Culturally Driven Freshwater and Fish Monitoring: Opportunities for Social-Ecological Learning in the Northwest Territories' Dehcho Region

by

Sydney Stenekes

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Department of Resource Economics and Environmental Sociology
University of Alberta

ABSTRACT

There is growing concern about the sustainability of freshwater ecosystems in northern Canada that are under significant stress from climate change, resource development, and hydroelectric development, among others. Community-based monitoring (CBM) based on traditional ecological knowledge (TEK) has the potential to contribute to understanding impacts on the environment and community livelihoods. This thesis shares insights about culturally driven monitoring, through collaborative research with Kátł'odeeche First Nation (KFN) in the Northwest Territories. This research was initiated in 2018 to improve understanding of the changes occurring in the Hay River and Buffalo River sub-basins, which extend primarily across the Alberta and Northwest Territories borders. Drawing on 15 semi-structured interviews conducted with KFN elders, fish harvesters, and youth, this research illustrates the kinds of social–ecological indicators used by KFN to track changes in the health of aquatic systems as well as the fishing livelihoods of local people. Utilizing indicators, fishers observe declines in fish health, water quality, water quantity, and ice thickness in their lifetime. Community members perceive these changes to be a result of the cumulative effects of environmental stressors. The indicators as well as trends and patterns being observed and experienced can contribute to both social-ecological learning in the community as well as the governance of the larger Mackenzie River Basin. In addition, this research generates outcomes about knowledge sharing, social-ecological learning and CBM based on interviews with KFN and six government and academia actors. Overall, findings increase understandings of the content, mechanisms and flows (relationships) by which knowledge is shared in the context of freshwater and fish monitoring within KFN and among various actors, including Indigenous communities, territorial and federal governments. Evidently, CBM provides opportunities for social-ecological learning,

which is necessary in improving the management of the Hay River and Buffalo River sub-basins and the larger Mackenzie River Basin, as it contributes to increased understanding of environmental change. This research highlights the importance of relationships among actors in promoting knowledge sharing and uncovers various barriers that may hinder opportunities for social-ecological learning and knowledge sharing through CBM.

PREFACE

This thesis is the original work of Sydney Stenekes. This research received ethics approval from the University of Alberta Research Ethics Board, Project Name "Tracking Change in the Mackenzie River Basin", Project Number Pro00065907 on June 22, 2016.

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ACRONYMS

AAROM: Aboriginal Aquatic Resources and Oceans Management
CBM: Community-Based Monitoring
CBPR: Community-Based Participatory Research
CIMP: Cumulative Impact Monitoring Program
DFO: Department of Fisheries and Oceans
ENR: Environment and Natural Resources
GNWT: Government of the Northwest Territories
GSLAC: Great Slave Lake Advisory Committee
KFN: Kátł'odeeche Fırst Natıon
MRB: Mackenzie River Basin
MRBB: Mackenzie River Basin Board
NWT: Northwest Territories
TEK: Traditional Ecological Knowledge

CHAPTER 1.0: Introduction

1.1 Introduction

In Canada's sub-arctic and boreal regions, environmental stressors and cumulative effects, such as climate change and resource development, are adversely impacting freshwater lakes and rivers (Schindler & Smol, 2006). Indigenous peoples are considered particularly vulnerable to these environmental changes, as they depend on healthy ecosystems to hunt, trap, gather and fish to sustain their livelihoods, cultures and health (Herrmann et al., 2012; Kuhnlein, 2015). With growing concern among Indigenous peoples regarding the future health of freshwater systems, there is an increased need to monitor and interpret complex aquatic ecosystem change. As a result, community-based monitoring (CBM) that is informed by Traditional Ecological Knowledge (TEK) is increasing in Canada's north; this integration of TEK has improved the capacity of governments as well as communities to track environmental changes that have potential impacts on local people (Thompson et al., 2019; Kouril et al., 2016). CBM also has the potential to generate opportunities for knowledge sharing and social-ecological learning at various levels (i.e., within and across communities, among communities and researchers).

TEK has been relatively underrepresented in many aspects of monitoring and management of the Mackenzie River Basin (MRB); this gap is particularly evident in provincial jurisdictions (British Columbian, Saskatchewan and Alberta) including the Hay River and Buffalo River sub-basins (MRBB, 2012; Stantec, 2016). Even where there is recognition and efforts to include TEK, its role in learning and decision-making by individuals, communities and institutions is poorly understood. It is in this context that this thesis focuses on the role of TEK in community-based monitoring and social-ecological learning. The thesis work builds on collaborative research with Kátł'odeeche Fırst Natıon (KFN), a Dene community located in the Northwest Territories with strong connections to this transboundary watershed (Hay River and Buffalo River sub-basins of the MRB). The collaboration was undertaken with the principal aim of strengthening the capacity of KFN to engage in community-based monitoring of this freshwater ecosystem. A key opportunity in doing this work was also to inform the implementation of the Alberta-Northwest Territories (NWT) Bilateral Water Management

Agreement and potentially contribute to the collaborative governance of the MRB and management of the Hay River and Buffalo River sub-basins.

The thesis represents two specific research papers. The first emphasizes the importance of a culturally driven approach to freshwater and fish monitoring in Canada's north that includes community based social-ecological indicators of change based on TEK of KFN members (Stenekes et al., 2020). The second paper focuses on the dynamics of social-ecological learning including the mechanisms, flow and content of knowledge shared between different actor groups (local, regional, territorial and federal level) involved in the monitoring and management of the Hay River and Buffalo River sub-basins.

1.2 Objectives

In the context of the MRB, specifically the Hay River and Buffalo River sub-basins, little attention has been given to the documentation of social-ecological indicators relied on by Indigenous peoples. Given the many monitoring efforts that are ongoing in the Northwest Territories' (NWT) Dehcho Region, there are three key research objectives of this study:

1. Identify the Traditional Ecological Knowledge indicators used by KFN to assess the health of freshwater systems in their traditional territory (Chapter 3).

2.Document community observations and perceptions of social-ecological change in relation to freshwater systems (Chapter 3).

3. Explore how knowledge about the health of the water and fish is shared at local, regional, territorial and federal levels and investigate the opportunities for social-ecological learning through CBM (Chapter 4).

These research objectives were developed in partnership with KFN with the aim to help inform the design and implementation of a local CBM program based on TEK. The questions were also guided by previous Tracking Change research, which signifies a larger research project being conducted across the MRB to document the knowledge and perceptions of local peoples, including social-ecological indicators of change deemed important by Indigenous communities.

1.3 Theoretical Framework and Overview of Literature

1.3.1 Social-Ecological Systems and Natural Resource Management

The Hay River and Buffalo River sub-basins are the traditional territories and homelands of Kátł'odeeche First Nation. For thousands of years they have lived and stewarded this region in ways that have supported ecological, social and cultural sustainability. This worldview and the associated knowledge and practices (e.g., monitoring) which is common in many Indigenous cultures (Berkes, 1998) can be described as a social-ecological system (Berkes et al., 2008). This social-ecological lens is unique from conventional and colonial constructs of people and nature as separate (Berkes et al., 2008). Historically, the complexity of natural systems was primarily studied in isolation from social systems (Holling, 1978). However, this paradigm and dichotomy has been strongly critiqued by numerous scholars in ecology, sociology and environmental sociology for causing natural resource failures as well as adverse impacts on community well-being (Berkes, Folke & Colding, 1998; Hannigan, 2014). Scholarly work in environmental sociology has since focused on exploring the interactions and relationships between natural and human systems and adapted concepts of social-ecological systems that have emerged from the natural sciences in ways that recognize role of agency, power and cultural values (Berkes, 2018).

Reflecting on the history of natural resource management, prior to the 1970s, a 'command and control' approach dominated environmental management (Cundill and Rodela, 2012). Moreover, scientists and managers believed they could control nature through human intervention (i.e. conserve and protect wildlife) and made decisions based on the assumption of scientific certainty (Cundill and Rodela, 2012). However, following unexpected ecological changes in the 1970s and 1980s, ecological systems began to be recognized as complex and unpredictable (Holling, 1978; Walters, 1986; Cundill and Rodela, 2012). Scholars then acknowledged that experimentation based on hypothesis testing, along with continuous learning among resource managers, scientists, and policymakers, is important in order to cope with ecological uncertainty, generate awareness of ecosystem change across scales, and move towards social change (Cundill and Rodela, 2012). In the 1980s and 1990s, collaborative management emerged to address calls for greater participation of local peoples in natural resource management and decision-making (Cundill and Rodela, 2012).

1.3.2 Power Dynamics and Knowledge Systems in Environmental Management

To date, Indigenous knowledge and western science are valid knowledge systems in environmental monitoring and management (McKay & Johnson, 2017, p.17). Berkes (2009) conveys that Indigenous knowledge and western science can co-produce knowledge for environmental monitoring in communities. Western science as a knowledge system "combines a particular set of values with systems of knowing based on empirical observation, rationality, and logic, as opposed to received or felt truths or, exclusively, sensory perception or "lived experience"" (Usher, 2000, p.185).

Historically, Indigenous peoples and their knowledge systems have been excluded from environmental management, as western science has informed and dominated resource management decision-making (Nadasdy, 1999). Scholars and Indigenous peoples continue to advocate for the inclusion of TEK in resource management and for TEK to be recognized as an equal and valid knowledge system (Snively & Corsiglia, 2000). Across Canada's north, many scholars conducting natural resource management, conservation, and climate change related research are optimistic that western science and TEK can successfully integrate and complement one another or converge to provide a more comprehensive picture of the environment for improved resource management (Eckert et al., 2018; Huntington et al., 2004a; Huntington et al., 2004b; Moller et al., 2004, Riedlinger & Berkes, 2001).

In contrary, among the literature, there is also recognition that conflicts resulting from the use of different knowledge systems in resource management exist (Huntington et al., 2004b; Berkes, 2018). Nadasdy (1999) is critical of the possibilities surrounding the integration of TEK and western science. Nadasdy (1999) explains that unequal power relations exist between TEK holders, and resource managers and scientists, and thus, Indigenous peoples have been forced to communicate TEK by conforming to existing institutions and western governance structures. These institutions are formed based on certain principles and often contrasting values (Whyte, 2013; Berkes, 2018). Overall, Berkes argues that Indigenous knowledge threatens the alteration to existing power relations between Indigenous peoples, governments, industry, and western scientists (Berkes, 2000; Howard and Widdowsen, 1996).

1.3.3 Traditional Ecological Knowledge and Environmental Monitoring

TEK as an Indigenous knowledge system is learned from lived experience, family, community and shared through the passing down of stories. Contrary to some belief, TEK is empirical, as it is based on observations and experiences (Usher, 2000). Throughout the thesis, TEK is defined as "a cumulative body of knowledge, practice, and belief, evolving by adaptive processes and handed down through generations by cultural transmission, about the relationship of living beings (including humans) with one another and with their environment" (Berkes, Colding & Folke, 2000, p.1252). While there is no universal definition of TEK, this definition resonates best with this research, as it addresses misconceptions associated with the term. For instance, despite the classification of knowledge as 'traditional,' TEK is not historical nor fixed (Parlee, 2006). Instead, TEK is dynamic, as it evolves based on experience and adapts to change (Berkes, 2018). Additionally, TEK is based on long-term empirical observations of the environment (Mazzocchi, 2006) and its significance extends beyond knowledge itself, as it refers to a 'way of life,' the process of acquiring knowledge (Berkes, 2018). In essence, TEK is holistic, as Indigenous peoples' knowledge systems embrace physical, biological, cultural and spiritual elements (Johnson et al., 2016).

Interestingly, scholars have shown that the TEK of Indigenous fishers does not only contribute to the understanding of local change, but regional change when combined with other individuals' and communities' knowledge (Fenge, 1997). For instance, Inuit and Cree communities in the Hudson Bay and James Bay regions initiated a project which sought to document observations of environmental change based on the TEK of Indigenous peoples (McDonald et al., 1997). This project showcased the value of documenting observations attributed to climate change, resource and hydroelectric development from the perspective of Indigenous peoples to strengthen the monitoring and understanding of regional change (McDonald et al., 1997).

Historically, western approaches to natural resource management, including environmental monitoring have derived from scientific methods (Nadasdy, 2012). However, TEK is increasingly recognized as invaluable in environmental monitoring, and is considered fundamental in the understanding of ecological change (Berkes, 2018). In particular, scholars

argue that the inclusion of local peoples and TEK in monitoring in northern areas address gaps in scientific methods, as long-term scientific monitoring occurs sporadically (i.e. seasonally) and is financially and logistically difficult to organize (Marin et al., 2017). Additionally, scholars underline that TEK can "contribute to environmental assessment by providing a broader and deeper understanding of baseline conditions and a fuller understanding of local environmental processes, at a finer and more detailed geographical scale, than conventional scientific knowledge can offer…because it deals with outcomes and prediction: what people think will happen and why" (Usher, 2000, p.187).

1.3.4 Indicators Based on Traditional Ecological Knowledge

This research builds on other work on TEK indicators in CBM. TEK indicators provide rich knowledge and insights into the baseline conditions of environments (Berkes, 2018). Further, indicators may represent signs or signals of wellness and problems (Berkes et al., 2007) and draw from the "experience, understanding, and memory of the observer" (Berkes and Folke 2002; Moller et al. 2004). Interestingly, indicators may be based on sight, sounds, feel, smell and taste (Moller et al., 2004). Hunters and fishers, for example, are experts in the reading of signs and signals and exhibit a mental image of what is considered to be normal or unusual in terms of the conditions and quality of the environment and animals (Peloquin & Berkes, 2009; Berkes et al., 2007; O'Neil et al., 1997).

Indicators are also determined to be based on the knowledge and experiences of past and present generations and seek to provide "holistic snapshots of the environment on a continuous time scale" rather than elicit broader generalizations (Berkes et al., 2007, p.154). Berkes et al. (2007) state that the "[e]valuation of indicators over time allows users to receive feedback from the ecosystem, enabling them to assess various aspects of it" (p.152). In turn, indicators are flexible and can be altered to reflect change. While indicators are discussed in the literature as being predominantly qualitative (Berkes et al., 2007), other scholars highlight the ability for TEK to yield both qualitative and quantitative indicators (Parlee, 2011; Parlee et al., 2005). Quantitative indicators may include abundance of fish, water levels, fat content and length of fish and qualitative indicators may involve a description of the body condition, taste, smell of water, texture and colour of fish flesh (Parlee, 2011; Parlee et al., 2005).

In response to rapid ecological change, communities in the MRB are initiating CBM programs that aim to connect TEK indicators of aquatic ecosystem health with scientific indicators (Carver & Maclean, 2016). With the aim of co-producing knowledge and developing a more holistic approach to environmental monitoring and resource management, recent literature on indicators has focused on blending or braiding TEK with western science in Canada (Baldwin et al., 2017; Mantyka-Pringle et al., 2017; Gill & Lantz, 2014; Berkes, 2009; Moller et al., 2004) and in international contexts, such as New Zealand (Harmsworth et al., 2011). A Canadian study promoted a "two-eyed seeing" approach through the bridging of scientific and TEK indicators in order to address questions and improve understanding of freshwater system change in the Slave River basin (Mantyka-Pringle et al., 2017), which is a sub-basin in the MRB under threat of cumulative environmental impacts. "Two-eyed seeing" specifically recognizes the independent strengths of different knowledge systems in terms of the value and insights they provide to understanding ecosystem health (Mantyka-Pringle et al., 2017). For example, scientific indicators are often spatial (i.e. comparing different locations) and TEK indicators are often considered to be temporal (i.e. comparing across time) (Mantyka-Pringle et al., 2017; Moller et al., 2004). Therefore, scholars understand that scientific knowledge and TEK can complement one another by "increasing the spatial and temporal range of system information" (Baldwin et al., 2017).

In the literature, some scholars draw attention to the similarities between TEK and scientific indicators. For example, research determined the indicators used by Inuit hunters to be similar to scientific indicators in the tracking of healthy and recovering bowhead whale populations (Berkes et al., 2007). Although similarities may exist in the findings resulting from the use of indicators from different knowledge systems, many scholars recognize the differences in cultural contexts and methodologies employed (Berkes et al., 2007). Overall, while much attention has been given to the blending or braiding of western science and TEK in environmental monitoring, this paper builds on TEK indicator work, which demonstrates the validity of TEK as its own knowledge system. Evidently, TEK possesses many strengths of its own and offers a culturally driven approach to monitoring and understanding of social-ecological change.

Across the globe, recent studies have focused on the development of Māori indicators in the assessment of forest health in New Zealand (Lyver et al., 2017), local indicators of climate change to promote communities' resilience in Zimbabwe (Kupika et al., 2019), and traditional weather (i.e. climate) indicators used by farmers to inform decisions related to agricultural activities in South Africa (Zuma-Netshiukhwi et al., 2013). In the MRB, TEK indicators and local perceptions of freshwater system change have been documented in various communities, including the Cree situated in the Lesser Slave Lake region of Alberta (Parlee et al., 2012), the Denesoline of Lutsel K'e Dene First Nation (Parlee et al., 2005), and Indigenous peoples throughout the Athabasca watershed (Parlee, 2011) and Slave River basin (Baldwin et al., 2017). As reported by the Mackenzie River Basin Board (MRBB), Indigenous peoples throughout the MRB have noted poor fish health relative to past conditions, deteriorating colour, taste and odor of river water, and perceive the water to be unsafe to drink in certain areas due to increased contamination (MRBB, 2012). Despite this growing recognition of local peoples' knowledge in environmental monitoring, the MRBB 2012 issues report noted that TEK is underrepresented in the entire MRB, in comparison to scientific assessments (MRBB, 2012). Moving forward, the MRBB called for the consideration of both western science and TEK "to effectively detect, monitor, and manage environmental change" and comprehensively understand long-term baseline conditions of freshwater systems (MRBB, 2012, p.10).

1.3.5 Community-Based Monitoring

1.3.5.1 Defining Community-Based Monitoring and its Benefits

CBM is often discussed as a form of citizen science, which is emerging as a widely adopted and accepted method to data collection in the arctic and sub-arctic regions of Canada (Kouril et al., 2016). CBM often involves collaboration among various stakeholders (e.g., local peoples, government, industry, academia) to monitor, track and respond to community concerns regarding the environment (Whitelaw et al., 2003). CBM has an important role in promoting sustainability and provides local peoples with the opportunity to produce pertinent knowledge that can be used in decision-making (Whitelaw et al., 2003).

Scholars indicate that CBM initiatives are developing in response to government cutbacks in monitoring programs and activities, and the inability of the government to effectively

address complex environmental sustainability issues alone. In addition, there is a need for decision-makers to be provided with timely information on ecological change at the local level and a desire for increased local involvement and multi-stakeholder participation in environmental management (Whitelaw et al., 2003).

CBM has a vital role in understanding and evaluating environmental change (Gummer et al., 2006). Scholars highlight the opportunities of CBM in monitoring cumulative effects, including climate change (Kouril et al., 2016; Herrmann et al., 2012; Carver & Maclean, 2016), resource development (Parlee et al., 2014; Carver & Maclean, 2016) and hydroelectric development (Carver & Maclean, 2016) in Indigenous communities. While Indigenous led monitoring involves observations of change, "monitoring practices are strongly connected to, or are embedded within, other aspects of the land-based way of life including subsistence, trade, family and community organization" (Parlee, 2006, p14).

Scholars also highlight that CBM programs can act "as a tool to assert [Indigenous] sovereignty and jurisdiction" (Wilson et al., 2018, p.291). Moreover, CBM programs empower Indigenous peoples to participate in the collection and analysis of empirical data, and engage in decision-making processes (Lawe et al., 2005; O'Faircheallaigh, 2007), which they have been excluded from in the past. The documentation of Indigenous knowledge and local observations through CBM is therefore recognized as important in informing decision-making processes, as communities build capacity to monitor the environment themselves and seek power in resource management decisions that directly affect them (Herrmann et al., 2014, p.36). Additionally, "[g]reater recognition of TEK and community-based processes of monitoring by outsiders may also contribute to the mending of historic conflicts between governments and northern Indigenous peoples" and may provide opportunities for Indigenous peoples to contribute to resource management (Parlee et al., 2014, p.58). Overall, the rise of CBM efforts in Canada may suggest an increased recognition of Indigenous rights (Kouril et al., 2016, p.22).

Other stakeholders also recognize the value and benefits of TEK and CBM. Industry representatives note that TEK and monitoring can assist with planning efforts, including the mitigation of impacts and prevent environmental destruction and future conflict between Indigenous communities and industry (MaKay & Johnson, 2007). Government also acknowledges the efficiency and efficacy of CBM, citing its low cost, noting that consistent data

collection in remote areas by outsiders (i.e. government) can be expensive (Whitelaw et al., 2003; Johnson et al., 2015).

1.3.5.2 Community-Based Monitoring and Governance

CBM programs can be externally driven and professionally implemented, externally driven with local data collectors, collaborative with external data interpretation, collaborative with local data interpretation, and autonomous modelled (Danielsen et al., 2009). Wilson et al. (2018) expand on this model to link typology of CBM design to typology of governance arrangements. The externally driven programs are operated by settler governance structures. In contrast, collaborative and autonomous monitoring led by Indigenous communities are reflective of Indigenous driven co-governance, or Indigenous governance.

CBM literature often focuses on local peoples' involvement in data collection. Fewer studies highlight Indigenous communities' participatory role in monitoring objectives, design and decision-making based on the data/information collected (Thompson et al., 2020). Thompson et al. (2020) further add that "there is a risk of perpetuating projects that tokenize or coerce Indigenous communities rather than enabling transformation through the sharing of power" (p.9). Ultimately, the more Indigenous communities are represented and involved in the governance structure of CBM programs, the greater influence Indigenous communities will have over the design, goals and outcomes of the monitoring programs (Wilson et al., 2018). In the Northwest Territories, there is growing CBM focusing on water and fish that has resulted in partnerships with the territorial and federal government, academia and Indigenous communities (Fresque-Baxter and Kelly, 2017).

1.4 Background and Setting

1.4.1 Tracking Change

This research is undertaken as part of a larger six-year research project 'Tracking Change,' which seeks to document and share TEK related to social-ecological change in communities situated in the MRB, Amazon (Brazil) river basin and Mekong (Thailand) river basin. Overall, this project contributes to an increased understanding of these freshwater ecosystems, their sustainability and governance (Tracking Change, 2021). Tracking Change

further "documents place-based knowledge of changes in the Mackenzie [River] Basin, yielding insights into common approaches to monitoring change, the value of network-building, and social learning and engagement of youth as knowledge holders" (Fidel et al., 2017, p.22). This research aligns with Tracking Change's goals of documenting historical and contemporary observations, perceptions and indicators of changes to the health of fish species and the aquatic environment to inform governance. More specifically, this research contributes to the documentation of TEK for KFN and explores social-ecological change in KFN's traditional territory through the voices and stories of Elders, harvesters and youth. Many Indigenous communities' livelihoods depend on the health of freshwater systems. In turn, communities "watch, listen, learn and communicate about change because they care about the health of the land and the health of their communities" (Tracking Change, 2021).

1.4.2 Mackenzie River Basin

Figure 1-1 (www.trackingchange.ca) depicts the Mackenzie watershed, which signifies the largest river basin in Canada (Creery, 1979), as it occupies one-sixth the area of the country and comprises five jurisdictions, including British Colombia, Alberta, Saskatchewan, Yukon, and Northwest Territories (Lewis et al., 1991). Interestingly, the majority of Canada's freshwater flows north into the Arctic Ocean. The river system drains approximately 60% of Canada's freshwater and its outflow affects global climate and ocean circulation systems. As well, "its waterways, boreal forests and tundra land support a stunning variety of flora and fauna, including migratory birds, grizzlies and caribou" (Robinson et al., 2012, p.24). Evidently, there are political, cultural, and economic differences across the Mackenzie River Basin (MRB), due to the large physical area it covers (Creery, 1979). While approximately 400,000 people live in the basin, Indigenous peoples are estimated to represent 15% of the population, and since time immemorial freshwater systems have been culturally and spiritually significant to many communities residing there (Robinson et al., 2012). The "fish and wildlife of the basin are a critical source of food for a significant portion of the basin's people" (de Loë, 2014, p.137).

Figure 1-1. Map of Mackenzie River Basin (Source: Tracking Change)

KFN, a Dene community situated in Canada's NWT have occupied lands in their traditional territory on the southern shores of Great Slave Lake since time immemorial. Within the Hay River and Buffalo River basins, many lakes, rivers and creeks are socially, culturally, and economically significant to KFN. The intergenerational transmission of TEK has occurred and evolved through the practice of fish harvesting. The Hay River and Buffalo River sub-basins also reside within the larger Mackenzie River Basin (MRB) as shown in Figure 1-2 (Government of Alberta & Government of Northwest Territories, 2017). In recent decades, development has expanded across the Canadian sub-arctic and arctic regions, resulting in the construction of oil and gas pipelines, mining for diamonds and metals, hydroelectric development, and the building of all-season roads (Schindler & Smol, 2006). Thus, management of the health of the MRB is complex due to the numerous jurisdictions and downstream impacts of industrial development. More specifically, in the Hay River basin, the expansion of oil & gas activities continues (Stantec, 2016). Figure 1-3 depicts the various environmental stressors (hydroelectric development, oil & gas) located upstream of Hay River, NWT (SLR Global Environment Solutions, 2018).

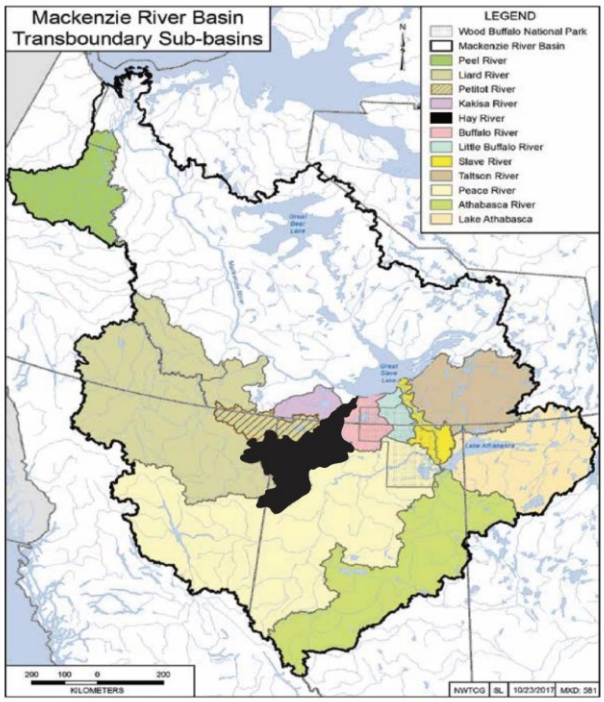

Figure 1-2. Map of Hay River and Buffalo River Sub-basins (Source: Government of Alberta & Government of Northwest Territories, 2017)

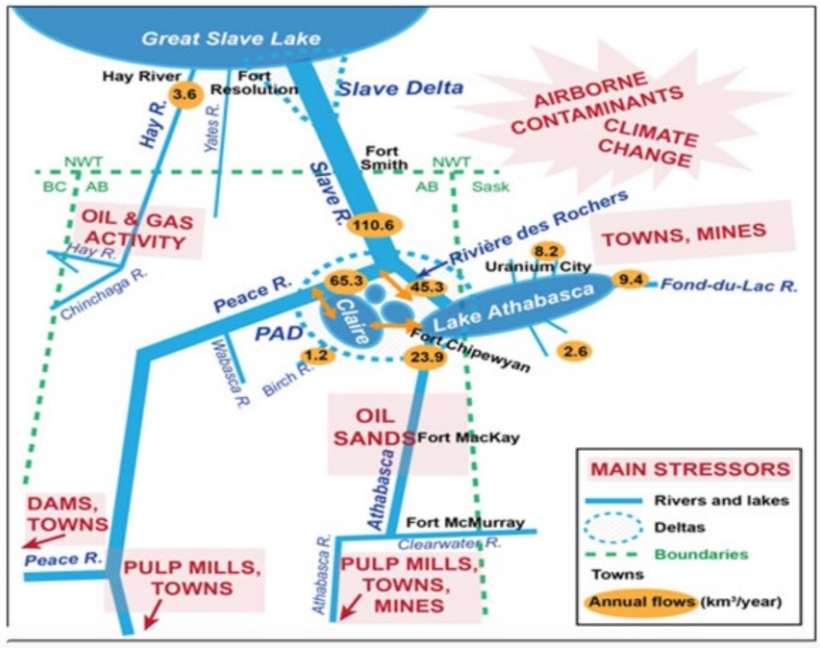

Figure 1-3. Map of Environmental Stressors in Mackenzie River Sub-basins (Source: SLR Global Environment Solutions, 2018).

