range of degrees and forms of cooperation between multiple groups of actors that may be appropriate for different projects, from intensive collaboration to a clear separation between the respective domains of actors. The most appropriate form of cooperation between actors will not be the same for every project, but at the very least, "a starting point for arriving at the needed openness would be that actors choose, consciously and

reflexively, which role to pursue in a project, how to define their identity in relation to other actors, and to make these choices known to these other actors" (Hegger et al., 2012, p. 58). The preliminary meeting with fishers revealed a lack of clarity about the roles of particular researchers who had worked in the community and the purpose of their research. In addition, interview data revealed that the researchers were unclear about the perspective and perceptions of fishers about research.

Notably, lack of clarity in the roles of actors was not limited to misunderstandings at the community-researcher interface; there was also a lack of communication and, in some cases trust, between different groups of community actors. Informal interactions with key informants revealed that there was mistrust between community members and the HTO. It was also evident that not all community members agreed with the interpretation that acoustic equipment was negatively impacting ringed seals. While it was not my goal to mediate or facilitate interactions between community actors and organizations, it was important to ensure that I was open and clear about the roles of community actors to prevent misunderstandings that could generate conflict – that the HTO understood the roles of the fishers, and vice versa. In this respect, I was able to work with multiple groups of community members and organizations to ensure that information was communicated between them.

The lack of clear communication between actors in Pangnirtung relates to the perception among them of benefits or rewards of the research being done around the fishery (Success Condition 6; Table 15). In the preliminary meeting with fishers, participants expressed uncertainty around potential benefits that research could have for their everyday lives, demonstrating a lack of perception of clear reward structures that could derive from knowledge co-production. On the other hand, the interview with the researcher revealed that the researchers working in Pangnirtung perceived a benefit from working with fishers related to general acceptance of research objectives and the value of local knowledge. In the interview, the scientific researcher expressed his belief that research data would be enhanced by the knowledge local fishers possessed of the fishery, including where and how to catch fish. He also expressed that building positive relationships with local fishers could be beneficial in repairing previous conflicts between researchers and the HTO.

The scientific researcher identified financial resources available for future research; however, Hegger et al. (2012) identify communication networks, physical resources, and discursive resources as facilitative of knowledge co-production and I did not find evidence that these specific resources were present in Pangnirtung (Success Condition 7; Table 15).

5.2. Community Workshop Results

5.2.1. Workshop #1

The first workshop took place in August 2015 and involved a lead fisheries researcher and a group of seven community fishers. Ten fishers were identified and recruited by a community liaison who works at the Pangnirtung fish plant. The community liaison identified the ten most productive fishers (based on pounds of fish landed) and it was presumed that these individuals would have knowledge of the fishery and could represent the general perspectives of community fishers. Seven community fishers attended the workshop. For each subsequent workshop, all of the original seven participants were invited, but some were unable to attend. Out of the original seven community participants, three attended all three workshops.

The initial workshop provided a space for the researcher and fishers to discuss their priorities for the Cumberland Sound fishery and articulate the reasons for these priorities, as well as their roles in pursuing these priorities (Table 16). The objective for this meeting was to begin to "bridge knowledge systems" (D. Armitage, 2005) by allowing participants to gain insight into the motivations of different actors and understand their goals and problem definitions about the fishery. To achieve this, the workshop was organized around three breakout sessions during which participants brainstormed questions and then reconvened to present answers to the full group. A summary of priorities identified by participants is presented in Table 17.

5.2.2. Workshop #2

The second workshop took place in April 2016 and involved four of the original group of community fishers. The goal of this workshop was to identify the information that could address the priorities identified at the first workshop and begin to establish a foundation for collaboration between academic and non-academic actors (Fig. 4).

During interviews, researchers explained that past fisheries research in Pangnirtung examined seasonal locations and movements of turbot in summer and winter and that acoustic telemetry is the preferred method to study seasonal fish movement. Researchers argued that they could generate more information on the distribution of turbot with an additional array of acoustic receivers at the mouth of Cumberland Sound (a proposal that was not approved by the HTO in previous years). It was also possible to study size classes of fish in Cumberland Sound through trawling methods. In terms of fisheries management, increased data on turbot distribution would help delineate the Cumberland Sound stock from the offshore stock in Davis Strait. The combination of data from the two fisheries (inshore and offshore) could lead to better-informed fisheries management decisions, such as quotas.

In terms of community information needs, fishers were interested in information that could help them increase fishing success. The discussions from this workshop revealed that fishers were primarily interested in increasing knowledge in two main areas: 1) bathymetric information throughout Cumberland Sound; and, 2) spatial distribution of turbot during the fishing season. Fishers explained that their fishing locations change within and between seasons, so when they set their lines, they do not know how deep the ocean is at particular locations or the structure of the ocean floor. Fishers explained that more detailed bathymetric data would help them identify productive fishing areas based on turbot habitat preferences and help reduce the likelihood of snagging their lines on underwater objects.

5.2.3. Workshop #3

The third workshop took place in August 2016 and involved four community fishers. The workshop focused on identifying a research design that could address the shared priorities

determined at the April 2016 workshop, including specific methods to generate data, the roles of scientific and community participants, and the ways in which information could be presented to benefit both academic and community actors (Fig. 4).

To prepare for this workshop, the research scientists reviewed the two main areas of interest prioritized by fishers at the April 2016 workshop: bathymetric data throughout fishing locations and turbot distribution during the winter fishing season. I then developed a possible research design that could generate these data, which involved two components. First, fishers would be provided with handheld depth finders for use during the winter fishery. Fishers could take the instruments on the ice with them while travelling to and from fishing locations and select specific sites for which they wanted bathymetric data. Depth charts do exist for Cumberland Sound but are generally too coarse to be helpful for fishers at their specific fishing locations. All of the locations measured by fishers would eventually be compiled onto a map and provided to the participants. Second, during the winter fishing season, scientists and fishers would work together to deploy approximately 10 pop-off satellite tags on turbot. The tags would be programmed to pop-off the fish in the fall of 2017, providing information about turbot movement and dive behaviour between the winter and summer seasons.

Fishers were pleased with this proposal and agreed that this design would work with their own fishing activities. Fishers understood the time needed to collect and analyze the data for final presentation and were pleased with the proposed timeline. Three of the four fishers who participated in the workshop stated that they would like to be involved in collecting the bathymetric data and participating in the tagging work. The researchers were also pleased with this design as it would generate bathymetric data at specific locations identified by fishers, enhancing understanding of the Cumberland Sound ecosystem, turbot habitat preferences, and seasonal movements of turbot, existing scientific objectives. Data on ocean depth and fish movement collected through the bathymetry and tagging activities would enhance both fisher and scientific understandings of likely turbot habitat throughout Cumberland Sound, particularly in winter fishing locations.

Unfortunately, In the fall of 2016, when preparations were underway for the bathymetry and fish tagging work, I realized that handheld instruments for measuring ocean

depths were not equipped to work through the sea ice in Cumberland Sound, which can reach thicknesses of >120 cm (Canadian Ice Service, 2017). Even if fishers drilled through the ice, the water depths would often be beyond the capabilities of handheld depth recording instruments. This meant that the research plan needed to be revised. The revised plan was to supply fishers with handheld GPS units (Garmin GPSMAP 64st) that they could use throughout the winter fishing season to mark waypoints of locations for which they would like to collect bathymetric data. In the summer open water season, fishers could then travel to the waypoints by boat to collect bathymetric information with boat-mounted equipment.

6. Discussion

This study considered the success of one potential process designed to generate the pre-conditions conducive to knowledge co-production between scientific and local actors in the context of a community-based fishery in the Arctic. Institutional, organizational, and socio-political conditions are complex and shaped by a multitude of interactive and dynamic forces. The process used in this study was informed by an evaluative framework and attempted to create conditions that could support future knowledge co-production. It is also likely that other events and factors, external to this study, impacted the conditions in Pangnirtung over the course of the study. With that said, external factors will always affect a research context, and it is the goal of knowledge co-production researchers to be able to assess conditions and plan research activities according to the particular local contexts in which research takes place. Nevertheless, attempting to recognize potential additional factors that affected the Pangnirtung context is valuable in providing an honest assessment of the success of the process used in this study.

The combination of factors both internal and external to a research project interact and it can be difficult to delineate clearly where one set of factors ends and another begins. For example, the HTO renewed the approval to continue the acoustic telemetry work in 2014, but this does not necessarily indicate that the underlying issues that affected researcher-community relationships in previous years were addressed. Rather, in this case, it is more likely

that the research renewal indicates that both the HTO and the scientific researchers had mutual interests in seeing the research continue. While it could appear that this indicates the presence of "shared understandings of goals and problem definitions" (Success Condition 2), without a deeper recognition of the perspectives that initially led to conflict and bridging the knowledge systems involved, it is unlikely that this element of the Hegger et al. (2012) framework was addressed adequately.

It may also have been the case that interpersonal interactions and changes in personnel played a role in the outcomes of the study. For example, it is possible that as different people assumed responsibility for interactions between community members and researchers, this changed the nature of working relationships between actors. The importance of interactions and relationships between individuals should not be downplayed, and having the appropriate people involved in relationship building is likely key to success and may have contributed to improved conditions in Pangnirtung beyond the specific research activities.

The initial conditions in Pangnirtung were not conducive to knowledge co-production. The activities I organized to engage scientific researchers and community fishers, primarily through three community workshops, were intended to establish the pre-conditions that would facilitate knowledge co-production. Using an evaluative framework developed by Hegger et al. (2012), I assessed the research activities based on their success in addressing and establishing seven Success Conditions needed for knowledge co-production (Table 15).

6.1. Actor Coalition

The actors in the Pangnirtung case included the scientific researchers, community fishers, and HTO board members. Interactions actors vary based on factors such as historic and present power dynamics and it was important to keep this in mind when establishing working relationships between actors. Establishing an actor coalition first depends on actors knowing one another, so the first workshop was an opportunity for a researcher and a group of community fishers to meet each other and have a focused discussion on a topic that is important to both groups. An effective actor coalition in Pangnirtung was not present initially,

in part due to previous conflicts that had arisen, and in part, because there was a lack of clarity among fishers of the roles and activities of researchers. Similarly, researchers were unaware of fishers who would be interested in their work. The first workshop created space for participants to articulate a broad range of priorities about the fishery, which I believed was important to create understanding between participants about their own realities and motivations. The first workshop was also an important step in assessing and attempting to deconstruct real and perceived power dynamics between participants.

An effective actor coalition also depends on clearly defining the expectations and needs of different actors and defining the roles people are able to fulfill within their own areas of work or expertise (Success Condition 1; Table 15). To this end, the second workshop continued to clarify the roles of researchers, including the type of information they are able to generate, the role of research-based knowledge in decision-making about the fishery, and whether this information could contribute to the priorities of community fishers.

Community fishers were primarily interested in information on the bathymetry and distribution of turbot in Cumberland Sound during the fishing season, which would help them improve fishing success. Data on the movement and locations of turbot throughout Cumberland Sound already existed from the acoustic and tagging work completed over the previous years. Maps showing the locations of tagged turbot throughout Cumberland Sound had been provided to the HTO; however, two issues were identified at the first workshop. First, fishers explained that they do not necessarily visit the HTO or have a great deal of contact with the HTO board, so it would be helpful for there to be more direct lines of communication between researchers and fishers. Second, fishers felt that the existing information on fish movements and locations in and out of Cumberland Sound was not site-specific enough to be directly useful to them. The existing maps show the locations of the acoustic receivers and which receivers picked up fish movements each month, demonstrating large-scale movements of fish throughout Cumberland Sound over the year. Fishers also needed to better understand the depth preferences of turbot and the depth and terrain of particular areas throughout Cumberland Sound to select productive fishing locations. The tags that were to be deployed would also provide information on turbot depths by season and general locations within

Cumberland Sound, inferred by depths, which would give fishers a better indication of where to fish.

The discussions from the first workshop helped identify the reasons for a lack of communication and exchange between researchers and community members and established that both groups of actors have an interest in creating more effective communication, an important step in the relationship building process that is needed to create an actor coalition. For the researcher, the workshop revealed that fishers are interested in the information that research can produce, but that there are more effective ways for researchers to connect with fishers throughout research processes. For fishers, these discussions revealed that researchers are interested in working with them directly and in ensuring that research-based knowledge benefits the priorities of fishers.

In addition to the discussions at the workshops, observing fishing activity during two winter turbot fishing seasons with one of the community participants was useful in building an actor coalition. I feel that this direct involvement demonstrated an interest on the part of researchers in understanding the realities of the fishery and the needs expressed by the fishers. The informal interactions that took place while out on the ice promoted trust and mutual understanding between actors and also provided the researchers with deeper first-hand insight into the fishery that was beneficial in addressing the next two Success Conditions in particular.

6.2. Shared Understanding of Goals

The process of creating a shared understanding of goals and problem definitions is related to both the identification of knowledge production goals and the framing and perception of the problem being investigated. In Pangnirtung, the researcher and community fishers identified the mutual priority to generate knowledge that could benefit the long-term sustainability of the community fishery. Researchers and community fishers framed the importance of this problem according to different scales but agreed that research-based knowledge should, and indeed could, benefit community fishing. The identification of more

specific goals had to do with the type and content of knowledge that could be generated through research that would be of interest to both researchers and fishers.

In the interview prior to the second workshop, measuring bathymetry did not arise as a primary focus of the research, so two key questions before pursuing this priority of the fishers were whether the researchers involved in the project could dedicate the resources to generating this information and whether it would contribute to scientific priorities. Interestingly, although the researchers involved in the project had not planned to conduct specific bathymetry studies in Cumberland Sound, they were quite interested in how the combination of bathymetric and turbot movement data could enhance understanding of turbot habitat preferences and behaviour. Moreover, data collected by fishers could be combined with DFO fishery monitoring data, generating possibilities for enhanced understanding of the ecosystem that was not previously available without such collaborative efforts.

6.3. Recognition of Actor Perspectives

The discussion at the first workshop sessions focused on participants' broad, long-term priorities for the fishery, including particular species of importance. Discussion questions were focused on clarifying participants' perspectives about the values and reasons for these priorities, rather than identifying specific goals for future work. Prior to identifying achievable goals for knowledge co-production research, it was important to allow participants to develop a deeper understanding of one another's knowledge systems and the foundations for why different actors think the way they do.

The first workshop revealed that community fishers were unclear about the reasons that researchers are involved in fisheries research and the value that researchers think their work has beyond their own immediate worlds. For instance, community participants expressed that Greenland sharks (*Somniosus microcephalus*), which are caught as by-catch during the turbot fishery, present problems for them in terms of lost income as a result of time taken away from fishing to deal with sharks. Fishers wanted to better understand the relationship between the fisheries research in Cumberland Sound and international management decisions about

Greenland sharks. The discussions were an important opportunity for the researcher to clarify that the knowledge produced through shark research is distinct from the decision-making process about international shark conservation. These discussions helped participants clarify the different underlying reasons that Greenland sharks are of interest to both researchers and community fishers and recognize one another's perspectives and priorities related to the species.

6.4. Division of Responsibilities by Actors and Role of Researchers

In terms of the pre-conditions that facilitate knowledge co-production, Hegger et al. (2012) discuss the organized reflection on the division of tasks by actors, suggesting that knowledge co-production is enhanced in situations where actors decide "consciously and reflexively, which role to pursue in a project, how to define their identity in relation to the other actors, and to make their choices known to these other actors" (p. 59). They specifically highlight the need for clarity around the role of researchers and research-based knowledge in knowledge co-production projects. I consider these two Success Conditions together due to the nature of the role of researchers in Pangnirtung. Clearly articulated roles based on actors' own perceptions sets the foundation for ongoing, enhanced communication and participation (D. Armitage, 2005).

