“This change isn’t good”:
Gitga’ata Traditional Ecological Knowledge of Environmental Change

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ABSTRACT

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Increasingly, those studying climate change are recognizing the potential of Traditional Ecological Knowledge (TEK) of Indigenous Peoples for providing insights into sustainable frameworks related to climate change mitigation policy, adaptation planning, and understanding of local-level climate change impacts. TEK has been shown to be highly valuable in identifying long-term trends in climate variables, re-constructing a baseline climate history for a people’s territory, and providing locally-generated hypotheses for the changes taking place and their relation to interacting ecosystem components.

However, it is becoming widely acknowledged that research with Indigenous Peoples must go beyond contributing advances to academic fields and must be jointly developed, performed in a way that is conducive to community values, and result in tangible benefits for the community as well as researchers. Climate change researchers or graduate students might not have the background, tools, or institutional support required to fully participate in collaborative research that is productive and meaningful, but this should be a key goal.

This thesis explores Traditional Ecological Knowledge of climate change through these two lenses in collaboration with members of the Gitga’at Nation of northwestern British Columbia. Gitga’ata people are highly knowledgeable about environmental change in their traditional territory. I document and discuss their observations, and bring these together with climate data to strengthen understanding of local impacts, concluding that Gitga’ata knowledge provides insights into local changes that the biophysical and climate modeling data alone does not capture. I also draw on my experience conducting this research to provide an overview of existing frameworks for meaningful research with Indigenous Peoples, to discuss these frameworks in relation to formal institutional requirements, and to support current recognition that productive research relationships with Indigenous communities are both possible and highly desirable.

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I would like to dedicate this thesis to my late grandfather Jean Paul Lamontagne, for teaching us kids the value of education, and for smiling when I told him that I was a Master's student—every single time. And to my Auntie Ann, who taught us all the meaning of strength.

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

GLOSSARY

CBPR: Community Based Participatory Research (e.g. Mulrennan et al. 2012)

CCAP: Climate Change Adaptation Plan that the Gitga'ata developed with funding from Indigenous and Northern Affairs Canada in four phases: 1) Values assessment 2) Vulnerability assessment 3) Identification of adaptation strategies and 4) Implementation (Reid et al. 2014).

MEB: Multiple Evidence Base approach (Tengö et al. 2014)

Sm'algyax: Coast Ts'msyen (also Tsimshian) language, spoken by the Gitga'at Nation members since the late 1800s. Literally translated, ***Sm'algyax*** means "the Real Language" (Gitga'at Nation 2004). ***Sm'algyax*** words in this document are italicized and in bold.

TEK: Traditional Ecological Knowledge (also referred to in this thesis as Indigenous Knowledge). "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. 2001, 1252)

Ts'msyen (also Tsimshian): An Indigenous cultural people and language group of the Pacific Northwest comprising seven Nations, including the members of the Gitga'at Nation.

CHAPTER 1

INTRODUCTION

This thesis addresses the current shift towards collaborative climate change research with Indigenous communities, particularly in a Canadian context. It is both a product of this shift and a response to it, in that it contributes to the growing body of academic literature that draws on both scientific and Indigenous knowledge to examine local-scale climate change impacts, while also reflecting on the historical context for and main features of these changing research practices, and exploring the ways in which they present unique challenges and opportunities for academic researchers.

The Gitga'at Nation has been dealing first-hand with the impacts of climate change in their coastal BC territory for millennia, and of anthropogenic climate change for approximately thirty years. My project is directed at better understanding these observed changes and their severity in order to contribute to the growing body of knowledge that the community has already begun collecting on the ways climatic shifts are interacting with the local lands, waters, resources and weather of their territory. Most of this work has involved the documentation of community knowledge through interviews and its organization into themes for discussion, but I have also made use of local-scale historical climate data to enhance the discussion of the changes occurring.

In this chapter, I introduce the Gitga'at Nation, address the importance of local climate studies, and provide an overview of my research with the community.

1.1 Background

1.1.1 GITGA'ATA

In the ***Sm'algyax*** language, Gitga'ata means "People of the Cane", a name derived from a sacred history in which the ancestral Chief established a new settlement at the place where two rivers meet, and long poles ("canes") were used to maneuver their canoes along the river, at the end of Kitkiata Inlet (Gitga'at Nation 2004).[1]

A member community of the Southern Ts'msyen First Nations cultural group, the Gitga'ata are a relatively small community of about 650 people. Approximately, 200 of this number live on the territory, with 450 living in Prince Rupert (140 km to the north) and elsewhere in British Columbia or abroad (Gitga'at Nation 2004). Hartley Bay, or ***Txalgiu*** is home to many members of the Gitga'at Nation and is located at 53.2530°N latitude and 129.1505°W longitude, 121 km to the south of Prince Rupert. Figure 1.1 shows Gitga'ata territory, which includes the present community of Hartley Bay.

Gitga'ata territory is located within the Coastal Western Hemlock biogeoclimatic zone, which is characterized by mountainous topography and ocean adjacency. Ample available atmospheric moisture combined with orographic lifting contributes to a climate that is mild and wet (Egan 1999). The coastal location of the community is significant; Gitga'at's long-term habitation in this zone signifies a deep and collective history of understanding and engaging with coastal processes, environments and resources, as well as an on-going capacity for adapting to change (Turner et al. 2006; Mulrennan 2014).

Gitga'ata society is comprised of four clans: ***Gispudwada*** (Blackfish or Killerwhale), ***Laxsgiik*** (Eagle), ***Ganhada*** (Raven) and ***Laxgibuu*** (Wolf). As a matrilineal society, the mother (or, in some cases, the maternal uncle) is the one to pass down clan affiliation, crests, names, and resource gathering areas (Gitga'at Nation 2004).

[1] Though the name "Gitga'at" is how the community officially identifies themselves, several individuals residing in Prince Rupert informed me that they find "Gitga'at" to be an offensive rendering of their true Nation name, which more closely approximated Kitkiata (Halpin and Seguin 1990). They informed me that "Gitga'ata" is the acceptable contemporary usage and I have therefore relied on this term whenever referring to the community, except for when using quotations or referencing community institutions or published materials.

Figure 1.1. A map of Gitga'ata territory, whose boundary is marked in blue. Hartley Bay, home to some of the Gitga'ata, is indicated. (Property of Gitga'at Nation)

At the time when European ships began arriving, the Gitga'ata had their winter village at Old Town ***(Laxgal'tsap)***, while maintaining several seasonal harvesting camps throughout their territory. Their language was ***Sguuxms***, spoken by the Southern Ts'msyen. First contact with colonizers occurred in 1787, and the Gitga'ata travelled to Fort Simpson and to Fort McLoughlin by canoe to trade with fur traders and the Hudson Bay Company. Anglican missionary William Duncan arrived in the region in the 1860s, and the Gitga'ata began to move to the newly established Christian community at Metlakatla Pass near Prince Rupert throughout the 1870s, returning to their territory for seasonal harvesting. During their time in Metlakatla, the Gitga'ata adopted ***Sm'algyax*** as their language, which was the more widely used language of the Coast Ts'msyen. When Duncan led the Metlakatla community to Alaska in 1889, twenty-seven Gitga'ata returned to their territory rather than travel north, and established a new settlement at Hartley Bay ***(Txalgiu)*** (Gitga'at Nation 2004). Shortly after, the community was "granted" seventeen parcels of their territories as reserves under the Indian Reserve Commission in 1889 and the McKenna- McBride Commission in 1913-1916. The Gitga'ata were asked to submit claims for additional reserves, but the Gitga'ata demanded that they be granted Aboriginal title to all of their lands and waters (rather than accept the parceling of their territory; Campbell 2011) They are one of five Bands comprising the Tsimshian First Nations Treaty Society, currently in the process of Treaty Negotiations ("Tsimshian Nation: First Nations & Negotiations: BC Treaty Commission" 2016), and publicly re-asserted their rights and title when they challenged the Federal court's 2014 decision to approve Enbridge's Northern Gateway project.

Since first contact with Europeans, the Gitga'ata have retained many of their traditional ways and continue to rely on various harvesting sites throughout their territory (Gitga'at Nation 2004). They have maintained two permanent harvesting camps. Old Town (or ***Laxgal'tsap***) is where they harvest berries *(**maay**)*, Chum *(Oncorhynchus keta; **gayniis**)* and Pink *(Oncorhyncus gorbuscha; **stmoon**)* salmon in summer and autumn.[2] Old Town was the site of their winter village before the move to Metlakatla, and is situated 19 km north of Hartley Bay along the Douglas Channel, in the Kitkiata inlet. Kiel (or ***K'yel***), for spring seaweed *(Pyropia abbottiae*; ***lha'ask**)* picking and halibut *(Hippoglossus stenolepsis; **txaw**)* fishing and other seafood harvesting, is located on the northwest part of Princess Royal Island (or ***Lax'a'lit'aa Koo***) near Whale Channel 40 km to the south of Hartley Bay. Hartley Bay's main river is a salmon-spawning stream, where some members of the Gitga'ata have built a hatchery for their Coho enhancement project, which they operate each year while also fishing the stream for Coho *(Oncorhynchus kisutch; **wüüx**)* and other salmon species.