In the past, jurisdictions exerted sovereignty with regards to control over waters within its boundaries, meaning decisions within jurisdictions failed to consider downstream effects of resource development (Lewis et al., 1991). However, jurisdictions in the MRB recognized this approach as unsuccessful and initiated a more cooperative approach to the management of the basin. The MRB Transboundary Master Agreement was signed in 1997 by all provincial and territorial jurisdiction ministers (Government of Canada et al., 1997), which resulted in the creation of the Mackenzie River Basin Board (MRBB). In 2015 the Alberta-NWT Bilateral Water Management Agreement was enacted, which provides a framework for cooperation and implementation of the MRB Transboundary Waters Masters Agreement (Government of Alberta & Government of Northwest Territories, 2015). Objectives of the agreement include of establishing biological indicators based on TEK and western science for the monitoring of transboundary water basins (Government of Alberta, & Government of Northwest Territories, 2017).

1.4.3 Kátł'odeeche Fırst Natıon

Kátł'odeeche Fırst Natıon (KFN) is a Dene community situated in the MRB. Dene, which translates to "the people," are the "original habitants of the area of land stretching east to west from the Hudson Bay to the interior of Alaska, and south to north from central Alberta to the Arctic Ocean" (KFN, 2009). There are distinct Dene groups that reside throughout the NWT with different languages and territories. KFN have occupied the Dehcho region of the NWT for thousands of years. Through the practice of fish harvesting and monitoring on KFN's traditional territory, TEK has been shared across generations. Figure 1-4 depicts a map of KFN's traditional territory, the lands surrounding the lower area of the Hay River basin and Buffalo River basin (KFN, 2009). The Hay River flows from the south, feeding into Great Slave Lake and Buffalo Lake, a tributary of the Buffalo River, drains into Great Slave Lake (Day, VanGerwen-Toyne & Tallman, 2013). Kátł'odeh (Hay River), Tucho (Great Slave Lake), Tagáa (Sandy Creek), Ejıe Túé Dehé (Buffalo River), and Ejıe Túé (Buffalo Lake), are culturally and spiritually significant freshwater systems to KFN.

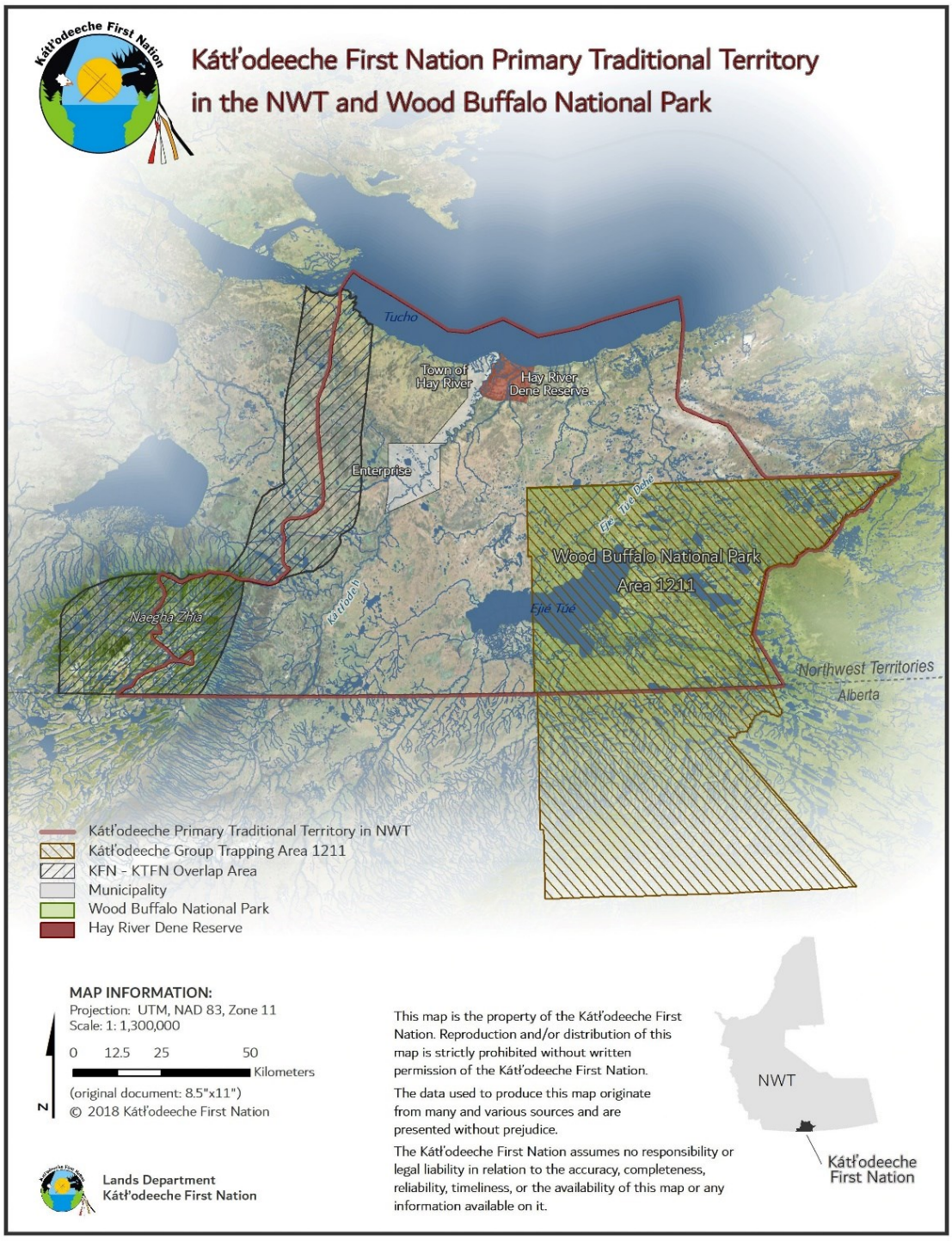

Figure 1-4. Map of Kátl'odeeche Fırst Natıon's Traditional Territory (Source: Kátl'odeeche Fırst Natıon)

Permanent settlement on the Hay River first occurred in the 1890s (Haas, 2011). However, the Dene have a long history of setting up fish camps during the warmer months at the mouth of the Hay River and living along the shores of Buffalo Lake in the winter (Hass, 2011). To date, Buffalo Lake remains an important traditional hunting area (Haas, 2011), and the Hay River Basin provides invaluable resources to the Dene as they continue to practice a traditional way of life (Stantec, 2016). Traditional activities include hunting, trapping, fishing, the gathering of berries and medicinal plants, and seasonal travelling (Stantec, 2016). As signatories of Treaty 8 in 1900, KFN have rights to hunt, trap, and fish on their traditional lands (Eagle-Eye Concepts, 2007). Peter Redvers, Lead of Negotiations and Consultation for KFN, emphasized that KFN holds the Aboriginal and Treaty right to manage its lands in order to support its long-term sustainability. Given the harsh climate of the sub-arctic region where the Dene lived and continue to call home, the Dene relied on a strong connection to the land in order to survive (KFN, 2009). Lakes, rivers and streams provided an abundance of fish, which were hung to dry in preparation for the winter and provided transportation corridors to traditional hunting areas.

The Great Slave Lake also has a long history of commercial fishing and Hay River serves as a major transportation hub of the north (Town of Hay River, 2019). From the Hay River, barges carry shipments up the Mackenzie River to northern communities and Hay River is home to the only railway line in the NWT. Highways also connect Hay River to southern provinces, increasing its accessibility and value as a transportation hub. Commercial fisheries were established on the lake beginning in 1945 (Day et al., 2013), and provided opportunities for the Dene to participate in a wage-earning economy. Despite a growing economy in the Town of Hay River, a "rapid shift from the traditional Dene lifestyle to a new one characterized by a wage-earning economy and advanced technologies, left many Dene in the lurch" (KFN, 2009). In addition, the Town of Hay River and KFN were separated by the Hay River and no roads were initially constructed to connect the community and the town together, which further isolated the Dene from mainstream society (KFN, 2009).

In 1973, Chief Daniel Sonfrere negotiated the Hay River Dene Reserve, which was established in 1974, in an effort to protect their traditional village from encroachment by the Town of Hay River (KFN, 2009). Today KFN resides on the southern shores of Great Slave

Lake and on the eastern banks of the Hay River. The reserve's geographic boundaries are illustrated in Figure 1-4. As shown in Figure 1-4, KFN's traditional territory also overlap with the lands of Ka'a'gee Tu First Nation (KTFN) and includes a large portion of Wood Buffalo National Park, which was established in 1922.

The majority of KFN residents on the reserve self-identify as South Slavey Dene, who speak a unique dialect of the South Slavey language, Dene Yatié. As reported by the 2016 Canadian census, there are 309 people currently residing on the reserve and although English is predominantly spoken, approximately 16% of the population continues to speak South Slavey (Statistics Canada, 2016). While more Dene are participating in the wage-economy in present-day, KFN continue to practice their way of life through traditional harvesting activities (e.g., subsistence fishing) on the land. KFN is also engaged in externally driven environmental monitoring activities (government, academia) and some community members participate in commercial fishing. Evidently, these freshwater systems have historical, contemporary and future value in sustaining KFN livelihoods.

Due to the transboundary nature of freshwater systems, there is increasing concern among KFN regarding the impacts of cumulative effects (e.g. resource development, climate change) on the health of aquatic ecosystems. More specifically, the oil and gas sector is applying the most pressure to the Hay River basin (Stantec, 2016). As shown in Figure 1-3, oil and gas exploration and production activities occur in the NWT and Alberta, upstream of KFN. In the NWT, extractive industries operate in "the northwest slope of the Caribou Mountains and the southeast areas of the Cameron Hills, which are important headwater areas for tributaries to the Hay River" (AANDC, 2014). In Alberta, oil and gas development predominantly occurs within the Hay-Zama Lakes area (AANDC, 2014). KFN is also located approximately 91 km from the historically abandoned Pine Point Mine (Spicer et al., 2020). The Pine Point Mine opened in 1964 and ceased operations in 1988. Concerns regarding groundwater pollution, wildlife populations and human health were linked to contamination of the surrounding environment by heavy concentrations of metals in the mine's tailings dam (Sandlos & Keeling, 2012). In recent years, exploration has since resumed at Pine Point for zinc and lead deposits and Osisko Mining

Limited has entered the environmental assessment stage of their proposal to reopen the mine (Williams, 2021).

Although some areas in KFN's traditional territory remain less affected by industrial activity, there are growing concerns regarding the health of freshwater systems for future generations and an increasing need to gather a baseline of environmental information, which can be used to track environmental change over time. In response, KFN is establishing a CBM program to identify key indicators of change based on TEK and affirm control over the stewardship and monitoring of their lands. The goal is to identify and distinguish between ecological change generated from cumulative effects, such as climate change and resource development over time. KFN's Nahendeh Kehotsendı (Watching the land) program in recent years has received funding from the Government of the Northwest Territories' (NWT) Cumulative Impact Monitoring Program (CIMP) to support the development of the CBM program. While the environmental monitoring program is comprehensive and extends beyond the aquatic environment, this paper focuses on contributing to the freshwater and fish monitoring aspect of the program.

1.5 Overview of Thesis

This thesis has two core papers: Chapter 3 (Culturally Driven Monitoring: The Importance of Traditional Ecological Knowledge Indicators in Understanding Aquatic Ecosystem Change in the Northwest Territories' Dehcho Region) and Chapter 4 (Freshwater and Fish Monitoring: Opportunities for Social-Ecological Learning in the Northwest Territories' Mackenzie River Basin). The thesis begins with this introduction (Chapter 1), which outlined the key research objectives, the study's setting and context and provides an overview of the literature and theory that frame this research. Chapter 2 presents and reflects on the methodological framework of this research, while Chapter's 3 and 4 discusses the specific methods employed for each paper in greater detail, along with each research methods' limitations.

With the aim to help inform KFN's CBM program, and the implementation of the Alberta-NWT Bilateral Water Management Agreement, Chapter 3 documents community developed social-ecological indicators of freshwater system change based on KFN's TEK and

uncovers KFN perceptions related to aquatic ecosystem health. This paper specifically seeks to contribute to literature on the development of TEK derived and community-based indicators in the context of freshwater systems. Chapter 3 is informed exclusively by interviews with KFN, as this paper narrates a story of social-ecological change through the voices of KFN. In September 2020, Chapter 3 was published in the Sustainability Journal in the special issue 'Advancing the Involvement of Indigenous and Local Communities in Monitoring and Understanding Freshwater Ecosystems' (Stenekes et al., 2020).

Chapter 4 investigates the content, flow and mechanisms, by which monitoring information and knowledge pertaining to the health of freshwater systems is shared at various institutional levels and explores the role of CBM in fostering opportunities for social-ecological learning. Interviews with KFN and other actors (government, scientists and researchers) directly inform this paper's results and discussion. Chapter 4 draws on social-ecological learning, Indigenous knowledge systems and CBM to identify suggestions for improved information sharing across NWT actors engaged in monitoring.

Lastly, Chapter 5 summarizes the thesis' findings and presents recommendations for future areas of research.

CHAPTER 2.0: Methodology

2.1 Introduction

This chapter presents the methodological framework of the thesis. Moreover, this chapter draws on methodological theories and personal reflections based on fieldwork experiences to examine the research process and provides an overview of the research activities and partnership. This research is in collaboration with Kátł'odeeche Fırst Natıon (KFN) and emerged based on existing relationships that my supervisor, Dr. Brenda Parlee had with the community and Peter Redvers, Lead of Negotiations and Consultation for KFN. This chapter also details research ethics and outlines the tools and methods of analysis utilized. Ultimately, this research project was inspired by Indigenous methodologies that aim to decolonize the research process and sought to apply a community-based participatory research (CBPR) approach. My positionality as a researcher, and Indigenous research methodologies such as insurgent research are further elaborated on throughout this chapter.

2.2 Positionality

Who am I? Throughout this research project, I have spent time reflecting on my positionality as a non-Indigenous researcher. Prior to my thesis, much of my previous research experience encompassed working with Indigenous and rural communities in Latin American countries such as Mexico and Bolivia. While I was researching master's programs, I contemplated continuing to focus on Latin American communities. However, I found it problematic that I didn't have a strong understanding of my own country's complex history and more specifically an in-depth understanding of Canada's contemporary relationships with Indigenous peoples. I grew up in Hamilton, Ontario which is situated upon the traditional territories of the Erie, Neutral, Huron-Wendat, Haudenosaunee and Mississaugas and my limited knowledge included learning about the Caledonia land disputes through the news. Moreover, the extent by which the history and culture of Indigenous peoples was taught in primary and secondary education was far too limited. This realization of my own ignorance ultimately led me to make the decision to remain in Canada for my master's and work in partnership with an Indigenous community in my own country.

In qualitative research, many scholars distinguish between insider and outside status when discussing researcher positionality. According to Gair, "[t]he notion of insider/outsider status is understood to mean the degree to which a researcher is located either within or outside a group being researched, because of her or his common lived experience or status as a member of that group" (p.137, 2012). Based on this understanding, I am considered an outside researcher, as I identify as a white settler who did not grow up on the Hay River Dene Reserve with KFN. In turn, an important part of the research process is recognizing and addressing the limitations of my positionality.

In the insider versus outsider scholarly debate, Swisher, an Indigenous scholar, states "how can an outsider really understand life on reservations, the struggle for recognition, sovereignty, economic development, preservation of language and culture […] to ask appropriate questions and find appropriate answers?" (Swisher 1998). Although I strive to be empathetic, I acknowledge that I do not share the same lived experiences as the community, nor am I a TEK holder. Therefore, posing questions that I deem important without community involvement would have likely resulted in impractical research being undertaken. Instead of making assumptions regarding KFN's research priorities or interests, I learned the value of asking questions. Also, as an outside researcher I at times felt unequipped to communicate TEK appropriately, as I feared I would detach meaning from its context and cultural roots. Overall, I realized the importance of practicing self-reflection as an outside researcher throughout the research process. As a non-Indigenous researcher, this entailed growing awareness of community priorities and interests in isolation from my own and applying sensitivity to the transcription and analysis of the data in order to limit the decontextualization of TEK. Throughout this project, I have been fortunate to have the support of my community partner, Peter Redvers. Peter acted as a gatekeeper to the community and this project would truly cease to exist without his support and extensive contributions. I am immensely grateful for the guidance I received from Peter, as he instilled in me as a researcher the upmost importance of understanding context and strongly encouraged me to take a few steps back in the research process in order to effectively listen and learn about KFN prior to commencing any research.

2.3 Methodological Framework – Decolonizing Research

2.3.1 Historical and Contemporary Relationships Between Researchers and Indigenous Communities

Historically, Indigenous peoples have been treated as research objects, rather than research leads or partners themselves (Fletcher, 2003). In turn, past wrongdoings and treatment of Indigenous peoples in research have generated mistrust between Indigenous communities and researchers. More specifically, communities are reluctant to trust scientific findings (Jack et al., 2010). Indigenous communities and scholars have been critical of researchers' poor communication, stating that communities do not often receive results back from researchers following participation in research studies, yet they are constantly being asked to participate in subsequent studies (Fresque-Baxter, 2015). Fresque-Baxter notes in the context of water quality monitoring that "the lack of information sharing can reinforce feelings of mistrust" (p.240).

Hakkarainen et al. conclude that "history and relationships between actors shape outcomes of knowledge exchange" (2020, p.281). The effective communication of environmental health and risk research therefore relies on meaningful and culturally appropriate research dissemination strategies. Jack et al. (2010) state that communicating scientific findings in plain language with limited jargon is crucial when sharing research with communities. In past and present day, research is disseminated in ways that may not be deemed culturally appropriate by communities, through for example an academic journal article (Wong et al., 2020). Jack et al. (2010) argue that research is best communicated through face-to-face interactions and Young et al. (2016) encourage researchers to participate in wider community meetings to build relationships and trust, and aid in knowledge sharing. It is recognized however that not all scientists possess the skills needed to communicate highly technical findings to communities. The role of a cultural broker can therefore play an important role in assisting with translation and interpretation of research findings (Fresque-Baxter, 2015). Armitage et al. (2015) acknowledge that communicating across knowledge systems is challenging. For example, some scientists experience difficulties engaging with people whose knowledge is based on interactions with the land and is shared through storytelling. Wong et al. (2020) call for a decolonized approach to research that moves towards and commits to reconciliation through the shifting of power, in addition to trust building (Armitage et al., 2015).

Throughout the literature, recommendations to researchers to engage in effective research dissemination include taking the time to engage and listen to communities' needs during the research process (Wong et al., 2020). In addition, culturally appropriate research deliverables including translation services to communicate findings in Indigenous languages and utilizing various knowledge sharing mechanisms (e.g., video, audio, social media) can better promote effective knowledge sharing of research findings. "[I]t is important to acknowledge that successful knowledge transfer for an Indigenous community is not measured in the number of scientific journal publications as it is in academia. MJJ, Kluane First Nation Elder, emphasizes that knowledge sharing and co-production is ultimately a success if the knowledge generated becomes part of the oral history of the Indigenous community" (Wong et al., 2020, p.775).

2.3.2 Community-Based Participatory Research

The literature on participatory research, collaborative and community-based research shaped my plans for engaging with KFN. In particular, numerous Indigenous (Smith, 2013; Gaudry, 2011) and non-Indigenous scholars (Castleden et al., 2012; Fletcher, 2003) inspired me to view research as a decolonizing process and encouraged me to critically reflect on my approach to conducting outsider research.

Scholars critical of unethical research have condemned "parachute" researchers, who extract data from communities at their own convenience and fail to effectively engage with communities throughout the research stages (Castleden et al., 2012; Castellano, 2004). In efforts to address past wrongdoings (i.e. colonial legacy of research) and deconstruct power imbalances between researchers and communities, scholars demanded changes to researchers' approaches to working with Indigenous communities (Smith, 1999). According to Fletcher (2003), CBPR initially emerged in the 1970s, challenging the dominant development paradigm (i.e. top-down approach) practiced in developing countries. Specifically, CBPR signified a bottom-up approach to development and "empower[ed] local communities to be agents in their own change" (Fletcher, 2003).

In health and social science disciplines, CBPR is increasingly cited as an appropriate research methodology for working with Indigenous communities. CBPR promotes a transfer of

decision-making power and ownership to Indigenous communities, so that power is shared between the researcher and community (Castleden et al., 2012). In other words, CBPR extends beyond the inclusion and participation of communities in research projects and recognizes communities as research partners and collaborators. Mutual learning and the co-creation of knowledge is emphasized by CBPR and science is not deemed superior to community knowledge systems (e.g. TEK) (Castleden et al., 2012). Fletcher (2003) also conveys the importance of allowing Indigenous communities to develop their own interpretations and analysis of the research findings and notes that final results should be disseminated in a format that is beneficial to community members. Given the past injustices and exploitation of Indigenous knowledge, I employed a CBPR approach and specifically adopted an insurgent research model, which sought to include KFN in all stages of the research project. Collaboration and partnership with KFN were crucial to ensure meaningful, practical and mutually beneficial research outcomes.

Scholars advocate for the flexibility of CBPR, as there is no one-size fits all approach (Castleden et al., 2012; Fletcher, 2003). However, at the foundation of CBPR is relationship building, where CBPR allows for the formation of respectful relationships and trust between researchers and Indigenous communities (Fletcher, 2003). The four R's of research including "respect, relevance, reciprocity and responsibility" are considered key principles of CBPR (Kirkness & Barnhardt, 1991) and relational accountability, which involves creating ethical research relationships (Gaudry, 2011; Wilson, 2008; Henry et al., 2016). Experienced qualitative researchers increasingly encourage researchers to engage in preliminary fieldwork prior to initiating the research project (Caine et al., 2012). Specifically, Caine et al. (2009) reflect on personal research experiences and note that engaging in preliminary fieldwork often translates to increased local participation in the research design and improves researcher understandings of local contexts and potentially northern issues. I was fortunate to have the support from my supervisor and funding to participate in preliminary fieldwork activities. Similar to the experiences of Caine et al., only after these visits to KFN did I have an increased understanding of the research interests and historical context of the community. As I learned from my supervisor and other scholars, it is important for researchers to spend time "drinking tea" with communities (Castleden et al., 2012). On the other hand, I recognize that as a master's student a

couple of weeks of preliminary fieldwork is not a significant amount of time. Given the funding and time constraints, along with the fact that I did not have a driver's license, which could have provided me with more opportunities to visit the community or get around town easier to meet people, I do believe the two weeks were crucial in shaping my relationships with my community partners and the direction and outcomes of the research.

2.3.3 Insurgent Research Model

In the past, research in the academy has tended to follow an extractive as opposed to an insurgent approach (Gaudry, 2011). Therefore, this project sought to decolonize the research process (Smith, 1999) and adopt an insurgent research model, which aims to guide researcher responsibility back to the community and direct knowledge creation and the dissemination of research findings towards Indigenous peoples (Gaudry, 2011). Contrary to insurgent research, extractive research views the academy as the primary audience of research dissemination. As a result, extractive research often fails to produce meaningful and practical research outcomes for the community, despite their invaluable contributions and insights into the research project (Gaudry, 2011).

Overall, Gaudry (2011) outlines four key principles that embody insurgent research, which inspired my research approach. First, research must be rooted in and respect Indigenous worldviews. This research project specifically aims to showcase the value of TEK, as its own knowledge system, in understanding aquatic ecosystem change.

Second, insurgent research involves producing outcomes or deliverables that are of meaningful and practical use to Indigenous communities. Castleden et al. explain the challenges of creating an organic research relationship, and conducting research that reflects community priorities, and seeks to produce meaningful and useful research (2012, p.176). While this thesis has academic contributions, the findings (i.e. social-ecological indicators, information sharing) of this project were primarily developed to inform KFN's community-based monitoring (CBM) program. I also collaborated with KFN to develop culturally appropriate research deliverables for the community. The research deliverables consisted of a book of quotes and stories of environmental change and a plain language newsletter.

Third, in insurgent research Indigenous communities are considered the judges of the validity of the research findings and outcomes (Gaudry, 2011). Another criticism of extractive research is related to the "arrogance of the expert status assumed by researchers" and the historical imbalance of power relations between Indigenous peoples and academic researchers. Thus, in order to decolonize the research process, expert status was given to respected Elders in the community. I did not consider myself to be an expert and instead listened and learned from the diverse actors I interviewed for the project. In addition, to promote community participation in the verification of research findings, I met with community members one-on-one in March 2020, whom I interviewed in 2018 to gather feedback and ensure I had not misinterpreted any of the findings. Despite being able to meet one-on-one with fourteen of the fifteen community members I interviewed, I felt this process was a bit rushed, although being an incredibly important stage in the research process. Looking back, I wish I had more time to meet with community members to have more detailed and meaningful conversations and ask more questions, as it had been over a year since I had last visited. Not knowing at the time that a global pandemic would halt future travel for research only a week later, I feel fortunate that I was able to travel up north for data verification.

Fourth, insurgent research is "action oriented," meaning research promotes self-determination among Indigenous groups, and empowers and motivates Indigenous communities to take action (Gaudry, 2011). With the aim of the research results to inform best practices for information sharing, and contribute to the design of KFN's CBM program, the hope is that this research can be utilized by the community, specifically in local decision-making surrounding future monitoring initiatives and efforts. In addition, this research documents the TEK of Elders for future generations. Preserving culture through the continued transmission of TEK from Elders to youth is considered to be of great importance to the community. While I believe this research strived to empower KFN through the documentation of TEK, only community members and my community partners can determine the impact of this research.