The first workshop provided a deliberate opportunity for participants to articulate their own perceptions of their roles in the fishery. Hegger et al. (2012) identify the importance of researchers making their role clear to all participants. In the context of knowledge co-production involving community actors, it is equally important for community members to clarify their roles. Some community participants were unclear about the relationship between the various researchers working in Pangnirtung. There was confusion about the institutional affiliations of particular researchers, the roles they had in various decision-making processes, and perceptions about personal benefits researchers gained from their work. At the first workshop, fishers expressed uncertainty about who the researcher worked for, the specific research he was involved in, and his role in policy-making about the fishery. The researcher was

able to answer these questions and this was an important opportunity to clarify misunderstandings in the roles of participants which ultimately allowed for a more focused and productive discussion. While the opportunity to clarify these questions took place only in a localized setting with relatively few people, it highlights the importance of actors being clear about identities and roles and suggests that it would be valuable to carry out this type of exercise at broader community scales.

The third workshop was focused more specifically on identifying potential and desired roles of actors in knowledge production about the fishery. The previous conflicts between researchers and community organizations and the disconnection between fishers and the HTO meant that clearly defining the roles and areas of expertise of actors was critical for establishing conditions that would support cooperation and participation. Hegger et al. (2012) refer to "intensive cooperation", in which scientific and community actors work to collaboratively design and carry out knowledge production. Such cooperation is "necessary to arrive at mutual understanding and to learn to speak each other's language" (p. 58). Our third workshop was a critical step in actors moving from the identification of mutual areas of interest to being able to make decisions to advance those interests. The success of this workshop was also, therefore, a critical step in generating the pre-conditions conducive to knowledge co-production. This workshop created the conditions for actors, particularly community fishers, to reflect on and understand their role as one of active decision-maker rather than passive participant in research.

In discussing a potential research design with community fishers in the third workshop, it was important that this workshop reinforced the collaboration and involvement of community actors in all stages of research that characterizes knowledge co-production (Table 14). Therefore, it was important that fishers be involved not only in the identification of knowledge priorities and creation of research questions that took place in the first and second workshops, but also shaping the research design that would be used to collect data and the process through which information would be translated into knowledge useful to the real-world priorities of participants. It was critical to identify methods that community participants were interested in and that were compatible with their realities. To this end, I emphasized that I was

presenting one possible research design developed based on the goals discussed at the previous workshop and that if this option would not work well with the fishers' own work and lifestyles, I could identify an alternative design. The fishers expressed that they were pleased with the research design and the opportunity it presented for them to select the locations for the bathymetric data collection. Being able to carry out the work while travelling by snowmobile afforded them the freedom to select locations while not taking too much time out of their fishing work.

6.5. Presence of Reward Structures

In their framework, Hegger et al. (2012) identify the differences in perceived rewards between academic and societal actors for participating in knowledge co-production. The necessity of ensuring the presence of reward structures was evident in Pangnirtung throughout the workshop activities. In the first workshop, all community fishers expressed a willingness to be involved in research if they were paid for their time and work. In particular, time spent being involved in research would mean time taken out of fishing so fishers explained that participation in research would need to be economically worthwhile.

The perception of reward structures in Pangnirtung was evident in the outcomes of the second and third workshops as participants narrowed down a set of research interests into activities to pursue. During the second workshop, discussions focused on identifying the benefits that fishers perceived would arise from the actual data and information produced through potential research. It was an explicit goal in planning the second workshop to identify ways in which information generated from research activities could benefit the priorities of fishers, namely improving fishing productivity.

During the second and third workshops, fishers again highlighted the need for their involvement in research to be economically feasible. For instance, one participant explained that if they are involved in deploying tags on fish, those fish need to be returned to the water, so that is income the fisher is losing. In terms of the benefits of the research data, however, participants identified specific locations in Cumberland Sound for which more detailed

bathymetric data would benefit their fishing. One participant explained that ice timing and the location of the floe edge have changed over time, making the timing of the fishing season and potential fishing locations variable each year. Participants agreed that the floe edge has progressively moved further north in Cumberland Sound, making former fishing locations inaccessible. As a result, participants requested more specific bathymetric information for the locations they are now concentrating their fishing.

Interestingly, while all participants at the second and third workshops expressed a belief that research could benefit them, not all participants had a desire to be personally involved. Informal interactions with community informants following the third workshop revealed that some fishers would rather not disclose their fishing locations for the purposes of bathymetric measurements or tag deployment.

For the researchers involved, there were tangible and intangible benefits. The benefit of having local fishers more involved in research was increased data on existing scientific priorities. The HTO was also interested in generating additional scientific data on turbot movement without the use of acoustic equipment, so results from the second workshop that revealed a shared priority between researchers and fishers in tracking fish movement was important. Researchers were able to identify fishers to work with to continue studying turbot movement through the use of satellite tags, which was beneficial and acceptable to researchers, fishers, and the HTO. In addition, researchers acknowledged the broader need to include local community actors in research, which has been identified by funding agencies, Indigenous organizations, and within the research literature (e.g. Association of Canadian Universities for Northern Studies, 2003; Inuit Tapiriit Kanatami, 2018; Simon, 2017). The benefit to the researchers in community fisher involvement was therefore increased legitimacy in their research programs and processes.

6.6. Presence of Resources

The discussion by Hegger et al. (2012) of the presence of resources is helpful in assessing the lasting impacts of the activities organized through this study. It is the presence of

specific resources and enhanced adaptive capacity that helps to ensure community actors are able to continue to engage in knowledge co-production processes. Hegger et al. (2012) note that while the transmission of explicit knowledge (often limited to the factual information held by people) may be achieved relatively quickly between actors, transmission of more tacit knowledge requires specific resources that enable people to spend extended periods of time working together and developing trust. Resources such as administrative support, physical places to meet, organizational forms that encourage creative thinking, and opportunities for face-to-face communication, are important in achieving more nuanced forms of knowledge exchange and conversion of explicit to tacit forms of knowledge (Hegger et al., 2012). It is the latter form of knowledge exchange that is important in knowledge co-production.

The presence of discursive resources can contribute to creating the pre-conditions for successful knowledge co-production. In this respect, researchers are often well positioned to provide concepts, or "boundary objects", related to a problem that can encourage collaboration and communication (Hegger et al., 2012; Kemp & Rotmans, 2009). These concepts can be used as discursive tools to help bridge understandings (Hegger et al., 2012). Kemp and Rotmans (2009) discuss the concept of "boundary work" as "the way in which actors construct a social boundary around 'science'…In order to gain and keep credibility, legitimacy, and authority for the scientific practice, scientists demarcate science from other practices such as religion or politics. But boundaries may be blurred deliberately to facilitate boundary crossing and bridge-building" (p. 305) in the effort to achieve knowledge co-production. In Pangnirtung, the fishery and the Cumberland Sound ecosystem were used as a type of boundary object to provide an idea around which actors could focus knowledge exchange, "fulfilling a mediating role between different epistemological communities" (Hegger et al., 2012, p. 60).

The experiences dealing with the change in the research plan provide evidence that actors had developed what Hegger et al. (2012) describe as specific competencies. Hegger et al. (2012) describe these competencies as skills related to negotiation, translation, and mediation. To these more specific skills, I would add the concept of adaptive capacity described by D. Armitage (2005), described as the ability of individuals and organizations to work with

uncertainty and exhibit flexibility to experiment with novel solutions to challenges. He argues that adaptive capacity differs from the more general understandings of capacity (e.g. financial, technical, or human resources) and refers to "equitable relationships among different organizational interests (public, private)" (D. Armitage, 2005, p. 255). In the Pangnirtung context, an important element of building adaptive capacity related to establishing equitable relationships between academic and community actors, including restructured power dynamics and decision-making processes.

Both the fishers and the researchers were pleased with the revised research plan, which ended up having additional benefits. For both groups, the more advanced capabilities of a boat-mounted instrument would provide a more detailed image of the ocean floor, enhancing the quality and usefulness of the data. For the fishers, it would take far less time to mark waypoints on GPS units than to drill through the ice to measure depths, meaning that a greater number of points could be marked more quickly and with less physical effort at each location, reducing the time that needed to be taken out of winter fishing work. The ability of both researchers and fishers to adapt to the challenges that arose and collaboratively change the research plan indicated that each group had trust in the other and had developed adaptive capacity in their working relationships with one another.

7. Conclusions

This study examined a research approach, referred to as knowledge co-production, that engages multiple actors who represent a plurality of perspectives for the purpose of addressing both scientific and locally relevant, real-world problems (D. Armitage et al., 2011; Berkes, 2009; Dale & Armitage, 2011; Godemann, 2008; Christian Pohl et al., 2010). The intersection of a variety of ecological, economic, and social needs by both academic and local actors related to the Cumberland Sound fishery made the context of this study well-suited to an examination of knowledge co-production. There was an identified need among community fishers, organizations, scientific researchers, and management bodies for additional knowledge about the fishery, and there was recognition of a need to explore a novel approach to knowledge

production given the particular institutional, organizational, and socio-political conditions in Pangnirtung.

Siew et al. (2016) have identified the need to better understand the contexts and conditions within which knowledge co-production can be effectively applied. According to Siew et al. (2016), the "specific cultural, social, and political conditions in the research areas" (p. 813) affect whether a knowledge co-production approach is appropriate and likely to succeed. D. Armitage (2005) and Hegger et al. (2012) provide useful insights into understanding the nature of the institutional, organizational, and socio-political conditions that support knowledge co-production.

The objectives of this study were to examine the initial institutional, organizational, and socio-political conditions in Pangnirtung, assess whether these conditions were conducive to knowledge co-production, and then engage with a process to establish the pre-conditions that would facilitate knowledge co-production about the Cumberland Sound fishery. The initial conditions in Pangnirtung, defined by the nature of the interactions between scientific researchers, government organizations, community fishers, and local community organizations and the structural context in which they operate (Hegger et al., 2012), were not initially conducive to knowledge co-production. I engaged fisheries scientists and community fishers in a process (Fig. 4) designed to address seven Success Conditions for knowledge co-production described in Hegger et al. (2012).

The activities planned in Pangnirtung were designed to address previous conflicts and misunderstandings between actors and establish new relationships between scientific researchers and community fishers. These relationships led to the identification of shared priorities and research activities to address these priorities. In terms of the central principles of knowledge co-production (Table 14), the process used in Pangnirtung created the space for actors to engage with the range of needs related to the fishery. The activities created the physical and discursive space for both academic and non-academic actors to engage with one another's perspectives and collaboratively develop a plan for co-producing knowledge about the fishery. This knowledge will hopefully be used by community fishers and organizations to

address their real-world priorities and contribute to decision-making about the fishery that addresses both community and scientific objectives.

Application of knowledge co-production methodologies in the Canadian Arctic remains an emerging field. Understanding how a knowledge co-production approach might benefit Arctic communities, researchers, and environments requires learning through case studies. Future studies should give careful consideration to the complex ways in which conditions are impacted by interpersonal interactions among actors and the unique organizational contexts at community levels. Relationships and interactions between and within organizational structures, at both the community and academic levels, are complex and nuanced. As such, the steps required to establish the pre-conditions conducive to knowledge co-production will be different across cases, requiring varying degrees of time and resource investments on the part of actors and facilitators. Hegger et al. (2012) note that "[p]hysical proximity is found to be conducive for knowledge creation as face-to-face relations help to build trusting relationships that enhance the sharing of tacit knowledge" (p. 60). The reality in Arctic research that researchers usually live and work in distant southern communities is an important consideration in potential knowledge co-production projects. Considerations about the time and resources needed for adequate face-to-face interactions should be thoroughly considered in project planning stages and should be discussed in research outputs and reporting to enhance the ability for future studies to learn lessons from individual case studies.

Chapter Five: Discussion

1. What is the Thread Between Cases?

My dissertation addressed the central research question, *what are the contexts and conditions that support knowledge co-production and what methods are effective in creating these conditions and engaging actors?* It examined these questions in the context of Arctic marine wildlife research that involves both academic and local actors. In particular, I used a case study approach to work with scientific researchers and Inuit community members and organizations to explore the contexts, conditions, and methods that are conducive knowledge co-production. The cases shared a focus on marine wildlife research, the interaction of academic and local knowledge holders, and the intended use of both social and natural science research methodologies.

This research contributes to a gap in the literature related to the need to identify methods to engage in and evaluate transdisciplinary research, including approaches characterized by knowledge co-production (Carew & Wickson, 2010; Jahn & Keil, 2015; Klein, 2006). While the central principles of transdisciplinary research and knowledge co-production have been increasingly articulated since the 1970s, it is still taking shape through its application. It is important to continue to understand when research is likely to benefit from knowledge co-production, meaning we need to explore the conditions under which knowledge co-production is more likely to succeed. In addition, there is still a need to understand research methods that are conducive to co-producing knowledge and frameworks to evaluate the success of knowledge co-production (Wickson et al., 2006). I was interested in both advancing the theoretical thinking behind knowledge co-production and conscious of the need to contribute to understanding around the practice of knowledge co-production and particularly how its application might look in a relatively unexplored research context.

I developed an adapted framework that combined elements from existing frameworks in the literature to explore the three components of the research question (context, conditions, methods). The larger combined evaluative framework connected the data related to each

component explored across the cases (Appendix A). In terms of assessing contexts, I used a definition of knowledge co-production adapted from existing literature, particularly Hirsch Hadorn, Hoffmann-Riem, et al. (2008), Christian Pohl (2005), and Godemann (2008) that contained four central components that I used as criteria to determine whether each case study was suited to a potential application of knowledge co-production. I selected cases that 1) contained complex problems; 2) involved multiple perspectives of an issue, including both scientific and societal; 3) aimed to produce practically relevant knowledge driven by the need to solve a real world problem; and, 4) aimed to improve conditions in society for the common good (Godemann, 2008; Hirsch Hadorn, Hoffmann-Riem, et al., 2008; Christian Pohl, 2005).

To explore the structural and process conditions within which knowledge co-production is more likely to succeed, I used a framework adapted from Hegger et al. (2012) that identified seven Success Conditions that they suggest are more likely to increase the perceived credibility, salience, and legitimacy of knowledge produced. Their framework established the position that there are a set of pre-conditions that need to be established before researchers attempt to pursue knowledge co-production. Therefore, it is the responsibility of actors to work within their specific contexts to determine what steps are needed to establish these pre-conditions and maintain them throughout the research.

To consider methods that are likely to support knowledge co-production, I explored the use of workshops and used an adapted framework developed by Dale and Armitage (2011) that identified five dimensions of knowledge co-production. Dale and Armitage (2011) and D. Armitage et al. (2011) use five dimensions to examine the success of knowledge co-production in the context of marine mammal co-management in the Arctic. Their frameworks were developed and applied in a similar actor-and-knowledge-system context to this research. While their evaluation focused on the entire process of co-management, including the numerous methods, processes, and interactions involved in co-management, the five dimensions were also useful to examine the success of specific processes within one research method intended to co-produce knowledge.

2. Lessons Learned Across Case Studies

2.1. Arctic Research as a Context for Knowledge Co-Production

Social and environmental changes occurring in Arctic regions are complex and highly integrated across both academic disciplines and knowledge systems. The direct and associated impacts of climate change on Arctic ecosystems and human communities, including declining sea ice habitat, species range shifts, and cultural pressures such as food insecurity, require research and decision-making that crosses academic and societal borders and can deal with uncertainty. We simply cannot address the multifaceted and intersecting pressures facing the Arctic from the confines of singular disciplines or knowledge systems. Addressing environmental pressures and changes in the Arctic requires coordination between the social and natural sciences (Lynch et al., 2015); research can benefit from the form of coordination between disciplines that transdisciplinarity advocates (Max-Neef, 2005).