The Gitga'ata rely on seasonal harvesting of plant and marine resources, as well as hunting land mammals, for subsistence (fig. 1.2). Many families have multiple stand-alone freezer units where they store traditional foods. However, sharing of foods among extended Gitga'ata family members is still identified by many community members as being of vital importance by many community members. Many people also take part in one or more of fishing, hunting, and gathering activities. Edible Red Laver seaweed

[2] ***Sm'algyax*** names taken from (Turner et al. 2012)

(Pyropia abbottiae; ***lha'ask)***, Western Red-cedar *(Thuja plicata;* ***smgán)***, different varieties of salmon ***(yeeh, müsoo, stmoon, wüüx, gayniis)***, cockles *(Clinocardium nuttallii;* ***gaboox)*** and Northern Abalone *(Haliotis kamschatkana;* ***bilaa)*** continue to act as cultural keystone species for the community, in that people identify strongly (and indeed are associated by others) with these species, and their significance is maintained through their intensity of use, contribution to trade, role in ceremonies and narrative, and other elements (Garibaldi and Turner 2004).

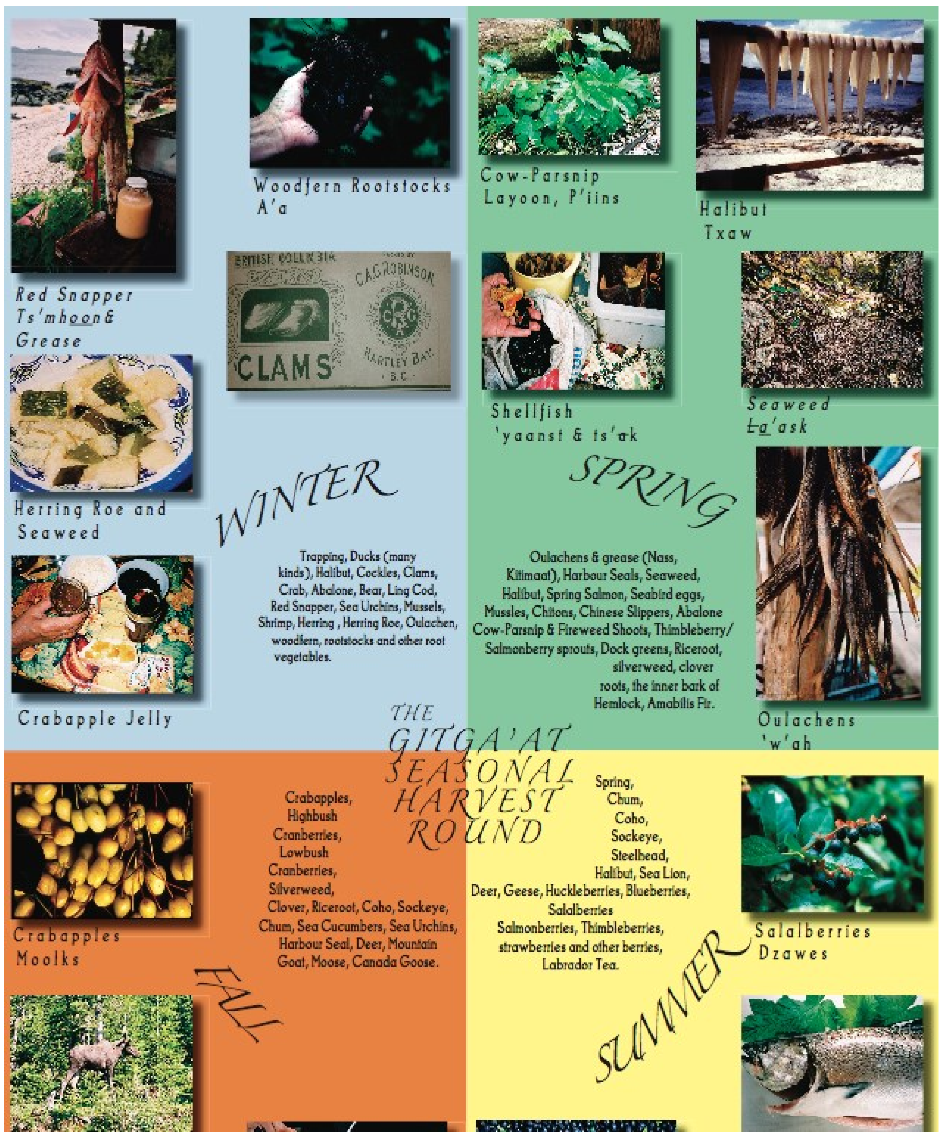

Figure 1.2. Poster segment of the "Gitga'at Seasonal Harvest Round" presented to the Gitga'ata by Nancy Turner and other researchers involved in the Coasts Under Stress project 2001-2003. Photos by Nancy Turner. Seasonal round by Helen Clifton, Isobel Eaton and Nigel Haggan. Poster design by Avi Lambert.

It's likely that the Gitga'ata's seasonal harvest round has evolved many times to suit changing conditions. Their ability to depend reliably on some of these resources has also been compromised, to some extent, by a loss of knowledge transmission and cultural continuation attributed to colonial forces. These include the imposition of new foods onto the Gitga'ata from settlers, the appropriation of Gitga'ata land and resources, denial of access to seafood harvesting, a forced dependence on the wage economy, the vilification of important cultural practices (such as feasts and ceremonies) under the Indian Act of 1876, and the removal of children to residential schools in the 1920s and their forced aversion to traditional foods (Turner and Turner 2008; Turner et al. 2013). Lately, changes to the timing of weather and seasons as well as to the behavior, distribution and abundance of valued species have also been having an impact on Gitga'ata ability to reliably harvest culturally important foods (Nancy J. Turner et al. 2006; Nancy J. Turner and Clifton 2009).

The Gitga'ata have also been faced with widespread external perturbations throughout their territory. Timber claims resulted in the clear-cut logging of much of the forest around Old Town in the 1970s and 80s (Turner 2010), which had negative ecosystem-wide effects, including impacts to the salmon streams.[3] The abalone of the territory, a cultural keystone species to the Gitga'ata (Garibaldi and Turner 2004) were overexploited and ultimately depleted by non-Gitga'ata when the federal Department of Fisheries and Oceans used Gitga'ata's knowledge of abalone beds to issue licenses to outsiders in the 1980s (Turner 2010; Chapter 3).

Currently, the Gitga'ata are being prominently featured in the news for their on-going political struggles against Enbridge's proposed Northern Gateway project, which (if it goes forward in its current form) will export liquefied bitumen by pipeline from the Alberta oil sands to a marine port in Kitimat, then ship it via tankers through the difficult-to-navigate waters of the Douglas Channel and islands of the inland passage on its way to Asian markets (Northern Gateway 2016). This will bring daily tanker traffic directly through a vast stretch of Gitga'ata territory. Because the Northern Gateway project poses

[3] Interview with author, March 2015

unacceptable risks to their waterways and all marine and non-marine wildlife dependent on them, the Gitga'ata launched a lawsuit in January 2014, following the recommendation of the Federal Joint Review Panel that the project go ahead ("First Nation Seeks Declaration of Aboriginal Title in Challenge to Enbridge Northern Gateway Pipeline" 2016). Though the project was formally approved in June 2014 by the Conservative Federal government, a British Columbia Supreme Court ruling in January 2016 determined that the province had failed in their duty to consult with coastal First Nations when they agreed to a joint environmental impact assessment with the Federal government. A provincial assessment has therefore been ordered by the court ("Supreme Court Rules BC Government Must Review Enbridge Northern Gateway Pipeline and Consult with Gitga'at First Nation | Coastal" 2016).

1.1.2 Importance of local climate change studies

1.1.2.1 Climate change basics

Global climate change has been identified as one of the defining issues of our time (IPCC 2013). As greenhouse gases continue to be contributed to our atmosphere at increasing and unprecedented rates, the world is bracing for a major climatic shift. Temperature increases, extreme weather events, sea level rise, melting glaciers, ocean acidification, and regional re-distributions of precipitation patterns are only some of the changes we might expect should global temperatures increase by more than 2°C relative to pre-industrial (i.e., 1750) levels (IPCC 2013).

Climate change has been defined as "a change in the state of the climate that can be identified (e.g. using statistical tests) by changes in the mean and/or variability of its properties, and that persists for an extended period, typically decades or longer. It refers to any change in climate over time, whether due to natural variability or as a result of human activity" (IPCC 2007).

Current rates of warming have not been seen in the last 8,000 years (IPCC 2007). Over 133 years (1800-2012), a mean global temperature increase of approximately 0.85°C was observed. Each of the last three decades has been warmer than any decade since 1850, and the years 1983-2012 likely represented the warmest averaged thirty-year period in 1400 years (IPCC 2013). In fact, the year 2015 was the hottest year on record by a wide margin, with 2011-2015 as the warmest five-year period on record (World Meteorlogical Association 2016). This and other evidence suggests that warming of the globe is therefore occurring without question, and is accelerating. At the same time, global average sea level has been increasing while snow cover and sea ice in the northern hemisphere have been showing significant decreases (IPCC 2013; fig. 1.3).