2.3.4 Challenges in Practicing CBPR

While efforts were made at various stages of this research project to adopt a CBPR and insurgent research approach, I acknowledge that in practice CBPR research is confronted with

many challenges. Castleden et al. (2012) discuss the challenges of operationalizing CBPR in university-based research projects. For example, timelines and funding constraints, along with obligations to fulfil academic thesis requirements, shift the priorities of researchers. In turn, shifting priorities affects researchers' abilities to engage in meaningful community-based research. Personally, I have found balancing the responsibilities I have to the community and academy difficult at times. I have felt guilty taking so long to analyze research findings and report results back to the community. When I first began my masters, I was optimistic that I would write my thesis quickly and I would have additional time to conduct more voluntary research for the community. However, the reality is data analysis and writing take quite a bit of time, especially when there are external or personal interruptions such as a full-time job. Also, initial interview findings led to a second period of data collection with different actors, which expanded and lengthened the data collection and analysis stage. Despite the fact that it took me approximately a year to travel back to the community and disseminate findings to KFN, the presentation of research findings in a tangible deliverable to the community was very important to my research partners and myself.

2.4 Research Partnership and Ethics

A research partnership was established between the University of Alberta and KFN in 2017 following conversations with KFN's Lead of Negotiations and Consultation, Peter Redvers. As mentioned, the community has been leading the development of their own CBM program. The objectives of KFN's CBM program mirrored the Tracking Change project, as the monitoring program sought to emphasize Traditional Ecological Knowledge (TEK) in its design and overall understanding of aquatic ecosystem change. The Tracking Change Project, supported by the Social Sciences and Humanities Research Council (SSHRC PG 895-2015-1024) provided funding for the project, along with the University of Alberta's Northern Research Award and the Northern Scientific Training Program. In addition to receiving university ethics approval, the Tracking Change Project obtained an Aurora Research Institute license (#16515), which is required to conduct research in the Northwest Territories.

2.5 Research Scoping and Activities

There were several phases to conducting fieldwork: scoping, data collection and data verification/reporting. Prior to beginning my studies at the University of Alberta, I was in contact with my supervisor Dr. Brenda Parlee to discuss potential research projects and opportunities to work with an Indigenous community on a collaborative project. My research interests were very broad, as I was more so interested in engaging in a community-based research project. In other words, I wanted to work directly in partnership with a community and have their interests and priorities inform my research topic. In August 2017, I had a conference call with Peter Redvers, Lead of Negotiations and Consultation for KFN, and we discussed opportunities for a collaborative research project.

After beginning my MSc. in September 2017, I had the opportunity to meet Peter Redvers and KFN representatives during a CBM data tools workshop in Yellowknife, Northwest Territories in March 2018. This workshop provided me with the opportunity to learn about the CBM program KFN was developing, along with the broader, common challenges and lessons learned of other Northern communities designing CBM programs. I was then invited to attend a Traditional Knowledge Indicator Workshop with KFN in July 2018 in Hay River, Northwest Territories. Following this workshop, I attended a fall fish camp in late September 2018 along the banks of the Hay River. I am immensely grateful for my community partner and the opportunities I had to volunteer and participate in workshops and cultural activities with KFN, as these face-to-face interactions allowed for the building of relationships with Elders and fishers in an informal setting and aided in identifying many interviewees.

In addition, scoping included reviewing literature and various communications to familiarize myself with the ongoing freshwater ecosystem monitoring activities in KFN's traditional territory. I quickly realized that locating monitoring information online that was specifically relevant to KFN was an overwhelming process, as many different governments and scientists are leading various initiatives. This finding, along with Dr. Brenda Parlee's extensive knowledge and experience working with communities in the Mackenzie River Basin (MRB), raised the question "how does KFN share and/or receive information about the health of the water and fish at local, regional, territorial and federal levels?" Interviews with KFN in 2018

further posed questions such as “how is monitoring information shared across communities and between government, researchers and communities?” Thus, additional actors at various institutional levels (government, academia) were also contacted and interviewed for the project.

2.6 Data Collection – Semi-Structured Interviews

Data collection occurred over two separate time periods and involved interviews with multiple actors. Moreover, in-depth interviews were first conducted with KFN Elders, harvesters and youth in October 2018 in Hay River, Northwest Territories. Chapter 3 focuses on the findings of interviews with KFN. Following interviews with the community, interviews were arranged with government (researchers, program staff) and academic researchers from May to August 2019 over the telephone and email. Chapter 4 showcases the findings of interviews with all actors and institutions (KFN, government and academia). Chapters 3 and 4 discuss in greater detail the data collection process and analysis utilized. A semi-structured interview guide was used for interviews with KFN (Appendix D) and government and academic actors (Appendix E).

2.7 Community Research Assistants

Two community research assistants were hired for this project to assist with coordinating interviews, translation and the data verification process. While, fourteen of the fifteen community members interviewed felt comfortable speaking in English, one asked for the community researcher to be present in case they required assistance with interpreting the questions in English, and/or translating their responses from South Slavey. This research would not have been possible without the help of Doug Lamalice and Anne Marie Kasper. Their relationships in the community were integral to introducing me to fishers and arranging interviews. I am also grateful for the transportation they provided me to visit and connect with community members and interviewees.

2.8 Participant Recruitment

Participant recruitment involved a combination of recommendations from my community research partners and snowball sampling. I had the opportunity to meet many of the community members I interviewed at a fall fish camp in September 2018, which allowed for introductions and a rapport to be built prior to any requests for interviews. During my time in the community in October 2018, my community research assistant would first often call the community member

we were interested in interviewing and ask if they would be interested in participating in an interview. If they were interested, a time and meeting location would be arranged. Interviews ranged from 30 minutes to 2 hours. The locations of the interviews varied, as some community members preferred to meet at the band office, in their home, or at the community store. KFN interviewees informed further interviews with other actors (e.g., scientists and government) and often encouraged me to connect with specific researchers. For the interviews with other actors, my community research partners and supervisor also provided recommendations on government actors to contact for interviews that were either involved in monitoring efforts in KFN's traditional territory or at the regional and territorial level.

2.9 Consent

All interview participants were given a Tracking Change project information sheet (Appendix A and B), which explained the intentions and purpose of the project in plain language, and a consent form (Appendix C) to obtain written consent. One interview guide was provided to KFN Elders, harvesters and youth (Appendix D), and a separate guide was given to government and academia actors (Appendix E). Community members were also provided with an informal poster that explained the research project and background information about myself. Prior to starting each interview, I would have participants read the information sheet and the consent form. The consent form was completed by participants if they agreed to participate in the study. Community members always signed the consent form prior to the interview beginning, while other actors would either send the signed consent form electronically by email, along with their written responses to the interview questions, or following telephone interviews. I would often read the information sheet with participants and frequently ask them if they had any questions. Interview participants were also reminded that they could change their minds with regards to their participation in the study at any point during or following the interview. I explained to participants that transcripts would be delivered back to them for review to verify results and they would have up to one month to request changes or withdraw from the study before information resulting from the interview could be published. Verification of interview data was crucial to ensure interview participants were comfortable with the knowledge that they shared, and that the findings were not misinterpreted. While a number of interviewees were comfortable having their name published in the thesis, there were many who were not

comfortable and preferred to remain confidential. With this in mind, to respect confidentiality, it was decided that no personal names of those interviewed would not be identified in this thesis.

2.10 Compensation

In order to achieve relational accountability with Indigenous communities, practicing reciprocity is vital. Reciprocity is "more than just acknowledging ownership of one's knowledge, "[i]t is also about recognizing that knowledge must be 'gifted'" (Henry et al., 2016, p.196). Thus, in exchange for community member's participation in the research study, each community member was given monetary compensation. For a 30 minute to an hour length interview, elders and harvesters were given $75, and youth were given $50. If interviews extended beyond an hour, additional compensation was offered.

Originally, I had planned to give community members a gift card to the Ehdah Cho Store to support local business on the reserve. However, gift cards had to be ordered in and did not arrive in time. This was an oversight on my part, as I did not anticipate needing to order gift cards in advance. Instead, monetary compensation was given in the form of cheques. After consultation with KFN, it was decided that staff who were employed by the band office and interviewed during work hours would not be offered honoraria. However, community members who were interviewed during their own time would be compensated, as they were giving up time that they could be working (i.e. fishing). Overall, it was important to respect and follow KFN's policies regarding honoraria and gift respected Elders, harvesters and youth for their knowledge. Other actors interviewed for this research project, such as government and academia, were not offered honoraria, as phone calls and email correspondence were coordinated during work hours.

2.11 Analysis

Consent was granted by all 15 community members for the interviews to be audio-recorded. As a result, all KFN interviews were transcribed and coded using conventional content analysis. Notes, audio/transcripts and written email responses from interviews with the government and academic actors were also coded using thematic analysis. Qualitative content analysis is a method used to analyze text data (Hsieh & Shannon, 2005). More specifically, conventional content analysis involves uncovering themes through the coding and categorization

of textual data. However, the categories are developed based on the narrative that emerges from the data (Hsieh & Shannon, 2005). In other words, the categories and codes are created directly from the data as opposed to existing theory or literature, which allows new insights to emerge (Hsieh & Shannon 2005). My process of coding for all interview data involved first reading the transcripts, notes and written email responses while highlighting and taking notes by hand. Then quotes were organized into an excel spreadsheet into broader categories, which assisted in the identification of key themes.

2.12 Verification

Data verification and the dissemination of research findings primarily occurred in March 2020, as I travelled to KFN to meet with community members in person. As a non-Indigenous researcher, I recognize that there is potential for TEK to be misinterpreted, especially if "it has been removed from the values and spiritual foundations that give it meaning" (Simpson, 2001, p.140). Therefore, I personally hand delivered interview transcripts to all 15 KFN interviewees to verify my interpretation of their TEK and the themes and findings that emerged from interviews. With each individual transcript, I highlighted the quotes that I selected to use directly in my thesis, or more generally to inform the research findings. This allowed for community members to have a clear understanding of how the knowledge they shared was utilized. I also verbally discussed my interpretation of the findings one-on-one with community members. At the time of my trip to visit KFN, the global pandemic has just started to impact Canada. In turn, there was not an opportunity to safely host a large community workshop to present research findings back to the community. In terms of verification with other actors (government, academia), I sent copies of interview transcripts and notes to contacts over email and asked participants to confirm my understanding of their responses. Again, all relevant material that was utilized to inform the research was highlighted to ease the review process for the participants. I am extremely grateful for my community research partner Peter Redvers who generously reviewed and provided feedback on Chapter 3 prior to publication and the thesis in its entirety to review my interpretation of findings and ensure my representation of KFN was accurate.

2.13 Data Storage

All audio files, interview transcripts, written responses and notes were saved on a password protected computer and backed up on an external hard drive. Hard copies were also securely stored in a locked General Service Building office at the University of Alberta. Upon completion of my thesis, all files will continue to be safely stored at the University of Alberta for five years.

2.14 Outcomes and Culturally Appropriate Research Deliverables

Overall, this project has contributed to various academic and community outcomes, including a journal publication and book of quotes for the community. Further, at the community level, I assisted with the testing of methodology of KFN's CBM program (i.e. gathering data at a traditional fish camp) and contributed to KFN's Cumulative Impact Monitoring Program (CIMP) reporting requirements through the development of a summary report for the fish camp. In addition, the documentation of TEK will help inform future CBM efforts for KFN and provide a baseline of knowledge and observations to reference in future years. It was important to the community and myself to present the research back to KFN in a culturally appropriate way. Interviewees were directly involved in brainstorming the best ways, or tools to communicate research findings back to the community.

Given that chapter 4 identifies best practices for sharing research and monitoring information among communities, researchers and government, it would have been hypocritical of me to not consider culturally appropriate research dissemination for my own research. In turn, a book of quotes and stories with pictures of KFN's traditional territory was developed based on KFN interviews (Appendix G). This book is solely for KFN. Names of Elders, harvesters and youth are attached to each story and quote, since all KFN interviewees consented to have their names included in any material that was produced specifically for the community. This book was well received by community members who participated in the research project and was hand delivered when I visited the community in March 2020 to engage in verification. A newsletter outlining key findings of the research was also created and given to community members at the same time as the book (Appendix F). In hindsight, data verification and the delivery of research results back to the community should have taken place during two separate trips, as I ran the risk

of the book needing to be updated if different interpretations or understandings were uncovered during the verification stage. Due to funding and timeline limitations, this trip combined verification and research dissemination. One of the Elders did uncover a typo for a lake in the book, as he recalled mentioning a different lake at the time of the interview. Thankfully, leftover funding allowed for the reprinting of the book to ensure updated and accurate copies could be shared with KFN. This experience however reiterated how important verification is for ensuring an accurate interpretation of research findings.

2.15 Limitations

Prior to beginning my master's research, students often shared with me that the time spent in the community would fly by and it would not feel long enough. Although I'm grateful for the month I got to spend with KFN over the course of a couple years, I wish I spent more time in the community. There were several fishers I did not have the opportunity to meet and I was unable to arrange follow-up interviews with some community members due to time constraints. During interviews, the time needed to explain the project and introduce myself (at least to interviewees I had not met yet) varied. While I aimed to keep the interview guide short in length, 1-2 hours for an initial interview did not always provide enough time to ask detailed follow-up questions. Regardless, explaining the project and my intentions as a researcher was not only an ethical requirement, but important to address historical injustices, as community members shared with me their experiences of mistreatment by researchers in the past.

Another limitation of this research is that the English language does not always convey the meaning of a concept, or phrase in South Slavey (Dene Yatié). Although interviews were conducted in English, the importance of language in traditional harvesting activities and its continued teaching was emphasized during interviews with KFN. I recognize the importance of language in the documentation of TEK and acknowledge this gap in this research. Although this thesis did not focus on documenting the names of fish species and stories of social-ecological change in South Slavey, I hope future efforts and projects consider this.

2.16 Conclusion

In summary, this chapter provides an overview of the methodological framework of this research project. This research is guided by decolonizing research methodologies, including CBPR and insurgent research. KFN's participation and collaboration in the research project was essential to ensure mutually beneficial research outcomes. In terms of qualitative methods utilized in this study, semi-structured interviews were chosen and considered to be the appropriate method to document TEK and gain insight into social-ecological learning (i.e. knowledge sharing) across various institutional levels.

CHAPTER 3.0: Culturally Driven Monitoring: The Importance of Traditional Ecological Knowledge Indicators in Understanding Aquatic Ecosystem Change in the Northwest Territories' Dehcho Region

3.1 Introduction

In Canada's subarctic and boreal regions, environmental stressors such as climate change and resource development are adversely impacting freshwater lakes and rivers (Schindler & Smol, 2006). The cumulative effects of stress over the last 50 years have created new kinds of uncertainties for Indigenous peoples who depend on these ecosystems for their livelihood and well-being. Community-based monitoring (CBM) offers opportunities for communities to learn and adapt in ways that ensure the long-term sustainability of both the environment and community.

In the literature, scholars broadly define CBM as an approach whereby "concerned citizens, government agencies, industry, academia, community groups and local institutions collaborate to monitor, track and respond to issues of common community concern" (Whitelaw et al., 2003, p. 410). In northern Canada, there are a growing number of CBM programs focused on issues of climate change (Carver and Maclean, 2016; Herrmann et al., 2012; Kouril et al., 2015), resource development (Carver and Maclean, 2016; Parlee et al., 2014) and changes in various aspects of wildlife health (e.g., contaminants, surveillance of caribou movements) (Parlee et al., 2014). With the purpose of informing resource management, Indigenous-led CBM initiatives frequently involve the monitoring of species, habitats, and ecosystems (Yarnell & Gayton, 2003). There is also growing recognition of the value of Indigenous knowledge in monitoring as expressions of land rights, governance, and sovereignty are asserted through CBM and Guardian programs (Wilson et al., 2018). What tends to be unique about Indigenous-led programs is their holistic approach to tracking both social and ecological change in ways that are culturally appropriate and address local needs.

With the aim of understanding how a social–ecological approach to community-based monitoring is useful to Indigenous communities in the Mackenzie River Basin (MRB), Canada, this paper shares outcomes of collaborative qualitative research with Kátł'odeeche First Nation (KFN). This research is part of a larger CBM research project called Tracking Change, which seeks to document the voices and traditional ecological knowledge (TEK) of Indigenous peoples situated across the MRB and other freshwater basins in Thailand and Brazil (Tracking Change,

2020). The purpose of this paper is to demonstrate how narratives about cultural landscapes can inform the development of meaningful indicators for monitoring at local and regional scales. In addition, this research aims to address knowledge gaps in existing MRB monitoring efforts, specifically in the Hay River and Buffalo River basins through the documentation of KFN's TEK. This paper first explores key TEK literature in the broader context of environmental monitoring and then engages with literature focusing on indicators, CBM, and governance in the MRB. Next, the study area and methods are outlined in detail, followed by the presentation, discussion, and conclusion of the research findings.

3.2 Literature Review

3.2.1 Traditional Ecological Knowledge and the Social–Ecological Lens

The social–ecological lens of Indigenous communities is critical to the value of TEK in monitoring. Numerous scholars have articulated the value of this complex systems approach in improving environmental management and sustainability outcomes at various scales (Berkes et al., 1998; Ostrom, 2009). A social–ecological approach to monitoring moves away from thinking about people and nature as separate from one another and monitoring the task of objective and technical surveillance of a pool of resources. Rather, social–ecological approaches conceive the environment as a cultural landscape that has different dynamics and values to various peoples. TEK helps us to understand all of the unique dimensions, values, uses, relationships associated with being or dwelling in a particular place (Ingold, 2000). It is this richness of dwelling in place that underpins the TEK of Kátł'odeeche First Nation and the indicators developed through this research project.

TEK is defined by "a cumulative body of knowledge, practice, and belief, evolving by adaptive processes and handed down through generations by cultural transmission, about the relationship of living beings (including humans) with one another and with their environment" (Berkes et al., 2000, p. 1252). TEK is increasingly recognized as invaluable in environmental monitoring by scientists, researchers, and resource managers. Moreover, TEK is considered fundamental in the understanding of ecological change (Berkes, 2018), including cumulative effects such as climate change (Carver and Maclean, 2016; Herrmann et al., 2012; Kouril et al., 2015), resource development [Carver and Maclean, 2016; Parlee et al., 2014), and hydroelectric

development (Carver and Maclean, 2016). Indigenous people who live off of the land and its resources witness and experience environmental changes long before scientists (Lawe et al., 2005). Furthermore, people who rely on local resources for their livelihoods have a vested interest in learning from their environment and assessing ecosystem health in ways not considered by outsiders (Lauer & Matera, 2016). Because of local peoples' long-term or diachronic view, they can easily distinguish between natural ecological variability and anthropogenic change (McDonald et al., 1997; Parlee et al., 2005). Although some scientists and institutions (e.g., resource management, environmental impact assessments) have been disregarding the knowledge and views of Indigenous peoples (Ellis, 2012), there is increasing recognition that TEK can fill "gaps in scientific knowledge, offer alternate interpretations of observations, and provide a more holistic and long-term understanding of the environment" (Berkes et al., 2007; McKay & Johnson, 2016; Parlee et al., 2014).

3.2.2 Indicators Based on Traditional Ecological Knowledge

In the last 50 years, scientists have grown increasingly interested in the development and application of ecological indicators to assess the condition of the environment (Niemi & McDonald, 2004). In the discipline of ecology, there exist many definitions of indicators. Despite a substantial body of literature related to ecological indicators, criticism has emerged from social science disciplines stating that scientific indicators are often too technical and of little interest or relevance to local communities (Parlee, 2006). In this context, there is a growing body of work and an area of practical research related to the development of culturally ground community-based indicators that reflect the values and knowledge-related needs of local peoples, including Indigenous peoples (Mwesigye, 1996). In much of the TEK literature, scholars refer to indicators as signs and signals used by Indigenous peoples to identify ecological change and communicate about such change (Berkes, 2018; Berkes et al., 2007; Parlee et al., 2005). Māori peoples, for example, have developed indicators to monitor forest health in New Zealand (Lyver et al., 2017). Local indicators for monitoring the impacts of climate change and, in turn, changes to biophysical and socioeconomic systems are also increasingly cited in Canadian and international literature (Boissière et al., 2013; Dinero, 2013; Pearce et al., 2010; Kupika et al., 2019; Reyes-García et al., 2016; Tam et al., 2013).

There are a variety of indicators that have been developed to describe ecological change in the MRB. These range from indicators related to water quality, water quantity, and ice regime, to fish health, wildlife health, and population (Baldwin et al., 2018; Mantyka-Pringle, 2017; Parlee et al., 2012; Parlee et al., 2005; Parlee, 2011; Wilson et al., 2019). With the aim of co-producing knowledge and developing a more holistic approach to environmental monitoring and resource management, recent literature in the MRB has focused on blending or braiding TEK with western science-based indicators (Baldwin et al., 2018; Mantyka-Pringle, 2017). Less attention, however, has been paid to social, economic, and cultural indicators and how these are interrelated with ecological change in the MRB, and Hay River and Buffalo River basins in particular. Critical studies of these indicators and their ontological meaning and context has not been well-developed. The interconnections among these indicators, their use in monitoring, and the governance of the river basin are also major gaps in the literature.

3.2.3 Governance

The extent to which indicators and systems of CBM are interconnected with governance varies across programs, resources, and jurisdictions. Historically, in colonized countries across the globe, governments exerted power over Indigenous peoples and their territories and excluded Indigenous peoples in resource management decision-making. Natural resource management systems and associated monitoring consequently rely heavily on western science (Nadasdy, 2012). This is changing, in some countries faster than others, with increased recognition of TEK and community-based resource management (Berkes, 2018).

In Canada, CBM programs are supported by, or are outcomes of, collaboration with government. More specifically, a CBM program supported by the Government of the Northwest Territories (NWT) was developed to help address community concerns about water quality and is a strong part of the implementation of the NWT Water Stewardship Strategy. Similarly, the Dehcho Aboriginal Aquatics Resources and Oceans Management is another collaborative CBM program that has received federal support from the Department of Fisheries and Oceans (Fresque-Baxter & Kelly, 2018). In other regions monitoring programs have developed as alternatives to government-led programs. For example, in the oil sands region of Alberta, Mikisew Cree First Nation created its own monitoring program as a result of lack of trust in government and industry-

generated data about the health of the Athabasca River (Parlee, 2016). What these programs suggest is that one-size-fits-all approaches to monitoring are not as useful as place-based approaches that reflect the knowledge, needs, and interests of local communities and have tight feedback loops to local decision-making.

One important opportunity for linking outcomes of monitoring by Kátł'odeeche First Nation is the Mackenzie River Basin Transboundary Master Agreement (Government of Canada et al., 1997), specifically the Alberta–NWT Bilateral Water Management Agreement (Government of Alberta et al., 2015). One of the major objectives of the agreement is to develop biological indicators for the monitoring of transboundary water basins and the recognition of different knowledge systems (i.e., TEK and western science) in the development of indicators (Government of Alberta & Government of Northwest Territories, 2017).

3.3. Setting and Methods

3.3.1 Study Area

Kátł'odeeche First Nation (KFN) have occupied lands in their traditional territory of the Northwest Territories' Dehcho region for thousands of years and have passed on traditional ecological knowledge (TEK) through the practices of fish harvesting and monitoring. There are approximately 309 people currently residing on the Hay River Dene Reserve (Statistics Canada, 2016), the majority of whom self-identify as First Nation (i.e., South Slavey Dene) (KFN, 2019). While more Dene are participating in the wage economy in the present day, KFN continues to practice traditional activities such as hunting, trapping, fishing, and the gathering of berries and medicinal plants (KFN, 2019). There are both commercial and subsistence fishers in the community, as well as fishers who participate in environmental monitoring activities led by KFN, government, and academic researchers. As signatories of a treaty with the Government of Canada and the First Nations of the region (Treaty 8), members of KFN have the rights to hunt, trap, and fish on their traditional lands (Eagle-Eye Concepts, 2007).

Figure 3-1 depicts a map of the study area. The Buffalo River basin is located directly to the right of the Hay River basin on the map. These sub-basins reside within the larger Mackenzie River

Basin (MRB) (Government of Alberta & Government of Northwest Territories, 2017). The MRB signifies the largest river basin in Canada (Creery, 1979), as it occupies one-sixth the area of the country and comprises five jurisdictions (Lewis et al., 2010). Kátł'odeh (Hay River), Tucho (Great Slave Lake), Tagáa (Sandy Creek), Ejıe Túé Dehé (Buffalo River), and Ejıe Túé (Buffalo Lake) are socially, economically, culturally, and spiritually significant bodies of water to KFN, as relationships with these bodies of water shape their identity, well-being, and livelihoods. As the Hay River and its tributaries flow from the south, there is increasing concern among KFN members regarding the impacts of cumulative effects (e.g., oil and gas development, hydroelectric development, climate change) on the health of aquatic ecosystems for future generations. In turn, KFN is developing a community-based monitoring (CBM) program to assert control over the monitoring of their lands.

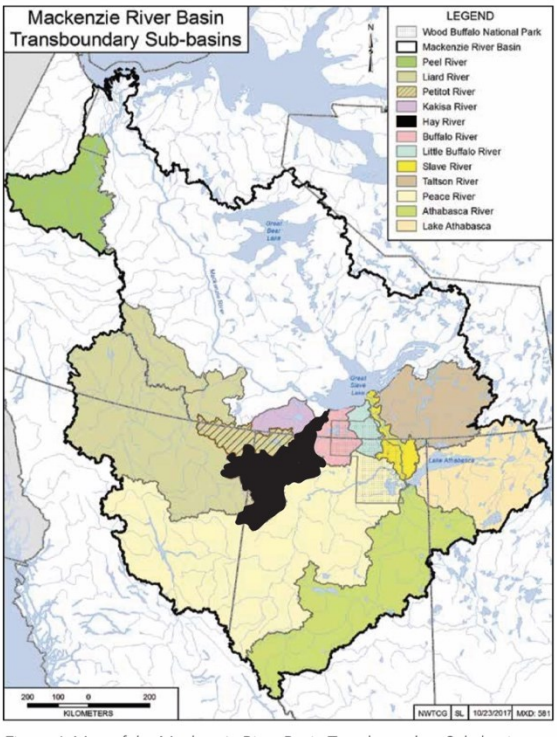

Figure 3-1. Map of Study Area—Hay River and Buffalo River Sub-basins (Source: Government of Alberta & Government of Northwest Territories, 2017)

3.3.2 Monitoring Activities in the Hay River and Buffalo River Basins

There has been increasing efforts to embrace TEK in freshwater and fisheries monitoring across the MRB (e.g., Northwest Territories' Community-Based Water Monitoring Program, the Transboundary Rivers Monitoring Program on the Hay River, and the Aboriginal Aquatic Resource and Oceans Management CBM program in the Dehcho region). Despite these efforts, the extent to which TEK is included in monitoring programs varies. Moreover, while TEK may inform the design of scientific monitoring programs, fewer programs are based exclusively on TEK indicators. The NWT's water monitoring inventory emphasizes the dominance of scientific parameters and technical indicators in current monitoring systems in both the MRB and Dehcho region (Government of the Northwest Territories, 2013)

In terms of existing research in the Hay River basin, there are few studies assessing aquatic biota and no long-term monitoring of the basin's aquatic health. In addition, there is limited baseline data to assist in identifying and monitoring potential changes in the Hay River basin that are a result of anthropogenic change and/or climate change (Stantec, 2016). To date, research and monitoring activities in the Hay River basin continue to be predominantly scientific (Aboriginal Affairs and Northern Development Canada, 2014). Few publications exist that document the TEK of communities located throughout the lower Hay River and Buffalo River basins. Evidently, more comprehensive assessments of the basin are needed to improve watershed management and address knowledge gaps.