Given the complexity of environmental issues in the Arctic, my research has shown that the process of wildlife research in this region is a potentially appropriate context in which to pursue knowledge co-production. Lessons from each case study support an argument that the context of Arctic marine wildlife research fits the criteria for knowledge co-production. Consistent with the contexts to which knowledge co-production is appropriate and shown to be valuable, each of the case studies contained complex problems, defined by an element of uncertainty and interdependence of the factors that comprise the nature of the research problem (Klein, 2014). The subsistence, cultural, and economic bases of Inuit relationships with wildlife means that ecological changes have multifaceted impacts on human communities and this was apparent in each case study. The Kugaaruk and Iqaluit case studies both focused on ringed seals (*Pusa hispida*), an ecologically, culturally, and economically valuable species (Government of Nunavut, n.d.; Kingsley, 1990; Kingsley et al., 1985; Laidre et al., 2008; Stirling, 1997). Although there are no immediate conservation concerns about ringed seals, changing environmental conditions across their range presents uncertainty about their status in the future and changes to ringed seal populations will impact local communities and other marine species, including polar bear (*Ursus maritimus*). The Iqaluit workshop added community,

scientific, and manager voices to the complex set of considerations involved in ringed seal research and management. The workshop results revealed the variety of interests that participants have in ringed seals throughout Nunavut and the need to capture these interests in research and decision-making. The interviews in Kugaaruk contextualized the value of ringed seals at the community and scientific levels and situated the importance of the species within a larger social-ecological system. In Pangnirtung, the intersection of local economic development, global fisheries management, and conservation demonstrated the complex nature of interests and priorities involved in the case. As Arctic ecosystems become increasingly ice-free there is growing interest in expanding commercial fisheries into previously inaccessible places (MacNeil et al., 2010). The intersection of management and conservation needs related to the expansion of commercial fisheries with local interests increased the complexity of the research problems in the Pangnirtung case.

Further to the appropriateness of the case studies for knowledge co-production, each case involved the voices and interests of multiple groups of actors who represented diverse priorities related to the research problem. The research in each case also intended to use, or at least recognized the need to use, both social and natural science research methods to some degree. In this way, each case crossed both disciplinary and academic/non-academic boundaries. In Kugaaruk, for instance, the purpose of the sampling project was explicitly to collect biological samples from seals and gather local knowledge about seals for the purpose of enhanced understanding of the Gulf of Boothia ecosystem. The workshop breakout sessions in Iqaluit further highlighted the value, expressed by both science and community groups in integrating scientific and local knowledge about seals. Community groups at the workshop expressed a desire to be more directly involved in scientific research and for scientists to involve community members throughout the entire timeline of research projects. In Pangnirtung, participant observation data demonstrated that local fishers and the HTO expressed different priorities with regards to fisheries research, demonstrating how the perspectives among community actors diverge at times. There were also scientific interests in fisheries research in Cumberland Sound and it was evident that throughout the history of

research in Pangnirtung, captured through interviews and document review, these diverse voices had not developed a shared understanding of goals.

While demonstrating the appropriateness of Arctic wildlife research for knowledge co-production, this research has also shown that it is possible that past projects have used elements of knowledge co-production without specific intent to pursue knowledge co-production. In Kugaaruk, results found that five of Hegger et al.'s (2012) Success Conditions of knowledge co-production were present without the researchers intending to pursue knowledge co-production. Other seal research and monitoring projects throughout the Canadian Arctic use comparable harvest-based methods to those used in Kugaaruk (e.g. Chambellant, Stirling, Gough, & Ferguson, 2012; Gaden et al., 2012; Harwood, Smith, & Melling, 2000; Stirling, 2005), so there is the potential that other research has incorporated elements of knowledge co-production simply as a matter of striving for successful projects and working relationships with local actors. For instance, the breakout session results from the Iqaluit workshop demonstrated that scientists working throughout the Arctic recognize the value in engaging local knowledge holders in research, which is a basic principle of knowledge co-production. Community participants at the workshop expressed the desire to see additional economic opportunities from research, including being more actively involved in all stages of research. It is not uncommon for harvest-based sampling projects to pay hunters for submitting samples, so hunters do benefit from their involvement in research and interview participants in Kugaaruk identified this as a main source of what Hegger et al. (2012) might refer to as the "presence of reward structures". The results from Kugaaruk and Iqaluit indicate that there are actors in at least one area of Arctic wildlife research who are likely to be open to more deliberately pursuing knowledge co-production because the main conditions for successful knowledge co-production are elements of research projects that in some cases are already pursued.

There may be challenges in pursuing knowledge co-production in scientific wildlife research related to the disciplinary limitations of participating academic actors. Crossing disciplines can be difficult and daunting for researchers trained in a specific field and set of methods, so it is also important that as we attempt to bring together social and natural scientists that this be done in a way that benefits both groups of actors without risking

legitimacy within their respective fields. The depth of qualitative information about the Gulf of Boothia ecosystem gathered through interviews in Kugaaruk suggests that knowledge co-production offers an opportunity for research to achieve scientific priorities while, and perhaps as a result of, crossing academic disciplines and involving local knowledge. Both the Pangnirtung and Iqaluit cases support this finding and indicate that knowledge co-production can bring methods and processes to research that both academic and non-academic actors find acceptable and achievable, in particular the use of facilitated workshops (discussed more in section 2.3 below). Participant observation data from the workshop in Iqaluit indicates that the academic participants found the workshop process and results valuable for their work.

2.2. Conditions Conducive to Knowledge Co-Production

The use of knowledge co-production has continued to grow in the scientific literature over the past 15 years and is increasingly common in environmental research. In a search of the database Web of Science for publications that used the term "knowledge co-production", there was one publication that included the term in 2003 and by 2017 that number had increased to 34 publications. In the same list of 145 results, 64% of publications were in the fields environmental science or environmental studies. Conference sessions devoted to knowledge co-production have also become common at large conferences such as the ArcticNet Annual Scientific Meeting (2015) and Arctic Change (2017). Despite its growing use in research, there is a need to continue to develop and articulate ways to evaluate the success of knowledge co-production to ensure that it achieves what it claims with regards to engaging local actors, more successfully representing the nature of complex problems, and generating knowledge that contributes to decision-making (Carew & Wickson, 2010; Jahn & Keil, 2015; Klein, 2006). In addition to evaluating the success of knowledge co-production after the fact, it will be useful for actors to evaluate the conditions that define a research context to determine whether it is likely to support successful knowledge co-production (Hegger et al., 2012; Siew et al., 2016). Claims that knowledge co-production has been successful without critical and careful reflection about how quality has been assured risks presenting the process as straightforward or easily

pursued in any research and local context. This research indicates that knowledge co-production is neither easily achieved nor immediately applicable, but rather that there are particular social-political, organizational, and institutional conditions that are more likely to lead to its success and that researchers need to give careful and deliberate attention to creating these conditions. As researchers, we should be aware of these conditions in order to successfully engage in and benefit from knowledge co-production.

One of the common themes across each of the case studies was the time commitment required to expect to engage in knowledge co-production. It will require a greater time commitment to pursue knowledge co-production than some traditional single discipline-based research approaches. Researchers, decision-makers, and community actors need support from the institutions within which they operate to dedicate the time needed to engage in knowledge co-production. Actors involved in knowledge co-production will need to evaluate the conditions within a research context and work to establish the pre-conditions that can facilitate knowledge co-production. It is likely that there are analytic frameworks, in addition to the one provided by Hegger et al. (2012), to describe and evaluate conditions conducive to knowledge co-production. The point of this research is to suggest that this activity should be a priority for researchers. Researchers should expect to budget for the time and associated costs it will take to shape the conditions that can support knowledge co-production prior to expecting that knowledge co-production can be successful. At the same time, future research could focus on developing additional evaluative frameworks related to understanding, assessing, and creating the conditions that can facilitate successful knowledge co-production, particularly in Arctic contexts.

Certain conditions arose across all three case studies and deserve specific attention in future knowledge co-production research in the Arctic. First, the need to ensure clarity around the roles of actors was foundational to effective collaboration between researchers and community members in this research. In Pangnirtung, it was clear that misunderstandings about the identities and roles of researchers had contributed to a lack of trust and conflict between the community and the researchers. On the other hand, increased deliberation around the roles of researchers and community actors in Kugaaruk would have likely increased

success in that case. In Iqaluit, the success of the workshop was likely due, in part, to the time participants were able to devote to clearly describing their roles within their own institutional and local contexts.

The second condition that arose across all cases was related to the broad theme of communication within and between groups of actors. As an important aspect of communication, there will continue to be challenges related to language and our ability to work within multilinguistic contexts will impact the success of research. While it might appear self-evident, having effective translation to facilitate communication not only of words but cultural concepts was critical in creating mutual understanding between researchers and community members in this research. The need for effective translation likely fits within what Hegger et al. (2012) describe as the need for specific resources and this finding is supported by previous Arctic studies (e.g. Dale & Armitage, 2011). A deeper issue around communication was related to creating shared understanding of goals and problem definitions (the first Success Condition). It was evident across cases that while actors might agree on general topics that research addresses, there was lack of understanding about the specific objectives and the long-term intention of the knowledge generated.

Related to the need to create a shared understanding of research goals, a recurring theme across all three cases was that community actors were unaware of research results. While this issue is not specifically addressed by Hegger et al. (2012), it cuts across a number of their Success Conditions and could warrant being categorized as its own condition. Without feeling like they have meaningfully contributed to ongoing problem definition (the first Success Condition), it is less likely that local actors will seek out, interpret, and attach significance to research results. Conversely, without a clear grasp of the meaning and significance of results, it will likely be difficult for local actors to contribute to ongoing understanding of goals and problem definitions. Along the lines of what Doubleday and Connell (2017) refer to as publishing with “objective charisma”, part of the task of researchers, therefore, is to find innovative and clear ways to communicate their research results in language and through methods and outlets that make sense to local actors. This task requires those involved in knowledge co-production to take specific inventory of the resources available (the seventh

Success Condition) for communication at the local level and ensure that these are being used effectively.

2.3. Methods Conducive Knowledge Co-Production

A primary goal of transdisciplinary research is to increase collaboration between social and natural scientists (Christian Pohl, 2005). One challenge in research that works to bring together the social and natural sciences is identifying research methods that facilitate collaboration and integrate knowledge across disciplines (Vlasova & Volkov, 2016). Studies have noted the importance of effective facilitation in knowledge co-production efforts (e.g. Reed & Abernethy, 2017) and my research contributes insights to the need to identify specific research methods that are suited to knowledge co-production. Achieving interdisciplinary research within the social or natural sciences is challenging on its own; research that crosses the social and natural sciences will continue to prove both important and challenging. Transdisciplinary research complicates this challenge further by involving the participation of non-academic, local knowledge holders and research methods must also be acceptable to their knowledge systems. This research demonstrated the value in fostering a sense of "methodological literacy" between academic actors so that the validity and rigor of different research approaches are appreciated by actors situated in different academic traditions. Results from the case studies offer insights into methods that are suited to engaging multiple actors in knowledge co-production that can contribute to both academic and community priorities. Further, it highlights the value of deliberate and effective facilitation.

In this research, I was interested in two aspects related to the methods used. First, I was interested in identifying methods that are effective in evaluating the conditions that can support knowledge co-production. Second, I was also interested in understanding methods that show potential in facilitating knowledge co-production. A number of previous studies have examined knowledge co-production in environmental and wildlife research and co-management and reflect on research methods that have been useful in evaluating and facilitating knowledge co-production. For example, D. Armitage et al. (2011) and Dale and

Armitage (2011) used semi-structured interviews, questionnaires, and focus groups to evaluate the success of knowledge co-production in three case studies of wildlife co-management in the Canadian Arctic. While not explicitly about knowledge co-production, Huntington's (2002) reflections on the use of workshops to facilitate exchange between holders of scientific and Traditional Knowledge are relevant in understanding interactions between actors and the potential use of workshops in knowledge co-production. Idrobo and Berkes (2012) report on the use of participant observation, open-ended and semi-structured interviews, and focus groups to facilitate knowledge co-production in a case in Pangnirtung, Nunavut.

This research provides insight into the use of semi-structured interviews to evaluate the Success Conditions of knowledge co-production (Kugaaruk and Pangnirtung) and thematic workshops to facilitate knowledge co-production (Iqaluit and Pangnirtung). Semi-structured interviews were effective for the purposes of this study because they allowed open-ended time structures, facilitated translation, and allowed for deeper understanding of concepts. Interview participants had different thoughts and amounts of information about the nature of their experiences with research and interview formats created the time and space for these thoughts to emerge. The knowledge co-production literature places a great deal of emphasis on the need to allow participants to remain situated within their own knowledge systems while creating understandings between them. Understanding actors' perspectives from the basis of their own frames of reference takes time and effort and semi-structured interviews allows researchers to engage with this process.

The workshop structure worked well in both Iqaluit and Pangnirtung because it allowed me to act as a facilitator and purposefully work towards intended outcomes. Reed and Abernethy (2017) have noted the importance in having a facilitator to produce meaningful results in knowledge co-production efforts. In the Pangnirtung workshops in particular, I acted as intermediary and facilitator, roles that allowed me to mediate between the different perspectives and help participants achieve collective learning towards developing a common goal (Hegger et al., 2012; Christian Pohl et al., 2010). My ability to be involved as researcher and facilitator allowed me to simultaneously evaluate the initial conditions in Pangnirtung and work to change conditions to be more conducive to future knowledge co-production. In Iqaluit, the

goal was to co-produce knowledge about ringed seal research across Nunavut. Purposefully designing and facilitating the workshop provided the time, pace, and space for participants to follow a process and create understanding. As the facilitator, the workshop format allowed me to observe the discussions and adjust the process as needed to respond to ideas that arose throughout the sessions.

When reporting on knowledge co-production, it is important to emphasize the academic rigor of the approach and methods. As a methodology that explicitly seeks to bridge academic disciplines, forethought is required to design methods, document knowledge, analyze data, and frame results in ways that are useful and acceptable to the range of actors and knowledges involved. For knowledge co-production and actors' roles in the activities to be appreciated and respected, it is important that methods are designed and structured according to rigorous academic standards. The risk in not doing so is that academics in particular may not take the activities seriously or may mistakenly believe that knowledge co-production simply occurs rather than being a methodology that requires purposeful design. Similarly, when engaging local actors, it is important that methods be appropriate for local processes and knowledge systems and that they are capable of capturing and representing the complexity of local understandings of an issue. In the Pangnirtung case study, it took time to convince actors to follow the workshop process, which perhaps did not seem intuitive to the way they were used to discussing an issue. In the end, the results of the case indicate that following a purposeful design and process produced more meaningful outcomes.

2.4. Expectations and Claims of Knowledge Co-Production

A little over a decade ago, Wickson et al. (2006) noted that while transdisciplinarity had experienced a strong emergence in research literature, there was still a lack of consensus on what transdisciplinarity was or how to evaluate it. Since then, researchers have reported on case studies and explored principles and applications of transdisciplinary research and knowledge co-production. Nevertheless, an understanding of how to achieve knowledge co-

production is still emerging and has been slow, in part because of a lack of clear evaluative processes (Jahn & Keil, 2015; Reed & Abernethy, 2017).

Part of the difficulty in evaluating knowledge co-production stems from the fact that it is a somewhat constantly shifting terrain that adjusts to the people and conditions involved. In some cases, certain conditions of successful knowledge co-production may be present and contribute to the perceived strengths of research even when a project wouldn't claim to have thoroughly or even deliberately pursued knowledge co-production. As noted above, the Kugaaruk case suggests that knowledge co-production can occur on a spectrum where certain conditions are present while others remain absent. It can be useful to identify instances where research has implemented particular conditions that facilitate knowledge co-production while recognizing that the project has not necessarily achieved knowledge co-production. In Pangnirtung, there was work to be done to establish pre-conditions that could help facilitate future knowledge co-production but the local and institutional conditions are not likely to remain static over time. The Pangnirtung case study illustrated the inherently iterative process of knowledge co-production in the sense that conditions can and will change over time depending on various factors both internal and external to the research process, meaning that someone else's experience there may differ from mine. For instance, local organizations play an important part in the status of local conditions and changes within these organizations will require ongoing work on the part of researchers and other actors to ensure conditions remain conducive to knowledge co-production.