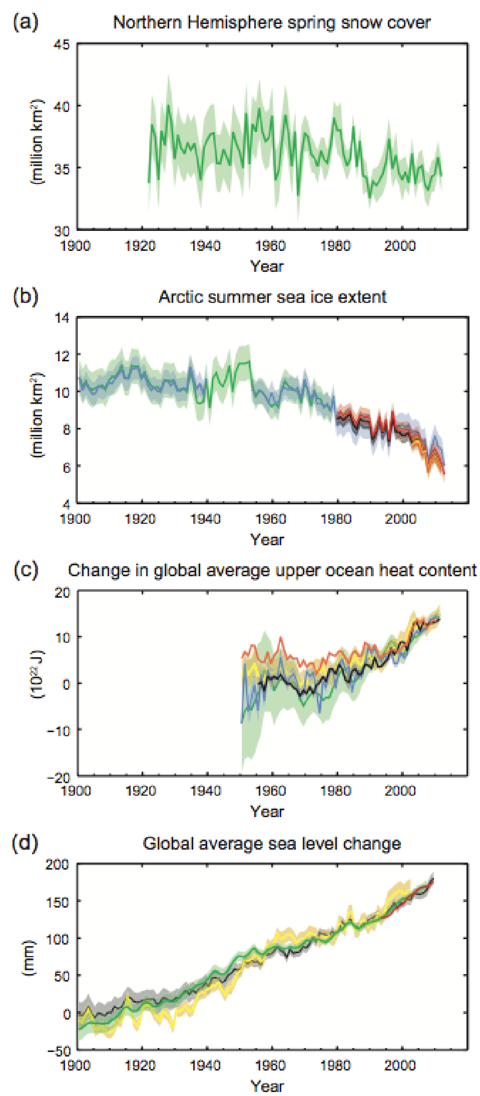

Figure 1.3. Observed changes in (a) northern hemisphere spring snow cover; (b) Arctic summer sea-ice extent (c) upper ocean heat content relative to the 1970 mean, and (d) global mean sea level relative to 1900-1905 mean (IPCC 2013)

These trends are projected to continue. The time period 2016-2035 is expected to be 0.3 to 0.7°C warmer than 1986-2005, regardless of emissions scenario (which in these years are all quite similar in terms of CO_2 emissions). After this, temperature projections begin to diverge based on choice of emissions scenario. By the end of the 21st century, increases may be in the range of 0.3°C to 4.8°C, depending on the scenario and taking uncertainty ranges into account. Direct and indirect impacts of such warming on ecosystems, food resources, coastal systems, industry, human health, and water have the potential to be extensive and severe (IPCC 2013).

Warming is very likely to be greatest over land surfaces in the high northern latitudes, and will cause widespread melting of ice and snow, more frequent extreme heat events, poleward displacement of mid-latitude storm tracks, and increased precipitation. Over North America, climate change is likely to be manifested in decreased snowpack, winter or earlier spring flooding and reduced summer flows west of the Western mountains, extreme heat events, extreme precipitation events, and coastal stress (IPCC 2007).

Climate models are valuable tools in investigating future or hypothetical climate system responses to changes occurring at a multitude of scales. They are our primary means of obtaining estimates of change, and can take many complex feedback mechanisms and cascading effects into account in their calculations. Though uncertainties are inherent in any model, and each has its own strengths and weaknesses, these models are being improved upon all the time and are becoming ever more accurate and precise in their output and predictive powers (Flato et al. 2013).

Climate models are simplifications of the climate system and its components. Examples of these components, which drive the climate system through exchanges of energy, atmospheric gases, and water, are the atmosphere, ocean, vegetative cover, land surface, ice, and solar energy (Le Treut et al. 2007). Global climate models, or general circulation models (GCMs), manipulate these exchanges (e.g. by increasing the exchange of carbon from the land surface to the atmosphere) to obtain spatially and temporally specific data depicting the resulting changes in climatic variables such as temperature, precipitation, and atmospheric circulation as well as deriving numerous sub-variables (such as frost-free period or length of growing season).

The global environmental changes noted in the section above will manifest themselves in vastly different ways at regional and local scales. However, it is very difficult to apply global climate model results calculated for a large grid cell to a single location within that grid cell with a high degree of confidence (Sobie and Weaver 2012). Given that the grid cell of an average global climate model will be $100km^2$ at best, with everything within the cell being averaged over this area, small-scale influences over climate are not taken into account. Orographic and topographic features, for instance, which can sufficiently alter atmospheric processes so as to create “microclimates”, are not well-simulated by global climate models (Sobie and Weaver 2012).

Regional climate models (RCMs) are designed for a specific geographic region of the globe, accounting for the above-mentioned local-scale processes, and operate through a nested model process (output from GCMs are input into a RCM, thereby driving it) (Meehl et al. 2007). Unlike GCMs, RCMs are capable of simulating specific areas at high resolutions because only subsets of general circulation processes are modelled. However, RCMs are very time-consuming and expensive to run, as they require high computing power to calculate climatic processes at numerous individual points (Meehl et al. 2007).

Even downscaled climate data, which are spatially interpolated data (such as from global climate models or climate station interpolation) that have been superimposed (Wang et al. 2012), statistically correlated with (Sobie & Weaver 2012), nested (as in the case of regional climate models; Laprise 2008), or otherwise geospatially linked with high-resolution surfaces to enable finer estimates, are associated with whatever uncertainties were inherent in the original large-scale data as well as uncertainties in the downscaling process. Downscaled climate data is therefore a good candidate for being augmented through combination with Traditional Ecological Knowledge, as its high-resolution nature allows researchers to bring this knowledge together with observations from individual places. For instance, local-scale expertise could portray actual effects of global processes and describe complex local feedback mechanisms between the biophysical environment and climate that models could never capture (Nichols et al. 2004).This potential application of local experiences, observations and inferences is explored further in Chapter 4.

1.1.2.3 Climate change and Indigenous Peoples

Indigenous Peoples are often disproportionately impacted by climate change because they are frequently (though not uniformly) at a geographical, social, political, and/or economic disadvantage (Salick and Byg 2007). In spite of this, Indigenous groups are not passive victims of climate change. Many, like the Gitga'ata, are striving for ways to mitigate and adapt to the impacts of climate change on their way of life (Ford et al. 2014; Reid et al. 2014). Indeed, the Indigenous Peoples of Western North America have faced and responded to environmental change throughout their very long histories in their territory (Turner and Clifton 2009). Ford and Smit (2004) developed a framework for assessing vulnerability to climate change in Arctic Inuit communities, and found that adaptive capacity was just as important as exposure in determining how vulnerable a community was to environmental changes. These adaptive capacities, however, are vulnerable to non-climatic stressors resulting from cultural changes, increasing participation in the wage economy, economic stresses, health issues, and resource development projects.

The Gitga'ata have been describing observed environmental changes in their territory for some time, and have begun to respond adaptively to some of the impacts (Turner and Clifton 2009).[4] Their flexibility in the face of unforeseen circumstances and their endurance in maintaining cultural and traditional practices, even as they are forced to reconfigure the ways in which they carry some of them out, are testaments to their knowledge of and deep connection with their ancestral territory (Turner and Clifton 2009).

1.1.3 My research with the Gitga'ata

I am a white female academic scholar with no cultural claim to First Nations, Inuit or Métis heritage, and my work with the Gitga'at Nation was my first experience of research with a First Nations community. This constitutes an important lens through which I carried out my project, and it will doubtlessly have affected my research process every step of the way: the questions that I asked myself as well as those I posed in interviews,

[4] An example of one of these adaptive strategies is the use of freezers to preserve their seaweed until it is warm enough to be dried outdoors (Turner et al. 2006; Turner and Clifton 2009)

the kind of research material that I collected, the scope of literature I read and the way I presented it, and the methods that I chose to analyze my data, among others. As discussed by Donna Haraway (1988) and many others, all scholars are situated within a particular context that will permeate the work that they carry out, called "situated knowledges". I also acknowledge the community-driven nature of my project and my efforts to allow community aims to be the primary force shaping my research. Indeed, my experiences working for and with the Gitga'ata have in turn altered the way that I approached and interpreted my own work. Above all, I remain eager to learn from the community and am grateful for the opportunity to work alongside them as research partners.

As research assistant to my current co-supervisor Dr. Damon Matthews in 2012, I was introduced to the Gitga'ata through his mother-in-law, Dr. Nancy Turner. Dr. Turner has collaborated with the Gitga'ata since 2001 on various projects pertaining to traditional foods, local plants, cultural values, and adaptation to changing environmental conditions (for example, Turner et al. 2006; Turner et al. 2012; Turner and Thompson 2006; Lantz and Turner 2003; Turner and Clifton 2009).

In 2012, Dr. Turner informed Dr. Matthews of a research opportunity that might be of interest to his students. The Gitga'ata were in the first year of a Climate Change Adaptation Program (CCAP), funded by Indigenous and Northern Affairs Canada (INAC) and aimed at developing a values-based climate change adaptation plan for the community (Reid et al. 2014). The Gitga'at CCAP was headed by the Hartley Bay Band Council in partnership with researchers from the University of Victoria and EcoPlan International. The team was dedicated to taking stock of Gitga'ata vulnerabilities and resilience to the impacts of climate change, and subsequently developing appropriate adaptation measures and promoting further resilience. Accordingly, they had been holding interviews and group discussions regarding community knowledge of climate change.