3.3.3 Methodological Approach

The research approach was inspired by the previous work of Indigenous scholars (Gaudry, 2011; Smith, 1999) and non-Indigenous scholars (Castleden et al., 2012; Fletcher, 2003) who have extensive experience building ethical research relationships with Indigenous communities. A community-based participatory research (CBPR) approach (Fletcher, 2003) and insurgent research approach, which aims to guide researcher responsibility back to the community (Gaudry, 2011), were adopted in order to engage in ethical research with KFN and generate mutually beneficial research outcomes. KFN guided all aspects of the research project, including decisions about research focus, research design, interviewee selection, community researcher engagement, interpretation of findings, and reporting. In addition to academic outcomes, plain languages

materials and culturally appropriate outputs were created for the community (i.e., book of stories) (Appendix G). Given the researcher (lead author) was an "outsider" to the community and given budget constraints, which allowed the lead author to spend only a short period of time in the community to learn from a small sample of interviewees, the outcomes should be considered exploratory. More research is needed to more deeply inform the development of the CBM program such that it meaningfully reflects the histories, relationships to the land, and practices of KFN.

3.3.4 Semi-Structured Interviews

Fifteen semi-structured interviews were conducted in English with KFN elders, harvesters, and youth in October 2018 in Hay River, Northwest Territories. The Lead of Negotiations and Consultation for KFN, the Environmental Program Manager, and a community researcher identified interview participants, including key Traditional Knowledge holders and community members engaged in fish harvesting. A community researcher supported the lead author in carrying out the interviews (Table 3-1).

Table 3-1. Interviewee Sample

Interviewees	Male	Female
Elders	6	2
Harvesters	2	2
Youth	2	1

Nearly all of the fishers identified by our KFN research partners were interviewed. According to our community research partners, fewer community members are practicing fish harvesting in the present day. The purpose of the interviews was to document KFN observations, experiences, and diverse perspectives related to the Hay River, Great Slave Lake, Sandy Creek, Buffalo River, and Buffalo Lake areas. Given the nature of the research, a qualitative approach and semi-structured interview method were employed in order to capture the rich narratives of TEK holders and community members engaged in fish harvesting. The semi-structured interview was deemed an effective tool by researchers in the "accurate and comprehensive" documentation of TEK (Huntington, 1998). Most importantly, interviews were determined to be a culturally appropriate research method for the study by KFN. The semi-structured interview guide included questions such as: how do you know if the fish is healthy; how do you know if the water is healthy and safe to drink; what signs do you look for; are you observing any changes in the health of the water and

fish? Although the focus of the interviews was on aquatic ecosystem health, interviewees also spoke more broadly about social and ecological change. The interviews were also place-based; in addition to research–interviewee interactions on the land, many of the narratives shared by interviewees had a spatial reference (i.e., focused on a specific river, lake, etc.).

Community members had the opportunity to provide in-depth reflection on various topics and communicate their knowledge through stories and lived experiences. While it was necessary to guide the discussion at moments, it was important to allow interviewees time to share stories, as some led to information and connections that may not have otherwise emerged. Each individual was given the opportunity to talk about one or more bodies of water. Although some interviewees were comfortable focusing on a specific place, we were reminded by elders that Dene people naturally see all elements of the environment as connected, not separate. Therefore, allowing community members to freely discuss lakes, rivers, and creeks and other wildlife in no particular order was important, as their memories were flooded with rich ecological knowledge while they recalled in detail travelling across their traditional territory and harvesting fish at different times of the year.

3.3.5 Content Analysis

Consent was granted by all 15 community members for the interviews to be audio recorded and transcribed. Following conventional content analysis (Hsieh & Shannon, 2005), transcripts were coded by minor themes and later grouped into core themes. Based on preliminary analysis, the initial categories identified were descriptive of the health of freshwater systems and local values and use of these systems. Subsequent analysis resulted in the identification of the indicators or signs and signals used by interviewees to describe specific changes in water quality, water quantity, fish health, ice conditions, and stressors such as resource development, hydroelectric development, and climate change.

3.4 Results

3.4.1. The Significance of Freshwater Systems to Kátł'odeeche First Nation

According to Kátł'odeeche First Nation (KFN), the health of freshwater systems is imperative for the survival of human and animal populations and the continuation of KFN cultural traditions.

The connection was highlighted by KFN elders: "*That's where our great grandfathers they lived ... People settled here because of the lake. They did their fishing, that's how they made a living, that's how they survived*" (Elder 6). Another elder added, "*the water's important you know. You can't do anything without water … everything is connected to water*" (Elder 7). Similarly, youth took pride in explaining the historical importance of freshwater bodies to their community:

> *My people are from Buffalo River and they would live over the winter in Buffalo River, but they would come to the delta here, or along the banks of the Great Slave Lake to set nets and dry fish for the winter … The water is very important to us logistically, as well as locally. This is our entire existence right here, our entire history* (Youth 1).

Elders specifically emphasized the importance of fish for historical modes of transportation: "*Water gives us food and gives food to our dogs because at that time our dogs were all we had ... We didn't have skidoos ... Dogs were our main transportation …*" (Elder 8). While chuckling, an elder recalled that "*water used to be our highway down to Buffalo Lake*" (Elder 7). The continued practice of subsistence fish harvesting and the reliance on fish as a traditional food source in the present day were also expressed by community members. An active fisher in the community explained that "*Sandy Creek has always provided us with everything that we need and if people want stuff they just go over there and get what they need ... It's just like our [grocery] store*" (Harvester 1).

While community members linked the importance of water and fish to their survival and traditional way of life, they also conveyed the spiritual meaning associated with freshwater systems:

> *I have got to eat fish, I have got to have fish. I crave for fish … That's our life out there, the [Great Slave] lake is part of us, it's part of me. I think the lake is part of our spirit because even me I go out on the beach and sit there. I can heal myself by doing that ... the lake it's powerful … the air, the lake, the smell. You know it's beautiful. It makes you strong again* (Elder 6).

Ultimately, freshwater systems are deeply connected to KFN's well-being and the historical value of these bodies of water has been passed on for generations. Interviewees expressed that

fishing has brought them a lot of joy in their lifetimes and discussed the importance of sharing knowledge with youth in order to provide them with the knowledge necessary to monitor ecological change and engage in environmental stewardship.

3.4.2 Perceptions of Fish Health

A KFN elder with decades of experience commercial fishing on Great Slave Lake emphasized the value of TEK in understanding and interpreting ecological change, specifically contrasting the long-term nature of his knowledge with scientific research:

> *If you do the things that I do over the last 50 years or so and you get to see all these changes … Like say research started 5 years ago and they tell you all this and that ... They think that everything's normal because it's only 5 years back and not the 50 years that I know* (Elder 5).

Drawing on the TEK of KFN, Table 3-2 displays common TEK indicators of change and fishers' observations. While the most common observations reported by interviewees are documented in Table 3-2, it is important to note that variation exists among interviewees' observations associated with each indicator. Thus, indicator frequency does not necessarily correspond to the number of interviewees who reported an observation. Instead, the indicator frequency refers to the number of interviewees who mentioned the indicator.

Indicators (i.e., ways of monitoring) are commonly shared across the community. While some indicators are more general, others have temporal, spatial, and seasonal dimensions and are linked to specific fish populations. Inspired by the work of Parlee et al. (2005), the observations corresponding to each indicator were transformed into questions by the authors with the aim of being used for future monitoring in the community. Not all indicators outlined in Table 3-2 will be discussed in detail. Rather the key indicators that are linked to social–ecological change by KFN will be analysed. It is important to note that although texture and colour of fish gills were reported by the community as meaningful indicators, community members specifically linked gill texture and colour to the freshness of fish and not necessarily to the overall health. No observations associated with changes in gill texture and colour were mentioned by interviewees.

Table 3-2. Fish Health Indicators and Observations of Social–Ecological Change

Indicator	Indicator Frequency (# of Interviewees Who Referenced Indicator)	Observations (Most Commonly Reported by Interviewees)	Questions for Future Monitoring
Spawning and Fish Eggs	6	Recent changes in fish spawning patterns (e.g., difficult to predict when fish spawn up the Hay River in the fall time).	Are the fish spawning in different areas, at different times of year? Are fish spawning up the Hay River in the fall time? Are there eggs in the fish? Are there more or less than normal? What colour are they? Are they bigger or smaller in size than usual?
Abundance and Fish Populations	4	A lot of healthy whitefish are being caught in the Hay River. More trout are being caught in the Great Slave Lake in recent years.	Are there more or less fish (whitefish, jackfish, pickerel, trout etc …)? Are there new fish species? Are there more trout, pickerel being caught in recent years?
Size	4	The fish appear to be round and fat in Sandy Creek.	Are the fish skinny/bony? Are the fish round/fat?
Presence of Abnormalities/Deformities	7	Increasing numbers of fish are being caught with abnormalities in Great Slave Lake. Fish with pus are not being consumed by humans or being fed to the dogs.	Are there any scars, sores, bruising, puncture wounds (pus), growth, worms, and bugs found outside or inside of the fish? Are the fish safe for humans to consume? Are the fish safe to feed to dogs?
External and Internal Colour	5	Whitefish in the Hay River are darker than in the Great Slave Lake. Whitefish are pale/white in the lake.	Are the whitefish pale/white? Is the meat or liver discoloured?
Fat Content	4	The whitefish in Great Slave Lake appear to have a high fat content.	Do the fish have more or less fat than normal?
Texture	4	No reported observations.	Is the flesh of the fish firm or soft?
Colour of Fish Gills	4	No reported observations.	Are the fish gills dark pink/red?
Smell	3	The fish caught in the Hay River smell funny.	Do the fish smell funny? Do the fish smell like diesel?
Taste	2	The fish taste soapy from the Hay River, in comparison to Great Slave Lake.	Do the fish taste soapy?
Stomach Content	2	The fish in Hay River appear to be dirtier and have more silt in their stomachs than the fish found further out in the Great Slave Lake.	Is the stomach of the fish clean? Is there dirt or silt in the stomach?

Depending on the season, KFN focuses its harvest on specific fish populations and in a particular area. For example, whitefish (*Coregonus clupeaformis*) are known to spawn up the Hay River in the fall, while there is a coney run, also known as inconnu (*Stenodus leucichthys*), on the Buffalo River in the spring. According to KFN, spawning typically indicates the best time to

harvest fish, as the fish are considered to be a healthy size and many are filled with eggs. An elder noted that in the past spawning time periods were consistent, meaning fish spawned up the river during a select few days in the fall time. However, nowadays the elder noted difficulties in predicting spawning periods and associated this observation with climate change, specifically altering weather patterns: "*People would say the fish are going up [the river] in basically 2 or 3 days … but now I notice it's 2 to 3 weeks ... I think climate change has got a lot to do with what is happening out there*" (Elder 5).

In terms of community members' perceptions of fish health across freshwater bodies, the majority of interviewees shared observations related to the Hay River and Great Slave Lake. Fewer interviewees discussed Sandy Creek, Buffalo River, and Buffalo Lake. According to community members, fish populations in KFN's traditional territory were perceived to be generally healthy. However, some observations provided by interviewees were also consistent with KFN indicators of poor fish health. The variation in interviewees' responses are further discussed. Nonetheless, in comparison to the past, increased caution was given to the consumption of fish, as external and internal changes to the condition of fish were observed:

> *I guess years ago, I don't think you really had to worry about fish being different, or infected … I remember in my younger days, you go to Buffalo Lake, you go to Fish Point, you go to Buffalo River and when you catch a fish, it's always a clean fish. There's no mark on the fish ... That's how it used to be, but now ... it's different altogether ... it's different than what it used to be like years ago ...* (Elder 7).

While many TEK indicators used by KFN to determine fish health have been passed on for generations, new descriptive indicators developed, as distinctive and abnormal changes in the physical condition of fish were observed.

Based on interviews, there was increasing concern among fishers regarding the temporal differences in fish health, as more fish being caught in Great Slave Lake and Hay River are exhibiting indicators of poor health in recent years than in the past. Changes were noted specifically with regards to fish aesthetics (i.e., condition of fish), including the appearance of

scars, growth, or puncture wounds with pus. According to KFN interviewees, the presence of abnormalities and deformities on the body of the fish signified indicators of declining fish health:

> *The ones that you watch for are the ones that have a puncture wound ... they form some kind of pus inside ... When I opened it up the pus just burst open and started leaking … There's lots of growth on some on them from inside. Even those [fish] I won't give to the people. I always watch stuff like that. If they're scarred or really bad I just throw the fish away* (Harvester 1).

The catching of fish with abnormalities resulted in the automatic disposal of the fish, as they were deemed unsafe to consume for both humans and dogs. The harvester further explained that mainly whitefish in comparison to other fish species were exhibiting these abnormalities (Harvester 1). Similarly, others explained feelings of uncertainty with regards to the quality of fish caught in the Hay River, as some community members perceived the river fish to be unsafe to consume: "*[Lately] people don't think it's good to fish in the [Hay] river here and eat the fish*" (Elder 7). While some fishers reported catching healthy fish, their perceptions were influenced by other fishers' experiences, as monitoring information is shared within the community and regionally with other communities. Despite evidence of declining fish health, other fishers recognized the general health of fish populations, as they based their perceptions upon the frequency of catching sick fish, which appeared to be relatively small to date:

> *I'm fishing all the time [in the Hay River], so I see the fish that are coming in … I see that they're healthy ... I ran into a few here and there that were getting some growth and stuff on them, but nothing majorly … I mean that's one out of maybe 5000 fish, so I know everything is still pretty healthy* (Harvester 4).

An elder who commercially fished on Great Slave Lake deemed the fish to be generally healthy as well, referencing the high fat content and pale colour of the whitefish: "*Right now to my knowledge I know the whitefish are very healthy … The fat content of it and the inside is basically just white inside … I didn't catch any really terrible fish, or anything like that. They're just nice whitefish*" (Elder 5).

Although fish were reported to be fairly healthy, spatial differences in the health of fish caught in Great Slave Lake versus the Hay River were discussed by several fishers. An elder explained that "*the river fish and the lake fish are different … Whitefish from the lake is pale and white, but the river fish is darker*" (Elder 1). Another fisher supported these observations, stating that he/she preferred to travel further out on Great Slave Lake to set net, as this fisher perceived the fish to be healthier in the lake in comparison to the river:

> *We'll go out 5 km for nice fish, so it's not river fish where it's dirty and has silt and stuff inside the stomach. It would have a nice clean and clear stomach content … It tastes better being from the lake, as opposed to the river. It tastes soapy in the river … the whole fish smells funny, it tastes funny … It seems like the further you go out, the cleaner the fish* (Harvester 3).

Evidently, multiple senses beyond the visual appearance of fish, such as taste and smell, were used by KFN interviewees in the detection of abnormalities and monitoring of fish health.

In terms of perceptions of change, one of the elders clarified that scarring and punctures found on the bodies of fish could be caused by predatory fish (Elder 5). However, KFN interviewees primarily associated declining fish health with contamination resulting from extractive industries (Harvester 1) and acknowledged the concerns of poor fish health in communities living further upstream near oil sands development. Nonetheless, given that freshwater systems are interconnected, and water flows from the south, KFN members were growing concerned for the future health of aquatic ecosystems: "*We're still good so far in this area for fishing … we're just concerned about it. If it continues the way it is right now people are going to feel it years from now …*" *(*Elder 7).

3.4.3 Perceptions of Water Quality, Quantity, and Ice Thickness

Table 3-3 depicts meaningful social–ecological indicators of freshwater system health according to the TEK of KFN elders, harvesters, and youth. The indicators of change were framed around several themes: water levels, water quality, and ice thickness. Again, interviewees' observations and indicators were predominantly centred around Hay River and Great Slave Lake.

Table 3-3. Freshwater System Indicators and Observations of Social–Ecological Change

Indicator	Indicator Frequency (# of Interviewees Who Referenced Indicator)	Observations (Most Commonly Reported by Interviewees)	Questions for Future Monitoring
Access to Clean and Safe Drinking Water	12	The water is safe to drink further out on Great Slave Lake, towards the middle. People are now having to travel further out, away from Hay River, to access clean drinking water. The water is not safe to drink during the spring ice break-up.	Do you have to travel further to access clean and safe drinking water on Great Slave Lake? How many kms from the mouth of Hay River? Where and when is it safe to drink water? Are there times and places where it is no longer safe to drink the water? Does the water have to be boiled before it is safe to drink?
Colour of Water and Clearness	11	The water is darker, murkier, and less clear in the Hay River than it once was.	Has the colour or clearness of the water changed? Is the water dark, murky, dirty or yellow?
Perceived Risk of Contamination	11	Diesel surfaced when puncturing a hole in the ice on Great Slave Lake. Increased concerns regarding the health of freshwater systems located downstream of resource development.	Is the body of water in close proximity or downstream of industry? Are contaminants like diesel present in the water?
Algae Growth	4	More "green stuff" or algae is present in Hay River and Great Slave Lake near the shore.	Is there "green stuff" or algae on the water?
The Health of Fish and Other Animals	4	The fish are not dying (e.g., floating dead in the water).	Are other animals (fish, wildlife) healthy?
Taste	2	The water tastes the best further out on Great Slave Lake.	Does the water taste fresh?
Temperature	1	No reported observations.	Is the water temperature warming?
Water Levels	8	Creeks and streams are drying up and water levels are declining in Great Slave Lake, Hay River and Buffalo River. There are more sandbars in Hay River and Buffalo River and more shoreline appearing on Great Slave Lake. Islands and rocks are emerging in the Hay River. There is increased concern regarding the impacts of climate change and hydroelectric development on water levels.	Are water levels declining in rivers and lakes? Are small creeks and streams drying up? Are there new sandbars/islands appearing in the Hay River, on Buffalo River? Is the shoreline changing on Great Slave Lake? Are certain traditional areas difficult to access (e.g., Alexandra Falls, Buffalo River)? Are you able to walk across certain rivers in the summertime? Is the body of water located downstream of hydroelectric development?
Ice Thickness	2	The ice thickness is decreasing on Great Slave Lake. It used to be 7 feet, now it's closer to 2-3 feet.	Is ice thickness decreasing? Are winter temperatures warming?

3.4.3.1 Deteriorating Water Quality: Spatial and Temporal Differences

Interestingly, numerous community members' perceptions of water quality were determined by the health of the fish and wildlife in their traditional territory, as the health of animals and freshwater were interconnected (Harvester 1). One harvester discussed how he/she relied on the health of the

fish to verify assessments of water quality: "*If the water is healthy, the fish are going to be healthy. If the fish are starting to get sick and somebody is telling me well the water is fine, well I will find it hard to believe*" (Harvester 4).

Other common indicators used by KFN interviewees to assess water quality included changes to the colour and clearness of the water. Furthermore, water described as dirty, murky, and dark was considered to be of poor quality and perceived as unsafe to drink, whereas water that was clear was perceived as clean and safe to drink. Altogether, spatial differences existed in community members' perceptions of water quality. More specifically, interviewees drew comparisons between the conditions of the Hay River and Great Slave Lake. For example, youth contrasted the dirtiness of the river water and shoreline of Great Slave Lake to the clear water found further out on Great Slave Lake, away from the mouth of Hay River:

> *The water in the river is dirty ... On the lake, along the shores it's really dirty ... I remember going swimming here in the Great Slave Lake along the beach and me and my sister were pretending to be mermaids at the time. We were so young, and we opened our eyes underneath the water and we couldn't see each other like at all ... It was really dirty, like really brown, but once you go out into the lake it actually gets really clear ... The water looks blueish in the middle of the lake* (Youth 2).

Interestingly, interviewees' observations related to the differences in water quality on the Hay River and Great Slave Lake were shared across generations. Evidently, signs coinciding with turbidity were strong indicators of water quality.

In terms of perceptions of drinking water, more than half of community members perceived the water on Great Slave Lake to be safe to drink without purifying or boiling it, but emphasized the safest and cleanest drinking water was located closer to the middle of the lake:

> *If you go far enough out to the lake, away from where the Hay River, or Buffalo River, or Slave River feeds into the lake and you get out to the open water [where] it's more clear, you can just take water from there and drink it* (Youth 1).

Furthermore, in order to access safe drinking water, community members were now required to travel greater distances out on Great Slave Lake, away from the mouth of the Hay River. An elder reflected on the changes observed in her lifetime:

> *The water quality has changed since I was a kid … You can tell when you are getting closer back to the [Hay] river … the water starts to change colour and it gets almost yellowish. But when you're out there, you can grab a glass and drink it … it's ice cold and it's amazing and it's so clean! … [But] now you probably have to travel quite a ways out [on the lake]. I'm going to say maybe about 3 km, but before it was just over here, not very far …* (Elder 4).

In stark contrast, water from the Hay River in the present day was generally perceived as unsafe to drink, although several community members boiled it to make tea and/or coffee.

In terms of seasonal indicators, interviewees commented on the appearance of algae in the summertime, which was commonly referred to as "green stuff." The presence of algae deterred KFN members from drinking the water. An elder recalled an experience on the Hay River with her husband:

> *One year when we were in the river I told him to get some water for me to make coffee and when he brought that water up, he said I don't think you should make coffee because all over in the river there was little tiny green stuff* (Elder 2).

In addition, temporal differences in water quality on the Hay River were also discussed by community members. For instance, three elders reported witnessing changes in the colour of the water on the Hay River in their lifetime. One elder explained that "*the water changed colour. It used to be just about clear and now it's just like tea …*" (Elder 8). Moreover, a harvester recalled drinking water from the Hay River as a child, noting the water was less murky in the past: "*[W]hen I was younger growing up on the Reserve we used to get our drinking water right from the [Hay] River … because it used to be clear*" (Harvester 2). Ultimately, various observations contributed to an understanding that Hay River water quality has deteriorated over time and perceptions regarding water quality have changed. Reinforcing these changes, KFN youth spoke about personal observations, along with the knowledge and stories passed on from older generations:

"*People have said that Hay River used to be clean, or used to be clear when they were children, but in my lifetime, the river has always been brown and murky*" (Youth 1). Despite variation in temporal observations of the water quality in the Hay River, there was consensus among interviewees that water conditions in the Hay River have deteriorated over time and the river water was of poor quality to date.

Explanations for deteriorating water quality were connected to those linked to declining fish health. Moreover, KFN members deemed resource development activities (e.g., oil sands) in the south to be responsible for downstream contamination of freshwater systems, specifically the Hay River, Slave River, and Great Slave Lake:

> *Nowadays there's so many things that get in our water system ... all that stuff that's coming through from the mines up there [from the south] ... I know people are concerned here ... what happens when that stuff starts getting into our lake, how do we stop it from getting it into our lake?* (Harvester 2).

Evidently, community members' perceptions regarding access to safe drinking water from natural freshwater sources were influenced by their awareness of industrial activities upstream. For example, some community members avoided drinking water from the Hay River, as they considered the water to be contaminated from pulp mills that are located along the river's tributaries:

> *Well I was always told that you never drink any water unless it's from some place way far out. I wouldn't trust drinking anything on the Hay River, just because of the simple fact that I know that there's a lot of different water basins that empty into it. Like I know the Chinchaga River empties into it and I know up that way there's [pulp] mills ...* (Harvester 4).

Moving forward, community members proposed increased testing of the water and fish in order to identify linkages between poor water quality, sick fish, and human health.

3.4.3.2 Declining Water Levels

Of the four themes, declining water levels generated the strongest consensus among interviewees. Although no interview questions purposely inquired about observations related to water levels, more than half of the interviewees reported decreasing water levels in recent years as a major concern. The Hay River, Great Slave Lake, Sandy Creek, Buffalo River, and smaller streams and creeks were bodies of water referenced by interviewees in connection to declining water levels. Access to traditional hunting areas, the drying up of creeks and streams, changing shorelines, and the appearance of islands, sandbars, and rocks represented social–ecological indicators used by KFN to assess changes in water levels. For example, an elder spoke about the low water levels, specifically the drying up of a creek near Buffalo Lake in the month of December:

> *It seems like we're losing more water every year and I noticed creeks that used to flow, they no longer flow at all ... I go out to Buffalo Lake and there's one spot where that little creek overflows just before I think it's in December ... there's no water there now ... The water's going to be a big problem I think in the future* (Elder 5).

Community members blamed low water levels for their inability to access certain areas by boat. Elders shared common concerns and stated that reduced water levels in the fall time impeded navigation and access to traditional hunting areas, as there was high risk for motor boats to become trapped on sandbars. An elder recounted a recent experience on the Buffalo River: "*The water goes so low that we can't do the actual hunt that I used to do ... go up the river and hunt for moose ... I hit a sand bar and had to spend a night on the boat*" (Elder 5). Other community members noted a drop in the shoreline along the Great Slave Lake, indicating lower water levels on the lake. More significant changes, however, were observed to be on the rivers. Referring to the Hay River, a harvester recalled in the past being able to travel to Alexandra Falls, a place of cultural and spiritual significance to the community: "*I remember the water being so high you could take boats way up to the falls. Now you can't because there's so many rocks ... the water levels are really low*" (Harvester 3). The appearance of islands on the Hay River, near the mouth, were also repeatedly mentioned by interviewees:

> *The problem is the water is getting lower and lower every year ... In the past I used to just go out and I didn't see any islands. Now I go out there and on the other side of the*

river, there's a big island way over there ... trees are growing on there. I never saw that when I was growing up (Elder 1).

Although interviewees were not prompted to provide explanations for the decreasing water levels, four elders and harvesters perceived the low water levels to be connected to hydroelectric development upstream: "*I know they're building dams in BC and that's where our water's coming from ... it goes into Athabasca and Slave River, and then it comes through this way*" (Elder 5). Again, KFN members emphasized the interconnectedness of freshwater systems, as they flow across jurisdictions. Another elder spoke more generally about the perceived impacts of hydroelectric dams on water levels in the region:

I think that the hydro dams they're putting up ... they're talking about [site] C dam in the newspaper and Slave River I think at Fort Smith ... It's going to be more of a problem if there is no water ... Even now I used to go fall hunt, but the water is so low I couldn't go to Buffalo Lake, to go hunt moose in the fall. The water is so low, so if they put up the dam pretty soon we'll be able to walk across the river (Elder 8).

While the elder voiced his concern for the future building of dams, he did not attribute the reduced water levels specifically observed on the Buffalo River to current hydroelectric development. The elder further distinguished between the socioeconomic benefits for the south and the anticipated consequences for the north, as communities that depend on northern freshwater systems, including KFN, attributed declining water levels in recent years to hydroelectric development. Concerns regarding the availability of freshwater for future generations were shared and expressed by community members:

Water is a living thing. The way it flows, it's alive. If it's not flowing, what is it going to be like? ... You know I think about my great grandchildren … I won't be around to see, but what are they going to have? ... I pity my grandkids ... Now all those guys who are fighting to put a pipeline into the north or wherever ... My grandkids … my great grandkids are going to fight for a water pipeline to go that way [from here to BC someday]. It's sad ... (Elder 1).

All in all, the KFN community voiced strong concerns related to declining water levels and provided numerous examples of indicators used to monitor and assess changes.

3.4.3.3 Decreasing Ice Thickness

Lastly, community members who engaged in ice fishing reported changes to the condition of the ice in recent years, specifically on the Great Slave Lake. An elder who grew up ice fishing on Great Slave Lake described changes to the measurements of ice thickness in his lifetime:

> *Now today, the lake doesn't freeze. When I started going with my uncle … when he set nets there was just about 7 feet of ice. He used to kneel on his knee … he used to try to get to the bottom. Today he's lucky ... he won't even hit 3 feet of ice now. When I grew up, oh I tell you, it was 30, 40 [degrees Celsius] below every day. Today, it gets to 20 [degrees Celsius below] sometimes, but not often ... It's a lot warmer …* (Elder 1).