The case studies in this research also provide lessons about the extent of our expectations of knowledge co-production and indicate the need to be patient, measured, and humble in our claims. As a process without rigidly defined and structured methods or evaluation criteria, knowledge co-production varies across contexts and will be an iterative, rather than linear, process (Hirsch Hadorn, Hoffmann-Riem, et al., 2008). The case studies in this research have shown that when engaging in knowledge co-production, particularly with actors and projects that have not been exposed to the approach, the time and financial resources required will vary between contexts. Researchers should therefore be prepared to invest the time and resources needed. In the context of Arctic research, the geographic

distance and time it takes to travel to research locations present additional challenges. Travel to Arctic communities is expensive and time consuming and research funding schedules don't necessarily match up with community schedules and availability, so these factors should be kept in mind when planning and reporting on the results of knowledge co-production.

To contribute to advancing the theory and practice of knowledge co-production, researchers should focus on being precise in their claims about the extent to which knowledge co-production has been deliberately pursued and achieved. Given the nuanced complexity that defines many research contexts, localized and specific lessons from case studies offer some of the most valuable contributions to our collective understanding of knowledge co-production. We should be prepared to appreciate these more specific lessons and not expect every attempt at knowledge co-production to provide a panacea to research challenges and knowledge needs.

3. Limitations of the Research

This research examined multiple case studies focused on marine mammals (seals and polar bears) and one fish species (Greenland halibut, *Reinhardtius hippoglossoides*) in Nunavut. Although results are promising with regards to the prospects for applying knowledge co-production in the broader context of Arctic wildlife research, I acknowledge that this study was limited in its scope based on the relatively small sample size of case studies examined, and that research contexts vary greatly across the Arctic. There are important differences in the institutional, organizational, and political frameworks throughout the four Inuit regions in Canada and other international Arctic contexts. These differences could mean that other local or species contexts are more or less suitable for knowledge co-production in ways not foreseen here; however, it is also likely that regardless of the particular context, the problems will be complex and involve multiple academic and local perspectives and so it is worth examining their potential for knowledge co-production.

This research contributes ideas and direction to future conceptual development of knowledge co-production as an approach to research and interaction between actors. The nature of the three case studies examined here varied in scope, the actors involved, and in the

local and historical contexts of the research problems involved in each case. In that regard, each case study provides an example of one way to examine knowledge co-production; at the same time, being able to make more comprehensive conclusions about the concepts examined in each case will depend on a deeper investigation of the particular variables that characterized each case, such as the nature of interactions between local and external actors, the local and external institutional relations and dynamics, and the nature of the research problems themselves and the politics involved in defining those problems.

I recognize that the specific evaluative frameworks used in this research may not be applicable to all cases, and further that there may be additional conditions or dimensions of successful knowledge co-production not identified here that are important in other contexts. As methods to evaluate success continue to emerge through our collective experiments with knowledge co-production, strengths or weaknesses to my approach may become more apparent. Nevertheless, as a reflection of the iterative nature of the research approach itself, the lessons we learn about doing and evaluating knowledge co-production must also continue to feed into future research to continue to build a set of best practices based on the best available knowledge and experience.

The evaluative framework used in Chapter Three to examine the ringed seal workshop in Iqaluit was adapted from a framework used in Dale and Armitage (2011) and D. Armitage et al. (2011). They identified five dimensions of knowledge co-production and used them to analyze experiences around marine mammal co-management, whereas I applied their framework to consider knowledge co-production in the context of research. There are differences in the temporal nature and institutional scale between these two contexts and I recognize that it may be argued that their framework is not directly applicable here; however, their framework and the five dimensions of knowledge co-production it outlines reflects the central principles and criteria of knowledge co-production discussed by others (e.g. Balsiger, 2004; Godemann, 2008; Hirsch Hadorn, Hoffmann-Riem, et al., 2008; Christian Pohl, 2005). Therefore, given that knowledge co-production focuses on both knowledge generation and application, it is reasonable that their framework could apply at multiple scales given that the aims of knowledge co-production would presumably remain consistent whether it is occurring

in the context of research or co-management. I would also add that for this framework to be fully useful, it should be extended to look for evidence that the knowledge produced through knowledge co-production efforts is reintegrated into the knowledge systems and understandings of participating actors.

A final conceptual limitation of this research concerns the degree to which I can expect the conditions examined and addressed, particularly in Pangnirtung, to persist beyond the project and my involvement. A true change in conditions in the sense referred to throughout this research requires the creation of new institutions and relationships that can ensure conditions remain conducive to knowledge co-production. For example, while it appeared that conditions had been positively affected throughout the course of this research, re-examining the conditions in the future to determine whether those changes were sustained through the creation of new institutional arrangements and dynamics would be helpful to fully reflect on the success of my efforts.

As with many Arctic research projects, I also faced limitations primarily as a result of financial constrictions. The high costs of Arctic research (a challenge noted by many researchers in the Iqaluit workshop) meant that I was limited in how many interview participants I could engage in Kugaaruk and the length of time I was able to spend in both Kugaaruk and Pangnirtung. On subsequent visits to Kugaaruk, additional community members expressed an interest in participating in interviews but I did not have time available in the community to pursue this. On a related note, I was able to travel to both Kugaaruk and Pangnirtung at least once a year for results validation and to continue various parts of the research; however, I found that, specifically in Pangnirtung, the research process might have benefitted from more frequent visits by keeping community participants more consistently involved. While there was a core group of people who remained involved throughout the project, I believe additional community fishers would have remained more actively involved if activities had been more frequent.

4. Future Opportunities

This research contributes to our understanding of the connectedness between different groups of people, their priorities, roles, and knowledges related to environmental problems, particularly in wildlife conservation and management. The approach to knowledge generation and use that knowledge co-production articulates and promotes is one that will be increasingly valuable to decision-makers in the context of global environmental change. Klein (2004) notes that the "problems of society are increasingly complex and interdependent. Hence, they are not isolated to particular sectors or disciplines, and they are not predictable. They are emergent phenomena with non-linear dynamics, uncertainties, and high political stakes in decision-making" (p. 517). This is markedly true in the area of wildlife conservation and the threats increasingly facing wildlife populations throughout the world related to biodiversity and habitat loss.

The model of wildlife management and conservation in North America is built on the premise of democratic management and access to wildlife. Among other implications, this model means that the Canadian public is given opportunities to participate in decision-making concerning wildlife in this country. The political and colonial history of Canada has also separated Indigenous communities from their traditional territories and practices. There is growing recognition of the connections between cultural and biological diversity (Cormier-Salem, 2014; Maffi, 2005). At the same time, there is recognition of the right of Indigenous and local communities to be involved in the governance of their resources (Maffi, 2005). Internationally, emerging discussions about Indigenous Protected Areas have gained recognition as effective ways to recognize Indigenous jurisdiction and involve Indigenous communities in the conservation of biodiversity (Beltran, 2000). In Canada, Arctic communities and leaders have identified the need for scientific priorities to work alongside community research priorities (Simon, 2017).

Science-based approaches to conservation in North America have evolved over the past 120 years (Organ, Geist, & Mahoney, 2001). Declining wildlife population and habitat have emerged as international conservation priorities in the 21st century and Canadians in particular have emphasized their support for increased action on these issues (Earnscliffe Strategy Group, 2017). Half of Canada's wildlife has declined since 1970 and ongoing habitat fragmentation and

loss ensure such declines will continue (World Wildlife Fund, 2017). To achieve commitments made under the Convention on Biological Diversity, Canada committed to a series of 20 targets aimed at the protection of biodiversity, known as the Aichi Biodiversity Targets, including a commitment to protect 17% of terrestrial and freshwater and 10% of marine areas by 2020. In the 2018 federal budget, the Government of Canada responded to national calls to prioritize conservation and committed $1.3 billion to conservation (Government of Canada, 2018). Arctic regions are experiencing some of the most pronounced and drastic effects of global environmental changes, with implications for wildlife and human communities and it has been recognized that conservation of Arctic ecosystems is key for Canadian biodiversity (ACIA, 2005; de March et al., 1998; Huntington, 2009; IPCC, 2007).

These conservation challenges highlight the need for meaningful and effective ways for academics, local communities, and decision-makers to work together in knowledge production processes. Solutions to conservation challenges will be stronger when those solutions address the needs of both human and ecological communities. In particular, conservation actions will be enhanced when they consider the social-ecological dimensions of environmental problems within the context of local community needs. I argue that this research can contribute to our ability to address this need by exploring the potential benefits of one approach to knowledge generation and application. Knowledge co-production blurs the boundaries between actors and can help create connections between local resource users, researchers, policy-makers, and managers, who all have important roles to play in the management and conservation of wildlife and landscapes into the future.

Bibliography

ACIA. (2005). *Arctic Climate Impact Assessment*. Cambridge, UK: Cambridge University Press.

Agrawal, A. (1995). Dismantling the Divide between Indigenous and Scientific Knowledge. *Development and Change, 26*(3), 413-439.

Armitage, D. (2005). Collaborative environmental assessment in the Northwest Territories, Canada. *Environmental Impact Assessment Review, 25*(3), 239-258. doi:10.1016/j.eiar.2004.06.012

Armitage, D., Berkes, F., Dale, A., Kocho-Schellenberg, E., & Patton, E. (2011). Co-management and the co-production of knowledge: Learning to adapt in Canada's Arctic. *Global Environmental Change, 21*(3), 995-1004. doi:10.1016/j.gloenvcha.2011.04.006

Armitage, P., & Kilburn, S. (2015). *Conduct of Traditional Knowledge Research—A Reference Guide*. Retrieved from Whitehorse, YT:

Association of Canadian Universities for Northern Studies. (2003). *Ethical Principles for the Conduct of Research in the North*. Retrieved from Ottawa:

Auerbach, C. F., & Silverstein, L. B. (2003). *Qualitative data: An introduction to coding and analysis*. New York: New York University Press.

Avila, I. C., Kaschner, K., & Dormann, C. F. (2018). Current global risks to marine mammals: Taking stock of the threats. *Biological Conservation, 221*, 44-58. doi:10.1016/j.biocon.2018.02.021

Balsiger, P. W. (2004). Supradisciplinary research practices: history, objectives and rationale. *Futures, 36*(4), 407-421. doi:10.1016/j.futures.2003.10.002

Bell, M. (2002). *Nunavut literacy development in the context of Inuit Qaujimajatuqanginnut (IQ) (Inuit Traditional Knowledge): A discussion paper*. Retrieved from Yellowknife: http://www.ilitaqsiniq.ca/sites/default/files/files/nunavut_literacy_development.pdf

Bellard, C., Bertelsmeier, C., Leadley, P., Thuiller, W., & Courchamp, F. (2012). Impacts of climate change on the future of biodiversity. *Ecology Letters, 15*(4), 365-377. doi:10.1111/j.1461-0248.2011.01736.x

Beltran, J. (Ed.) (2000). *Indigenous and Traditional Peoples and Protected Areas: Principles, Guidelines and Case Studies*. Gland, Switzerland and Cambridge, UK: IUCN and WWF International.

Berkes, F. (2009). Indigenous ways of knowing and the study of environmental change. *Journal of the Royal Society of New Zealand, 39*(4), 151-156.

Berkes, F. (2017). Environmental Governance for the Anthropocene? Social-Ecological Systems, Resilience, and Collaborative Learning. *Sustainability, 9*(7). doi:10.3390/su9071232

Brubacher Development Strategies Inc. (2004). *An Overview of Nunavut Fisheries*. Retrieved from Ottawa: http://www.nunavuteconomicforum.ca/public/files/library/FISHERIE/An%20Overview%20of%20Nunavut%20Fisheries%20(March%202004).pdf

Brunet, N. D., Hickey, G. M., & Humphries, M. M. (2014a). The evolution of local participation and the mode of knowledge production in Arctic research. *Ecology and Society, 19*(2). doi:10.5751/es-06641-190269

Brunet, N. D., Hickey, G. M., & Humphries, M. M. (2014b). Understanding community-researcher partnerships in the natural sciences: A case study from the Arctic. *Journal of Rural Studies, 36*, 247-261. doi:10.1016/j.jrurstud.2014.09.001

Bryman, A., & Teevan, J. J. (2005). *Social Research Methods* (Canadian ed.). Don Mills, Ontario: Oxford University Press.

Buckham, M. (2013). *Barriers and Facilitators to Indigenous Knowledge Incorporation in Policy Making: The Nunatsiavut Case.* (M.A.), Trent University, Peterborough, ON.

Canadian Ice Service. (2017). *Regional Ice Analysis: Hudson Bay*.

Canadian Science Advisory Secretariat. (2008). *Cumberland Sound Greenland Halibut (Turbot) Inshore FIshery*. (Science Advisory Report 2008/040).

Carew, A. L., & Wickson, F. (2010). The TD Wheel: A heuristic to shape, support and evaluate transdisciplinary research. *Futures, 42*(10), 1146-1155.

Chambellant, M., Stirling, I., Gough, W. A., & Ferguson, S. H. (2012). Temporal variations in Hudson Bay ringed seal (Phoca hispida) life-history parameters in relation to environment. *Journal of Mammalogy, 93*(1), 267-281. doi:Doi 10.1644/10-Mamm-a-253.1

Cheung, W. W. L., Lam, V. W. Y., Sarmiento, J. L., Kearney, K., Watson, R., & Pauly, D. (2009). Projecting global marine biodiversity impacts under climate change scenarios. *Fish and Fisheries, 10*(3), 235-251. doi:10.1111/j.1467-2979.2008.00315.x

Christie, P. (2012). Climate change opens up Arctic fisheries – but should Canada cut bait? *The Globe and Mail*. Retrieved from http://www.theglobeandmail.com/news/national/climate-change-opens-up-arctic-fisheries-but-should-canada-cut-bait/article4431852/?page=all

Commision Decision C(2015) 5253 of 30 July 2015, (2015).

Cormier-Salem, M.-C. (2014). Participatory governance of Marine Protected Areas: a political challenge, an ethical imperative, different trajectories. *Sapiens, 7*(2).

Creswell, J. W., & Creswell, J. D. (2018). *Research Design: Qualitative, Quantitative, and Mixed Methods Approaches* (5th ed.). Thousand Oaks, California: SAGE Publications, Inc.

Creswell, J. W., & Poth, C. N. (2018). *Qualitative Inquiry and Research Design: Choosing Among Five Approaches* (4th ed.). Thousand Oaks, California: SAGE Publications, Inc.

Dale, A., & Armitage, D. (2011). Marine mammal co-management in Canada's Arctic: Knowledge co-production for learning and adaptive capacity. *Marine Policy, 35*(4), 440-449. doi:10.1016/j.marpol.2010.10.019

Davidson-Hunt, I. J., & Michael O'Flaherty, R. (2007). Researchers, Indigenous Peoples, and Place-Based Learning Communities. *Society & Natural Resources, 20*(4), 291-305. doi:10.1080/08941920601161312

de March, B. G. E., de Wit, C. A., & Muir, D. C. G. (1998). Persistent Organic Pollutants. In AMAP (Ed.), *AMAP Assessment Report: Arctic Pollution Issues* (pp. xii+859). Oslo, Norway: Arctic Monitoring and Assessment Programme (AMAP).