This work was to take place in three consecutively funded years, the first of which involved the production of a full Values Assessment, followed by a Vulnerability Assessment. Phase three of the CCAP involved an adaptation plan, which assigned priority to addressing changes that the Gitga'ata's most valued resources, infrastructure, or cultural practices are highly vulnerable to. The team that pioneered the project divided the Vulnerability Assessment into the Sociocultural Vulnerability Assessment and the Biophysical Vulnerability Assessment, the latter of which involved a thorough literature review of the then-current scientific knowledge of climate change (and associated effects) in the area corresponding to Gitga'ata territory. I took this project on in October 2012 and produced the report in March 2013. In January 2013, I had the opportunity to visit the community of Hartley Bay for the first time and to discuss preliminary results as well as members' observations of change and their concerns for the CCAP project. When I submitted my application to graduate school in February 2013, my proposed research topic was the modelling of salmon abundance and distribution in Gitga'at territory under future climate change scenarios.

During their work with the community on the identification of socio-cultural impacts, the CCAP team recorded a high number of observations of environmental change. These were related to direct climate changes such as seasonal temperature and precipitation, as well as many indirect effects such as on their fish, berry, and seaweed harvests. Dr. Turner told Dr. Matthews and me about the Knowledge Bank project that she and the community hoped to develop in the future (which would document and centralize community knowledge in a user-friendly and accessible way for present and future generations), and the possibility that I could contribute to this somehow. In the end, it was conceived that I might could continue with the recording of Gitga'ata observations of climate change through more focused and in-depth interviews. I could then draw this community knowledge and the CCAP workshop observations together with localized climate data to attempt a description of the changes taking place in Gitga'ata territory, something that could then be usefully applied as a basis for further research and community-led adaptation measures. Dr. Chris Picard, Science Director to the Gitga'ata, encouraged me to begin the process of reading through a Research Protocol that he sent me.

I began my MSc studies in May 2013 under the co-supervision of Dr. Matthews (whose background in climate systems and climate modelling lent support to my readings and understanding of climate processes) and Dr. Monica Mulrennan (whose sustained experience working collaboratively with Torres Strait Islanders and the James Bay Cree provided the opportunity for guidance and reading assignments that would help me to better understand my responsibilities to the Gitga'ata). The co-supervision of Dr. Matthews and Dr. Mulrennan has also shaped my research questions and the methodologies I used.

Two of the courses that I took at the graduate level were methodology courses, given that my mixed-methods project required that I learn research design as well as statistical analyses. I also participated in Dr. Mulrennan's Indigenous Resource Management course, which was supremely helpful in introducing me to literatures relating to Traditional Ecological Knowledge and its treatment in academic contexts, Indigenous conceptions of environmental resources and management, and key events in Canadian Aboriginal history.

Since beginning in my MSc program in May 2013, I have visited the community in February 2014 for a series of research networking workshops, where I was able to speak with community members and learn more about the territory, and in March 2015 for my own fieldwork.

I visited the Gitga'ata in Hartley Bay from March 2^{nd} to 8^{th} and in Prince Rupert from March 9^{th} to 15^{th} 2015. In that time I conducted fourteen interviews with nineteen individuals (outlined in further detail in Chapter 4). These interviews were conducted in person, either in the home of the participant(s), their workplace, or a publicly accessible venue such as a group study room in Northwest Community College in Prince Rupert. Participants were asked whether I could record the interview, and most agreed. At most interviews, which typically lasted half an hour to an hour, either Dr. Turner or Spencer Greening (or both) were present. Topics included direct climatic changes such as the trends in seasonal weather as well as environmental changes such as in river systems or to species distribution, behavior, harvesting, or processing. Given that it was my first time conducting interviews (and that it was much easier to be an avid audience than an interviewer), interviews were loosely structured, and all participants were extremely knowledgeable and accommodating.

1.1.4 Gitga'ata Research Protocol and Concordia Ethics Approval

The Gitga'ata have their own research agreement process whereby researchers and community representatives must sign the Gitga'at Summary Protocol (written by the Gitga'at Band Council and other community members) that outlines the expectations of consultation, knowledge ownership (intellectual properly), research credits, sharing of benefits, procedures for obtaining participant consent, plans for analysis and interpretation of data, production of progress reports, dissemination of results, co-authorship, conflict resolution processes, and other considerations. The researcher is free to make amendments to the Protocol as necessary but the final decision about whether the research goes forward under the outlined terms rests with Gitga'ata leadership. The Gitga'at Summary Protocol was approved by a Band Council representative and signed on January 3, 2015.

The University Human Research Ethics Committee (UHREC) at Concordia categorizes research with Indigenous communities as constituting above minimal risk and therefore has special requirements for students submitting applications for review. One requirement is that the student include proof that they have entered into a formal research agreement with their partner community and are abiding by Chapter 9 of the Tri-Council Policy Statement on Ethical Conduct for Research Involving Humans, which states that the researcher must fulfill such commitments as to jointly determine with the community what level of engagement is deemed necessary and appropriate; to recognize First Nations Governing Authorities in seeking the review and approval of any research proposal before conducting research (keeping in mind that individual consent will still be required from all participants); to recognize the role of Elders and other knowledge holders; to ensure privacy and confidentiality for all participants, as outlined in Ch. 5 of the Policy; and to offer the opportunity to review findings, to ensure continued communication; and other considerations.

The Ethics Review Board meets once a month to review applications that are above minimal risk; they reviewed my application at their meeting on January 15th. I was given comments on various aspects of my application, which I revised and re-submitted at the beginning of February. I received full approval by the board at the beginning of March, just in time for my fieldwork.

1.2 Thesis theme and objectives/ hypotheses to be tested

The major theme of this research is 'academic climate change research and Indigenous Peoples', with a focus on the Giga'ata Nation and their unique position in relation to climate change. The characterization of climate changes occurring at the local level in Gitga'ata territory is a major component of this project. I explored local-scale climate change impacts from the perspectives of a First Nations community and from climatic data, as well as completed a review of some of the literature on working with different knowledge systems for increased environmental understanding (and the challenges involved in doing so).

Another key component of this work is an engagement with the current shift toward research partnerships between researchers and Indigenous communities that are respectful and appropriate. I have considered the historical context for research with Indigenous Peoples, discussed the commonalities between several different frameworks for meaningful research, and explored the implications of engaging in culturally appropriate research in the context of formal academic institutions.

The objectives of this research are therefore to:

1) Synthesize current community knowledge of changes occurring in Gitga'ata territory for community inclusion in knowledge repositories and future research or planning;

2) Identify commonly discussed components of meaningful research partnerships with Indigenous communities from the academic literature;

3) Explore the opportunities and challenges of successfully incorporating Indigenous research methodologies in an academic context, to encourage other researchers or students to engage in collaborative research that benefits Indigenous communities; and

4) Explore the extent to which downscaled climate data and Traditional Ecological Knowledge can complement each other, and discuss the benefits to researcher and community of bringing them together in equal consideration

In Chapter 2, I review some of the literature examining the interface between Indigenous and scientific knowledge and explore the benefits (to researchers and to Indigenous communities) of having Indigenous Knowledges inform academic research in ways that are appropriate to and respectful of community values.

In Chapter 3, I outline several methodologies for researchers seeking to engage in respectful and mutually beneficial research partnerships with Indigenous groups, and identify key themes. In relation to these themes, I then consider my experience as a graduate student and the place that these methodologies have in climate change research.

In Chapter 4, I consider climate change in Gitga'ata territory from community workshops and interviews and from downscaled climate data from the ClimateBC downscaling software. I detail my chosen methodologies, present major climatic trends in the territory alongside community evidence of environmental change, and discuss the mutually reinforcing and supplemental nature these two knowledges.

CHAPTER 2

LITERATURE REVIEW

The main bodies of literature explored in this chapter are related to definitions and concepts of Traditional Ecological Knowledge (TEK); the interface between scientific and Indigenous Knowledge; and the critical exploration of researchers' perceptions and application of TEK.[5]

I begin with a short overview of the engagement of TEK in climate change studies before outlining some of its definitions and conceptualizations. I then review literature that discusses the benefits and difficulties for researchers engaging with two different knowledge systems; discusses the role that these differences have played in rationalizing a broadly held understanding of TEK as "inferior" or less relevant than science; and critically examine the practice of "integrating" TEK into western scientific frameworks. These are primarily written by western scientific researchers for western scientific researchers; I conclude by presenting TEK as valuable not only for the advancement of research, but as a tool for cultural continuity, knowledge transmission and enhanced governance.

Together, these bodies of literature have informed my approach to my field research and analyses, and are an important basis for the cultivation of awareness related to my work. Of particular salience in this literature is the obvious richness and significance that these knowledges can have for climate change studies, as well as the ways in which researchers' underlying perceptions of TEK can shape its treatment and representation.

2.1 Short history of Traditional Ecological Knowledge in climate change research

Historically, and under a positivist scientific framework, the knowledges of Indigenous

[5] The terms 'Traditional Ecological Knowledge' (TEK) and 'Indigenous Knowledge' (IK) are often used interchangeably in the literature. I rely primarily on 'TEK' (as it is the term most commonly used to refer to the knowledge of Canadian Aboriginal Peoples) but also use 'Indigenous Knowledge' when referring to knowledge systems.