Similarly, a fisher who frequently ice fishes on the lake with her family expressed tremendous concern for recent changes in ice thickness:

> *It's not as thick as it used to be. I remember a hole being 7 feet down … like to jig a hole and to drill it out and everything. It was like 7 feet thick and now it's … you'll be lucky if you get 2 feet. That's how it was last year and I've never seen that before in my lif*e (Harvester 3).

The fisher added that the freeze up and weather conditions, specifically snowfall, in that particular year were contributing factors to the decreased ice thickness, as snow insulates the water below. KFN fishers further linked thinner ice to the effects of climate change, including warming temperatures. Evidently, the depth of ice served as an important quantitative indicator in the monitoring of climate change in KFN's traditional territory.

3.5 Discussion and Conclusions

There is increasing interest in community-based monitoring (CBM) in many parts of the world, including northern communities in Canada (Fresque-Baxter & Kelly, 2017; Kouril et al., 2015; Thompson et al., 2019). Traditional ecological knowledge (TEK) is also increasingly recognized as an important source of knowledge for learning about and understanding complex

ecosystem change (Berkes, 2018; Peloquin & Berkes, 2009). Within this context, a research project was carried out with Kátł'odeeche First Nation (KFN) in the Northwest Territories to determine what kinds of indicators would be more meaningful and culturally appropriate in the development of a CBM program in this region, specifically the Hay River and Buffalo River basins of the Mackenzie River Basin (MRB).

The outcomes of the research, which included 15 interviews with elders, harvesters, and youth, identified key indicators and observations of change linked to fish health, water quality, water levels, ice conditions, as well as a range of other aspects of aquatic ecosystem health. As the quotes suggest, interviewee narratives were strongly connected to place and land-based practices (e.g., traditional fish harvesting). The work was consistent with previous research findings (McDonald et al., 1997; Parlee et al., 2005) in reaffirming that elders and fishers have a detailed understanding of the dynamics of their local ecosystems. Their temporal insights are not short term in nature but speak to very long-term patterns of change.

Furthermore, elders were able to distinguish variability in ecological events that were not previously seen before. These included climate-related events as well as resource development impacts. For instance, the presence of abnormalities such as growth and sores on fish have been observed in recent years, whereas in the past these signs, which indicate poor fish health, neither were necessary nor did they exist, as elders recalled growing up and observing healthy fish absent of any abnormalities.

Although exploratory, the outcomes of the research with KFN may be useful in informing the development of a local TEK-driven CBM program that is tied to broader monitoring in the Northwest Territories and Alberta, as well as the implementation of the bilateral agreements for monitoring and management of the Hay River watershed. The absence of long-term scientific monitoring of the aquatic health in the Hay River and limited baseline data (Stantec, 2016) further emphasize the importance of TEK in addressing temporal knowledge gaps and generating baseline information that can be used to monitor future changes to the basin.

In addition to these outcomes, the monitoring program can be more than a tool for describing ecological change; it can also "become [a] tool for ongoing learning and communication with the elders and harvesters that hold and have ownership of this knowledge" (Parlee et al., 2005, p. 168). Currently, indicators in this study are used by KFN to monitor fish health, water quality, water levels, and ice depth and directly inform local decision-making with regards to the consumption of fish, drinking water, safety, and navigation. KFN fishers, for example, assess water levels utilizing indicators (i.e., observations of islands, sandbars, rocks) and, in turn, are able to make decisions related to navigation (i.e., their ability to access traditional hunting areas safely by boat). While CBM governance structures and the extent of Indigenous participation within CBM programs vary (Wilson et al., 2018), CBM may signify an expression of Indigenous governance if communities have direct control over the social–ecological monitoring of freshwater systems and are leaders in the design of monitoring methods and outcomes. Externally and scientifically driven monitoring programs led by government or industry will not capture the TEK and place-based knowledge of local peoples.

Finally, on a regional scale, KFN indicators of change seek to contribute to the intended outcomes of the Alberta–Northwest Territories Bilateral Water Management Agreement (Government of Alberta & Government of the Northwest Territories, 2015), which aims to strengthen transboundary governance and management of the MRB through the development of indicators for monitoring. The process of developing indicators through direct collaboration with KFN contributes to the environmental monitoring and governance literature, as the process of identifying social–ecological indicators based on fishers' observations, knowledge, and experiences can inform collaborative governance and the transboundary management of watersheds. Future research that documents TEK indicators of other communities living throughout the Hay River and Buffalo River sub-basins, along with the larger MRB, is needed to further explore relationships between social and ecological change, understand local communities' adaptation strategies to change and inform watershed governance.

CHAPTER 4.0: Freshwater and Fish Monitoring: Opportunities for Social-Ecological Learning in the Northwest Territories' Mackenzie River Basin

4.1 Introduction

"Water is life and sustaining it requires sharing and learning among people with a vested interest in protecting it now and into the future" (Fresque-Baxter & Kelly, 2017, p.179). The complexities surrounding transboundary management of watersheds calls for comprehensive monitoring of water and fish health, collaboration among diverse actors and effective knowledge sharing and learning about social-ecological change across horizontal and vertical linkages. Community-based monitoring (CBM) is increasing in Canada's north to monitor, track and access environmental change (Thompson et al., 2019; Kouril et al., 2016). While CBM may be informal (e.g., subsistence fishing) or formal (e.g., on the land programs, monitoring programs) and comprise a variety of different actors, CBM promotes opportunities for the intergenerational transfer of Traditional Ecological Knowledge (TEK) among Elders, harvesters and youth, and dialogue between scientists and TEK holders. In turn, CBM is understood as a mechanism that may facilitate opportunities for social-ecological learning (Villaseñor et al., 2016; Olsson et al., 2004).

While there has been significant attention given to understanding social-ecological learning in co-management institutions, or participatory processes, less attention has been given to the role of social-ecological learning in CBM at local levels and among Indigenous peoples (Cundill & Rodela, 2012). Specifically, in the MRB, there is a growing literature that highlights CBM in Mackenzie River Basin (MRB) communities (Berkes et al., 2007; Carver & Maclean, 2016), however less research has focused on knowledge sharing at various institutional levels in the MRB. Guided by literature on social-ecological learning, Indigenous Knowledge systems, and community-based monitoring, this paper presents the outcomes of research with Kátł'odeeche Fırst Natıon (KFN) from 2018-19 about knowledge sharing and community-based monitoring. Specifically, this paper highlights the content, mechanisms and flows (relationships) of knowledge sharing in relation to freshwater and fishing monitoring within KFN and between different actor groups including First Nations, territorial and federal governments. Based on the insights from this case study research, the paper provides suggestions to improve CBM, and

management of the Hay River and Buffalo River sub-basins and Makenzie River watershed more broadly.

4.2 Literature Review

Throughout this paper, the terms 'social learning' and 'social-ecological learning are referenced. While the focus of this research is on social-ecological learning, natural resource management and social-ecological systems literature frequently cites the term social learning. In turn, the literature review will present scholarly work that discusses both concepts. However, the discussion of this paper and the results will be through the lens of social-ecological learning, as this research is inspired by the work of Berkes et al. (2008), Folke et al. (2005), Olsson et al. (2004), and Rodriguez and Vergara-Tenorio (2007).

4.2.1 The Concept and Application of Social Learning in Natural Resource Management

The term 'social learning' was first coined by psychologist Albert Bandura. Bandura's 'Social Learning Theory' (1997) challenges traditional schools of thought that attribute human behaviour solely to determinants within the individual (i.e. internal impulses), or external influences. Bandura explains that in reality people learn in a social environment by observing and imitating others.

Although Bandura's definition of social learning is frequently referenced throughout the literature, it has been criticized by other disciplines for being too narrow, as it does not recognize all forms of learning that occur, specifically in the field of natural resource management (Pahl-Wostl, 2006). For instance, while Bandura (1977) places the emphasis on individual learning that occurs in a social context, natural resource management literature often refers to learning at a level beyond the individual, such as in a group, or society (Cundill & Fabricius, 2009). Overall, it is important to note that social learning has no universal theoretical basis and is considered an interdisciplinary concept.

Fazey et al. (2005) elaborate on conventional social learning theories, and explain that individual learning, driven by external experiences, can be communicated within a group, or organization, which initiates another process of learning, as knowledge is shared and interpreted

collectively. Thus, it is important to recognize and understand both individual and group (i.e. organizational) learning, as focusing solely on individual learning disregards the social and institutional context in which it took place (Armitage et al., 2011). Ultimately, individual learning, and group learning interact with one another, and the collaboration among individual actors is crucial to ensure a better understanding of environmental change (Olsson et al., 2004).

Overall, the term social learning holds different meanings, and is commonly referred to as both a process, and outcome (Lee & Krasny, 2015). Lee and Krasny (2015) call for the literature to distinguish between learning processes, which are understood as the process by which people learn from each other, and outcomes, which refer to the learning and its resulting action that occurs due to social interactions. Plummer and FitzGibbon (2008) establish attributes associated with social learning processes in environmental management: interaction, systems orientation, integration and reflection/reflexivity. Ensorl and Harvey (2015) explore social learning through categorization of what is learned, or the outcomes/impacts of learning. Cognitive learning, which includes factual knowledge, normative learning, which refers to changes in norms, values and beliefs, and relational learning, which involves the building of trust, and respect of other worldviews, represent different types of learning that may correspond to outcomes, or changes to practice, values, institutions, and systems (Ensorl & Harvey, 2015). This categorization can also be applied across different levels (i.e. individual, network and systems), as cognitive, normative and relational learning lead to impacts, or outcomes at different scales.

The paper by Reed et al. (2010), ‘What is Social Learning?’, is widely cited in the understanding, and conceptual clarity of social learning, as it criticizes social learning literature for being quite vague and broad. Reed et al., (2010) note several issues with current literature, stating that assumptions are often made that suggest social learning contributes to pro-environmental behaviour and sustainability, however, other processes, or factors may be contributing to these outcomes. Reed et al. (2010) further argue that the concept is often confused with the conditions or methods required to facilitate social learning, such as stakeholder participation. Moreover, participatory processes do not guarantee the occurrence of social learning. While social learning has been described as a participatory process that can result in

improved environmental management outcomes, Armitage et al. (2008) recognize that learning has the potential to be superficial and may not always contribute to meaningful change in environmental management outcomes.

Reed et al. (2010) address these critiques by proposing an alternative definition of social learning. In order for learning to be considered social learning it must satisfy certain criteria. First, it must demonstrate that a change in understanding has occurred within individuals, which may involve surface level learning of new information, or deeper level learning reflected by a change in attitudes, worldviews, or beliefs. Second, learning must extend beyond the individual, or small groups, to wider social units, or communities of practice. In research, the bringing together of groups of individuals are not likely considered communities of practice. Rather, the individuals are representatives from various communities of practice. Thus, social learning occurs once the ideas and attitudes learned by individuals in the small group are transferred to individuals in the wider social units, or communities of practice they are situated in. Ultimately, learning occurs through social interactions between actors within a social network, including direct interaction (e.g. oral conversation), and media technology (e.g. mass media, phone and internet) (Reed et al., 2010). In summary, Reed et al. define social learning as "a change in understanding that goes beyond the individual to becomes situated within wider social units or communities of practice through social interactions between actors within social networks" (2010, p.6). Berkes (2018) states that social learning is an important process in the integration of Indigenous knowledge and western science knowledge systems.

Despite growing optimism that social learning can lead to improved environmental decisions and adaptation, there are many factors discussed throughout the literature that may constrain learning. In particular, barriers to multi-actor learning include competing worldviews, values, culture, and knowledge that are in conflict with one another (Armitage et al., 2008). As a result, challenges exist in having diverse stakeholders co-produce new resource management knowledge, and agree on indicators, and impacts of environmental change (Davidson-Hunt, 2006). Social learning processes that allow for dialogue between Indigenous peoples and western resource managers, and promote respect for different ways of knowing, and communication (i.e. narrative or measurement) is essential. Unfortunately, in social learning forums people have the

potential to convince and inform others of the validity of their knowledge (Davidson-Hunt, 2006), which can hinder learning opportunities. “Contextual issues such as times constraints, attendance fluctuations, levels of literacy, issue salience and power relations” represent other factors that affect peoples’ learning experiences (Cundill & Rodela, 2012, p.11).

To date, historic power inequalities are embedded in many institutions, specifically environment management regimes in Canada’s north, and a lack of trust often exists between various stakeholders, such as resource users, managers, and government officials (Armitage et al., 2011). Therefore, collaboration and learning require the building of trust (Armitage et al., 2008). In Canada’s north, learning is also influenced by stakeholders’ willingness to experiment and accept potential risks, along with the strategies and tools used to communicate information, and facilitate cross-cultural learning. In addition, comprehensive land claims generate increased collaboration and participation of communities in resource management (Armitage et al., 2008). All in all, the capacity of institutions, and political spheres play a role in shaping social learning processes, and outcomes.

4.2.2 Social-Ecological Learning, Traditional Ecological Knowledge and Community-Based Monitoring

It is important to note that social learning emerged as a western concept, and therefore must be carefully, and uniquely applied to understand learning among Indigenous peoples. Its broad definitions and emergence in natural resource management literature however allow for culturally appropriate applications. On an international scale, CBM literature has discussed social learning in the context of participatory and collaborative monitoring initiatives. For instance, Wiseman and Bardsley (2016) describe the importance of building knowledge through social learning in an Indigenous CBM program in Australia through field trips, storytelling, and oral sharing. Another study explores social learning in participatory water quality monitoring in rural Mexico (Burgos et al., 2013). Findings indicate that CBM promotes social learning, as CBM facilitates interactions, such as collaboration, cooperation, knowledge exchange, and knowledge co-production (Burgos et al., 2013). Similarly, Fidel et al. (2017) acknowledge that the sharing of community observations and information/data related to environmental change gathered through CBM activities contributes to social learning, which is an

important element of resiliency.

Villaseñor et al. (2016) discuss social learning as a potential outcome of participatory monitoring initiatives, and tool that can lead to adaptation and greater resilience to environmental change. Fernandez-Gimenez et al. (2008) empirically study social learning in the context of CBM in five community-based forestry organizations in the western USA to explore social learning as an outcome of collaborative and community-based monitoring. Evidence of social learning at multiple loop levels was found among the case studies. Information generated from participatory monitoring however is not always effectively transferred into decision-making to inform management (Villaseñor et al., 2016), resulting in the value or outcome of social learning being difficult to determine.

In a statement addressed to the Arctic Observing Summit, Johnson et al. (2018) acknowledge that "social systems for distribution of resources and information within communities play an important role in facilitating use of observations locally" in CBM (p.4). CBM programs may rely on popular community knowledge transmission mechanisms, including radio, videos, and Facebook, and monitoring programs may be designed around traditional harvesting activities. Johnson et al. (2018) also differentiate between informal and formal opportunities that support social-ecological learning. Formal opportunities include culture and on the land camps, elder-youth connection programs, training, and youth mentorship programs to learn various skills. CBM opportunities that encourage people to spend more time on the land have the potential to facilitate the transmission of Indigenous languages and TEK between Elders and youth (Berkes, 2005; Johnson et al., 2018). In addition, CBM may promote knowledge sharing and collaboration with other stakeholders and communities (Raygorodetsky & Chetkiewicz, 2017). Johnson et al. (2015) further explain that "communities around the Arctic are engaged in informal monitoring and observing based on TK and ongoing environmental engagement, and they have their own ways of sharing this knowledge" (p.4). Johnson et al. (2015) call for "[increased] documentation of local observing traditions and systems, including how monitoring information is shared among residents of a community" as it "would help ensure future CBM initiatives build on and integrate insights from these existing local observing systems" (p.4). Johnson et al. (2015) further note that "[CBM] initiatives are more likely to be

applied in decision making at a local scale" and given that CBM is community focused, "sharing data and information across scales at the regional or national levels can be more challenging" (p.34).

A Canadian case study explores the importance of social-ecological learning in monitoring in James Bay. Concerns regarding the impact of a hydro project on Cree fishing harvesting generated an interest in local and regional environmental monitoring. The Cree and the Inuit in Hudson Bay relied on their TEK of sea ice, current, wildlife, and plant distributions to conduct their own monitoring (Olsson et al., 2004). 35 communities decided to form a network in order to share location specific TEK, and local observations of environmental change. Horizontal linkages through community-community discussion, and vertical linkages through regional tribal organizations and government departments aided in improved ecological monitoring, and the understanding of ecosystem change (Olsson et al., 2004). Overall, local Indigenous peoples were directly responsible in building various networks, which would allow for information flows. In the case study of James Bay, the establishment of networks and sharing of information through CBM initiatives exemplifies processes that may facilitate knowledge sharing and social-ecological learning at local and regional levels (Johnson et al., 2015).

Berkes (2009) studies the complexity of social-ecological systems and emphasizes that knowledge sharing and co-production contribute to greater understanding of ecosystem health, environmental change and improved resource management. Moreover, Berkes (2018) argues that observations and understandings of environmental change at various levels (local, regional, global) are needed to further advance knowledge related to climate change. Within this body of literature, social-ecological learning is referred to as a "long-term self-organizing process," where social-ecological co-evolution occurs through interaction with the environment and learning following ecological crises (Folke et al., 2005; Olsson et al., 2004; Cundill & Rodela, 2012, p.10). Furthermore, social-ecological learning has the potential to build resilience in socio-ecological systems, as it aims to inform resource users' and managers' abilities to respond to ecological change and seeks to achieve more sustainable outcomes (Folke et al., 2005; Olsson et al., 2004; Cundill & Rodela, 2012).

Throughout the literature there is theoretical and empirical support for the significance of social-ecological learning, especially in the context of Canada's north. In 'Sacred Ecology,' Berkes (2018) explains that resource crises contribute to social-ecological learning at the institutional level, as new management strategies develop. In a Cree case study, Berkes (2018) explains that the conservation practice of caribou was restored through social-ecological learning and TEK. Following an overhunt of caribou in Chisasibi, the Cree experienced a disappearance of caribou in the 1900s and attributed this disappearance to the wasteful hunt. Cree hunters learned from the experience through the teachings of Elders and oral history, which led the community-based system to adapt and evolve (Berkes, 2018). Elders, the holders of knowledge and values, have an important role in the social-ecological learning process, as they "provide corporate memory for the group, the wisdom to interpret uncommon or unusual events, and they help enforce the rules and ethical norms of the community" (Berkes, 2018, p.132). As well "elders span the generations to provide information feedbacks" (p.148).

Rodriguez and Vergara-Tenorio (2007) further note the importance of social-ecological learning among local groups, as it contributes to improved local resource management practices, and the achievement of sustainable outcomes. Local knowledge is determined to be learned and transmitted through social interactions in communities and provides invaluable empirical knowledge with regards to the environment, and information about traditional organizational structures and decision-making processes, cultural identities, and place attachment (Rodriguez & Vergara-Tenorio, 2007). The recovery of TEK to understand Indigenous peoples' experiences adapting in a complex environment is considered a primary objective of social-ecological learning that overall enhances local empowerment (Rodriguez & Vergara-Tenorio, 2007). Individual learning creates a foundation for collective learning and effective knowledge transmission involves mutual exchanges between communities and technicians/researchers, and the transfer of knowledge within families and across communities. Social-ecological learning through knowledge transmission allows people to obtain similar information, which can increase peoples' understanding, ownership, and acceptance of potential solutions to problems (Rodriguez & Vergara-Tenorio, 2007).

It is important to recognize that "the ways in which TEK and associated worldviews are acquired and transmitted are diverse" (Turner & Spalding, 2013, p.4). Some scholarly work studies the transmission of TEK, connecting the findings to Indigenous pedagogies, including experiential (learning by doing), observational and place-based learning (Turner & Spalding, 2013). Despite some research recognizing the role of social-ecological learning in the transmission of TEK, Cundill and Rodela (2012) explain that there is not a substantial amount of literature that asserts social-ecological learning as a "self-organizing process of social-ecological interaction over long periods of time [whereby] local people are able to learn and transmit knowledge among themselves and to future generations" (p.11). In turn, this research applies this definition and understanding of social-ecological learning to contribute to this gap in the literature by exploring the transmission of TEK in KFN's traditional territory. This paper is further inspired by and draws on the work of Berkes et al. (2008), Folke et al. (2005) and Olsson et al. (2004), who conceptualize social-ecological learning as a process of social-ecological co-evolution through interaction with the environment and learning among resource users and managers following ecological crises.

4.3 Methods

4.3.1 Methodological Approach

As mentioned in Chapter 2, this study employs a decolonizing approach to research with Indigenous communities and is inspired by both Indigenous (Smith, 2013; Gaudry, 2011) and non-Indigenous scholars (Castleden et al., 2012; Fletcher, 2003). This research is guided by community-based participatory research approaches (Fletcher, 2003), a collaborative research methodology, and adopts an insurgent research model (Gaudry, 2011) in order direct researcher responsibility back to the community.

4.3.2 Data Collection

4.3.2.1 Semi-Structured Interviews with KFN

Interviews were conducted with KFN elders, harvesters and youth in October 2018 in Hay River, Northwest Territories. Semi-structured interviews were chosen as the appropriate method to document TEK (Huntington, 1998) and obtain detailed information from community members, including examples of how information is exchanged. Much information shared during

interviews was related to Indigenous learning and the transmission of TEK. The interviews were semi-structured to ensure flexibility in terms of the questions asked and the order they were asked. The key questions of interest inquired about knowledge sharing at various levels and distinguished between knowledge shared with community members (i.e., received) and knowledge shared by community members (Appendix D).

If time allowed, questions were also asked about what information related to water and fish, community members would like access to and the best ways for researchers to share findings with KFN etc. When conducting interviews, the questions were broken down further and simplified in order to not overwhelm interviewees. Examples of mechanisms (i.e. ways of sharing knowledge) were provided to interviewees in order to help generate memories or stories. However, interviewees were not limited to discussing only the mechanisms identified in the questions. As mentioned in Chapter 3, interviewees were selected based on their involvement in and knowledge of traditional fish harvesting activities. The project's community partners, Peter Redvers and Patrick Riley, along with community researcher, Doug Lamalice, assisted in selecting community members to be interviewed.

4.3.2.2 Interviews with Government and Academic Actors

Based on the information learned from the interviews with KFN in October 2018, interviews with government and academic actors were organized from May to August 2019. Overall, community members expressed interest in obtaining results from government-led water and fish monitoring activities, as there was confusion around the ongoing monitoring in the region and the dissemination of key research findings. Learnings from initial interviews with KFN prompted the development of research questions to respond to community questions and concerns.

Snowball sampling was used as a method to identify government and academic actors, as KFN interviewees discussed their relationship with several government researchers and encouraged me to connect with them. Snowball sampling draws on the social networks of interviewees to inform research participants (Parker et al., 2019). My community partners, Peter Redvers and Patrick Riley, and supervisor, Dr. Brenda Parlee, also assisted in identifying

representatives from the GNWT, DFO and academic institutions, who are directly involved in water and fish monitoring activities in KFN's traditional territory and the NWT more broadly. An attempt was made to interview a similar number of government and academic representatives in comparison to KFN members. 14 individuals were contacted by email and were asked to be interviewed for the project. However, only 9 interviewees responded and 4 of the interviewees opted to collaborate on a response together, as they worked in the same department and division of government. A total of 6 interviews were completed with government and academia. Table 4-1 displays the composition of the interview sample. None of the government and academic interviewees resided in Edmonton. Therefore, 3 of the interviews were conducted over the phone and ranged from 45 minutes to 1 hour and 3 of the interviewees preferred to respond over email with written responses. Consideration was given to travel to Yellowknife to conduct interviews with the GNWT in person in 2019, however, due to funding limitations and the nature of monitoring related work (i.e., staff travel) it was decided that phone/email interviews would be the most convenient. While the focus was to obtain answers to KFN's questions, 3 interviewees did not work personally with KFN, and thus spoke more broadly about the collection and dissemination of freshwater and fish monitoring information in the NWT. Multiple efforts were made to connect with researchers specifically engaged in freshwater and fish monitoring initiatives in KFN's Traditional Territory, however, several scientists did not respond to the interview requests. Nonetheless, the interviews were regionally and territorially focused. It is important to note that interview data was supplemented with online research (e.g., review of reports, data sharing platforms and websites) in order to expand on actors' references to specific knowledge sharing mechanisms.

Scholars note there are both advantages and disadvantages to telephone and email interviews. While perceived anonymity by the interviewee and convenience are cited by scholars as benefits of telephone interviews for qualitative research, challenges include difficulties in building relationships or establishing rapport and the inability of the interviewer to notice body language and respond to visual cues (Drabble et al., 2016). Similarly, email interviews are said to be an inexpensive and efficient tool that allow for research recruitment and participation from people that may not otherwise be accessible (Meho, 2006). Despite the challenges associated

with email interviews and telephone, for this research email and telephone were deemed important methods to utilize due to time or financial constraints and geographic boundaries.

4.3.3 Data Analysis

All of KFN interviews were audio recorded and transcribed. Comparatively, only one actor interviewed over the phone consented to the interview being recorded. Therefore, the majority of interview data for government and academic actors was in the form of email correspondences and interview notes. Nonetheless, notes and transcripts were coded using thematic analysis (Hsieh and Shannon, 2005). KFN interview transcripts were initially coded according to institutional level. How knowledge was shared (i.e. mechanisms, flow), in addition to what knowledge was shared was then coded and organized into an excel spreadsheet under each institutional level. The need for certain information and the best ways to share information as identified by community members was also coded. Ultimately, themes emerged following this initial coding in terms of the different ways KFN shares and/or receives knowledge related to water and fish and the types of knowledge shared at local, regional, territorial and federal levels. Based on the data collected and KFN's interpretation of the interview questions, in this paper, the local level is defined as the community level (KFN), the regional level encompasses other communities located throughout the MRB and regional monitoring initiatives, the territorial level is used interchangeably for GNWT, and the federal level is referred to as the government of Canada, specifically DFO. Visual mapping with a pen and paper also took place to make sense of the data and themes and highlight the direction of flow of information (i.e. if the information was being received and/or shared by KFN).

Despite the lapse in time between the interviews with KFN and other actors, along with the differences in interview guides, the data was coded similarly. Specifically, the government and academic actors' data was first coded into broad categories, including knowledge content and mechanisms. Less attention was paid however to the direction of flow of information since most government and academic interviewees referenced knowledge sharing more broadly, which was likely due to how the question was structured. Interesting dialogue resulted from government and academic actors when asked what the challenges and strengths were in sharing

monitoring information at various levels. Therefore, themes pertaining to both the strengths and challenges of sharing monitoring information and outcomes were identified.

4.3.4 Description of Interview Participants

It is important to note that all government and academic interviewees had a technical, scientific background in freshwater and/or fish monitoring. Despite this shared education, actors held different positions, roles and responsibilities across various governments and institutions. As mentioned, not all actors directly engaged with KFN. Table 4-1 summarizes the roles and responsibilities of key actors: KFN (local), GNWT (territorial), DFO (federal), AAROM (regional) and academic scientists, who engage with partners at various levels. Since representatives of the government and academy did not want to be identified by name in this research, in order to maintain confidentiality, interviewees will be referenced and analyzed according to the actor.