De Weger, E., Van Vooren, N., Luijkx, K. G., Baan, C. A., & Drewes, H. W. (2018). Achieving successful community engagement: a rapid realist review. *BMC Health Serv Res, 18*(1), 285. doi:10.1186/s12913-018-3090-1

Dennard, S. T., MacNeil, M. A., Treble, M. A., Campana, S., & Fisk, A. T. (2009). Hierarchical analysis of a remote, Arctic, artisanal longline fishery. *ICES Journal of Marine Science, 67*(1), 41-51. doi:10.1093/icesjms/fsp220

Department of Executive and Intergovernmental Affairs. (2015). European Union approves exemption for Nunavut seal hunt. *Government of Nunavut*. Retrieved from http://www.gov.nu.ca/eia/news/european-union-approves-exemption-nunavut-seal-hunt

Derocher, A. E., Lunn, N. J., & Stirling, I. (2004). Polar bears in a warming climate. *Integr Comp Biol, 44*(2), 163-176. doi:10.1093/icb/44.2.163

DeWalt, K., & DeWalt, B. (2002). *Participant observation: a guide for fieldworkers*. Walnut Creek, California: Altimira Press.

Diduck, A., Bankes, N., Clark, D., & Armitage, D. (2005). Unpacking social learning in social–ecological systems: case studies

of polar bear and narwhal management in northern Canada. In F. Berkes, R. Huebert, H. Fast, M. Manseau, & A. Diduck (Eds.), *Breaking ice : renewable resource and ocean management in the Canadian north*: University of Calgary Press.

Diver, S. (2017). Negotiating Indigenous knowledge at the science-policy interface: Insights from the Xáxli'p Community Forest. *Environmental Science & Policy, 73*, 1-11. doi:10.1016/j.envsci.2017.03.001

Doerr, E. D., Dorrough, J., Davies, M. J., Doerr, V. A. J., & McIntyre, S. (2015). Maximizing the value of systematic reviews in ecology when data or resources are limited. *Austral Ecology, 40*(1), 1-11.

Doubleday, Z. A., & Connell, S. D. (2017). Publishing with Objective Charisma: Breaking Science's Paradox. *Trends Ecol Evol, 32*(11), 803-805. doi:10.1016/j.tree.2017.06.011

Dowsley, M., & Wenzel, G. (2008). "The Time of the Most Polar Bears": A co-management conflict in Nunavut. *Arctic, 61*(2), 177-189.

Earnscliffe Strategy Group. (2017). *National Conservation Survey*. Retrieved from https://earnscliffe.ca/wp-content/uploads/2017/11/National-Conservation-Survey.pdf

Einsiedel, E. F., Boyd, A. D., Medlock, J., & Ashworth, P. (2013). Assessing socio-technical mindsets: Public deliberations on carbon capture and storage in the context of energy sources and climate change. *Energy Policy, 53*, 149-158. doi:10.1016/j.enpol.2012.10.042

Elzinga, A. (2008). Participation. In G. Hirsch Hadorn, H. Hoffmann-Riem, S. Biber-Klemm, W. Grossenbacher-Mansuy, D. Joye, C. Pohl, U. Wiesmann, & E. Zemp (Eds.), *Handbook of Transdisciplinary Research*: Springer Science.

Favaro, B., Claar, D. C., Fox, C. H., Freshwater, C., Holden, J. J., Roberts, A., & Derby, U. V. R. (2014). Trends in extinction risk for imperiled species in Canada. *Plos One, 9*(11), e113118. doi:10.1371/journal.pone.0113118

Fernandez-Gimenez, M. E., Huntington, H. P., & Frost, K. J. (2006). Integration or co-optation? Traditional knowledge and science in the Alaska Beluga Whale Committee. *Environmental Conservation, 33*(4), 306-315.

Fisheries and Oceans Canada. (2006). *Fishery Management Plan: Greenland Halibut* Winnipeg, MB.

Fleck, L. (1981). Genesis and Development of a Scientific Fact. In T. J. Trenn & R. K. Merton (Eds.). Chicago: University of Chicago Press.
Franzoni, C., & Sauermann, H. (2014). Crowd science: The organization of scientific research in open collaborative projects. *Research Policy, 43*(1), 1-20.
Furgal, C. M., Garvin, T. D., & Jardine, C. G. (2010). Trends in the study of Aboriginal health risks in Canada. *International Journal of Circumpolar Health, 69*(4).
Furgal, C. M., Kovacs, K. M., & Innes, S. (1996). Characteristics of ringed seal, Phoca hispida, subnivean structures and breeding habitat and their effects on predation. *Canadian Journal of Zoology, 74*(5), 858-874. doi:10.1139/z96-100
Gaden, A., Ferguson, S. H., Harwood, L., Melling, H., Alikamik, J., & Stern, G. A. (2012). Western Canadian Arctic ringed seal organic contaminant trends in relation to sea ice break-up. *Environ Sci Technol, 46*(8), 4427-4433. doi:10.1021/es204127j
Gearheard, S., & Shirley, J. (2007). Challenges in community-research relationships: Learning from natural science in Nunavut. *Arctic, 60*(1), 62-74.
George, J. (2009). Baffin hunters threaten revolt over Nunavut government polar bear quotas. *Nunatsiaq News*. Retrieved from http://www.nunatsiaqonline.ca/stories/article/973_baffin_hunters_threaten_revolt_over_nunavut_bear_quotas/
Gibbons, M., Limoges, C., Nowotny, H., Schwartzman, S., Scott, P., & Trow, M. (1994). *The New Production of Knowledge: The New Dynamics of Science and Research in Contemporary Societies*. Stockholm: Sage Publications Ltd.
Gill, M. J., Crane, K., Hindrum, R., Arneberg, P., Bysveen, I., Denisenko, N. V., . . . Watkins, J. (2011). *Arctic Marine Biodiversity Monitoring Plan (CBMP-MARINE PLAN)*. Retrieved from Akureyri, Iceland:
Godemann, J. (2008). Knowledge integration: a key challenge for transdisciplinary cooperation. *Environmental Education Research, 14*(6), 625-641. doi:10.1080/13504620802469188
Government of Canada. (2018). *Budget 2018*. Retrieved from https://www.budget.gc.ca/2018/docs/plan/toc-tdm-en.html
Government of Nunavut. (n.d.). Nunavut Economy. Retrieved from http://www.gov.nu.ca/eia/documents/nunavut-economy
Halpern, J. M., & Christie, L. (1990). TEMPORAL CONSTRUCTS AND "ADMINISTRATIVE DETERMINISM": A CASE STUDY FROM THE CANADIAN ARCTIC. *Anthropologica, 32*(2), 147-165.
Harwood, L. A., Smith, T. G., & Melling, H. (2000). Variation in reproduction and body condition of the ringed seal (Phoca hispida) in western Prince Albert Sound, NT, Canada, as assessed through a harvest-based sampling program. *Arctic, 53*(4), 422-431.
Harwood, L. A., Smith, T. G., Melling, H., Alikamik, J., & Kingsley, M. C. S. (2012). Ringed Seals and Sea Ice in Canada's Western Arctic: Harvest-Based Monitoring 1992 – 2011. *Arctic, 65*, 377-390.
Head, B. W., & Alford, J. (2013). Wicked Problems. *Administration & Society, 47*(6), 711-739. doi:10.1177/0095399713481601
Heberlein, T. A. (2012). Navigating environmental attitudes. *Conserv Biol, 26*(4), 583-585. doi:10.1111/j.1523-1739.2012.01892.x

Hegger, D., Lamers, M., Van Zeijl-Rozema, A., & Dieperink, C. (2012). Conceptualising joint knowledge production in regional climate change adaptation projects: success conditions and levers for action. *Environmental Science & Policy, 18*, 52-65. doi:10.1016/j.envsci.2012.01.002

Higgins, J. P. T., & Green, S. (Eds.). (2011). *Cochrane Handbook for Systematic Reviews of Interventions* (Version 5.1.0 ed.): The Cochrane Collaboration.

Hirsch Hadorn, G., Biber-Klemm, S., Grossenbacher-Mansuy, W., Hoffmann-Riem, H., Joye, D., Pohl, C., . . . Zemp, E. (2008). The Emergence of Transdisciplinarity as a Form of Research. In G. Hirsch Hadorn, H. Hoffmann-Riem, S. Biber-Klemm, W. Grossenbacher-Mansuy, D. Joye, C. Pohl, U. Wiesmann, & E. Zemp (Eds.), *Handbook of Transdisciplinary Research*: Springer Science.

Hirsch Hadorn, G., Hoffmann-Riem, H., Biber-Klemm, S., Grossenbacher-Mansuy, W., Joye, D., Pohl, C., . . . Zemp, E. (Eds.). (2008). *Handbook of Transdisciplinary Research*: Springer Science.

Hirsch, S. F. (2002). The power of participation: Language and gender in Tanzanian law reform campaigns. *Africa Today, 49*(2), 51-75.

Hiscock, P. (2013). *NWMB Submission: CSTMA - Inshore Fishing Boundary*. Retrieved from

Hoffmann-Riem, H., Biber-Klemm, S., Grossenbacher-Mansuy, W., Hirsch Hadorn, G., Joye, D., Pohl, C., . . . Zemp, E. (2008). Idea of the Handbook. In G. Hirsch Hadorn, H. Hoffmann-Riem, S. Biber-Klemm, W. Grossenbacher-Mansuy, D. Joye, C. Pohl, U. Wiesmann, & E. Zemp (Eds.), *Handbook of Transdisciplinary Research*: Springer Science.

Horlick-Jones, T., & Sime, J. (2004). Living on the border: knowledge, risk and transdisciplinarity. *Futures, 36*(4), 441-456. doi:10.1016/j.futures.2003.10.006

Hsieh, H. F., & Shannon, S. E. (2005). Three approaches to qualitative content analysis. *Qual Health Res, 15*(9), 1277-1288. doi:10.1177/1049732305276687

Huntington, H. P. (1998). Observations on the utility of the semi-directive interview for documenting traditional ecological knowledge. *Arctic, 51*(3), 237-242.

Huntington, H. P. (2000). Using Traditional Ecological Knowledge in science: Methods and applications. *Ecological Applications, 10*(5), 1270-1274.

Huntington, H. P. (2005). "We dance around in a ring and suppose": Academic engagement with traditional knowledge. *Arctic Anthropology, 42*(1), 29-32.

Huntington, H. P. (2009). A preliminary assessment of threats to arctic marine mammals and their conservation in the coming decades. *Marine Policy, 33*(1), 77-82. doi:10.1016/j.marpol.2008.04.003

Huntington, H. P., Brown-Schwalenberg, P. K., Frost, K. J., Fernandez-Gimenez, M., Norton, D. W., & Rosenberg, D. H. (2002). Observations on the workshop as a means of improving communication between holders of traditional and scientific knowledge. *Environmental Management, 30*(6), 778-792. doi:10.1007/s00267-002-2749-9

Hussey, N. E., Hedges, K. J., Barkley, A. N., Treble, M. A., Peklova, I., Webber, D. M., . . . Fisk, A. T. (2017). Movements of a deep-water fish: establishing marine fisheries management boundaries in coastal Arctic waters. *Ecol Appl, 27*(3), 687-704. doi:10.1002/eap.1485

Hussey, N. E., Kessel, S. T., Aarestrup, K., Cooke, S. J., Cowley, P. D., Fisk, A. T., . . . Whoriskey, F. G. (2015). ECOLOGY. Aquatic animal telemetry: A panoramic window into the underwater world. *Science, 348*(6240), 1255642. doi:10.1126/science.1255642

Idrobo, C. J., & Berkes, F. (2012). Pangnirtung Inuit and the Greenland Shark: Co-producing Knowledge of a Little Discussed Species. *Human Ecology, 40*(3), 405-414.

Inuit Tapiriit Kanatami. (2018). National Inuit Strategy on Research. In: Inuit Tapiriit Kanatami.

IPCC. (2007). *Intergovernmental Panel on Climate Change, Climate Change 2007, Synthesis Report*. Cambridge, UK: Cambridge University Press.

IPCC. (2014). Climate Change 2014: Impacts, Adaptation, and Vulnerability. Part A: Global and Sectoral Aspects. Contribution of Working Group II to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change. In C. B. Field, V. R. Barros, D. J. Dokken, K. J. Mach, M. D. Mastrandrea, T. E. Bilir, M. Chatterjee, K. L. Ebi, Y. O. Estrada, R. C. Genova, B. Girma, E. S. Kissel, A. N. Levy, S. MacCracken, P. R. Mastrandrea, & L. L. White (Eds.). Cambridge, United Kingdom and New York, NY, USA: Cambridge University Press.

Irvin, R. A., & Stansbury, J. (2004). Citizen Participation in Decision Making: Is It Worth the Effort? *Public Administration Review, 64*(1), 55-65. doi:10.1111/j.1540-6210.2004.00346.x

Jahn, T., & Keil, F. (2015). An actor-specific guideline for quality assurance in transdisciplinary research. *Futures, 65*, 195-208.

Johnson, B., & Christensen, L. (2008). *Educational research: quantitative, qualitative, and mixed qpproaches*. Thousand Oaks, California: Sage Publications.

Joint Seretariat. (2015). *Inuvialuit and Nanuq: A Polar Bear Traditional Knowledge Study*. Retrieved from

Jones, A., Barnett, B., Williams, A. J., Grayson, J., Busilacchi, S., Duckworth, A., . . . Murchie, C. D. (2008). Effective communication tools to engage Torres Strait Islanders in scientific research. *Continental Shelf Research, 28*(16), 2350-2356. doi:10.1016/j.csr.2008.03.027

Kemp, R., & Rotmans, J. (2009). Transitioning policy: co-production of a new strategic framework for energy innovation policy in the Netherlands. *42*(4), 303-322.

Kingsley, M. C. S. (1990). Status of the Ringed Seal, Phoca-Hispida, in Canada. *Canadian Field-Naturalist, 104*(1), 138-145.

Kingsley, M. C. S., Stirling, I., & Calvert, W. (1985). The Distribution and Abundance of Seals in the Canadian High Arctic, 1980-82. *Canadian Journal of Fisheries and Aquatic Sciences, 42*(6), 1189-1210.

Klein, J. T. (2004). Prospects for transdisciplinarity. *Futures, 36*(4), 515-526. doi:10.1016/j.futures.2003.10.007

Klein, J. T. (2006). Afterword: the emergent literature on interdisciplinary and transdisciplinary research evaluation. *Research Evaluation, 15*(1), 75-80.

Klein, J. T. (2014). Discourses of transdisciplinarity: Looking Back to the Future. *Futures, 63*, 68-74. doi:10.1016/j.futures.2014.08.008

Kohlbacher, F. (2006). The Use of Qualitative Content Analysis in Case Study Research. *Forum: Qualitative Social Research, 7*(1).