Peoples were initially dismissed as “anecdotal, non-quantitative, without method, unscientific” (Hobson 1992). However, there are accounts of the study of Indigenous Knowledge systems in the fields of ethnographic science as early as the 19th century (Mulrennan 2013). In the Northwest Coast cultural area, the late 1800s and early 1900s were times of anthropological ethnographic exploration, as "salvage ethnologists" sought to document Indigenous cultural elements that still remained intact before modernizing forces from elsewhere on the continent could erase them (Newell 2015). While sometimes resulting in biased and Eurocentric characterizations of Canadian First Nations communities and cultures by outsiders, these ethnographic endeavors also frequently produced close, enduring, and mutually beneficial research partnerships between researchers and Aboriginal Peoples (Newell 2015).

In the 1950s the field of cultural ecology began to focus on these knowledge systems in relation to adaptation to the environment, and the terms “Indigenous Knowledge” and “Traditional Ecological Knowledge” began to appear in some resource management literature (Mulrennan 2013). Early studies on TEK in Canada in the 1970s also began the work of incorporating Indigenous Peoples' knowledge systems into land claim negotiations, demonstrating traditional land use and occupancy as well as drawing further attention to these extensive knowledge systems as potentially applicable to the fields of resource management, co-management, environmental impact assessments, conservation, sustainable development, and environmental history (Ermine et al. 2010).

The field of climate science, however, arguably became receptive to TEK following the United Nations Convention on Biological Diversity, created during the Rio Earth Summit in 1992 (Mulrennan 2013). The report published subsequent to this convention made explicit a number of provisions to promote the joint generation and two-way dissemination of scientific knowledge and TEK in a number of fields, including climate science. The establishment of the UN Working Group on Indigenous Populations in 1982 as well as the Brundtland Report of 1987 were both important pre-cursors to the discussions that took place in Rio, as they primed policy-makers and scientists alike to recognize Indigenous rights and to value traditional skills and knowledges (Mulrennan 2013).

While each new wave of acceptance was met with some opposition as well as important cautionary critiques on the ways in which these knowledges were utilized and conceptualized (section 2.4), growing scientific awareness of ecosystem-based approaches, the precautionary principle, and multi-stakeholder engagement was conducive to the inclusion of TEK (Mulrennan 2013). Co-management proponents in particular have been active in seeking out arrangements that will base management decisions on both western and Indigenous knowledges (and their joint generation) (Mulrennan 2013), though it has been criticized for doing so in ways that distort the non-scientific knowledge and constrain options for Indigenous participation within western frameworks, ultimately disempowering them (Nadasdy 2003).

The Intergovernmental Panel on Climate Change (IPCC) made few mentions of Indigenous Peoples in their 2007 Fourth Assessment Report (AR4). In Chapter 20 of the IPCC Fourth Assessment Report, the authors note that climate change policy "requires the inclusion of local knowledge, including Indigenous knowledge, to complement more formal technical understanding generated through scientific research". In the Working Group Two (WGII) report "Impacts, Adaptation and Vulnerability", Indigenous knowledges are discussed in relation to mitigation; adaptation and resilience; sustainable development; and their uses in weather forecasting. Indigenous Peoples in the polar regions are framed as being highly at risk to climate changes in their unique territories, and the embrace of problematic Euro-American conceptualizations of the "Endangered Other" in this report has been criticized (Hall and Sanders 2015). Meanwhile, that they are not afforded the recognition of any "special rights" in regards to climate change (Ford et al. 2012) is consistent with commentary that Indigenous Peoples have been marginalized in the mainstream climate discussion and by the IPCC (e.g. Turner and Clifton 2009; Ford 2010; Huntington 2011).

That is not to say, however, that there hasn't been research carried out focusing on Indigenous groups in relation to climate change, and the more recently published Fifth Assessment Report (AR5; IPCC 2013) includes Indigenous knowledge in their synthesis of the literature on adaptation and adaptive capacity; decision-making; detection and attribution of climate change; food production and food security; human security; climate forecasting; observed impacts; and threats to the survival and applicability of Indigenous knowledge. Compared to the AR4, they have engaged with literature that addresses and values TEK on a more fundamental level:

> TEK, however, does not simply augment the sciences, but rather stands on its own as a valued knowledge system that can, together with or independently of the natural sciences, produce useful knowledge for climate change detection or adaptation (Agrawal, 1995; Cruikshank, 2001; Hulme, 2008; Berkes, 2009; Byg and Salick, 2009; Maclean and Cullen, 2009; Wohling, 2009; Ziervogel and Opere, 2010; Ford et al. 2011; Herman-Mercer et al. 2011) [...] Furthermore, TEK- based observations and related interpretations necessarily need to be viewed within the context of the respective cultural, social, and political backgrounds (Agrawal, 1995). Therefore, a direct translation of TEK into a natural science perspective is often not feasible. (IPCC 2013 1001)

The report's endorsement of the use of TEK in climate change studies is reflective of a large body of literature that frames the integration and co-production of TEK and western science as valuable for studies in such fields as historical climatology, adaptation, natural disaster mitigation, biodiversity science, and sustainability (Kimmerer 2013).

The AR5 also reports on the overall lack of TEK's inclusion in adaptation planning, a factor in decreased community resilience to climate change, and refers to recommendations for more governmental and international engagement with Indigenous Peoples in decision-making processes involving traditional resources or territories. Participatory approaches to Indigenous knowledge documentation are then mentioned along with two major challenges: power dynamics and interpretation biases. Additionally, the report reviews research concerned with the threat posed by climate change to the strength of existing Indigenous Knowledges, given that these knowledges are now situated in a rapidly shifting physical, social and political landscape, which makes it difficult for them to evolve alongside changing ecosystems (as they have done for thousands of years). They also engage with research that discusses the on-going effects of colonization and how they are entangled with climate change outcomes in local Indigenous communities.

These examples illustrate the IPCC's growing willingness to engage with Indigenous knowledge in principle, and there are also strong indications in the AR5 that they are supportive in practice. The chapter on the detection and attribution of climate changes, for example, outlines many impacts that have been detected by scientific studies and local/Indigenous observations alike, and grants Indigenous observations high consideration and confidence. Further, they assert that local knowledges can and should be given equal priority in the production of new knowledge, to result in shared narratives that better represent all relevant information for decision-making.[6]

The Arctic Climate Impact Assessment (ACIA 2004) is another research synthesis project that took place in an international context, being headed by the intergovernmental Arctic Council (made up of eight countries with jurisdiction in the Arctic), and the non-governmental International Arctic Science Committee. Similar to the IPCC report, the ACIA attempted s to bring together existing sources of knowledge about the effects of anthropogenic climate change in the Arctic and their impacts. The report is essentially scientific, drawing on the available Arctic literature describing climate changes and resulting impacts on ecological and human systems, but it has a chapter dedicated to Indigenous perspectives of change (ACIA 2004).

There are also forums created by Indigenous Peoples as spaces for them to come together for the generation, sharing, and discussion of their knowledge of changing climatic conditions and their impacts. The International Indigenous Peoples' Forum on Climate Change (IIPFCC) is the caucus of Indigenous Peoples participating in global climate change negotiations related to the United Nations Framework Convention on Climate Change (UNFCCC). It is a highly structured organization with a formal role in all UNFCCC inter-sessional meetings and each Conference of Parties, and is open to all Indigenous people wishing to partake in negotiations (IIPFCC 2016). It is worth noting, however, that Indigenous Peoples fought for many years to have their knowledges recognized as valid and included at the UNFCCC (Doolittle 2010).

[6] Though an improvement over AR4, an analysis of chapter authors for the AR5 WGII indicates that only 2.9% had any background in publishing on Indigenous populations and climate change, which likely had an impact on the extent to and ways in which Indigenous content was included in the AR5. Given the IPCC reports' importance in determining policy, it is important to have expertise on Indigenous climate change issues shape them (Ford et al. 2012).

In a Canadian context, the Prince Albert Grand Council Elder's Forum on Climate Change was a meeting of Elders from the Prince Albert Grand Council (comprising twelve First Nations communities in Saskatchewan) with each other and with scientists in order to engage in respectful discussion and information sharing about climate change (Ermine et al. 2010). The report "Isi Askiwan-- The State of the Land" was published following these meetings. The structure and spirit of the forum were consistent with the traditional cultural protocols of the attending Nations, and the learning that took place was directed primarily by leaders of communities. Through semi-structured facilitation, Elders contributed their experiences with and observations of climate change, discussed observed major impacts on community well-being, and deliberated on adaptive capacity and adaptation options that are compatible with their worldviews.

The Climate Change Adaptation Program (CCAP), funded by Indigenous and Northern Affairs Canada (INAC), began in 2009 and came to an end in March 2016. Over seven years, INAC provided funding to over 175 projects (some of which were headed by the same communities in different years, as with the Gitga'ata, or targeting different aspects of climate change adaptation). Other communities have initiated the observation and analyses of local climate impacts (Krupnik and Jolly 2002; Ashford and Castleden 2001). These examples, in addition to any community-initiated climate change awareness campaigns, research partnerships, and adaptation strategies, are all indicative of the capacity that Aboriginal communities have demonstrated for proactive climate change adaptation.