Table 4-1. Interview Sample and Actors

Actor	# Interviewed	Roles and Responsibilities / Position
LOCAL **Kátł'odeeche First Natıon (KFN)**	15	• Since time immemorial KFN have been dedicated stewards of the land and have transmitted Traditional Ecological Knowledge across generations. • The band is developing a community-based monitoring (CBM) program and has received funding through the GNWT's Cumulative Impact Monitoring Program (CIMP). • KFN fishers, harvesters and youth are engaged in informal and formal water and fish monitoring activities across their traditional territory. Informal monitoring activities include engagement in traditional harvesting practices (i.e. monitoring on the land). Formal monitoring includes participation in KFN's CBM program activities, or seasonal employment working with GNWT, or DFO researchers to help collect water quality and fish samples.
TERRITORIAL	2	• Department of Environment and Natural Resources (ENR) leads the implementation of the NWT Water

Government of the Northwest Territories (GNWT)		Stewardship Strategy, which seeks to involve local peoples and communities in water stewardship activities, and the implementation of the AB-NWT Transboundary Bilateral Water Management Agreement. • ENR also supports communities in the development and implementation of CBM programs. • ENR conducts water quality monitoring in partnership with various actors (e.g., communities, academia) • CIMP provides funding to NWT communities and researchers to conduct TEK and scientific water and fish monitoring and research. While CIMP projects are predominantly scientific, stand-alone TEK projects are increasing and more scientific research is incorporating TEK into project design and monitoring activities.
REGIONAL **Aboriginal Aquatic Resources and Oceans Management (AAROM)**	1	• The AAROM program coordinates the Dehcho regional community-based water monitoring program. • Another objective of the AAROM program is to build capacity in communities with unsettled land claims and promote collaborative or co-management of aquatic resources. • The Dehcho AAROM program is community-based and provides communities with funding to hire field workers and technicians to conduct their own monitoring of water and fish. AAROM additionally trains local peoples to use monitoring equipment and technology.
FEDERAL **Department of Fisheries and Oceans (DFO)**	2	• DFO researchers/scientists conduct fish studies on bodies of water in KFN's traditional territory, including the Great Slave Lake and Buffalo River. • DFO researchers often employ local peoples (KFN) to assist with data collection.
ACADEMIA **Aquatic Scientist**	1	• Conduct research in academic institutions and work in partnership with communities, and government to develop and design environmental monitoring program frameworks (e.g. integration of science and TEK).

The Aboriginal Aquatic Resource and Oceans Management (AAROM) program "supports Indigenous groups as they develop, grow and maintain aquatic resource and oceans management departments that can provide fisheries, habitat, science, and oceans related services along a watershed and/or support participation in advisory and co-management processes and decision-making" (DFO, 2020). In essence, the Dehcho AAROM program facilitates community-based water monitoring across the Dehcho region of the Northwest Territories in collaboration with 9 First Nation and Métis communities, academic researchers and government departments. Project agreements are developed with communities and Indigenous peoples are contracted through AAROM to work as community monitors. Key objectives of the AAROM program are to build capacity in communities which do not yet have settled land claims and foster collaborative management in fisheries (Lafontaine, 2014).

Although AAROM is a federally established and funded program through the Department of Fisheries and Oceans (DFO), AAROM operates at a regional level in the Dehcho region. Thus, AAROM is considered to contribute to both regional and federal knowledge sharing, as the program generates opportunities for regional exchanges of information (e.g. community-based water monitoring and fish data) and acts as an intermediary between the DFO and communities (AAROM 1, 2019). ARROM's involvement in developing and facilitating community level programs and monitoring varies, as some communities have increased capacity and in turn, lead their own monitoring projects with AAROM issued funding (AAROM 1, 2019). Alternatively, AAROM coordinators work closely with communities on the land to implement programs and execute monitoring activities. Ultimately, ARROM provides technical and financial assistance to Dehcho communities to conduct aquatic ecosystem monitoring of interest and relevance to communities. Overall, the Dehcho ARROM program is a community-based program, as the program relies on extensive engagement with Indigenous communities and Indigenous ownership of projects and incorporates both science and TEK into monitoring activities.

4.3.5 Limitations

In terms of limitations, the length of the interview guide for KFN may have restricted the time needed to obtain more detailed responses and reflection related to knowledge sharing.

Questions pertaining to perceptions and indicators of water and fish health (Chapter 3) were often spoken about for a longer period of time at the beginning of the interview, leaving less time to discuss questions that addressed knowledge sharing. Also, although the interview questions related to knowledge sharing were designed to be broad in order for interviewees to draw on memories and stories that were deemed meaningful and important to them, some questions were more challenging than others to answer. For example, asking community members to recall how they share knowledge locally (e.g. with other fishers, family members) resulted in a flood of memories and detail, as knowledge sharing at the local level occurs more frequently and organically. In comparison, asking community members to recall how they share and/or receive information with government may not as easily be remembered, as the interactions do not occur as frequently. Interestingly, KFN's responses to this question correlated with their level of interaction and relationships with government and in turn their position in the community, as community members who are involved with council and participate in research and monitoring activities for example have increased opportunities to engage with government.

Another limitation of the study is the disproportion of government and academic actors interviewed in relation to community members (15:6). The initial focus of the research was to document KFN's TEK, perceptions of environmental change and knowledge sharing from their perspective. Opportunities for additional interviews with new actors emerged directly from interviews with KFN. While a larger sample of government and academic actors could have potentially generated new insights for this research, conducting more interviews was not possible due to fieldwork timeline and funding constraints. While interviews with KFN took place in person, other actors resided across Canada in different provinces and territories. Moreover, the coordination of interviews, including the time it took actors to respond to emails expressing interest in being interviewed, or providing me with the contact information of an individual more suitable to answer my questions, took several months. As a result, I eventually had to move along with data analysis and not seek more interviews.

In early stages of the research, I realized there exists a significant amount of freshwater and fish monitoring activities in the NWT that are conducted and led by various partners. Other actors/partners (e.g. Environment and Climate Change Canada, Parks Canada, Alberta

government) were not interviewed despite their involvement in environment monitoring, as no contacts were specifically mentioned by KFN interviewees or my community partner. In turn, I recognize that this paper is not comprehensive and does not include all of the actors and partners involved in freshwater and fish monitoring in the NWT. Furthermore, I acknowledge that the Mackenzie River Basin is a transboundary watershed and bodies of water deemed important by KFN flow north from the province of Alberta. I appreciate there are other valuable actors whom either did not respond to my interview request or were not contacted and included in the interview sample that have an important role in facilitating knowledge sharing and learning. Thus, this exploratory paper recognizes that there are other actors, mechanisms, opportunities and challenges in the context of freshwater and fish monitoring and information sharing in the NWT.

4.4 Results

4.4.1 Overview of Results

Inspired by the work of Kristine Wray who explored the Gwich'in Knowledge Complex and how the Teetł'it Gwich'in construct knowledge surrounding caribou (Wray, 2011), Figure 4-1 summarizes the actors (i.e., information sources) identified initially through interviews with KFN whom hold, generate and share information relevant to the health of freshwater systems in KFN's Traditional Territory and the broader NWT. As well, Figure 4-1 illustrates the different types of knowledge content that is shared among actors, the mechanisms by which knowledge is shared and the challenges/barriers that exist when sharing information. Throughout the presentation of results, attention will be specifically drawn to the common mechanisms cited by actors and challenges related to knowledge sharing.

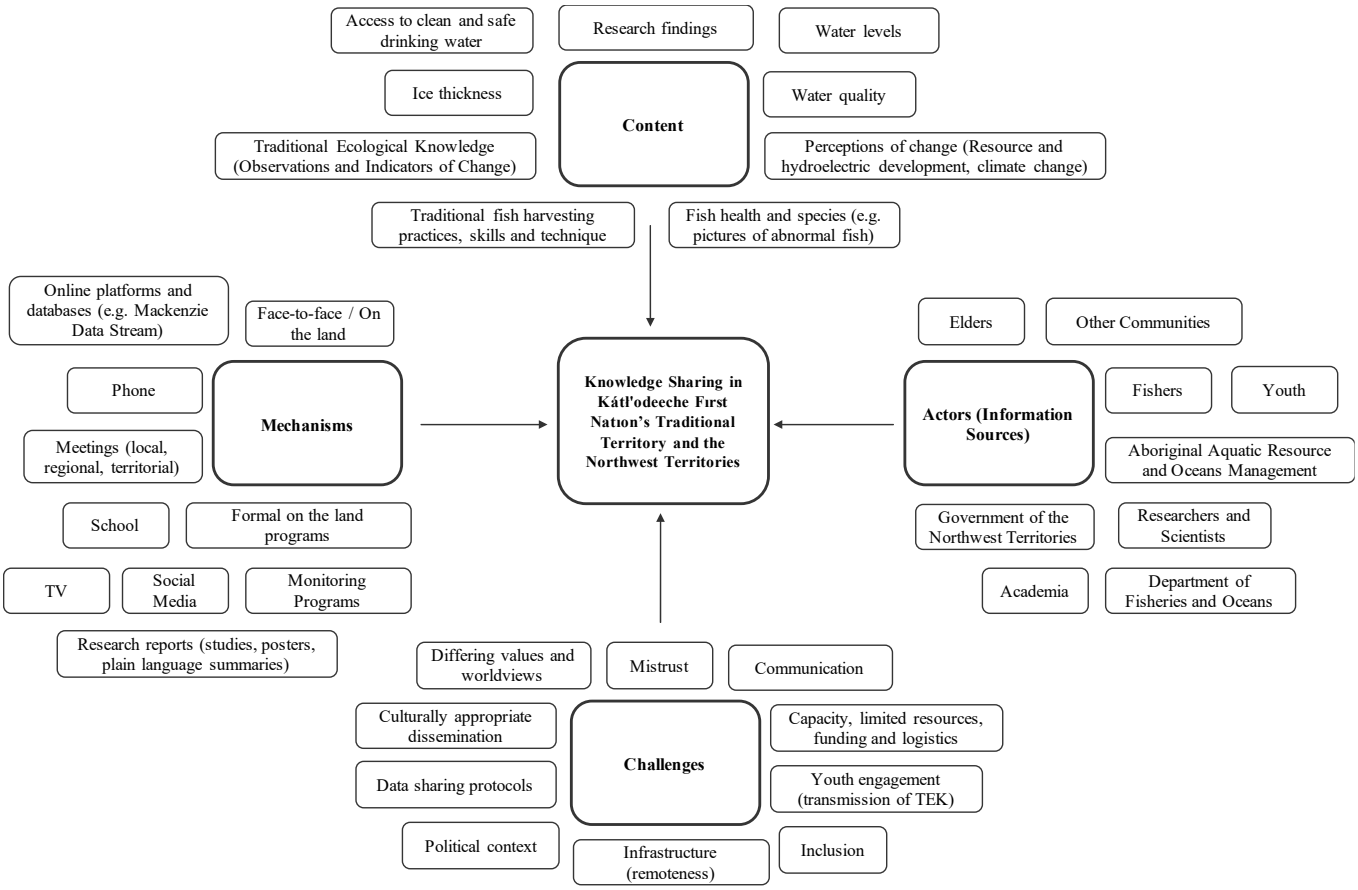

Figure 4-1. Freshwater and Fish Knowledge Sharing in Kátl'odeeche Fırst Natıon's Traditional Territory and the Northwest Territories – Actors, Mechanisms, Content and Challenges

4.4.2 Knowledge Sharing – Commonly Reported Mechanisms Among Actors

Based on interviews with KFN, all 15 community members expressed being actively involved in sharing and/or receiving knowledge at the local level, but less than half of KFN interviewees were involved in knowledge sharing at higher institutional levels. For instance, only 4 community members discussed sharing and/or receiving information from the GNWT and 6 community members reported sharing and/or receiving information from DFO.

As shown in Figure 4-1, 10 mechanisms were reported and referenced by actors during interviews as ways by which freshwater system information is shared. These mechanisms are further presented and organized in Table 4-2. The most commonly reported mechanisms include face to face and on the land interactions, meetings, and monitoring programs. These three

mechanisms (i.e., transfer mediums) which information flows through will be the focus of discussion.

Table 4-2. Effective Mechanisms for Knowledge Sharing According to Frequency

Actor / **Mechanism**	KFN (15)	AAROM (1)	GNWT (2)	DFO (2)	Academia (1)	**Total (/21)**
Face to face / on the land	15	1	1	1	1	**19**
Meetings	3	1	2	2	1	**9**
Monitoring programs	4	1	1	1		**7**
On the land programs	5					**5**
Phone	3			1		**4**
Social media (Facebook)	3	1				**4**
Research reports (studies, posters, plain language summaries)			2	1		**3**
Online platforms and databases		1	2			**3**
School	1					**1**
TV	1					**1**

It is important to note that this data does not necessarily correspond to a mutual flow or exchange of information, meaning actors may have only reported sharing information themselves and not receiving information or vice versa. Based on interviews with KFN Elders, harvesters and youth, the direction and flow of information for each mechanism is depicted in Figure 4-2. As mentioned, not all government actors worked directly with KFN, thus a similar analysis for other actors was not applicable, as most actors spoke more broadly about disseminating water and fish research and environmental information sharing throughout the NWT.

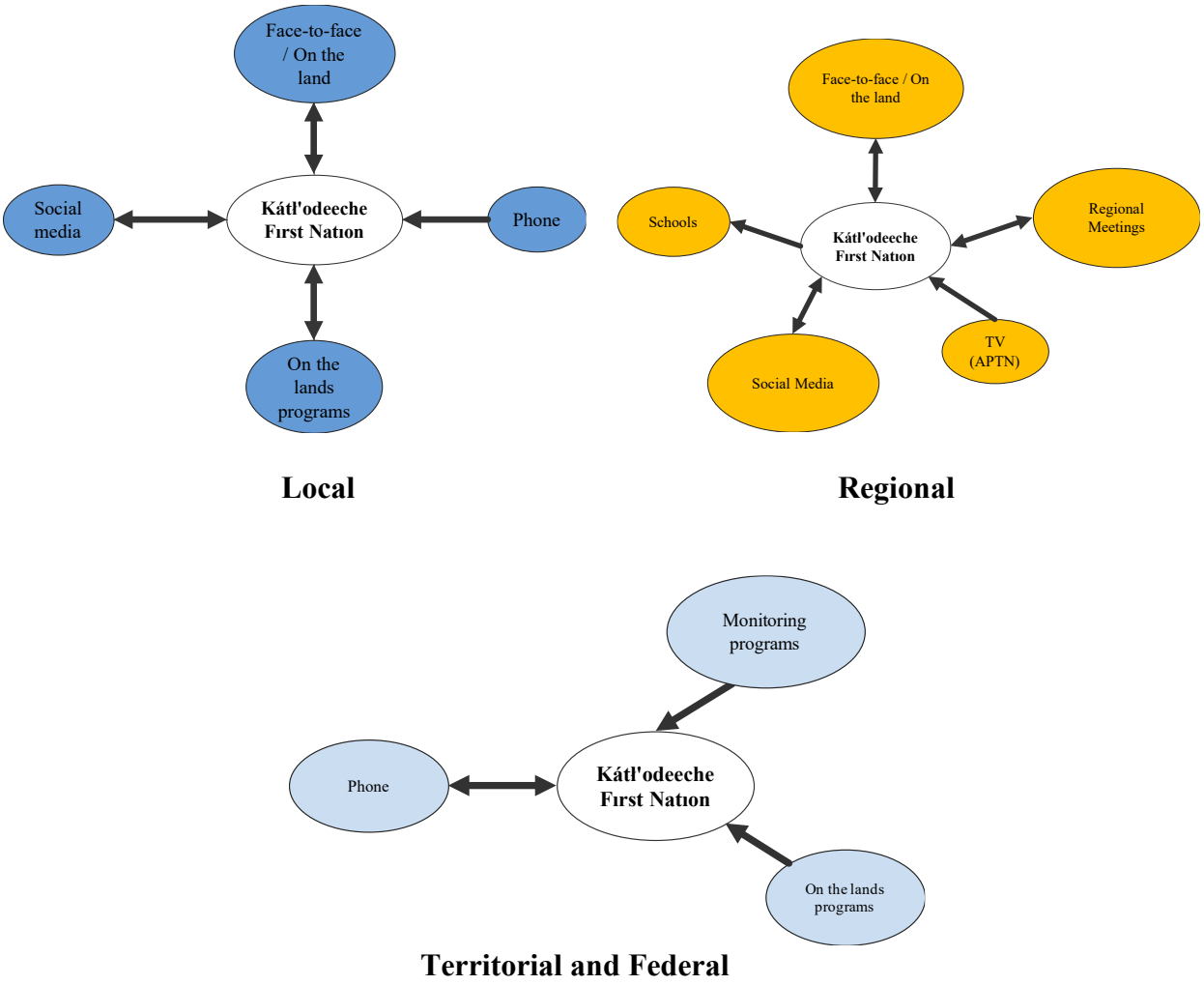

Figure 4-2. Knowledge Flow – How Kátl'odeeche Fırst Natıon Receives and/or Shares Knowledge

4.4.2.1 Face-to-Face and On the Land Interactions

KFN's interpretations to the question regarding knowledge sharing at the local level resulted in a wide range of responses (i.e. content) that extended beyond the health of the water and fish. In summary, information shared within the community includes, traditional skills, such as the technique of setting net and fixing fish, the best times and locations to harvest fish, Dene cultural stories, safety, locations to access clean and safe drinking water, and indicators, observations and concerns associated with freshwater system change. According to interviewees, family members, Elders and harvesters (local fishers), play an important role in passing down historic and contemporary knowledge (TEK) to younger generations. Knowledge sharing with regards to the practice of fish harvesting and health of freshwater systems also transpires between local fishers.

At the community level, TEK of freshwater systems is primarily shared and passed on from KFN harvesters and Elders to youth through on the land activities. The cultural transmission of TEK within the community and families is reiterated by interviewees. All 15 community members recalled learning to fish from family members and Elders. A KFN harvester was elated recalling their time spent in the bush, listening and learning from the stories of elders:

> *"To get knowledge like that, you have to go out with all the Elders, they're the storybooks…at night they tell you about the past history and where people fish...that's where I learned everything, just off of the Elders...what they did and where they went…"* (Harvester 1, 2018).

Other KFN harvesters and Elders indicated a strong desire for their children to learn about temporal changes to local freshwater systems. TEK has been passed on for generations through informal monitoring activities, including subsistence fishing. A KFN Elder described the transmission of TEK to younger generations on the land and acknowledged the significance of sharing temporal differences in fish health with youth:

> *My young guys go out with me on the Lake fishing…you know I tell them about what stuff used to be like, so they know what to do if they see different things..You know if we see something different, we all share it and talk about it... I think it's good for people to share what the difference is…"* (Elder 7, 2018).

Another harvester expressed their concern for the decrease in ice thickness on Great Slave Lake and discussed the importance of sharing ecological observations and indicators of ecosystem health with their children, in the hopes that they acquire the knowledge necessary to detect and assess future changes to the condition of ice and abnormalities related to fish:

> *"[I'm] just making them aware of how thick [the ice] used to be back in the day when I used to fish when I was young....or you know you see the fish and they know just by looking at a fish if there's something wrong with it. Like if it's not firm, or it's got discolouration…"* (Harvester 3, 2018).

KFN youth also described the process of learning about indicators of fish health from family members (harvesters) while out on the water:

> *"well [my uncle] would show me what fish is healthy and what fish is not…like if you were to open the gills of the fish, if they are pink then that means they are healthy fish to eat and if there is no colour to the gills [or] when it's like light pink, it's like [a] drowned fish…like they were in the net too long, and they drowned…"* (Youth 2, 2018)

While the youth interviewed alluded to face-to-face interactions and on the land activities as important mechanisms of learning, Elders noted that there are generational differences in how community members learn about the health of freshwater systems. A KFN Elder contrasted the way they learned from the land with the increased reliance on technology by younger generations in present-day:

> *"Well it just tells you after you do it for over 50 years... I'll know the difference [if] there are some changes… everything I know about the lake, the fish, the water, and the rivers*

from here to Buffalo, Buffalo Lake, and the creeks…I don't do anything using technology....I learn these things, just by doing it, or actually [being] there...some of these young people, they use all this technology, and [when they] want to know something they look it up, and it's there. But it's not actually how I learned it, and it's not the same. You actually experience the changes and all that...all kinds of stuff we learn, you know like it comes to you…. you can't actually teach it. Like to me it's not to teach, it's for them to observe, to observe what I do…" (Elder 5, 2018).

KFN commercial and subsistence fishers (harvesters) also have a unique relationship with one another, as they exchange social-ecological observations, primarily face-to-face and while on the land. For example, despite not personally observing any sick fish in the Hay River, a KFN Elder referred to another fisher's experiences when asked about their perception of fish health. The Elder recalled a story of their friend, who caught a fish in the west channel of Hay River that tasted like diesel. Signs of contamination, such as the taste of diesel are shared through fishers' social networks, influencing fishers' perceptions and contributing to feelings of uncertainty and concern among KFN regarding the quality of fish.

Several community members further recounted sharing information about social-ecological changes with other communities in the MRB. Elders highlighted the close connection members have to communities in Alberta. When visiting with communities across the border, an elder explained that her and her husband share concerns: *"they ask us 'how's the water over here?' so we told them, 'it's really, really shallow'"* (Elder 2, 2018). A harvester further emphasized the importance of documenting and sharing standardized monitoring information across communities to better understand ecological change within the basin.

While KFN emphasized the importance of sharing knowledge on the land and face-to-face within the community and regionally, the other actors echoed the significance of in person interactions. Despite this unified recognition, implementation varies, as actors alluded to the challenges of engaging with communities and sharing information face-to-face.

Among the actors, the AAROM coordinator stated that they attribute the success of the AAROM initiative to the community-based nature of the program and the building of individual relationships and trust with Dehcho communities: *"[the] strengths in working with communities is we have a one-on-one relationship with each of the communities...the reason we have success with the program is we are in the communities all the time, face-to-face with them"* (AAROM 1, 2019). In agreement, several KFN harvesters described having a close relationship with the Dehcho AAROM coordinator residing in Hay River. One harvester explained, *"we just collaborate, exchange notes…and every time I see [something] out of the ordinary, whatever I see, I show it to him and he does the same for me…"* (Harvester 1, 2018). The harvester specifically referred to taking pictures of abnormal fish to show to the AAROM coordinator:

> *There's lots of growth on some on the fish from the inside...I always watch for stuff like that, like if they're scarred, or really bad like that I just throw the fish away, or I'll take pictures of it and let [AAROM coordinator] know…"* (Harvester 1, 2018).

Evidently, fishers' networks and direct relationships with AAROM personnel, allow for significant information sharing opportunities that extend beyond the community.

4.4.2.2 Meetings

In total, 9 interviewees referenced meetings as an important mechanism to share information. While the sharing of information pertaining to freshwater systems and fish at the community level primarily occurs through informal interactions on the land and in person, several KFN interviewees discussed the importance of intercommunity meetings as a regional knowledge sharing platform. Moreover, community members stated that formal meetings provide communities from across the MRB opportunities to compare and contrast observations regarding the health of freshwater systems. One youth described the information KFN leaders and fishers share at organized intercommunity meetings in the MRB:

> *"we share information with neighbouring communities [at meetings] because we share our waterbody, our watershed, the Great Slave Lake... [information is shared about] the fish they found, what kind of fish there are, what the fish look like, the temperature of*

water… the general health of the water…everything goes back to the water" (Youth 1, 2018).

Similarly, an Elder sympathized with the concerns of a man from Fort Chipewyan, as he recounted learning at a meeting from a man that fish health and water quality is declining in Athabasca Lake and community members do not perceive the water and fish to be safe to drink or eat. The elder concluded the story by advocating for additional opportunities for intercommunity sharing: *"I think it's good for people to share what the difference is [in freshwater systems]…not only in the community, but some other communities too…"* (Elder 7, 2018). In fact, several interviewees stated that they would be interested in sharing information related to social-ecological changes with other communities throughout the region.

Although community members were not asked to elaborate on details of the meetings (i.e., names of the meetings they participated in), some community members spoke directly about their attendance at Dehcho meetings. The Dehcho is a region in the Northwest Territories comprised of various Indigenous communities. While KFN is no longer in negotiation for a comprehensive claim with the Dehcho First Nations, KFN continues to participate in regional co-management meetings. An Elder noted that these meetings provide opportunities for communities in the region to share concerns related to water quality, water levels and fish health.

In comparison to KFN, the other actors (AAROM coordinator, GNWT staff, DFO researchers, Academic scientist) discussed meetings as a critical mechanism to sharing environmental health, research and monitoring information. For example, the AAROM coordinator described participating in community meetings with KFN leadership and organizing gatherings with communities to share monitoring information. To assist communities, AAROM currently stores community-based monitoring data and conducts analysis to uncover trends and deliver results back to communities:

"when we go back to the communities each year…we bring to them an updated presentation of the trends that we see, or concerns that maybe they should be looking at...then if there's an issue, we go through that data and look for answers to their

> *questions or ways we could go about contacting the appropriate people, professors at universities, or DFO"* (AAROM 1, 2019).

Community meetings and gatherings are considered by the AAROM coordinator as being one of the best ways to share information, further adding that gatherings (e.g., festivals, symposiums) that involve joint collaboration and partnership with other actors (e.g., GNWT, Academia) are effective knowledge transfer mechanisms as they *"bring many different people together and different programs"* (AAROM 1, 2019).

Similarly, according to a GNWT staff member, an intimate feeling is associated with workshops and meetings and in turn, human interaction and in person presentations are more effective in sharing information with communities, than any other communication mechanism. Workshop settings inspire dialogue, including questions and concerns, and typically offer incentives for people to attend, such as food. Another GNWT interviewee believed that the sharing of information builds trust between different actors and in turn, results in meaningful discussion. An example of a meaningful exchange of information between a community member and GNWT staff was provided:

> "*The community member suggested that the water levels in the Slave River were down two metres which is a significant amount of water. By discussing river water levels further, both realized that the GNWT staff member was thinking about water levels in terms of a change in water depth (vertical) while the community member was thinking about water levels in terms of the river receding from shore (horizontal) – while both are correct observations, the differences of opinion would not have been reconciled unless they had had the opportunity to discuss their perspectives"* (GNWT 1, 2019).

Furthermore, the significance of the GNWT's CIMP program and meetings, including "The NWT Environmental Research and Monitoring Results Workshop," were also referenced by GNWT staff as mechanisms that generate opportunities for information sharing and results reporting at various levels. In 2018, a territory wide meeting was co-hosted in Yellowknife by GNWT CIMP and Yellowknife Dene First Nations. The purpose of the workshop was to "share

results of environmental research and monitoring related to wildlife, fish and water" and "provide a forum for discussion between researchers, communities and northern decision-makers" (Seabrook, 2018). A GNWT staff member noted the importance of these workshops in informing GNWT staff and scientists of community realities and concerns.