Kovacs, K. M. (2013). *Circumpolar Ringed Seal (Pusa hispida) Monitoring: CAFF's Ringed Seal Monitoring Network*. Retrieved from Tromsø:
Kovic, B. (2014). *Nunavut Wildlife Management Board's reconsideration and final decision regarding Pangnirtung Hunters and Trappers Organization's proposal to move the Cumberland Sound Turbot Management Area boundary line*. Nunavut Wildlife Management Board.
Kulchyski, P., & Tester, F. J. (2007). *Kiumajut (Talking Back)*. Vancouver: UBC Press.
Laidre, K. L., Stirling, I., Lowry, L. F., Wiig, O., Heide-Jorgensen, M. P., & Ferguson, S. H. (2008). Quantifying the sensitivity of Arctic marine mammals to climate-induced habitat change. *Ecol Appl, 18*(2 Suppl), S97-125.
Lichtenstein, A. H., Yetley, E. A., & Lau, J. (2008). Application of Systematic Review Methodology to the Field of Nutrition. *The Journal of Nutrition, 138*(12), 2297-2306.
Lortie, C. J. (2014). Formalized synthesis opportunities for ecology: systematic reviews and meta-analyses. *Oikos, 123*(8), 897-902.
Lynch, A. J., Thackway, R., Specht, A., Beggs, P. J., Brisbane, S., Burns, E. L., . . . Waycott, M. (2015). Transdisciplinary synthesis for ecosystem science, policy and management: The Australian experience. *Sci Total Environ, 534*, 173-184. doi:10.1016/j.scitotenv.2015.04.100
MacNeil, M. A., Graham, N. A., Cinner, J. E., Dulvy, N. K., Loring, P. A., Jennings, S., . . . McClanahan, T. R. (2010). Transitional states in marine fisheries: adapting to predicted global change. *Philos Trans R Soc Lond B Biol Sci, 365*(1558), 3753-3763. doi:10.1098/rstb.2010.0289
Maffi, L. (2005). Linguistic, cultural, and biological diversity. In *Annual Review of Anthropology* (Vol. 34, pp. 599-617). Palo Alto: Annual Reviews.
Max-Neef, M. A. (2005). Foundations of transdisciplinarity. *Ecological Economics, 53*(1), 5-16. doi:10.1016/j.ecolecon.2005.01.014
McCarney, P., Thiemann, G. W., Furgal, C. M., & Ferguson, S. (2014). *Ringed Seal Monitoring and Planning Workshop Report*. York University. Retrieved from http://yorkspace.library.yorku.ca/xmlui/handle/10315/31615
Moher, D., Liberati, A., Tetzlaff, J., & Altman, D. G. (2009). Preferred Reporting Items for Systematic Reviews and Meta-Analyses: The PRISMA Statement. *PLoS Med, 6*(7). doi:10.1371/journal.pmed.1000097
Moher, D., Shamseer, L., Clarke, M., Ghersi, D., Liberati, A., Petticrew, M., . . . Stewart, L. A. (2015). Preferred reporting items for systematic review and meta-analysis protocols (PRISMA-P) 2015 statement. *Syst Rev, 4*(1). doi:10.1186/2046-4053-4-1
Mößner, N. (2011). Thought Styles and Paradigms---A Comparative Study of Ludwik Fleck and Thomas S. Kuhn. *Studies in History and Philosophy of Science, 42*, 362-371.
Nadasdy, P. (2003). Reevaluating the co-management success story. *Arctic, 56*(4), 367-380.
Nel, J. L., Roux, D. J., Driver, A., Hill, L., Maherry, A. C., Snaddon, K., . . . Reyers, B. (2016). Knowledge co-production and boundary work to promote implementation of conservation plans. *Conserv Biol, 30*(1), 176-188. doi:10.1111/cobi.12560
Nowotny, H. (2003). Democratising expertise and socially robust knowledge. *30*(3), 151-156.

NSIDC. (2014). *Arctic sea ice reaches minimum extent for 2014*. Retrieved from Boulder, CO: http://nsidc.org/arcticseaicenews/2014/09/

Nunavut Wildlife Management Board. (2013). Minutes: Regular Meeting No. RM 002-2013, Rankin Inlet, June 11, 2013. In.

Nunavut Wildlife Management Board. (2015). *Nunavut Polar Bear Co-Management Plan*. Retrieved from

Organ, J., Geist, V., & Mahoney, S. P. (2001). *Why hunting has defined the North American Model of Wildlife Conservation* (Vol. 66).

Peklova, I., Hussey, N. E., Hedges, K. J., Treble, M. A., & Fisk, A. T. (2012). Depth and temperature preferences of the deepwater flatfish Greenland halibut Reinhardtius hippoglossoides in an Arctic marine ecosystem. *Marine Ecology Progress Series, 467*, 193-205.

Pereira, H. M., Leadley, P. W., Proenca, V., Alkemade, R., Scharlemann, J. P. W., Fernandez-Manjarres, J. F., . . . Walpole, M. (2010). Scenarios for Global Biodiversity in the 21st Century. *Science, 330*(6010), 1496-1501. doi:10.1126/science.1196624

Perovich, D., Gerland, S., Hendricks, S., Meier, W., Nicolaus, M., & Tschudi, M. (2014). Sea Ice. In M. O. Jeffries, J. Richter-Menge, & J. E. Overland (Eds.), *Arctic Report Card 2014*.

Pettit, J. (2012). Getting to Grips with Power: Action Learning for Social Change in the UK. *Ids Bulletin-Institute of Development Studies, 43*(3), 11-26.

Pimm, S. L., Jenkins, C. N., Abell, R., Brooks, T. M., Gittleman, J. L., Joppa, L. N., . . . Sexton, J. O. (2014). The biodiversity of species and their rates of extinction, distribution, and protection. *Science, 344*(6187), 987-+. doi:10.1126/science.1246752

Pohl, C. (2005). Transdisciplinary collaboration in environmental research. *Futures, 37*(10), 1159-1178. doi:10.1016/j.futures.2005.02.009

Pohl, C. (2008). From science to policy through transdisciplinary research. *Environmental Science & Policy, 11*(1), 46-53.

Pohl, C., Rist, S., Zimmermann, A., Fry, P., Gurung, G. S., Schneider, F., . . . Wiesmann, U. (2010). Researchers' roles in knowledge co-production: experience from sustainability research in Kenya, Switzerland, Bolivia and Nepal. *Science and Public Policy, 37*(4), 267-281. doi:10.3152/030234210x496628

Pohl, C., van Kerkhoff, L., Hirsch Hadorn, G., & Bammer, G. (2008). Integration. In G. Hirsch Hadorn, H. Hoffmann-Riem, S. Biber-Klemm, W. Grossenbacher-Mansuy, D. Joye, C. Pohl, U. Wiesmann, & E. Zemp (Eds.), *Handbook of Transdisciplinary Research*: Springer Science.

Rathwell, K. J., Armitage, D., & Berkes, F. (2015). Bridging knowledge systems to enhance governance of the environmental commons: A typology of settings. *International Journal of the Commons, 9*(2), 851-880. doi:10.18352/ijc.584

Raymond, C. M., Fazey, I., Reed, M. S., Stringer, L. C., Robinson, G. M., & Evely, A. C. (2010). Integrating local and scientific knowledge for environmental management. *Journal of Environmental Management, 91*(8), 1766-1777.

Reed, M. G., & Abernethy, P. (2017). Facilitating Co-Production of Transdisciplinary Knowledge for Sustainability: Working with Canadian Biosphere Reserve Practitioners. *Society & Natural Resources, 31*(1), 39-56. doi:10.1080/08941920.2017.1383545

Reeves, R. (1998). Distribution, abundance and biology of ringed seals (Phoca hispida): an overview. *NAMMCO Scientific Publications, 1*, 9-45.
Regulation (EC) No 1007/2009 of the European Parliament and of the Council of 16 September 2009 on trade in seal products, (2009).
Reid, W., Berkes, F., Wilbanks, T., & Capistrano, D. (Eds.). (2006). *Bridging Scales and Knowledge Systems: Concepts and Applications in Ecosystem Assessment*. Washington, DC: Island Press.
Russell, A. W., Wickson, F., & Carew, A. L. (2008). Transdisciplinarity: Context, contradictions and capacity. *Futures, 40*(5), 460-472. doi:10.1016/j.futures.2007.10.005
Ryan, G. W., & Bernard, H. R. (2016). Techniques to Identify Themes. *Field Methods, 15*(1), 85-109. doi:10.1177/1525822x02239569
Saldana, J. (2009). *Coding Manual for Qualitative Researchers*: SAGE Publications.
Samaddar, S., Okada, N., Choi, J., & Tatano, H. (2016). What constitutes successful participatory disaster risk management? Insights from post-earthquake reconstruction work in rural Gujarat, India. *Natural Hazards, 85*(1), 111-138. doi:10.1007/s11069-016-2564-x
Sardar, Z. (2010). The Namesake: Futures; futures studies; futurology; futuristic; foresight—What's in a name? *Futures, 42*(3), 177-184. doi:10.1016/j.futures.2009.11.001
Siew, T. F., Aenis, T., Spangenberg, J. H., Nauditt, A., Döll, P., Frank, S. K., . . . Wang, J. (2016). Transdisciplinary research in support of land and water management in China and Southeast Asia: evaluation of four research projects. *Sustainability Science, 11*(5), 813-829. doi:10.1007/s11625-016-0378-0
Simon, M. (2017). *A New Shared Arctic Leadership Model*. Indigenous and Northern Affairs Retrieved from https://www.aadnc-aandc.gc.ca/eng/1492708558500/1492709024236.
Simpkins, M., Kovacs, K. M., Laidre, K., & Lowry, L. (2009). *A Framework for Monitoring Arctic Marine Mammals - Findings of a Workshop Sponsored by the U.S. Marine Mammal Commission and U.S. Fish and Wildlife Service, Valencia, March 2007*. Retrieved from
Southcott, C. (Ed.) (2015). *Northern Communities Working Together: The Social Economy of Canada's North*. Toronto: University of Toronto Press.
Stevenson, M. G. (1996). Indigenous knowledge in environmental assessment. *Arctic, 49*(3), 278-291.
Stirling, I. (1973). Vocalization in the Ringed Seal (Phoca hispida). *Journal of the Fisheries Research Board of Canada, 30*(10), 1592-1594.
Stirling, I. (1997). The importance of polynyas, ice edges, and leads to marine mammals and birds. *Journal of Marine Systems, 10*(1-4), 9-21. doi:Doi 10.1016/S0924-7963(96)00054-1
Stirling, I. (2005). Reproductive rates of ringed seals and survival of pups in Northwestern Hudson Bay, Canada, 1991-2000. *Polar Biology, 28*(5), 381-387. doi:Doi 10.1007/S00300-004-0700-7
Stirling, I., & Parkinson, C. L. (2006). Possible effects of climate warming on selected populations of polar bears (Ursus maritimus) in the Canadian Arctic. *Arctic, 59*(3), 261-275.
Tester, F. J., & Irniq, P. (2008). Inuit Qaujimajatuqangit: Social History, Politics and the Practice of Resistance. *Arctic, 61*, 48-61.

TheStar.com. (2010). Nunavut cuts quota for polar bear hunt. *The Toronto Star*. Retrieved from http://www.thestar.com/news/canada/2010/03/06/nunavut_cuts_quota_for_polar_bear_hunt.html

Tregidgo, D. J., West, S. E., & Ashmore, M. R. (2013). Can citizen science produce good science? Testing the OPAL Air Survey methodology, using lichens as indicators of nitrogenous pollution. *Environmental Pollution, 182*, 448-451.

Tulloch, A. I. T., Possingham, H. P., Joseph, L. N., Szabo, J., & Martin, T. G. (2013). Realising the full potential of citizen science monitoring programs. *Biological Conservation, 165*, 128-138.

Usher, P. J. (2000). Traditional ecological knowledge in environmental assessment and management. *Arctic, 53*(2), 183-193.

van den Scott, L. J. (2012). Science, politics, and identity in northern research ethics licensing. *J Empir Res Hum Res Ethics, 7*(1), 28-36. doi:10.1525/jer.2012.7.1.28

van Parijs, S. M., Lydersen, C., & Kovacs, K. M. (2003). Vocalizations and movements suggest alternative mating tactics in male bearded seals. *Animal Behaviour, 65*(2), 273-283. doi:10.1006/anbe.2003.2048

Victor, L. (2008). Systematic Reviewing. *Social Research Update*(54), 1-4.

Vlasova, T., & Volkov, S. (2016). Towards transdisciplinarity in Arctic sustainability knowledge co-production: Socially-Oriented Observations as a participatory integrated activity. *Polar Science, 10*(3), 425-432. doi:10.1016/j.polar.2016.06.002

Vogt, E. E., Brown, J., & Isaacs, D. (2003). *The Art of Powerful Questions: Catalyzing Insight, Innovation, and Action*. Mill Valley, California: Whole Systems Associate.

Wassmann, P., Duarte, C. M., Agusti, S., & Sejr, M. K. (2011). Footprints of climate change in the Arctic marine ecosystem. *Global Change Biology, 17*(2), 1235-1249. doi:Doi 10.1111/J.1365-2486.2010.02311.X

Wenzel, G. W. (2004). From TEK to IQ: Inuit Qaujimajatuqangit and Inuit cultural ecology. *Arctic Anthropology, 41*(2), 238-250.

White, G. (2006). Cultures in collision: Traditional knowledge and Euro-Canadian governance processes in northern land-claim boards. *Arctic, 59*(4), 401-414.

Wickson, F., Carew, A. L., & Russell, A. W. (2006). Transdisciplinary research: characteristics, quandaries and quality. *Futures, 38*(9), 1046-1059. doi:10.1016/j.futures.2006.02.011

World Wildlife Fund. (2017). *Living Planet Report Canada: A National Look at Wildlife Loss*. Retrieved from Toronto, Ontario: http://assets.wwf.ca/downloads/WEB_WWF_REPORT_v3.pdf?_ga=2.28371199.254787061.1524412057-1433142740.1524412057

Yin, R. K. (2014). *Case Study Research: Design and Methods* (5th ed.): SAGE Publications, Inc.

Appendix A: Evaluative Framework Data Tables

		Context for Knowledge Co-Production			
		Involves complex problems and considers the range of factors that comprise the nature of an issue	Involves both academic and societal perspectives	Aims to produce knowledge that will contribute to decision-making	Aimed at improving conditions in society for the common good
CASE	**SOURCE OF EVIDENCE**				
Kugaaruk	Document Review	NGMP Proposal, "Community-Based Monitoring of Ice-Breeding Seals and Polar Bear Feeding in the Gulf of Boothia", 2011	NGMP Proposal, "Community-Based Monitoring of Ice-Breeding Seals and Polar Bear Feeding in the Gulf of Boothia", 2011	NGMP Proposal, "Community-Based Monitoring of Ice-Breeding Seals and Polar Bear Feeding in the Gulf of Boothia", 2011	NGMP Proposal, "Community-Based Monitoring of Ice-Breeding Seals and Polar Bear Feeding in the Gulf of Boothia", 2011
	Interviews	Sections B4, C, D, F	Section F: 11, 12, 13, 14, 15, 16	Sections E, F: 5, 6, 7, 9, 10	
	Participant Observation				
Iqaluit	Document Review		Simpkins, M., Kovacs, K. M., Laidre, K., & Lowry, L. (2009). A Framework for Monitoring Arctic Marine Mammals - Findings of a Workshop Sponsored by the U.S. Marine Mammal Commission and U.S. Fish and Wildlife Service, Valencia, March 2007.	Kovacs, K. M. (2013). Circumpolar Ringed Seal (Pusa hispida) Monitoring: CAFF's Ringed Seal Monitoring Network.	Kovacs, K. M. (2013). Circumpolar Ringed Seal (Pusa hispida) Monitoring: CAFF's Ringed Seal Monitoring Network.

		Context for Knowledge Co-Production			
		Involves complex problems and considers the range of factors that comprise the nature of an issue	Involves both academic and societal perspectives	Aims to produce knowledge that will contribute to decision-making	Aimed at improving conditions in society for the common good
	Workshop Agenda / Transcripts / Flip Charts	B2.3, B2.4, B3.1, B3.3, B3.4	B1.1, B1.2, B1.3, B2.1, B3.3, B3.4, B3.6	B3.3, B3.7, B4.1, B4.2 Table 13 (of dissertation).	Table 13 (of dissertation)
	Participant Observation				
Pangnirtung	Document Review	Pew Marine Conservation Fellowship, "Empowering the people: Inuit fishermen working to understand and manage sustainable Arctic fisheries", 2015	Pew Marine Conservation Fellowship, "Empowering the people: Inuit fishermen working to understand and manage sustainable Arctic fisheries", 2015	Pew Marine Conservation Fellowship, "Empowering the people: Inuit fishermen working to understand and manage sustainable Arctic fisheries", 2015 Pangnirtung HTO - NWMB Submission: CSTMA Inshore Fishing Boundary (May 2013) Research proposal to Pangnirtung HTO (Jan 2017)	Pew Marine Conservation Fellowship, "Empowering the people: Inuit fishermen working to understand and manage sustainable Arctic fisheries", 2015
	Interviews (Scientists)	Questions: 2, 13	Questions: 3, 5, 7, 8, 9, 10, 12, 13	Question: 2	
	Meeting (Fishers)	Question: 2	Questions: 2, 4, 7, 9		

		Context for Knowledge Co-Production			
		Involves complex problems and considers the range of factors that comprise the nature of an issue	Involves both academic and societal perspectives	Aims to produce knowledge that will contribute to decision-making	Aimed at improving conditions in society for the common good
	Workshop Agenda / Transcripts / Flip Charts	Workshop #1: B1, B2, B3.2, B3.3	Workshop #1: B1, B2, B3.4, B3.5 Workshop #2	Workshop #1: B1, B3.1 Workshop #2	
	Participant Observation	HTO meeting, informal interactions with HTO staff.		HTO meeting, informal interactions with HTO staff.	