Due in part to changing academic and ontological landscapes, the demands of Indigenous groups to have their voices heard, and research insights gained from the sharing of their knowledges, TEK in climate studies has progressed considerably, from being completely unacknowledged to featuring prominently in the latest IPCC Assessment Report. Though these advances began sixty years ago, it is worth remembering that some academic fields continue to reject the validity of Indigenous knowledges (Smith 1999; Hart 2010).

The ways in which TEK systems have been characterized in academic research have also evolved ((Berkes 2012)Mulrennan 2013). A perception of TEK as inferior to western science, popularly held as recently as the 1990s, was supported by an elevated level of interest in the differences between them (section 2.4). A gradual recognition of TEK as similar to ecological systems in their organization and complexity, however, eventually made way for the conceptualization of TEK as holistic, adaptive, embedded, and of potential application to many complex environmental problems (Berkes 2012; Mulrennan 2013). This is the conceptualization that most researchers recognize today, and is discussed in the following section.

2.2 Components of Traditional Ecological Knowledge

The most commonly cited definition of Traditional Ecological Knowledge (TEK) is that it is "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, 1252).[7]

Similarly, Brascoupe and Mann (2001) define TEK as “an ancient, communal, holistic and spiritual knowledge that encompasses every aspect of human existence" that is "unique to each tradition and is closely associated with a given territory" (3). Pierotti and Wildcat (2000) stress the multi-disciplinary nature of TEK and its central place in the evolution of a politic and an ethic that is deeply rooted in observation of and respect for the natural world.

TEK is developed through sustained intimacy and engagement with the environment, when people are integrated with their environment on many different levels (such as spiritually and physically; (R. W. Kimmerer 2002; R. Kimmerer 2013). It is holistic, adaptive, accumulated over generations and incrementally in one’s life, formed through

[7] In the literature reviewed in this chapter, the term “Traditional Ecological Knowledge” (TEK) has been used interchangeably with “Indigenous Knowledge” (IK), “Traditional Knowledge” (TK), “Traditional Ecological Knowledge and Wisdom” (TEKW; Turner et al. 2000), “Local Ecological Knowledge” (LEK), and “Native science”. I refer to both TEK and Indigenous Knowledge throughout this thesis.

practical experience, tested through trial-and-error, and transmitted orally or by shared experience (Berkes et al. 2000).

Though the definition of ‘traditional’ allows for cumulative change over time, to some the word conveys a sense of static information and practice, and some critics claim that the term does not leave room for newer methodologies employed by Indigenous groups to be considered within the realm of TEK. Recent research with Solomon Islanders, for example, shows that those who incorporated global ecological knowledge into their local knowledge showed the highest accuracy in detecting changes to the ecosystem following a major catastrophic event (Lauer and Matera 2016).

This coincides with wide recognition that TEK is actually dynamic and evolving, and consists not only of the knowledge itself but its creation, application, transmission, and underlying worldviews. According to Berkes et al. (2000), “The analysis of many Traditional Ecological Knowledge systems shows that there is a component of local observational knowledge of species and other environmental phenomena, a component of practice in the way people carry out their resource use activities, and further, a component of belief regarding how people fit into or relate to ecosystems” (1252). Berkes later added that institutional frameworks for the development, accretion, access to and transmission of this knowledge are also a vital component of TEK. Figure 2.1 depicts the nested nature of the inter-related components, of which knowledge is the only one that exists entirely within the realm of the others.

Figure 2.1The nested components of TEK (Adapted from Berkes 2008).

Turner et al. (2000), in their discussion of the TEK of several Aboriginal groups in British Columbia, identify several common features of TEK, which I have categorized in table 2.1 as examples of these four components.

Table 2.1. Features commonly associated with the Traditional Ecological Knowledge of Aboriginal communities in western British Columbia (right; adapted from Turner et al. 2000) grouped by the four components of TEK (left; adapted from Berkes et al. 2008).

Component of TEK	Common Features of TEK
Knowledge	Understanding of ecological processes; employment of ecological and phenological indicators
Practice/ Management	Adaptive practices for sustainable resource use
Social Institutions	Integrated systems for knowledge acquisition and transfer; leadership; governance; decision-making; planning
World Views/ Beliefs	Philosophies of respect and reciprocal interaction with the environment; close connection with ancestral lands; recognition of the power and sacred aspects of nature

Several of the characteristics of TEK just discussed are what make it suitable for long-term observations of change. Huntington et al. (2004), in their review of TEK of Arctic terrestrial ecosystems, discuss three broad categories of observations of environmental change: detecting trends (by interpreting several observations together to understand environmental tendencies), detecting new phenomena (such as plants, insects, severe weather events, etc.), and examining mechanisms of change (multiple phenomena, species, and locations are studied, with the end goal of identifying similar or divergent causes of observed changes).

Barnhardt's (2005) work with Alaskan Indigenous Peoples found that many view the weather's dynamics through a lens similar to that of mathematical fractals, wherein patterns are reproduced within themselves. This leads to a sophisticated understanding of weather patterns over many timescales (Barnhardt 2005). There is growing awareness that conventional science may be ill equipped to incorporate complexity. Through their immersion with valued resources and the environment on which they depend, Alaskan Indigenous Peoples were also found to have an understanding of the natural world as inherently complex and non-linear. Peloquin and Berkes (2010) came to similar conclusions in their work with the James Bay Cree, as did Ignatowski and Rosales (2013).

These studies indicate that some Indigenous individuals are familiar with notions of energy conservation, irregularities in patterns, and anomalies in form and force in their daily activities (Barnhardt 2005). Tibetan people, for instance, when describing climate changes differentiated between those changes that had been happening for several decades versus those that had only been seen in more recent years. Turner & Clifton (2009) have suggested that the specific nature of their observations in space and time allow the Aboriginal groups in coastal British Columbia to recognize odd years as distinct from long-term trends.

There has been a growing awareness of these contributions within the scientific community in recent years (Moller et al. 2003; Huntington et al. 2004; Krupnik and Ray 2007; IPCC 2014). One of the ways in which TEK may be of vital importance to climate researchers, therefore, is through a provision of "direct knowledge and insights relating to weather, environments, species and habitats" (Turner and Clifton 2009, 185). These and other benefits are explored in the next section.

2.3 Benefits of utilizing Traditional Ecological Knowledge for research

Scientists engaging with questions of climate (Weatherhead, Gearheard, and Barry 2010), environmental monitoring (Moller et al. 2003), and resource management (Krupnik and Ray 2007) are increasingly acknowledging TEK as a source of valuable information for their studies. In many regions, Indigenous communities are detecting early impacts that scientists and policy-makers are not observing (Zimmerman 2005). Riedlinger and Berkes (2001) considered the extent to and the ways in which TEK of climate held among members of northern communities can enhance and extend “conventional” understandings of climate change. Through an examination of case studies, the researchers found that TEK could be very beneficial in understanding climate change at temporal/spatial scales and in contexts that are absent in the current discourse on this important issue. They examine five key areas for scientific study to converge with TEK, in order to further science-based understanding of climate change in the Arctic. Those areas are discussed here with other corresponding literature.

First, local-scale observations and understandings, such as in relation to changes in sea ice, wildlife, permafrost, or weather, can inform scientific studies research with complex detail of local environmental processes and knowledge of long-term trends (Riedlinger & Berkes 2001). Weatherhead et al. (2010), Huntington et al. (2004) and Ignatowski & Rosales (2013) found that a trend is subject to less uncertainty if observed in different ways, while Weatherhead et al. (2010) found that TEK can significantly broaden the scope of information available about climate change. Turner and Clifton (2009) stress the heightened confidence and richness of knowledge that can result when the accrued place-based knowledge of generations is combined with scientific research into the environment of a locality.

Second, TEK can provide a source of climate history and baseline data at a scale not usually explored in climate studies, and can include knowledge of sea ice, wildlife, permafrost, or weather, among others (Riedlinger & Berkes 2001). Seasonal calendars and similar knowledge depicting the “normal” timing, duration and intensity of weather events can offer substantial insight into the baseline climate of a region, informing communities whether current changes are normal or outside the range of historical natural variability. Seasonal calendars are often inextricably linked with phenological indicators depicting the seasonal onset of resource availability, animal behaviors, or life stage of a particular plant (Lantz and Turner 2003). Through exploring how many discrete seasons the year is broken up into, how they are distinguished (such as prevailing wind direction or animal appearance), and season names, one can glean a detailed picture of the annual progression of weather conditions under normal circumstances (Lantz and Turner 2003; Turner and Spalding 2013). Combined with systematic present-day observations of shifting weather patterns and phenological observations, they can form a very valuable dataset (Green et al. 2010).

Third, TEK can act as a starting point for new research questions and hypotheses, such as whether observed changes are beyond the natural range of variation, or whether there is an increase in extreme weather events (Riedlinger and Berkes 2001). TEK, for instance, can provide insights and generate research hypotheses about possible causal mechanisms of change that scientists might not think to explore (Huntington et al. 2004; Gearheard et al. 2010). An example of this is when Helen Clifton remarked upon the possibility that berry bushes were failing because increased spring rains were affecting pollinators (Turner and Clifton 2009).