DFO organized meetings which generate opportunities for knowledge exchange include the Great Slave Lake Advisory Committee (GSLAC) and community consultation meetings. The DFO researchers argued that the best ways to share information are also through direct presentations with stakeholder communities in person, which typically occur on an annual or bi-annual basis. DFO researchers note that in person presentations *"provide KFN the opportunity to ask any questions or express any concerns with the project"* (DFO 2, 2019). A DFO researcher further reflected on the benefits to meeting with community members in person and the opportunities for mutual information sharing and learning:

> *"I find these in person meetings are the best way to present and explain updates and/or results, and the discussion with individuals afterwards is very helpful…I generally learn much more from the discussions that are generated by those in attendance. These discussions may lead to additional reasons why we may be seeing certain results. Sharing information with communities can benefit future projects as the feedback and discussion can often lead to improved sampling plans and design"* (DFO 2, 2019).

Elaborating on this, a Biologist and Professor with a Canadian University echoed the importance of holding meetings where both TEK holders and scientists are present. The Biologist recalled an instance where they thought they were communicating something new and interesting related to the soft texture of whitefish during spawning seasons. However, they were surprised to learn that the TEK holders were already familiar with this information and had held this knowledge for years.

Overall, actors acknowledge that meetings with different knowledge holders promote the sharing of scientific and Indigenous monitoring information and discussion surrounding interesting and/or contradicting findings and trends. Furthermore, based on interviews with all

actors, meetings (e.g., community, regional, Dehcho, CIMP, GSLAC meetings) facilitate opportunities for knowledge sharing at local, regional, territorial and federal levels.

4.4.2.3 Fish and Water Quality Monitoring Programs

Overall, 7 interviewees, including KFN members, the AAROM coordinator, GNWT staff and DFO researchers referenced monitoring programs as an important mechanism for knowledge sharing. Among the 7 interviewees, 4 community members from KFN reported participating in GNWT or DFO led water and fish monitoring initiatives. The territory wide collaborative and participatory water monitoring programs coordinated by the GNWT often work in partnership with communities, as Elders and harvesters are often hired as captains, or monitors to assist with the collection of water samples, alongside Environment and Natural Resources (ENR) researchers and technicians. KFN recognizes the value of developing partnerships with government agencies to address environmental concerns and acknowledges progressive changes with regards to the increased participation of communities in government led monitoring activities:

> *"I think we need to go out there and just tell our concerns to people that are in positions to help…[now] communities are getting involved with fish studies and water monitoring… so I think that it's a little better than what it used to be...The government just used to do their own thing...but now we're getting involved, so I think that it's a little bit more comforting that our people are involved"* (Elder 7, 2018).

A GNWT staff member notes the strengths in engaging with communities in water monitoring, explaining that *"it fosters relationships; it builds capacity; and it promotes water stewardship and information sharing"* (GNWT 1, 2019). GNWT interviewees further add that *"western scientists have much to learn from traditional land users. Community personnel are very familiar with the land, water and wildlife and provide very meaningful field information and knowledge about the local environment"* (GNWT 1, 2019).

Despite growing praise among communities and government regarding improved community and Indigenous engagement in environmental monitoring, community members who

have participated in government led scientific monitoring activities explain that they lack a clear understanding of findings from the studies. Moreover, while KFN reports gaining insight into scientific approaches and methods of monitoring from government scientists and researchers, gaps in information sharing, specifically in communicating monitoring outcomes and research findings were identified by KFN. An Elder recalled, *"well I asked them one time 'what are you guys finding?...you should give us a something that [tells us] what is wrong, if there's anything wrong. [They say] 'well everything's okay, so we don't need to bring anything back.'"* (Elder 1, 2018). The Elder noted that based on their experience the water is not okay, as they have been witnessing a decline in water levels in their lifetime.

Similar results were reported by KFN when discussing their involvement in DFO fish studies, which are currently taking place in Great Slave Lake and Buffalo River. According to an Elder, similar to the GNWT, DFO is increasingly including KFN in fish studies and scientific monitoring activities. KFN interviewees stated that their role in DFO monitoring activities includes assisting with data collection (i.e. setting net and gathering fish samples) and providing transportation (i.e. boat captain). One of the youth interviewed noted receiving equipment and technological training in exchange for their assistance with the AAROM program. While a KFN Elder discussed engaging in and learning about scientific assessments of fish and aquatic ecosystems from DFO researchers, the Elder indicated that their TEK is not always considered in monitoring related decisions. Similar limitations and gaps with regards to researchers communicating findings to community members in a timely manner were also communicated by KFN interviewees.

4.4.3 Less Commonly Reported Mechanisms

Interestingly, online platforms and databases, along with research reports (e.g., posters, studies, plain language summaries) were not referenced by any of the 15 community members that were interviewed, however, they were recognized by the AAROM coordinator, GNWT staff and DFO researchers as important tools to share information with communities, including KFN. These online platforms/databases and reports referenced by GNWT staff include the Mackenzie DataStream, NWT Discovery Portal, NWT Environmental Research Bulletin, consulting and summary reports and CIMP reports. In addition, the AAROM coordinator discussed utilizing the

Dehcho website and DFO researchers mentioned sharing research results via plain language summaries and posters.

Social media was also a mechanism that received less attention by interviewees. Only 3 community members reported sharing knowledge and observations regarding the health of the water and fish on social media (Facebook). For example, a harvester noticed an increasing number of pictures circulating on Facebook that revealed a drop in the shoreline. Similarly, another harvester described uploading photographs of abnormal fish and other animals to Facebook to share personal observations with others: "*I put it online on Facebook, so other people will know what to look for...once I post pictures like that then other people start sending their odd pictures"* (Harvester 1, 2018). One of the youth offered explanations as to why few community members utilize social media to share information, stating that it is more convenient in a small community to share information in person and not all community members have access to internet. There are also generational differences in the uptake of social media, as the AAROM coordinator noted that youth are more likely to have Facebook accounts in comparison to the older generations.

4.4.4 Challenges to Sharing Knowledge

4.4.4.1 Youth Engagement and Cultural Continuity

While KFN interviewees provided examples of the different ways knowledge is transmitted within the community across generations, challenges and concerns regarding the transmission of TEK to younger generations were raised: *"I try to pass it down to [my children], so that way it's not lost..."* (Harvester 4, 2018). Regarding the challenges that hinder the transmission of TEK to younger generations, a harvester noted *"it's not shared as much now because all the Elders are all passed on"* (Harvester 1, 2018). The generational differences in technology were also acknowledged by several Elders, as they reflected on not having access to television growing up. An Elder joyously recalled listening to the stories of Elders for entertainment in the absence of television: *"I used to live not too far from my grandfather and grandmother...If I saw an Elder going to visit my grandfather I would go over there too, so I can listen to stories...That was my TV and my radio [chuckles]"* (Elder 6, 2018).

To address these challenges, many community members agreed that it is imperative to share and communicate observations and social-ecological indicators of change to youth: *"having some people tell stories about what they've seen and what they know...I think we need more of that in the community…we need to give the younger generation more information on how they can help themselves later on"* (Elder 7, 2018). Moreover, communicating and sharing the names of different fish species in the Slavey language was also deemed important by community members to promote cultural continuity, as fewer people are learning the Dene language in present-day. Overall, increased engagement with youth in schools and bringing more youth on the land with harvesters and Elders to fish were strongly encouraged by community members to increase cultural continuity and facilitate increased youth engagement.

4.4.4.2 Capacity, Resources and Logistics

When researchers were discussing engaging with communities in person, challenges related to capacity were noted by the AAROM coordinator, as there is limited staff and extensive travel is required to frequently meet with communities and build relationships. Thus, the ability to hire more staff would result in increased capacity to engage communities face-to-face and coordinate more monitoring activities throughout the region.

A DFO researcher also linked limited resources including time and funding to barriers in fostering greater inclusivity. More specifically, a DFO interviewee stated that many consultative meetings are restricted to local leadership, in contrast to being open to the entire community. Given that most DFO researchers are not living in Hay River, NWT or other northern communities and in turn, expensive travel is required to access Canada's north, meetings must be planned and coordinated around fieldwork schedules. Moreover, researchers do not often have sufficient funds or time to arrange large community forums and workshops. The distance between DFO researchers and communities is recognized as a challenge to consistent and improved communication: *"Due to long distance communication it can be difficult to maintain frequent communication and keep communities updated with the [research] results. It is important to recognize this and make more of an effort to update communities"* (DFO 2, 2019).

4.4.4.3 Infrastructure in Remote and Northern Communities

When discussing disseminating research findings and monitoring information online or via social media, challenges regarding infrastructure and broadband in Canada's remote and northern communities were raised by the AAROM coordinator:

> *"The infrastructure to share things electronically is just not there yet. In Hay River we're lucky, but I recently just found out that some of the communities even in the Dehcho that we work with are not on fibre optics, so when I send something to someone in Kakisa it basically takes 15 minutes, a half an hour before they get it in their email, so there's still big issue with doing things digitally"* (AAROM 1, 2019).

Due to these geographic differences in infrastructure, there are limitations in the current use of online platforms to foster knowledge sharing across the Dehcho region.

4.4.4.4 Political Context

Lastly, communities' political contexts, which often inform communities' reluctance or openness to share information, specifically TEK with researchers, was highlighted by a DFO researcher as a challenge in sharing information:

> *"Few communities are reluctant to share knowledge and information with management fearing it may be used for promotion of commercial fisheries and other developments. Many of the land claims around Great Slave Lake are unsettled, [thus] communities are reluctant to share and make information public about shared, disputed or unsettled resources. Nowadays, many [of] the funding agencies require data and results to be shared on online portals at the end of projects, which is really challenging following the communities' data sharing protocols"* (DFO 1, 2019).

Interviewees further noted that data sharing, storage and ownership agreements are strongly required when conducting research with Indigenous communities.

4.4.4.5 Trust, Communication and Differences Across Knowledge Holders

According to a GNWT staff member, given the increasing number of freshwater monitoring projects operating across the territory, community concerns and frustrations are often related to not understanding the different projects being implemented geographically, and their associated objectives. The GNWT staff also acknowledged the shared challenges when engaging in a discussion with different knowledge systems. Moreover, scientists with limited experience working with communities, may experience difficulties communicating scientific and technical jargon in plain language. A DFO researcher echoed these challenges of communicating scientific findings to a general audience, stating that the research objectives and intent of the project (e.g. impacts and benefits) must be clearly addressed. One of the GNWT interviewees acknowledged this is an important skill for scientists to learn, as the failure to communicate properly may interfere with communities', specifically Traditional Knowledge holders' understanding of the relevance and importance of scientific methods in research studies. Through an example, a GNWT staff member explains that if a scientist is undertaking research that involves collecting stickleback, communities may not see the value, or relevance of sampling these small fish. Thus, the measurement of interest must be explained effectively, in addition to the objective of the project. This GNWT staff members also recognizes that the two knowledge systems can work in parallel and don't always necessarily need to be integrated.

Alternatively, scientists may experience difficulties in understanding and interpreting TEK, as posed by a GNWT staff member. Similar to TEK holders, scientists may not understand the importance and relevance of TEK without sufficient contextual knowledge or appreciate the value in acquiring contextual knowledge. Overall, the GNWT staff member emphasized that in order to achieve a meaningful dialogue and an exchange of information across actors, all actors must be open minded and willing to ask questions. Unfortunately, there exist personality differences across individuals, thus, not all actors are willing to listen to, understand, and accept different perspectives. The biologist interviewed further explained that variances in styles of communication, and more specifically differences in vocabulary, along with cultural norms, are major factors that contribute to misunderstandings between scientists and communities. In turn, the biologist states that developing a shared vocabulary and understanding is necessary, but takes times and patience. In addition, allocating sufficient time to build relationships and trust with

communities and TEK holders is essential. In summary, differences in knowledge systems and conflicting worldviews between scientists and TEK holders were highlighted more broadly as barriers to effective relationship building, the establishment of trust and engagement with communities.

4.5 Discussion and Conclusions

4.5.1 Key Issues in Fish and Water Monitoring in the Hay River and Buffalo River Sub-Basins

As evident in chapter 3, KFN observes and reports changes to freshwater systems in their traditional territory, including declining fish health and water quality, along with decreasing water levels and ice thickness. More specifically, observations include the presence of abnormalities (growth and sores) on fish which signifies poor fish health and reduced water quality in the Hay River basin, lower water levels throughout the Hay River and Buffalo River sub-basins and significant decreases in ice thickness on the Great Slave Lake. Currently there is no long-term scientific monitoring of aquatic ecosystem health in the Hay River basin and the documentation of TEK in communities residing in the basin has been limited (Stantec, 2016). Therefore, the TEK of KFN Elders, fishers and youth contributes to temporal knowledge gaps and provides a baseline of information that can be referenced overtime to monitor the basin.

In turn, these observations of change coincide with increased knowledge sharing within the community and outside of the community (with various actors) to communicate about change and concerns regarding the health of the water and fish. Gathering and sharing information pertaining to aquatic ecosystem health is necessary for improved watershed management and decision-making at local, regional, territorial and federal levels. TEK and knowledge sharing informs community members' perceptions of change and decisions related to traditional fish harvesting, navigation and consumption of water and fish. KFN however notes differences in monitoring results and outcomes between scientists and TEK holders. Moreover, this finding is consistent with literature that identifies conflicts between western science and Indigenous knowledge systems (Berkes, 2018; Dowsley & Wenzel, 2008; Huntington et al., 2004b). Government researchers and academia acknowledged the importance of engaging with communities to interpret scientific findings, which may provide opportunities for meaningful dialogue and the understanding of differences.

4.5.2 Key Mechanisms in Social-Ecological Learning in KFN's Traditional Territory

According to KFN Elders, harvesters and youth, face-to-face interactions are considered to be the most effective mechanism to share knowledge regarding the health of the water and fish at both the community level and higher institutional levels. This finding is consistent with other literature, as face-to-face interactions are referred to as an effective and appropriate mechanism to share research with Indigenous communities (Jack et al., 2010). Interviews with KFN provided insight into how community members view the process of learning about environmental change and the transmission of TEK as a social-ecological process. Indigenous pedagogies such as learning through observation (i.e. watching), experience (i.e. learning by doing), from oral tradition and storytelling (i.e. listening) were further explained by community members. Elders expressed the strengths of learning about ecological change in KFN's traditional territory through observation and interactions with the local environment over long periods of time. Several community members associated the word "teach" with formal western styles of teaching. Instead, community members preferred to use terminology that aligned with Indigenous pedagogies (e.g. experiential and place-based learning). In turn, community members emphasized the importance of learning from the land and watching for changes in their local environment. KFN's attention to Indigenous pedagogies are consistent with other scholarly work which studies the transmission of TEK through experiential (learning by doing), observational and place-based learning (Turner & Spalding, 2013).

According to Cundill and Rodela (2012), little research asserts social learning as a "self-organizing process of social-ecological interaction over long periods of time [whereby] local people are able to learn and transmit knowledge among themselves and to future generations," (p.11). In turn, the findings from this paper address this gap in the literature, as local monitoring efforts practiced by KFN demonstrate and promote social-ecological learning within the community. Findings support Johnson et al. (2018) by distinguishing between informal and formal opportunities for social-ecological learning. Moreover, KFN fishers' monitoring on the land through traditional fish harvesting activities and more formal programs (e.g., school based on the land programing) provide opportunities for social-ecological learning, specifically the intergenerational transmission of TEK from Elders and harvesters to youth to generate increased understanding of aquatic ecosystem health. KFN interviewees acknowledged that youth

engagement is crucial in order to share knowledge, observations and concerns with future generations. As evidenced by this research, Berkes (2018) also notes that Elders play and important role in social-ecological learning processes as their knowledge and memories span generations and they have the ability to interpret environmental change and abnormal events. Moreover, social-ecological learning is recognized by KFN as significant in understanding and adapting to future ecological change, as it provides the younger generations with the knowledge, resources and tools to engage in environmental stewardship. As discussed and documented in Chapter 3, KFN Elders, harvesters and youth engage in social-ecological learning, as they share and communicate about changes to fish health, water quality, water levels and ice thickness through community developed social-ecological indicators and the transmission of TEK.

4.5.3 Relationships in Social-Ecological Learning in KFN's Traditional Territory

Social networks are understood as "patterns of relationships between individuals or groups" (Barnes-Mauthe et al., 2013, p.1) that "[link] people across geographic scales and social levels" (Kofinas et al., 2020, p.114). Moreover, social networks may promote information sharing and exchange and collaboration among diverse actors and knowledge holders (Barnes-Mauthe et al., 2013; Crona & Bodin, 2006). Based on interviews with KFN, fishers' social ties generate opportunities for knowledge sharing within and outside of the community. Overall, fewer KFN fishers share and receive knowledge at higher institutional levels, signifying a disconnect in information sharing. Findings demonstrate the value of relationships in promoting higher scales of knowledge sharing (regional, territorial, federal). For example, KFN interviewees spoke about familial ties and social interactions with other communities in the NWT and Alberta. Several fishers also noted having relationships with individual researchers and discussed their involvement in monitoring programs led by DFO, AAROM and the GNWT. More specifically, fishers' social networks and direct relationships with AAROM personnel allow for information sharing opportunities beyond the local community.

Regarding meetings as a mechanism to facilitate knowledge sharing across actors at higher institutional levels, interviewees noted that not all community members have the opportunity to participate in formal regional meetings. Moreover, not all community members are invited to participate and attend regional, territorial or federal meetings, resulting in only a

few community members having the opportunity to exchange health related monitoring information at meetings outside of their community. Actors further noted that many consultative meetings are restricted to local leadership. In addition, the extent to which information is mutually shared and learned depends on the actors present and their willingness to engage in discussion with one another. These findings suggest that there is an insider group in KFN that has increased opportunities to participate and engage in information sharing and potential social-ecological learning opportunities. The insider group is comprised of local leadership and fishers who are involved in CBM programs.

Evidently, fishers' social ties play an important role in bridging the divide in the sharing of monitoring information. Findings align with other research which conclude that fishers' knowledge sharing within the community and with other communities is primarily influenced by kinship, friendship and social relations (Ramirez-Sanchez & Pinkerton, 2009). Interestingly, findings are less consistent with research that identifies social media as important mechanisms for knowledge sharing (Solovyeva & Kuklina, 2020). While several KFN fishers noted sharing pictures and information related to environmental change on social media platforms such as facebook, face-to-face social interactions were determined to be more effective in supporting the sharing of monitoring information.

In James Bay, Canada, 35 communities created a network in order to share TEK and local observations of social-ecological change at the regional level. Horizontal and vertical linkages were present and individuals played a significant role in the building of trust and establishment of networks (Olsson et al. 2004). Similarly, this research demonstrates that fishers' networks can strengthen horizontal and vertical linkages and in turn promote knowledge sharing. While informal and formal horizontal linkages (e.g., community-to-community) are occurring, vertical linkages (e.g., across levels of organizations) are occurring less frequently and at a more informal level. The further establishment of social networks within the community among fishers and at higher institutional levels may enhance knowledge sharing efforts.

While all actors noted the importance of monitoring efforts in promoting knowledge sharing, only 4 interviewees had experiences engaging in formal monitoring initiatives. The

paper's findings concerning KFN's involvement in CBM (i.e., participatory monitoring) activities led by external actors indicate that unequal power dynamics between scientists and TEK holders persist, as challenges surrounding communication and research dissemination are identified.

In concurrence with existing work (Reed et al., 2010; Fidel et al., 2017; Burgos et al., 2013), the findings of this research suggest participatory monitoring programs have the opportunity to facilitate social-ecological learning through interactions between researchers and fishers on the land and at more formal meetings, and through the sharing of community observations and data. Moreover, CBM presents opportunities for different types of learning among actors, including cognitive, normative and relational learning, which are distinguished by Ensorl and Harvey (2015).

Despite monitoring programs generating increased opportunities for knowledge sharing and learning among researchers and Indigenous peoples, this research reveals that further action is needed by researchers involved in monitoring activities in KFN's traditional territory to foster social-ecological learning and information sharing. KFN fishers involved in monitoring efforts described gaps in information sharing, as they reported receiving little to no research results from scientists. or not agreeing with the findings of the studies due to their own knowledge conflicting with the results. Given that a number of interviewees discussed their previous negative experiences participating in research activities, findings suggest that poor communication and past adverse experiences perpetuate feelings of mistrust. The GNWT specifically recognizes the water quality monitoring program's limitations, stating that "one of the challenges with the program has been capacity to analyze and interpret data and get results out to communities and other interested parties in a timely manner" (Fresque-Baxter & Kelly, 2017). Findings are consistent with environmental health and risk communication literature, as scholars attribute researchers' lack of communication with communities to feelings of mistrust among community (Fresque-Baxter, 2015). In addition, historical and contemporary relationships between communities and researchers inform Indigenous peoples' trust of scientific research (Jack et al., 2010).

While interviewees recognize the importance of engaging with and among KFN and other communities in person and on the land through CBM, barriers to sharing information, in particular research dissemination, are identified through this research. Barriers include, limited capacity and resources (e.g., time, funding, staffing), logistics, infrastructure, political context, mistrust among actors, poor communication and differences in values and worldviews. Many of these challenges referenced by the AAROM coordinator, GNWT staff and DFO researchers to engaging with communities and sharing monitoring information are similarly referenced in the literature (Thompson et al., 2020).

In this research, actors recognize the necessary challenge of communicating scientific and technical results to communities in plain language, which is well understood by scholars as being a difficult task and a critical skill (Fresque-Baxter, 2015; Jack et al., 2010). In addition, findings are consistent with the literature that investigates barriers to multi-actor learning, citing differences in knowledge systems, worldviews and values, which may compete and be in conflict with one another (Davidson-Hunt, 2006; Armitage et al., 2008). Davidson-Hunt (2006) caution that people may try and convince others of the validity of their knowledge which impedes learning opportunities. Power inequities and dynamics that exist among different knowledge holders must be understood and relinquished by actors as they influence learning in social-ecological systems and the building of trust among actors (Reed et al., 2010; Cundill and Rodela, 2012; Armitage et al., 2008; Armitage et al., 2015).

Actors further acknowledge that information sharing and reciprocal learning at higher institutional levels requires actors to be open minded and respect differing worldviews:

> "it is often difficult for people who are more comfortable with technical information and 'hard facts' to engage someone whose knowledge emerges from ongoing interactions with the land, and who might communicate that knowledge through stories, perceptions of change, and a tendency to situate their knowledge in a broader discourse about values" (Armitage et al., 2015, p.361).

Davidson-Hunt (2006) call for social learning processes that provide a space for dialogue among TEK holders and scientists to promote respect for different knowledge systems in the understanding of environmental changes. As Reed et al. (2010) state:

> "it is not just the change in understanding or the scale at which it takes place that denotes social learning, but also the mode of social interaction through which learning occurs: (i) information transmission (i.e., simple learning of new facts through social interaction); and (ii) deliberation (referring to dialogue and a genuine exchange of arguments)" (p.5).

4.5.4 Suggestions for Improving CBM and Management of the Hay River and Buffalo River Sub-Basins and the MRB

Future participatory monitoring efforts led by external actors who engage with KFN and other Indigenous communities should consider these findings in their work. More specifically, in CBM researchers must meaningfully work to address barriers, improve engagement and develop culturally appropriate research dissemination practices with communities. Furthermore, scientific and government led CBM programs must "carefully consider the ways in which power and governance shape their programs and the ability of their monitoring to lead to meaningful management actions" (Thompson et al., 2020, p.1). In this paper, KFN identifies informal and formal CBM as an important mechanism for social-ecological learning. Given that CBM is increasingly braiding TEK and science and including local peoples in water and fish monitoring, a decolonized approach to research, monitoring, information sharing and learning must be undertaken to improve watershed management. Wilson et al. (2018) note that participatory CBM has the potential to facilitate the decolonization of research through the dismantling of power imbalances and building of relationships and trust. In the spirit of reconciliation, more researchers need to engage with communities in the early stages and commit to ongoing relationship building, dedicate time to go out on the land with Elders, harvesters and youth, prioritize the sharing of information with communities in a culturally appropriate way, and ensure meaningful inclusion of TEK in water and fish monitoring (as opposed to the tokenization of TEK).

CHAPTER 5.0: Conclusion

5.1 Overview and Significance of Research

This research in collaboration with Kátł'odeeche First Nation (KFN) narrates a story of social-ecological change through the voices of Elders, harvesters and youth. With the aim to help inform KFN's community-based freshwater and fish monitoring program and the implementation of the Alberta-Northwest Territories (NWT) Bilateral Water Management Agreement (Government of Alberta & Government of the Northwest Territories, 2015), Chapter 3 documents community developed social-ecological indicators of aquatic ecosystem change. This research identifies Traditional Ecological Knowledge (TEK) indicators used by KFN to assess and monitor the health of the water and fish in their traditional territory, specifically the Hay River and Buffalo River sub-basins. Chapter 3 further highlights the strengths of TEK in community-based monitoring (CBM) and understanding environmental change, as TEK addresses gaps in scientific monitoring methods and processes. Moreover, this research emphasizes the value of TEK in establishing historical and contemporary baseline of information, which can be compared to, referenced and expanded on over time.

Interviews with 15 KFN Elders, harvesters and youth share rich insights into how KFN monitors, understands and interprets social-ecological change. KFN fishers observe declining fish health, water quality, water levels and decreased ice thickness in their lifetime and indicators are utilized to describe and communicate about change. In turn, observations of change influence KFN members' decisions regarding the consumption of fish, drinking water, safety, and navigation. KFN perceptions of social-ecological change correspond with significant concern regarding cumulative effects, including resource and hydroelectric development, and climate change. Overall, this research contributes to the development of TEK indicators (Parlee et al., 2005) and distinguishes TEK as its own valid knowledge system. Together, with similar research being conducted across the Mackenzie River Basin (MRB) through the Tracking Change project (Martin et al., 2020), the documentation of Indigenous peoples' observations and TEK further contributes to a greater understanding of local and regional change in the MRB and may potentially inform collaborative transboundary governance of the watershed.

Through the lens of social-ecological learning, Chapter 4 expands on KFN's indicators and perceptions of social-ecological change to explore the content, mechanisms and flow by

which knowledge is shared within KFN and among other actors, including Indigenous communities, academia and the territorial and federal government. Berkes (2009) argues that knowledge sharing and co-production generate increased understanding of ecosystem health, environmental change and may lead to improved resource management. With this understanding, findings draw connections to key mechanisms that facilitate opportunities for knowledge sharing and social-ecological learning through CBM. Face-to-face interactions were predominantly cited by KFN, government and academic actors as an important mechanism in social-ecological learning and the sharing of knowledge regarding the health of freshwater systems across institutional levels. Interviews with actors also uncovered the importance of relationships (flow) in promoting knowledge sharing, as KFN fishers' social ties within the community, and with government actors and researchers through CBM initiatives generate increased opportunities for interaction and knowledge exchange. Actors report a lack of youth engagement, limited capacity and resources (e.g., time, financial and human), logistics, infrastructure, political context, mistrust among actors, poor communication and differences in values and worldviews (i.e., power imbalances) as barriers to knowledge sharing and social-ecological learning in the context of freshwater and fish monitoring. Suggestions to improve CBM, knowledge sharing and management of KFN's freshwater systems and the larger MRB include meaningful engagement with Indigenous communities in monitoring, the dismantling of power imbalances among actors and appropriate research dissemination. Culturally appropriate communication of research results and respect for TEK systems is necessary to promote knowledge sharing and relationship building at local, regional, territorial and federal levels.