		Conditions of Knowledge Co-Production					
		Broadest possible actor coalition within limits present	Shared understanding of goals and problem definitions	Recognition of differences in actor perspectives	Organized reflection on division of tasks by actors	Role of researchers and research-based knowledge is clear	Presence of reward structures
CASE	**SOURCE OF EVIDENCE**						
Kugaaruk	Document Review	NGMP Proposal, "Community-Based Monitoring of Ice-Breeding Seals and Polar Bear Feeding in the Gulf of Boothia", 2011		NGMP Proposal, "Community-Based Monitoring of Ice-Breeding Seals and Polar Bear Feeding in the Gulf of Boothia", 2011			NGMP Proposal, "Community-Based Monitoring of Ice-Breeding Seals and Polar Bear Feeding in the Gulf of Boothia", 2011
	Interviews	Section F: 2, 3, 9, 11, 15	Sections F: 1, 2, 15	Section F: 3, 5, 7, 8, 11, 12, 14, 15, 16	Section F: 2, 3, 9	Section F: 2, 9, 10	Section F: 6
	Participant Observation	Conversations with HTO staff and community liaison.	Community presentations.	Community presentations.		Informal interactions in community, community presentations.	Informal interactions in community, community presentations.
Iqaluit	Document Review						
	Workshop Agenda / Transcripts / Flip Charts						
	Participant Observation						

		Conditions of Knowledge Co-Production					
		Broadest possible actor coalition within limits present	Shared understanding of goals and problem definitions	Recognition of differences in actor perspectives	Organized reflection on division of tasks by actors	Role of researchers and research-based knowledge is clear	Presence of reward structures
Pangnirtung	Document Review	Pew Marine Conservation Fellowship, "Empowering the people: Inuit fishermen working to understand and manage sustainable Arctic fisheries", 2015	Pew Marine Conservation Fellowship, "Empowering the people: Inuit fishermen working to understand and manage sustainable Arctic fisheries", 2015	Pew Marine Conservation Fellowship, "Empowering the people: Inuit fishermen working to understand and manage sustainable Arctic fisheries", 2015			
	Interviews (Scientists)						
	Meeting (Fishers)						
	Workshop Agenda / Transcripts / Flip Charts	Workshop #1 Workshop #3	Workshop #1: B1.1, B1.2 Workshop #2	Workshop #1: B2.1, B2.2, B3.5 Workshop #2	Workshop #1: B2.4, B3.4 Workshop #3	Workshop #1: B3.1, B3.2 Workshop #3	Workshop #1: B3.4 Workshop #2
	Participant Observation	HTO meeting, informal interactions with HTO staff.	HTO meeting, informal interactions with scientists and HTO staff.	HTO meeting, informal interactions with scientists and HTO staff.	HTO meeting, informal interactions with scientists and HTO staff.	Informal interactions with community members.	

		Dimensions of Knowledge Co-Production				
		Knowledge gathering	Knowledge sharing	Knowledge integration	Knowledge interpretation	Knowledge application
CASE	**SOURCE OF EVIDENCE**					
Kugaaruk	Document Review					
	Interviews					
	Participant Observation					
Iqaluit	Document Review					
	Workshop Agenda / Transcripts / Flip Charts	B1.2, B1.3	B2.1, B2.2, B2.3, B2.4		B3.1, B3.2, B3.3, B3.4, B3.5, B3.6, B3.7	B4.1, B4.2 Table 13 (of dissertation)
	Participant Observation			Facilitation planning at end of Day 1.		
Pangnirtung	Document Review					
	Interviews (Scientists)					
	Meeting (Fishers)					
	Workshop Agenda / Transcripts / Flip Charts					
	Participant Observation					

		Challenges of Knowledge Co-Production		
		Role of power	Creating a shared understanding	Establishing a normative context
CASE	**SOURCE OF EVIDENCE**			
Kugaaruk	Document Review			
	Interviews			
	Participant Observation			
Iqaluit	Document Review			
	Workshop Agenda / Transcripts / Flip Charts		B1.1, B1.2, B1.3	Workshop opening. B1.1, B1.3
	Participant Observation	Arrangement of room (e.g. circular tables, tables distributed around room, community members prioritized). Community groups presented first.	We created time for questions after each presentation and facilitated discussion intended to clarify meanings.	
Pangnirtung	Document Review			
	Interviews (Scientists)			
	Meeting (Fishers)			
	Workshop Agenda / Transcripts / Flip Charts		B2.1, B2.2, B2.3	B1.1, B1.2
	Participant Observation	Organized workshop #1 so that community fishers had a lot of time to ask questions and direct the pace of discussion.	Time at workshop #1 for questions and answers of other participants.	Breakout sessions focused on main priorities and why participants hold these priorities.

Appendix B: Iqaluit Workshop Agenda

	Agenda	
Day 1 *March 6*	8:30-9:00	Welcome
	9:00-10:00	Community participant introductions Presentation: Paul Irngaut - NLCA, Inuit rights
	10:00-10:30	Research updates - Steve Ferguson – Community-based monitoring - Dave Yurkowski – Seal tagging
	10:30-10:45	Break
	10:45-11:30	*Breakout Session 1:* Knowledge priorities
	11:30-12:30	*Reporting Session:* What priorities do hunters / scientists have?
	12:30-1:30	Lunch
	1:30-2:00	Research updates - Derek Muir – Northern Contaminants Program - Manon Simard - Food safety - Pierre-Yves Daoust – Seal health
	2:00-2:45	*Breakout Session 2:* Communication and use of knowledge on ringed seals
	2:45-3:00	Break
	3:00-4:00	*Reporting Session:* Communicating effectively on ringed seals
	4:00-4:30	Closing

Day 2 *March 7*	8:30-8:50	*Day 1 Review:* Highlight of main questions & discussion points
	8:50-10:00	*Breakout Session 1:* What do hunters / scientists want to know?
		Breakout Session 2: What's next?
	10:00-10:15	Break
	10:15-11:30	*Reporting Session:* What's next for ringed seals in Nunavut?
	11:30-12:00	Closing Comments

Appendix C: Kugaaruk Interview Guide

A. Participant Attributes

1. When and where were you born?
2. How long have you lived in Kugaaruk?
   - Where did you live before?
   - How long did you live there?
3. Do you hunt?
   - If yes, move to Part B
   - If no, move to Part E

B. Hunter Attributes

1. How long have you been hunting? *(In Kugaaruk?)*
2. How often do you go hunting in [spring/summer/fall/winter]? How many times per week/month?
3. What animals do you hunt in [spring/summer/fall/winter]?
4. Why do you hunt seals?
   - *Probe:*
     - *What do you use them for?*
     - *Why is seal hunting important to you?*
     - *Why are seals important to you and your family?*
     - *Polar bears?*

C. Population Ecology and Habitat Use

Ask questions 1-15 for each season.

1. Where do you hunt seals in [spring/summer/fall/winter]?
   a. Can you please mark locations on a map?
2. What are [ringed/bearded] seals doing at this time of year?
   - *Probe:*
     - *Pupping*
     - *Basking*
     - *Mating*
     - *Feeding*
3. How are [ringed/bearded] seals distributed at this time of year?
   - *Probe:*
     - *Individually or in pairs in lairs?*
     - *Hauled out individually? In groups?*
     - *Separated by genders/age groups?*
4. What are the environmental conditions like where you find seals at this time of year?
   - Probe:
     - *Ice covered*
     - *Open water*

5. What is the ice like at this time of year?
6. How do you hunt seals at this time of year? What methods do you use?
7. Do you ever examine the stomach contents of seals at this time of year? Why do you do this?
8. What foods/species are seals eating at this time of year? How do you know?
9. How is seal body condition at this time of year (blubber thickness, fatness, etc.)?
10. Have you noticed any changes in seals in this season where you hunt them, since you began hunting?
    - *Probe:*
        - *Behaviour*
        - *Abundance*
        - *Diet*
        - *Health (e.g., signs of disease)*
11. What do you think caused the changes you noticed?
12. Where do you see polar bears at this time of year?
13. What are polar bears doing at this time of year?
    - *Probe:*
        - *Hunting*
        - *Mating*
        - *Traveling*
14. What species of seals do polar bears eat? How do you know?
    - *Probe:*
        - *Do both males and females each these species?*
        - *How are the hunting/feeding habits of males/females different?*
15. Has anything changed about how often you go hunting or where you go hunting or how you hunt for seals at this time of year since you started hunting around Kugaaruk?

GO BACK TO Q1 (repeat for next season until all seasons covered)

D. Changes in Wildlife

1. Have you noticed any times when seals were scarce in the areas you hunt? When (year, season)?
2. What do you think caused this?
3. Have you noticed any changes in interactions between polar bears and seals?
    - *Probe*:
        - *Eating habits*
        - *Interactions*
        - *Habitat uses*
4. Have sea ice conditions in the areas where you hunt changed over the years? How?

E. Perspectives on Sampling Project

1. Did you participate in seal sampling for this project?
    - If yes, move to 1
    - If no, move to 2

(If participant has participated in the project, use first set of questions; if he/she has not participated, use second set.)

1.

a. Why is the seal sampling project taking place? What is the goal of the project?
b. Why did you participate?
c. How many seals did you sample?
d. Was anything about the sampling or measurements you were asked to gather difficult? Why?
e. Would you participate in sample collection again? If not, explain.
f. Is there anything that can be done to make the sampling easier/better for you?
    - *Probe:*
        - *Timing (of study, of communication, etc.)*
        - *Communication*
        - *Materials (provided to hunters, information, etc.)*
g. How did you get involved in the project?
h. Why did you get involved?
i. How were the goals of the sampling project determined? Who set the goals?
j. Have you heard any of the results from the sampling program?
    a. What have you heard about the results? When did you hear about these? How did you hear about these?
k. What do you want to know from the results of the sampling project?
l. Would you participate in the sampling program if you were asked again (If no, explain)?
m. Do you think it is important/valuable for the sampling to occur? Why/why not?

2.

a. Do you know about the seal sampling project taking place in Kugaaruk?
b. What do you know about the sampling project? What is the goal of the project?
c. Why did you not participate in the project?
d. How did you hear about the sampling project?
e. What do you know about the researchers involved in the project?
f. How were the goals of the sampling project determined? Who set the goals?
g. What have you heard about the results? When did you hear about these?

F. Perspectives on Research

1. Can you tell me about the research on marine mammals that has taken place in Kugaaruk? (EFFECTIVENESS OF COMMUNICATION)
    - Probe:
        - *Have there been many projects in Kugaaruk in the past?*
        - *How many projects do you know of?*
        - *What kinds of research have been done?*
2. How have research priorities been determined? Who makes the decisions about what research will be done? (EFFECTIVENESS OF COMMUNITY INVOLVEMENT)
3. Can you tell me about the roles of community members/organizations in the research? (EFFECTIVENESS OF COMMUNITY INVOLVEMENT)
4. Have you ever been involved in research?
    - *Probe:*
        - *Participated in an interview*
        - *Focus group*

- *Survey*
- *Workshop*

5. Are there any specific research projects you know of or have participated in that you particularly liked or did not like? Identify the project, describe and explain. (PERCEPTION OF BENEFITS/RISKS)
6. Are there any positive benefits you think research has brought to your community? (PERCEPTION OF BENEFITS)
7. Do you have any concerns about research projects in your community? (PERCEPTION OF RISKS)
8. Is there anything you want to see changed about the way research is done? (CONCERNS ABOUT RESEARCH)
   - *Probe:*
     - *In setting research priorities*
     - *Specific questions*
     - *Communication*
     - *Community organizations that should be involved*
     - *Youth involvement*
9. Have you heard research results communicated back to the community? (EFFECTIVENESS OF COMMUNICATION)
   a. How have results been communicated? Who communicated them? How did you hear?
10. How do you want researchers to communicate results? (EFFECTIVENESS OF COMMUNICATION)
    - *Probe*:
      - *Specific methods to communicate*
      - *Where to find results*
      - *How often*
      - *What types of information do you need?*
11. What do you think is most important in building positive relationships between researchers and communities? (Q. 11-16: DEVELOPING A RESEARCH FRAMEWORK)
12. What values or principles guide your relationships with others?
    - *Probe*:
      - *Family members*
      - *Friends*
      - *Other relationships*
      - *Inuit relationships traditionally*
13. Where do these values come from? How did you learn them?
    - *Probe:*
      - *Childhood*
      - *Parents*
      - *Teachers*
      - *Religion*
      - *Cultural values*
14. How can these values guide interactions between researchers and community members?
15. Are there any key steps you think researchers should take when beginning research with the community?

What do you think researchers need to do throughout projects to ensure they maintain these values and relationships?

Appendix D: Pangnirtung Interview Guide (Scientist)

1. What do you do professionally? Why do you do it (why is that work important to you)?

2. What do you think the priorities are for the fishery currently? What do you think they should be?
    a. Management priorities, environmental health priorities, ecological/biological priorities, etc.
    b. Why do you think this?

3. What are <u>your</u> specific interests and priorities related to the fishery in Pangnirtung/Cumberland Sound (i.e. research or knowledge priorities)?
    a. Why are these your priorities?
    b. What does a healthy and sustainable fishery look like to you (give a general picture of the key characteristics)?
    c. How do you know that this is what defines a healthy and sustainable fishery (where does your knowledge on this come from)?

4. What information is needed to achieve these priorities?

5. How do you know this information is needed (what previous knowledge or experiences tell you that this information is needed)?

6. How would you get this information?

7. Who needs to be involved in generating this information?

8. What do you think your role is in pursuing these priorities/generating this knowledge about the fishery?

9. What is **<u>not</u>** your role in pursuing these priorities/generating this knowledge (what things need to be done but are not within your expertise or role you play in this process)?

10. What can you do in terms of contributing skills/resources to the community in pursuing these goals?

11. What can't or won't you do? Why not?

12. Other than yourself, does anyone else have a role in pursuing these priorities/generating this knowledge ? Who ? Why ?
    a. What role do you think the fishermen/ community members should have in helping achieve these priorities? Why?

13. Is it important for you to know or be aware of the priorities of fishermen in Pangnirtung? Why? (Why not?)

14. What do you think the priorities of the fishermen in Pangnirtung are related to the fishery?
    a. What makes you think these are priorities for them?
    b. Why do you think these priorities are important for them?

Appendix E: Pangnirtung Preliminary Meeting Guide (Fishers)

1. How are you involved in the fishery in Pangnirtung? What do you do? Why?

2. What are <u>your</u> specific interests and priorities related to the fishery in Pangnirtung/Cumberland Sound?
    a. What is most important to you for the fishery? What would you like to see happen with it? What concerns you about it? What would you like it to look like in 5 years?
    b. Why are these your priorities? How do you know these are priorities?

3. What information is needed to achieve these priorities?

4. How do you know this information is needed (what previous knowledge or experiences tell you that this information is needed)?

5. How would you get this information?

6. Who needs to be involved in generating this information?

7. What do you think your role is in pursuing these priorities/generating this knowledge about the fishery?
    a. What is the role of fishermen/harvesters in Pangnirtung in general?
    b. What can you contribute to generate this information/pursue these priorities?