Fourth, TEK can provide insight into impacts and adaptation in Arctic communities, such as changes to livelihoods and community life, changes to the ability to predict from environmental cues, or limitations to adaptation (Riedlinger and Berkes 2003). This extends beyond Arctic communities, and Turner and Clifton (2009) outline the flexible yet enduring legacy of Indigenous cultural identities, social institutions, and traditional practices that are present in communities who have maintained cultural continuity in the face of environmental change as well as colonizing and modernizing forces. The resilience of these systems under multiple external forces provides a model example for all communities and societies that stand to be affected by climate change.

Lastly, Riedlinger and Berkes (2001) point out the potential for TEK in long-term, community-based monitoring initiatives, such as the compilation of individuals' memories and observations from their experience at annual harvesting camps or the recording of newly arrived species in a territory. Traditional environmental monitoring methods are typically "rapid, low-cost, and easily comprehensible assessments" (Moller et al. 2003, 3) performed as they move through their regular hunting, fishing, and harvesting patterns. These methods evolve over time and may incorporate new technologies and/or practices (for example, Ansell and Koenig 2011; Berkes and Jolly 2002).

In addition, Turner and Clifton (2009) discuss the models of wisdom, leadership and decision-making that allow Aboriginal communities both to adapt to environmental change and to maintain sustainable approaches to environmental management.

Though these benefits make it very worthwhile for researchers to collaborate with Indigenous communities on projects that engage with TEK, some researchers have outlined some of the difficulties in drawing two knowledge types together around issues of environmental change. Others have critiqued some of the underlying assumptions and motivations of researchers working with TEK. I turn now to some of these difficulties, and introduce two major themes that have inspired reflexivity and set new standards for scientific best practice for researchers engaging with Traditional Ecological Knowledge.

2.4 Deconstructing differences and disintegrating knowledges

2.4.1 Challenges for researchers

Researchers attempting to incorporate two different types of knowledge of the same environmental phenomenon are bound to encounter difficulties in research design. Huntington et al. (2004) found in their review of scientific applications of TEK that the local nature of TEK tended to have unforeseen consequences on individual observations and that these were therefore never entirely comparable with a scientific study unless the location of the observations matched up exactly. For each knowledge type, the authors found that there were too few specific details available about the location, time, and precise magnitude of change, rendering comparison difficult or impossible. It was also found that TEK and science approach the same environmental problem from different perspectives, as well as through the use of different indicators. One common challenge was selecting an appropriate baseline for association between the two knowledge types, as the scientific record usually reflects a shorter timescale and a larger region than TEK. In instances where increased confidence is sought by combining scientific and community observations, therefore, it was often difficult to determine where they matched up. In regards to new phenomena, it was sometimes difficult for researchers to know if they were truly newly-occurring or if these were only being detected due to more meticulous observation (Huntington et al. 2004).

There are also important issues associated with scientific perceptions and treatment of TEK. According to Louis (2007) in her review of Indigenous methodologies in geographic research, “Indigenous people need to protect themselves from further misrepresentation, misinterpretation, fragmentation, mystification, commodification, and simplification of Indigenous knowledges” (132).

2.4.2 Different knowledge systems

One very common refrain in the literature is how different scientific knowledge is from TEK. Table 2.2 is a compilation of many examples of such dichotomies that have been discussed in the literature reviewed for this research, and offers many reasons to believe that TEK and scientific knowledge systems are drastically different and that these differences may make it extremely difficult to combine or align the two into a single study.

Table 2.2. Comparisons between scientific knowledge and Traditional Ecological Knowledge systems typically outlined in the literature and mentioned in the studies reviewed in this research. Note that these are generally cited by studies examining ecosystem management of broad environmental change, and may not be directly applicable to climate science (for example, the first category of temporal scale does not make sense in light of the very long time series typically employed in climate modelling).

Principle	Explanation	Examples
Diachronic-Synchronic Complementarity	Science: Short time series over large area TEK: Long time series (timescale of living memory or oral history) in small area	Green et al. 2010; Huntington et al. 2004; Moller et al. 2004
Globally versus Locally Verified	Science: Seeks universally applicable understanding; Replication TEK: Verified through sharing, multiple observations, and prior knowledge of social-	Barnhardt 2005

	ecological system	
Averages versus Extremes	Science: Numerical averages TEK: Separating extremes, variations, and unusual patterns from "normal"	Huntington et al. 2004; Moller et al. 2004
Quantitative versus Qualitative	Science: Precise quantitative data on system components TEK: Qualitative understanding of the whole	Krupnik & Ray 2007; Moller et al. 2004
Testing Mechanisms versus Formulating Hypotheses	Science: Addresses "why" questions TEK: Addresses hypotheses more relevant to immediate problem-solving	Barnhardt 2005; Moller et al. 2004
Objective versus Subjective	Science: Excludes individual people and human emotion from process TEK: Includes people, feelings, relationships, and sacredness; "humanized ecology"	Berkes 2012; Moller et al. 2004
Biophysical Causal Mechanisms versus Integrated Belief Systems and Social Institutions	Science: Searches for replicable theories of cause-and-effect relationships TEK: Allows for explanation based purely on traditional beliefs or consultation with elders	Barnhardt 2005; Huntington et al. 2004; Moller et al. 2004
Compartmentalized versus Holistic	Science: Separates social from ecological; controls for	Barnhardt 2005;

	external factors TEK: Takes all components of social-ecological system into account to inform conclusions	
Detached versus Contextualized	Science: Universally applied and separate from conditions in which it is created TEK: Direct personal interaction with environment	Agrawal 1995 Barnhardt 2005
Intellectual versus Applicable Competency	Science: Practitioners deemed competent based on theoretical knowledge TEK: Practitioners deemed competent based on "doing"	Barnhardt 2005
Analysis and Observations	Science: Formal and explicit TEK: Informal and implicit	Huntington et al. 2004

One body of critical literature surrounding scientific treatment of TEK is concerned with this tendency to dichotomize western knowledge and TEK and to focus on their differences as a means of (sometimes unconsciously) favoring western science. Agrawal (1995) disputes this reasoning and addresses three common themes in which TEK is usually regarded, by scientific standards of validity, to be "inferior" to science.

On substantive grounds, TEK was often cited as being based on subject matter that is directly related to daily activities and livelihoods, while science is related to abstract theories and philosophies and thereby requires more analytical understanding of environmental problems (Agrawal 1995). However, TEK is not related solely to everyday activities but also encompasses "non-technical insight, wisdom, ideas, perceptions, and innovative capabilities" (Thrupp 1989, as cited in Agrawal 1995). It is also true that science cannot be claimed to be entirely detached from the social structure within which it exists, as it has historically been (and continues to be) fuelled by interests and utilitarian purposes (Agrawal, 1995). The very funding mechanisms by which scientific research is supported – and the process whereby research is selected for support – are rife with political, economic and value-driven elements.

Methodologically, TEK was seen as being closed and non-systematic, without regular advancement, while science is viewed as systematic, objective, analytical, and continually building upon previous findings (Agrawal, 1995). Traditional ecological knowledge, despite the implications inherent in such a term (Morrow and Hensel 1992), is in factcontinually evolving and is highly dynamic. It also makes use of highly systematic observations in the course of regular monitoring (Agrawal, 1995).

Finally, regarding the issue of context, TEK is viewed as entrenched in daily life and organically occurring while science is believed to be based on abstract formulation and dissociated from the lives of individual people, and is therefore seen as existing without context (Agrawal, 1995). In reality, there are socio-political-cultural contexts to all scientific/technical solutions and there are many underlying influences inherent in the questions asked and the methods used (Agrawal, 1995).

Nadasdy (1999) furthers the critique by pointing out that attributing the lack of successful integration of traditional and scientific knowledge to fundamental differences in the two types of knowledge masks underlying power relations.

Other authors have taken note of the *similarities* between TEK and scientific knowledge. Kimmerer (2002; 2013) writes that they are both based on systematic observations of nature; they both describe typical or changing ecosystem components and the typical or changing relationships between them; and they are both capable of producing predictions of environmental patterns. Replicability of results, an attribute typically assigned to scientific knowledge, is equally important in TEK. While scientific researchers seek to produce generalizable results, TEK practitioners must also produce reliable knowledge as it is meant for use in safety measures, decision-making, and other applications (Huntington et al. 2004). In fact, peoples' lives depend on this knowledge. In addition, it is important to keep in mind that a "cross-fertilization" of knowledge is very common and we cannot expect TEK to evolve in isolation from pervasive scientific discourse (Tengö et al. 2014).

Despite these similarities, however, "differences in interpretations remain profound. There is no 'silver bullet' in bridging these two very different types of knowledge" (Krupnik and Ray 2007, 2952).

2.4.3 The problem with integration

The previous observation is not grounded in a renewed attempt to dichotomize the knowledges and to compare them on scientific grounds. It is a reminder that commonalities between the two are not a reason to treat TEK like scientific data. An example of this is when researchers attempt to subject TEK to the same tests of validity they do scientific knowledge. Any attempt at "incorporation" of TEK into scientific frameworks in order to "elevate" TEK to scientific status implicitly favors scientific knowledge and disempowers TEK (Agrawal, 1995). It is important that TEK is afforded its own validity within the scientific community if researchers wish to gain anything from it; it cannot be distorted into something that it's not (Barnhardt 2005).