Overall, Chapter 4 offers theoretical contributions to literature on social-ecological learning (Berkes et al., 2008; Folke et al., 2005; Olsson et al. 2004; Rodriguez & Vergara-Tenorio, 2007). In particular, this research presents social-ecological learning as a "self-organizing process of social-ecological interaction over long periods of time [whereby] local people are able to learn and transmit knowledge among themselves and to future generations," (Cundill & Rodela, 2012, p.11). To date, little research has conceptualized social-ecological learning in this manner. This paper's findings therefore provide insights into the role of social-ecological learning in KFN's traditional territory through CBM. In addition, this research reinforces the of work of Berkes et al. (2008), Folke et al. (2005) and Olsson et al. (2004), as

social-ecological learning can be understood as a process whereby interactions with the environment and ecological crises result in constant learning which assist resource users and managers in adapting and responding to ecological change.

5.2 Future Research

Through this project, additional research gaps and areas for future research have been uncovered. While this research took place prior to the global pandemic, it would be interesting to explore the impacts of Covid-19 on information sharing in the context of freshwater and fish monitoring in the broader MRB. Given that these research findings demonstrate that social-ecological learning and knowledge sharing within and among communities, government and academia best takes place on the land and face-to-face through CBM, additional methods and barriers to knowledge sharing may have emerged over the past couple of years. In this study, infrastructure and broadband in remote and northern communities was identified as a barrier to sharing information on social media or virtually. Thus, it would be interesting to investigate the various opportunities and challenges that have emerged in recent years and better understand how various actors have adapted in this context.

In addition, while this research documents locally relevant and culturally driven indicators of social-ecological change, there are few case studies that exist the document Indigenous led CBM programs, specifically the design of monitoring methods and objectives based on TEK (Thompson et al., 2019). In turn, future research with KFN and additional Indigenous communities in the MRB should practically detail Indigenous led CBM programs to share methods utilized, successes and lessons learned, as CBM programs may act "as a tool to assert [Indigenous] sovereignty and jurisdiction" (Wilson et al., 2018, p.291). Moreover, according to Johnson et al. (2015), more research is needed to investigate how CBM information and data may inform decision-making surrounding resource management at the local, regional, territorial and federal level.

Finally, this paper does not investigate or measure social learning outcomes beyond the local level at higher institutional levels among diverse actors. Therefore, future research that investigates and distinguishes between social learning outcomes and processes is needed (Lee & Krasny, 2015). This research has uncovered important mechanisms that may facilitate

opportunities for social-ecological learning among Indigenous peoples, government and researchers (i.e., face-to-face, meetings, monitoring programs). However, empirical research through an in-depth case study on specific multi-actor participatory processes (e.g., NWT CIMP meeting) would allow for more detailed analysis of social learning processes and outcomes, including the measurement of cognitive, normative and relational learning (Ensorl and Harvey, 2015). Furthermore, it would be interesting to explore how and if outcomes of social learning translate to decision-making or inform watershed management through the sharing of monitoring information at regional, territorial or federal meetings in the MRB. Employing in-depth social network analysis as a method would also be beneficial in understanding and evaluating the role of social networks in promoting information sharing within and across communities in the MRB.

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APPENDIX A: Participant Information Sheet (KFN)

PARTICIPANT INFORMATION SHEET

CULTURALLY DRIVEN FRESHWATER AND FISH MONITORING IN THE DEHCHO REGION

Research Lead / Organization

Sydney Stenekes, Master's student,
University of Alberta

Peter Redvers, Land Director,
Kátł'odeeche First Nation

Doug Lamalice, Community Researcher

Principal Investigator

Dr. Brenda Parlee, Canada Research Chair
University of Alberta

Why am I being asked to take part in this research study?

You are being asked to participate in this study because you are considered to have valuable knowledge about water and fish in Kátł'odeeche First Nation's traditional territory, which is part of the Mackenzie River Basin. We are interested in interviewing you about your knowledge related to three key questions: 1) How do you know if the water and fish are healthy? 2) What knowledge is shared *by* versus *with* KFN about water and fish? 3) How is knowledge shared? 4) How is knowledge used?

Before you make a decision, a researcher will go over this form with you. You are encouraged to ask questions if you feel anything needs to be made clearer. You will be given a copy of this form for your records.

Why is this research being done?

Many communities in the Mackenzie River Basin are experiencing changes in the environment and their communities. A major concern expressed by many Indigenous organizations is about the sustainability of water and fish. As a result, there has been an increase in community-based monitoring programs led by Indigenous communities, including KFN, to gather Traditional Knowledge. By having monitoring activities built around traditional fish harvesting, the goal is to collect seasonal information about the health of the water and fish, which can be compared overtime. I will be assisting Peter Redvers and Patrick Riley with KFN's community-based monitoring program by providing academic support for the importance of using culturally appropriate methods.

My supervisor, Dr. Brenda Parlee, and I are working under the Tracking Change Project. Dr. Brenda Parlee is working with researchers from the University of Alberta and other universities in Canada and internationally to help document the importance of water and fish, and any changes that people have seen in their lifetimes. There are 12-15 projects this year in which communities are going to be asking similar kinds of questions about the health of water and fish. The study is funded by the University of Alberta through the *Social Sciences and Humanities Research Council.* By learning about Traditional Knowledge indicators of change and the observations of Indigenous peoples in different communities, we will have a much better understanding of how the Mackenzie River Basin as a whole is changing. Also, we will be able learn about how people share information, and learn from one another within their communities and across the Mackenzie River Basin.

What will I be asked to do?

You will be asked to participate in an interview lasting approximately 1-1.5 hours. We would like to audio record the interview and ask you to record information on maps if possible. This interview will focus on how you know if the water and fish are healthy in Kátł'odeh (Hay River), Ejıe Túé Dehé (mouth of Buffalo River) and Tagáa (Sandy Creek). We would like to ask you questions in order to understand how knowledge is learned and shared. Also, we are interested in learning about the tools/methods that people use to share information about water and fish within and outside of KFN.

What will you need to do?

You will converse with an interviewer and you are free to tell him/her anything that you think is relevant to the study. You will also have an opportunity to provide feedback on materials prepared based on the results of the research.

What are the benefits to me?

As a participant in the study, you will have an opportunity to share your knowledge and concerns related to monitoring water and fish in your community. Your knowledge can help shape future policy and environmental monitoring programs in other communities. Overall, you will be able to learn from the results of the study at the community level, in addition to the results from the broader national and international study. As a thank you for your participation, you will receive an honorarium of $75 in the form of a gift card to the Ehdah Cho store. Other benefits of this project include documenting local Dene Traditional Knowledge about water and fish in KFN's traditional territory, and identifying useful and important ways/tools for sharing knowledge and learning about environmental change. Your knowledge will also have academic contributions, as researchers have not yet studied how local people learn from each other in Indigenous led freshwater and fish monitoring.

Do I have to take part in the study?

You do not have to participate in the study, and you can stop the interview anytime.

What will happen to the information?

- The stories that you share including any mapped, audio and video recordings will be held by researcher **Sydney Stenekes.** Another copy will be held at the University of Alberta for a minimum of 10 years. These transcripts will not be used for any other purpose. The band office will also receive a copy.
- We would like to acknowledge you by name in these reports. If you do not wish your name to be included, we will give you an anonymous identity (e.g., A1).
- You will receive a copy of the transcript of your interview after the interview is completed.
- You, and the community will have a chance to review any documents or publications that result from this study.
- If you decide to withdraw or edit your contribution, you will have 30 days to do so; after that 30 day period, however, we may not be able to remove information from reports if it has already become public.
- A summary from the project will be developed and shared with other communities in the Mackenzie River Basin so they can learn more from you about traditional knowledge indicators of water and fish
- health and knowledge sharing; you will receive summary reports from the other regions as well. The lead organization will not include information in the summary reports that it considers confidential or information you do not wish to be shared publicly.

- In addition to the summary reports from your region, Sydney Stenekes will work with other organizations and universities to create an academic outcome, as well as a deliverable and presentation to your community.

What if I have questions?

If you have any questions about the research now or later, please contact:

Research Lead / Organization

Sydney Stenekes
Department of Resource Economics and Environmental Sociology
Faculty of Agricultural, Life and Environmental Sciences 566 GSB
University of Alberta, Edmonton Alberta T6G 2H1
Tel: (613)-986-5207
stenekes@ualberta.ca

Principal Investigator

Brenda Parlee
Department of Resource Economics and Environmental Sociology
Faculty of Agricultural, Life and Environmental Sciences 507 GSB
University of Alberta, Edmonton Alberta T6G 2H1
Tel: (780) 492-6825 Fax: (780) 492-0268
brenda.parlee@ualberta.ca

Peter Redvers
KFN Lands Director
PO Box 3060
Hay River Dene Reserve, NT X0E 1G4
Tel: (867) 874-6701 Fax: (867) 874-3229

The plan for this study has been reviewed for its adherence to ethical guidelines by a Research Ethics Board at the University of Alberta. For questions regarding participant rights and ethical conduct of research, contact the Research Ethics Office at (780) 492-2615.

APPENDIX B: Participant Information Sheet (Government and Academia)

PARTICIPANT INFORMATION SHEET

CULTURALLY DRIVEN FRESHWATER AND FISH MONITORING IN THE DEHCHO REGION

Research Lead / Organization	*Principal Investigator*
Sydney Stenekes, Master's student, University of Alberta	Dr. Brenda Parlee, Canada Research Chair University of Alberta
Peter Redvers, Land Director, Kátł'odeeche First Nation	

Why am I being asked to take part in this research study?

You are being asked to participate in this study because you are considered to have valuable knowledge about freshwater and fish monitoring activities in the Mackenzie River Sub-basins (Hay River basin). We are interested in interviewing you about your knowledge related to three key questions: 1) What freshwater and fish monitoring are you involved in related to the Hay River basin, or other sub-basins? 2) What are the strengths and challenges of including communities in freshwater and fish monitoring? 3) What are the strengths and challenges of sharing monitoring information/outcomes across communities, between communities and scientists, and between communities and government? Could you provide any examples?

Before you make a decision, a researcher will go over this form with you. You are encouraged to ask questions if you feel anything needs to be made clearer. You will be given a copy of this form for your records.

Why is this research being done?

Many communities in the Mackenzie River Basin are experiencing changes in the environment and their communities. A major concern expressed by many Indigenous organizations is about the sustainability of water and fish. As a result, there has been an increase in freshwater and fish monitoring led by government, researchers and Indigenous communities. My supervisor, Dr. Brenda Parlee, and I are working under the Tracking Change Project, a study that is funded by the University of Alberta through the *Social Sciences and Humanities Research Council*. Dr. Brenda Parlee is working with researchers from the University of Alberta and other universities in Canada and internationally to help document Traditional Knowledge and the importance of freshwater systems and socio-ecological change from the perspective of Indigenous communities. In addition, we are looking to better understand the strengths and limitations in sharing freshwater and fish monitoring information at local, regional, territorial and federal levels.

What will you be asked to do? / What will you need to do?

You will be asked to participate in an interview lasting approximately 30 mins to 1.5 hours. We would like to audio record the interview if you consent to it. You will converse with an interviewer and you are free to tell him/her anything that you think is relevant to the study. You will also have an opportunity to

provide feedback on materials prepared based on the results of the research.

What are the benefits to me?

As a participant in the study, you will have an opportunity to share your knowledge and identify useful and important ways to share monitoring information/outcomes at local, regional, territorial and federal levels. Your knowledge will also have academic contributions, as social learning in the context of freshwater and fish monitoring has yet to be studied.

Do I have to take part in the study?

You do not have to participate in the study, and you can stop the interview anytime.

What will happen to the information?

- The stories that you share including any mapped, audio and video recordings will be held by researcher **Sydney Stenekes.** Another copy will be held at the University of Alberta for a minimum of 10 years. These transcripts will not be used for any other purpose.
- We would like to acknowledge you by name in these reports. If you do not wish your name to be included, we will give you an anonymous identity (e.g., A1).
- You will receive a copy of the transcript of your interview after the interview is completed.
- You will have a chance to review any documents or publications that result from this study.
- If you decide to withdraw or edit your contribution, you will have 30 days to do so; after that 30 day period, however, we may not be able to remove information from reports if it has already become public.

What if I have questions?

If you have any questions about the research now or later, please contact:

Research Lead / Organization

Sydney Stenekes
Department of Resource Economics and Environmental Sociology
Faculty of Agricultural, Life and Environmental Sciences 566 GSB
University of Alberta, Edmonton Alberta T6G 2H1
Tel: (613)-986-5207
stenekes@ualberta.ca

Principal Investigator

Brenda Parlee
Department of Resource Economics and Environmental Sociology
Faculty of Agricultural, Life and Environmental Sciences 507 GSB
University of Alberta, Edmonton Alberta T6G 2H1
Tel: (780) 492-6825 Fax: (780) 492-0268
brenda.parlee@ualberta.ca

Peter Redvers
KFN Lands Director
PO Box 3060
Hay River Dene Reserve, NT X0E 1G4
Tel: (867) 874-6701 Fax: (867) 874-3229

The plan for this study has been reviewed for its adherence to ethical guidelines by a Research Ethics Board at the University of Alberta. For questions regarding participant rights and ethical conduct of research, contact the Research Ethics Office at (780) 492-2615.

APPENDIX C: Participant Consent Form

515 – General Services Building

University of Alberta

Edmonton, AB

Canada T6G 2H1

PARTICIPANT CONSENT FORM

Culturally Driven Freshwater and Fish Monitoring in the Dehcho Region

Tracking Change Project

Research Lead / Organization

Sydney Stenekes, Master's student, University of Alberta

Peter Redvers, Land Director, Kátł'odeeche First Nation

Principal Investigator

Dr. Brenda Parlee, Canada Research Chair
University of Alberta

	Yes	No
Do you understand that you have been asked to be in a research study?	☐	☐
Have you read and received a copy of the attached Information Sheet?	☐	☐
Do you understand the benefits in taking part in this research study?	☐	☐
Have you had an opportunity to ask questions and discuss this study?	☐	☐
Do you understand that you are free to leave the study at any time, without having to give a reason?	☐	☐
Has the issue of confidentiality been explained to you?	☐	☐
Do you consent to the interview being audio recorded?	☐	☐
Do you consent to the interview being photographed?	☐	☐
Do you consent to the results of the interview being stored at the University of Alberta?	☐	☐
Would you like your name to be included in the public use of information from your interview?	☐	☐

Who explained this study to you? _____

I agree to take part in this study:

Signature of Research Participant _____

(Printed Name) _____

Date: _____

Signature of Witness _____
Only required if you anticipate that your participants will be unable to read the information sheet and consent form themselves. If so, an impartial witness must be present during the entire informed consent discussion and is witnessing that the participant understood what was discussed (i.e. not just witnessing the signature process).

I believe that the person signing this form understands what is involved in the study and voluntarily agrees to participate.

Signature of Investigator or Designee _____

Date _____

APPENDIX D: Interview Guide (KFN)

GUIDING QUESTIONS

Culturally Driven Freshwater and Fish Monitoring in the Dehcho Region

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Researcher:	Brenda Parlee, Peter Redvers and Sydney Stenekes
Affiliation:	University of Alberta
Funding:	Tracking Change Project, University of Alberta
Purpose:	The purpose of the project is to learn about Traditional Knowledge indicators related to the health of water and fish at Kátł'odeh (Hay River), Ejıe Túé Dehé (mouth of Buffalo River) and Tagáa (Sandy Creek). Also, this project aims to understand how knowledge is learned and shared, and seeks to identify tools/methods that are used to share information within and outside of KFN.

This interview will focus on the area you feel most comfortable speaking about (Kátł'odeh, Ejıe Túé Dehé, Tagáa)

1. Do you fish (set net) in this area? How long have you been fishing in this area?

2. What fish do you usually catch? How do you know when to harvest fish?

3. How do you know if the fish are healthy? What are the signs of a healthy fish?

4. How do you know if the water is healthy, or good to drink? What are the signs the water is healthy?

5. Where and/or from whom did you learn this? How was this knowledge taught, or shared with you?

6. Do you share your knowledge about the health of water and fish with others in the community, or others outside the community? If so, how? Can you tell me a story about how you share your knowledge? What are some good ways/tools that help you share? (E.g. Facebook, telephone, texting, face to face meetings, hanging out at the store, fish camps/cultural activities out on the land).

7. Do others from the community, other communities, governments, and/or researchers share knowledge about the health of water and fish with you? How does this usually happen? (E.g. Facebook, telephone, texting, face to face meetings, hanging out at the store, fish camps/cultural activities out on the land).

8. How do you use the knowledge that is shared with you? Does it affect where, or how you fish?

9. What source of information related to the health of the water and fish do you trust the most? What information does this source provide?

10. To better manage and take care of the water and fish in this area, what information would you like to have that you do not currently have?

For more information, contact:

Brenda Parlee
Department of Resource Economics and Environmental Sociology
Faculty of Agricultural, Life and Environmental Sciences 507 GSB University of Alberta, Edmonton Alberta T6G 2H1
Tel: (780) 492-6825 Fax: (780) 492-0268
brenda.parlee@ualberta.ca

Sydney Stenekes
Department of Resource Economics and Environmental Sociology
Faculty of Agricultural, Life and Environmental Sciences 566 GSB University of Alberta, Edmonton Alberta T6G 2H1
Tel: (613)-986-5207
stenekes@ualberta.ca

Peter Redvers
KFN Lands Director
PO Box 3060
Hay River Dene Reserve, NT X0E 1G4
Tel: (867) 874-6701 Fax: (867) 874-3229

APPENDIX E: Interview Guide (Government and Academia)

GUIDING QUESTIONS

Culturally Driven Freshwater and Fish Monitoring in the Dehcho Region

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Researcher: Brenda Parlee, Peter Redvers and Sydney Stenekes
Affiliation: University of Alberta
Funding: Tracking Change Project, University of Alberta
Purpose: The purpose of the project is to learn about freshwater and fish monitoring in Mackenzie river sub-basins (e.g. Hay River Basin) and the strengths and challenges in sharing monitoring information at local, regional, territorial and federal levels.

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1. Could you please tell me more about the freshwater and fish monitoring you are involved in within the Hay River basin, or other sub-basins?

2. Based on your experience, what are the strengths and challenges of including communities in freshwater and fish monitoring?

3. Based on your experience, what are the strengths and challenges of sharing monitoring information/outcomes across communities, between communities and scientists, and between communities and government? Could you provide any examples?

For more information, contact:

Brenda Parlee
Department of Resource Economics and Environmental Sociology
Faculty of Agricultural, Life and Environmental Sciences 507 GSB University of Alberta, Edmonton Alberta T6G 2H1
Tel: (780) 492-6825 Fax: (780) 492-0268
brenda.parlee@ualberta.ca

Sydney Stenekes
Department of Resource Economics and Environmental Sociology
Faculty of Agricultural, Life and Environmental Sciences 566 GSB University of Alberta, Edmonton Alberta T6G 2H1
Tel: (613)-986-5207
stenekes@ualberta.ca

Peter Redvers
KFN Lands Director
PO Box 3060
Hay River Dene Reserve, NT X0E 1G4
Tel: (867) 874-6701 Fax: (867) 874-3229

APPENDIX F: Newsletter

Tracking Change University of Alberta
www.trackingchange.ca

tracking change

Local and Traditional Knowledge in Watershed Governance

Culturally Driven Freshwater and Fish Monitoring: Opportunities for Social Learning in the Dehcho Region

Sydney Stanekes, University of Alberta

PRELIMINARY FINDINGS – WHAT HAVE WE LEARNED?

According to interviews, KFN is concerned about **changes to fish health, water quality, water levels and ice thickness**. More than half of community members interviewed observed declining water levels in KFN's traditional territory. Many community members report changes to the water quality in the Hay River in their lifetime. Community members do not drink water from the Hay River. Instead, they travel further out on Great Slave Lake to access clean and safe drinking water. KFN observes the fish to be generally healthy, but report that more unhealthy fish are being caught in recent years.

KFN is concerned about **climate change, the downstream impacts of oil and gas activities and hydroelectric dams** on the health of the water and fish in their traditional territory.

RESEARCH QUESTIONS

1. How does KFN know if the water and fish are healthy? How does KFN assess if the water is safe to drink and the fish are good to eat?

2. How is information about the health of the water and fish shared and/or learned in the community? How is information exchanged across communities, and between communities and researchers (university and government)?

INTERVIEWS WITH KFN

15 interviews took place with KFN elders, fish harvesters and youth in October 2018. 6 additional interviews were organized in 2019 with GNWT, AAROM, DFO and university scientists.

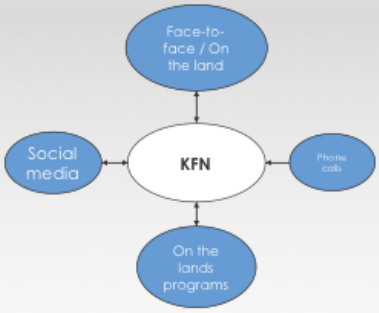
UNIVERSITY OF ALBERTA
MRBB MACKENZIE RIVER BASIN BOARD
Government of Northwest Territories / Gouvernement des Territoires du Nord-Ouest
Social Sciences and Humanities Research Council of Canada / Conseil de recherches en sciences humaines du Canada
Canada

HOW DOES KFN MONITOR?

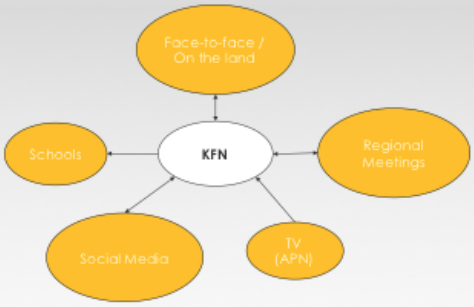
Fish Health	Water Quality	Water Levels	Ice Condition
Colour of fish gills (red), high fat content, firm texture (not soft), good taste, smell, and clean stomach content indicate that the fish are healthy. Abnormalities, such as **scars, sores, bruising, puncture wounds with pus, growth, worms and bugs** found on or in fish indicate poor fish health.	**Fresh taste, colour and clearness of water (not murky, brown) and the absence of "green stuff" (algae)** indicate clean water. **The health of fish/wildlife and location of the water source (downstream of mines)** are also used to assess water quality and determine if the water is safe to drink.	**Drying up of creeks and streams**, along with the **appearance of shoreline, sandbars, islands and rocks** indicate water levels are decreasing. Also, **community members' inability to access the falls and traditional hunting areas by boat** are a result of low water levels.	Measuring the **thickness of the ice** determines its condition. Ice thickness has decreased over the years.

HOW DOES KFN SHARE INFORMATION?

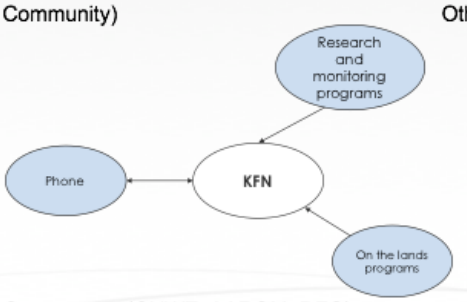
Overall, fewer community members reported exchanging information with the Government of the Northwest Territories and Department of Fisheries and Oceans. Most knowledge sharing (skills, techniques, ways of monitoring, observations of change) happens within the community, on the land and face-to-face. KFN learns from the land, through observation and in action (by doing). Some community members also use Facebook to share photos about changes they are observing on the land. Elders and experienced harvesters have an important role in the community, as they pass on their knowledge to younger generations.



KFN (Within the Community)



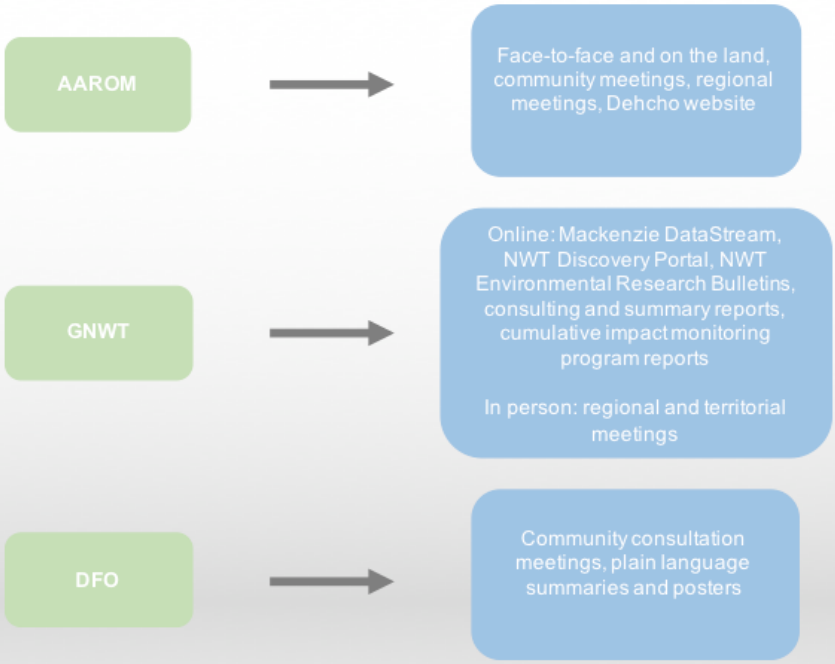
Other Communities



Government (GNWT, AAROM, DFO)

The arrows show if KFN is receiving (inward) or sharing (outward) information

HOW DO RESEARCHERS SHARE INFORMATION?



WHAT CHALLENGES EXIST IN SHARING INFORMATION?

Based on interviews with government staff and scientists, sharing information with communities is at times challenging. Examples of challenges include **long distance communication** between researchers and communities, along **with limited staff, funding and capacity to visit communities in person**. **Meetings where research is presented are not always public and open to the entire community**. Also, researchers note that the **communication of scientific research in plain language** is difficult and scientists must be willing to listen and learn from Traditional Knowledge holders. In terms of sharing information electronically, not all communities have **access to reliable and high-speed internet** to send and/or receive information.

A **lack of trust** between researchers and communities, and **data sharing protocols** may affect communities' desire to share information (Traditional Knowledge) with researchers.

WHAT ARE THE BEST WAYS TO SHARE INFORMATION?

Based on interviews with KFN, community members would like more research about the health of the water and fish to be shared with them. The best ways to share information are **face-to-face** (informal and formal meetings) and **on the land.** Some community members are also interested in learning about research results in **pamphlets and posters**.

Tracking Change University of Alberta
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For More information visit our website:

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Brenda Parlee
Resource Economics and Environmental Sociology
University of Alberta Edmonton, Alberta T6G2H1
bparlee@ualberta.ca

Patrick Riley, KFN Environmental Program Coordinator
PO Box 3060
Hay River Dene Reserve, NT X0E 1G4
kfnenvironmental@xatlodeeche.com

Sydney Stenekes MSc. Candidate
stenekes@ualberta.ca

Thank you to my funders!

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Tracking Change @mackenziebasin

Tracking Change Project @riverbasins

Tracking Change Mackenzie basin@ualberta.ca

If you have any questions, or would like to provide any feedback on this research please contact me (Sydney) @ stenekes@ualberta.ca

For more information about **Tracking Change…Research Projects,** details and updates about project funding, research news and information about team members or to find out about upcoming events, please visit our website at

Trackingchange.ca

or email us at

TrackingChange@ualberta.ca

All photos were taken by Patrick Riley (KFN Environmental Program Manager) and Sydney Stenekes (Graduate Student)

APPENDIX G: KFN Book of Stories