8. What is **<u>not</u>** your role in pursuing these priorities/generating this knowledge (what things need to be done but are not within your expertise or role you play in this process)?
    a. What can't or won't you do? Why not?

9. Other than yourself, does anyone else have a role in pursuing these priorities/generating this knowledge? Who?
    a. What is their role?
    b. What role do you think researchers/scientists should have in helping achieve these priorities? [What do you know about what researchers/scientists do?]
    c. How do you know that this is the role they should play? [Where do you get your knowledge about what researchers/scientists do?]

10. Is there anything you want/need to know about the role/expertise/skills of any other groups of people involved in the fishery?

11. What do you think the priorities (or interests) of [researchers/managers] are related to the fishery?
    a. Why do you think these are priorities for them?

12. Is it important for you to know the priorities (or interests) of [researchers/managers] related to the fishery?
    a. Why?

Appendix F: Pangnirtung Workshop #1 Agenda

9:00-9:15	Introduction to meeting
9:15-10:00	Roundtable introductions
10:00-10:30	Breakout Discussion 1 – What are your priorities for the meeting and the fishery?
10:30-11:00	Present
11:00-11:15	Coffee break
11:15-11:45	Breakout Discussion 2 – What do you need to pursue your priorities?
11:45-12:30	Present
12:30-1:30	Lunch
1:30-2:00	Breakout Discussion 3 – What do you want to know from each other?
2:00-2:45	Present
2:45-3:00	Closing & next steps

Appendix G: Pangnirtung Workshop #1 Guide

Breakout Discussion 1:

B1.1 What are your priorities for this meeting? Why did you choose to participate? What do you hope is achieved?

B1.2 What are your priorities for the fishery in Pangnirtung/Cumberland Sound?

Breakout Discussion 2:

B2.1 Why are these priorities? Why are they important?

B2.2 What questions do you have about these priorities? What do you need to pursue them? (What information, technology, personnel, etc.?)

B2.3 What questions do you have for [the fishers/scientists] about these priorities?

Scientist:
B2.4 (Possible) What is your role in pursuing these priorities? What is outside your role?

Breakout Discussion 3:

Scientist:
B3.1 Can you help get equipment/money to help fishermen? How/why not? Will you do this?

B3.2 What do you know about the status of sharks? Why is this the case? What is your role in this? Why are sharks important?

Fishers:
B3.3 Do you think Aaron's questions are important for understanding the fishery? Why/why not?

B3.4 Do you have any interest in being involved in research? Why/why not?

B3.5 What is the best way for researchers to communicate with you? How do you want to access information?

Appendix H: Letters of Informed Consent

Iqaluit

Study Name: Community Workshop on Ringed Seal Research in Nunavut, Iqaluit, March 5-6, 2014

Researcher:
Paul McCarney
Faculty of Environmental Studies
137 Health, Nursing and Environmental Studies (HNES) Building
York University
4700 Keele Street, Toronto, Ontario, M3J 1P3
Phone: 705-868-8061 Email: pmcc@yorku.ca

Purpose of the Research: The purpose of this workshop is to create a space for knowledge exchange related to ringed seal research in Nunavut, involving researchers; hunters involved in ringed seal research programs; representatives from regional, territorial, and the federal governments; wildlife management organizations; and community organizations. The objectives are to: 1) identify questions, strengths, and concerns about current programs; and, 2) determine mutual information needs and ringed seal knowledge priorities among researchers and communities. The long term goals are to identify opportunities and needs for further research, and begin to identify ways to strengthen relationships between researchers and community members, to ensure future research is responsive to the needs to communities in Nunavut and current environmental issues.

What You Will Be Asked to Do in the Research: You are being asked to participate in a two day workshop to share your knowledge in series of group discussion sessions about ringed seals and ringed seal research programs. At the end of the workshop, you may be asked to participate in a one-on-one interview to discuss your experiences at the workshop.

Benefits & Risks of the Research: The workshop is intended to provide a space for researchers and community members involved in research programs to express their opinions, ideas, concerns, and ask questions about research on ringed seals. The workshop will ask you to identify your priorities and information needs around ringed seal research. The goal of the workshop is to begin to answer questions you may have and plan to address the ideas discussed so that research programs can be more responsive to the needs of northern residents. This workshop will benefit you in the long term by identifying the information you need about ringed seals and planning to address these needs.

We do not foresee any risks or discomfort from your participation in the research.

Withdrawal: Your participation in the study is completely voluntary and you can choose to stop participating in the study, or certain sessions, at any time. Your decision to stop participating will not affect your relationship with the researcher or any other group associated with this project. In the event you withdraw from the study, all associated data collected will be immediately destroyed wherever possible.

Confidentiality: All information you supply during the research will be held in confidence and unless you provide your consent, your name will not appear in any report or publication of the research. If you

choose to allow your name to be appear in any report or publication, you will have the opportunity to review information you provided for accuracy. Data from the workshop will be audio recorded and recorded by hand written or typed notes. Data will be stored in a locked building and only research staff will have access to this information. Data will be stored for the duration of the researcher's project (approximately 3-4 years), after which it will be destroyed. Confidentiality will be provided to the fullest extent possible by law.

Questions About the Research? If you have questions about the research in general or about your role in the study, please feel free to contact Paul McCarney either by telephone at 705-868-8061, or by e-mail (pmcc@yorku.ca).

This research has been reviewed and approved by the Human Participants Review Sub-Committee, York University's Ethics Review Board and conforms to the standards of the Canadian Tri-Council Research Ethics guidelines. If you have any questions about this process, or about your rights as a participant in the study, please contact the Sr. Manager & Policy Advisor for the Office of Research Ethics, 5th Floor, York Research Tower, York University (telephone 416-736-5914 or e-mail ore@yorku.ca).

Legal Rights and Signatures:

I _____, consent to participate in the Ringed Seal Community Workshop conducted by Paul McCarney. I understand the nature of this project and wish to participate. I am not waiving any of my legal rights by signing this form. My signature below indicates my consent.

Signature

_____ _____

Participant Date

Signature

_____ _____

Principal Investigator Date

Kugaaruk

Study Name: Inuit Community Perspectives on Ringed Seal and Polar Bear Monitoring in the Gulf of Boothia

Researcher:
Paul McCarney
Faculty of Environmental Studies
137 Health, Nursing and Environmental Studies (HNES) Building
York University
4700 Keele Street, Toronto, Ontario, M3J 1P3
Phone: 705-868-8061 Email: pmcc@yorku.ca

Purpose of the Research: The purpose of this research is to investigate the health and ecology of ringed and bearded seals in the Gulf of Boothia and to collect information on seals that will allow monitoring of the feeding habits of polar bears. One component of the project includes the collection of biological information and samples from ringed and bearded seals by hunters who have been provided with sampling kits. A second component includes interviews with hunters and other community members about their knowledge of seal abundance and distribution. The long-term goal is to determine how climate warming and increased development may affect ringed seals, bearded seals, and polar bears, with the goal of assisting in conservation and maintaining healthy, abundant populations capable of sustaining harvesting needs of communities around the Gulf of Boothia.

Additional objectives of interviews are to: 1) identify questions, strengths, and concerns about current marine mammal research programs; and, 2) determine needs and knowledge priorities among communities related to marine mammal research. Long-term goals are to identify opportunities and needs for future research and ways to strengthen relationships between researchers and community members, to ensure research is responsive to the needs to communities in Nunavut and current environmental issues.

What You Will Be Asked to Do in the Research: You are being asked to participate in a one-on-one interview that will take approximately one hour to discuss your knowledge of ringed and bearded seal distribution and abundance and polar bear feeding habits in the Gulf of Boothia. The interview will also ask you about your experiences being involved in research programs and working with researchers, and about your perspectives on research in your community.

Benefits & Risks of the Research: This research will create enhanced information about seal and polar bear ecology in the Gulf of Boothia, which will contribute to the long-term conservation of the species. Knowledge from the interviews will contribute towards identifying ways to address community needs, and creating stronger research programs and relationships between communities and researchers. You will be provided a copy of any publications from the research if you wish.

We do not foresee any risks or discomfort from your participation in the research.

Withdrawal: Your participation in the study is completely voluntary and you can choose to stop participating in the study, or certain sessions, at any time. Your decision to stop participating will not affect your relationship with the researcher or any other group associated with this project. In the event

you withdraw from the study, all associated data collected will be immediately destroyed wherever possible.

Confidentiality: All information you supply during the research will be held in confidence and unless you provide your consent, your name will not appear in any report or publication of the research. If you choose to allow your name to be appear in any report or publication, you will have the opportunity to review information you provided for accuracy.

If the researcher wishes to use a direct quote from your interview, do you give your permission:

- ☐ Yes
- ☐ No

If *yes*, do you give permission for your real name to be used:

- ☐ Yes , use my real name.
- ☐ No, I would like a non-identifiable term to be used.

With your permission, the interview will be audio recorded. Data will be stored on a secure computer and only the researcher will have access to this information. Data will be stored for the duration of the researcher's project (approximately 3-4 years), after which it will be destroyed. Confidentiality will be provided to the fullest extent possible by law.

Questions About the Research? If you have questions about the research in general or about your role in the study, please feel free to contact Paul McCarney either by telephone at 705-868-8061, or by e-mail (pmcc@yorku.ca).

This research has been reviewed and approved by the Human Participants Review Sub-Committee, York University's Ethics Review Board and conforms to the standards of the Canadian Tri-Council Research Ethics guidelines. If you have any questions about this process, or about your rights as a participant in the study, please contact the Sr. Manager & Policy Advisor for the Office of Research Ethics, 5th Floor, York Research Tower, York University (telephone 416-736-5914 or e-mail ore@yorku.ca).

Legal Rights and Signatures:

I _____, consent to participate in the research being conducted by Paul McCarney. I understand the nature of this project and wish to participate. I am not waiving any of my legal rights by signing this form. My signature below indicates my consent.

Signature

_____ _____

Participant Date

_____ _____

Principal Investigator Date

Pangnirtung

Study Name: Inuit Community Members and Scientists Working to Understand Priorities for Arctic Fisheries

Contact Information: If you have any questions about the research or your involvement, please feel free to contact:

Dr. Aaron Fisk

Professor and Canada Research Chair
University of Windsor
Great Lakes Institute for Environmental Research
401 Sunset Avenue, Windsor, Ontario, N9B 3P4
Phone: 519-984-9931 Email: afisk@uwindsor.ca

Paul McCarney

Faculty of Environmental Studies
137 Health, Nursing and Environmental Studies (HNES) Building
York University
4700 Keele Street, Toronto, Ontario, M3J 1P3
Phone: 705-868-8061 Email: pmcc@yorku.ca

Purpose of the Study: The purpose of this meeting is to bring together community members from Pangnirtung involved in the fishery to identify common knowledge and priorities.

This meeting will be part of a longer-term research project intended to understand Inuit community member perspectives on fisheries management and technology used in fisheries research. The goal of the research is to identify facilitators and barriers to relationships between scientists and community members related to fisheries research, and to identify opportunities to increase community member involvement in research.

What You Will Be Asked to Do: You are being asked to participate in a one day meeting to share your perspectives and priorities related to the fishery in Cumberland Sound. You may also be asked to participate in a one-on-one interview immediately following the meeting.

Benefits & Risks of the Study: The purpose of this meeting is to increase understanding of the most important priorities of community members in Pangnirtung related to the fishery. It is hoped that a better understanding of community priorities will allow for the identification of opportunities and resources to pursue these priorities; lead to stronger research programs that reflect community needs; and enhance community capacity to be involved in research.

You will be provided a copy of any publications generated from results of this meeting if you wish. We do not have an estimated time frame for the next stages of the project, but you are free to contact the researchers involved in the study at any time for an update. The community will be provided with updates at least once per year on the progress of the study and any next steps that are being planned.

We do not foresee any risks or discomfort from your participation.

Compensation for Participation: You will be compensated with $200.00 for your participation in this meeting.

Withdrawal: Your participation in the meeting and any follow up interview is completely voluntary and you can choose to stop participating at any time. Your decision to stop participating will not affect your relationship with the researcher or any other individual involved with this project. In the event you withdraw, all information associated with your participation will be destroyed wherever possible.

Confidentiality: All information you supply will be held in confidence and unless you provide your consent, your name will not appear in any report or publication. If you choose to allow your name to appear in any report or publication, you will have the opportunity to review information you provided for accuracy.

If the researcher wishes to use a direct quote from you, do you give your permission?

- ☐ Yes
- ☐ No

If *yes*, do you give permission for your real name to be used?

- ☐ Yes , use my real name.
- ☐ No, I would like a non-identifiable term to be used.

Do you give your permission to have your photograph taken as part of your participation?

- ☐ Yes
- ☐ No

The meeting will be audio recorded. Audio files will be stored on a secure computer and will be protected by password. Only the meeting facilitator will have access to the files. Data will be stored for approximately 3-4 years, after which it will be permanently erased from the computer. Confidentiality will be provided to the fullest extent possible by law.

Rights of Participants: If you have any questions regarding your rights as a participant, contact: Research Ethics Coordinator, University of Windsor, Windsor, Ontario, N9B 3P4; Telephone: 519-253-3000, ext. 3948; email: ethics@uwindsor.ca.

Legal Rights and Signatures:

I _____, consent to participate in the study being conducted by Dr. Aaron Fisk and Paul McCarney. I understand the nature of this project and wish to participate. I am not waiving any of my legal rights by signing this form. My signature below indicates my consent.

Signature

_____ _____

Participant Date

_____ _____

Principal Investigator Date

Appendix I: Ethics Approval Documents

YORK
UNIVERSITÉ
UNIVERSITY

Certificate #:	**2014 - 064**
Approval Period:	**02/28/14-02/28/15**

OFFICE OF RESEARCH ETHICS (ORE)
5th Floor, Kaneff Tower

4700 Keele St.
Toronto ON
Canada M3J 1P3
Tel 416 736 5914
Fax 416 650-8197
www.research.yorku.ca

Memo

To: Mr. Paul McCarney, Environmental Studies – Graduate Programme, pmcc@yorku.ca

From: Alison M. Collins-Mrakas, Sr. Manager and Policy Advisor, Research Ethics *(on behalf of Duff Waring, Chair, Human Participants Review Committee)*

Date: **Friday, February 28, 2014**

Re: Ethics Approval

Community Workshop on Ringed Seal Research in Nunavut

I am writing to inform you that the Human Participants Review Sub-Committee has reviewed and approved the above project.

Should you have any questions, please feel free to contact me at: 416-736-5914 or via email at: acollins@yorku.ca.

Yours sincerely,

Alison M. Collins-Mrakas M.Sc., LLM
Sr. Manager and Policy Advisor,
Office of Research Ethics

YORK
UNIVERSITÉ
UNIVERSITY

OFFICE OF RESEARCH ETHICS (ORE)
5th Floor, Kaneff Tower

4700 Keele St.
Toronto ON
Canada M3J 1P3
Tel 416 736 5914
Fax 416 736-5512
www.research.yorku.ca

Certificate #:	**2015 - 064**
Approval Period:	**02/20/15-02/20/16**

Memo

To: Paul McCarney, Graduate Student of Environmental Studies, pmcc@yorku.ca

From: Alison M. Collins-Mrakas, Sr. Manager and Policy Advisor, Research Ethics
(on behalf of Denise Henriques, Chair, Human Participants Review Committee)

Date: **Friday, February 20, 2015**

Re: Ethics Approval

Inuit Community Perspectives on Ringed Seal and Polar Bear Monitoring in the Gulf of Boothia

---

I am writing to inform you that the Human Participants Review Sub-Committee has reviewed and approved the above project.

Should you have any questions, please feel free to contact me at: 416-736-5914 or via email at: acollins@yorku.ca.

Yours sincerely,

Alison M. Collins-Mrakas M.Sc., LLM
Sr. Manager and Policy Advisor,
Office of Research Ethics