This leads to another important ethical issue confronted by researchers who seek to combine Indigenous and scientific knowledge. The artificial archiving or "ex-situ preservation" of TEK seeks to isolate, document, and store TEK in archives, where it can be easily disseminated to other contexts and spaces. This approach is inappropriate in that it isolates knowledge that is integrally linked with cultural lifestyles and values, "freezes" knowledge that is dynamic and continually evolving, and privileges those with habitual access to scientific spaces over the knowledge-holders themselves (Agrawal 1995).

These and other inherent biases have led some to demonstrate the trouble with the idea of "knowledge integration" itself. The combination by scientists of two knowledges for a more robust understanding of an environmental problem may be based in good intentions but is wrought with power imbalances, hidden assumptions, and behind-the-scenes processes that only further disrespect Indigenous knowledges and disempower their holders (Nadasdy 2005). Integration of TEK necessitates its compartmentalization into discrete categories corresponding to scientific data of interest, and its distillation into information that can be easily matched with the data, with a corresponding cleavage from its rich and complex context. The result, according to Nadasdy (2004), is that the “artifacts” resulting from these processes are stripped of the qualities inherent in the original knowledge. "That is, rather than being holistic, qualitative and intuitive, TEK artifacts tend to be categorized, written, quantitative and analytical [...] these artifacts are largely useless to people's everyday lives – even in the communities where they were produced." (10)

The Prince Albert Grand Council Elder’s Forum on Climate Change report “Isi Askiwan- the State of the Land” (Ermine et al. 2010) similarly outlined the view that academic discussion of TEK is often shallow, as it does not encompass "the location from which the Elders' voice comes" (8). To be representative of community realities, their worldview must be articulated, considered and understood by academic scholars engaging with TEK. They frame their views as follows:

> The two knowledge systems are different and often do not understand each other. As a result, they have not worked together to address issues such as global climate change. The lack of understanding between western science and First Nations knowledge continues to persist. However, as David Peat suggests, “science is about understanding; it is one of the ways we attempt to answer the perennial questions about the nature of existence.” This definition of science has some resonance with First Nations perspectives and worldviews. It suggests a common ground on which to build a relationship.[8] (Ermine et al. 2010, 36)

Maybe the common ground can be nurtured, while the integration imperative and other dominantly western research frameworks can be replaced by an approach that celebrates each of the knowledges for their respective strengths and seizes on opportunities to explore differences between them (Klenk and Meehan 2015). Rather than “validate” either set of knowledge through the integration of one into the framework of another, it is therefore recommended that they are brought together equally in the interest of gaining

[8] David Peat is a an author and physicist who, through dialogue with Elders and Indigenous scholars, explored the worldviews and sciences of North American Indigenous Peoples and challenged positivistic assumptions of western scientific frameworks. (http://www.fdavidpeat.com/ideas/native.htm)

confidence in conclusions, identifying new ideas for further investigation, comparing information at different spatial scales, or examining potential explanatory mechanisms that address both sets of observations (Huntington et al. 2004). The starting point of western science should be to respectfully accept the validity of traditional knowledge rather than subjecting it to external scrutiny (Whyte 2015).

2.5 The real value of Traditional Ecological Knowledge

Scientific awareness and treatment of TEK has progressed considerably and thanks to critical study and advocacy on the part of both Indigenous and western scholars, academic researchers are becoming more conscious of the ways in which they recognize and utilize Indigenous Knowledges.

Whyte (2015) further entreats researchers to consider "the value of Indigenous knowledges for us, the members of Indigenous Peoples, for our own planning, especially in relation to today's climate destabilization ordeal that is entangled with the problems we have with settler states" (Whyte 2015, 7). Houde (2007) includes "links to life on land, language, identity, and cultural survival" (10) as one of the six facets of TEK. The Samoan community in Polynesia regard knowledge as power that is "to be guarded for a 'purpose', rather than for better and improved understanding of knowledge systems, as seen from a western perspective" (Lefale 2010, 319).

Whyte (2015) shares his own view of Indigenous knowledges as irreplaceable collective capacities that support community self-determination through their use in crucial planning efforts and "adaptation to meta-scale forces including settler-colonialism and environmental change", emphasizing that "Indigenous knowledges are capacities Indigenous Peoples can use to facilitate their own governance" (15). This definition of Indigenous knowledge carries within it the conditions of its use by outsiders.

Whyte cautions against the incomplete understanding of Indigenous knowledge that sometimes accompanies its use by western scientists exclusively as a "value-added" or "supplemental" source of information in scientific research, or else as a source for hypotheses and research questions that wouldn't otherwise be explored. Indigenous knowledges, more than lending additional information for improved science, which may or may not benefit them in a "trickle-down" sense, have governance value for Indigenous Peoples. By unconsciously favoring the governance structures of their own research institution and ignoring those of their Indigenous partners, researchers inadvertently show a lack of respect for the intentions that Indigenous Peoples have for their future and for the role that they would like the sharing of their knowledges to fulfill (Whyte 2015).

> To be more respectful, the scientists would have to ensure that Indigenous Peoples have the time and space to be able to strengthen their internal knowledge systems, protect key aspects of their knowledge from going public, and influence the design of scientific research to suit the guidance they receive under their Indigenous knowledges. (Whyte 2015, 23)

Collaborating with Indigenous Peoples on the usage of their knowledges can therefore not only lead to better understanding of environmental problems, but can empower communities in the decision-making processes involving their territories (such as through increased resources, training opportunities, and opportunities to reinforce their knowledge systems), if steps are taken to prioritize a mutually beneficial research process. In Chapter 3, I outline research methodologies that are rooted in a pursuit of common ground and mutual respect between researcher and community, exploring their common themes and relating them to the graduate research experience and to climate change research with Canadian Aboriginal communities.

CHAPTER 3

WHO IS IT FOR? EVALUATING FRAMEWORKS FOR MEANINGFUL RESEARCH WITH INDIGENOUS COMMUNITIES: MY GRADUATE RESEARCH WITH THE GITGA'AT NATION

Abstract

Climate change researchers, following researchers in other scientific fields, have begun to engage with Indigenous communities in documenting their knowledge of a quickly changing local environment. This is a reflection of researchers' growing awareness of how valuable the knowledge and wisdom of Indigenous Peoples can be in contributing to our understanding of this global concern. Past and current struggles of Indigenous communities to be fully recognized for their contributions to scholarly research, and to have their territories and knowledges respected by non-Indigenous researchers, have contributed to a shift in scholarly approaches to work with Indigenous communities. Frameworks for meaningful, respectful, and culturally appropriate research are becoming prominent, but when applied in an academic institutional context, can lead to unique challenges for the researcher. In this paper I explore the common themes of these frameworks and draw on my graduate research with the Gitga'at Nation as a case study for a discussion on the tensions between a community-defined research agenda and academic expectations. I conclude that the benefits to community and researcher that result from meaningful research frameworks easily outweigh the difficulties, and that academic researchers should not be discouraged from engaging in research partnerships with Indigenous communities by the pressure to either do it perfectly or not at all.

3.1 Introduction

Though Indigenous Peoples' experiences with academic researchers have been mixed and at times very negative, there is a current shift toward productive research partnerships with Indigenous communities that provide meaningful and long-term benefits to them.

The first research partnerships in Canada took place in a context of ethnographic expeditions, wherein anthropologists sought to document the traditions and cultures of Indigenous groups before they were lost to colonizing and modernizing forces (Newell 2015). Though the very practice of documenting Indigenous cultures as an outsider is rooted in colonialism and in deeply problematic power relations (Smith 1999), the outcomes of these expeditions were not uniformly negative (Newell 2015; Section 3.1.2).

However, many Indigenous communities and their knowledges have been mistreated, misrepresented, and misappropriated as a result of interactions with academic researchers (e.g. Agrawal 1995; Nadasdy 1999; Smith 1999; Menzies 2004; Louis 2007; Section 3.1.1). The original Tri-Council Policy Statement for Ethical Conduct for Research Involving Humans in Canada framed these transgressions as follows:

> Research involving Aboriginal communities may raise difficult ethical issues, sometimes novel and sometimes old. [...] Indeed, there are historical reasons why Indigenous or Aboriginal Peoples may legitimately feel apprehensive about the activities of researchers. In many cases, research has been conducted in respectful ways and has contributed to the well-being of Aboriginal communities. In others, Aboriginal Peoples have not been treated with a high degree of respect by researchers. Inaccurate or insensitive research has caused stigmatization. On occasion, the cultural property and human remains of Indigenous Peoples have been expropriated by researchers for permanent exhibition or storage in institutes, or offered for sale. Researchers have sometimes treated groups merely as sources of data, and have occasionally endangered dissident Indigenous Peoples by unwittingly acting as information-gatherers for repressive regimes. Such conduct has harmed the participant communities and spoiled future research opportunities. (TCPS 1998, 6.2)

In the late 1980s, there was a call for meaningful inclusion of Indigenous people within the academy and for more equitable, appropriate and beneficial research methodologies as Indigenous groups advocated for their own research rights . The Tri-Council Policy Statement (1998) listed in point form some “Good Practices” to follow in conducting research with Aboriginal groups, which included the importance of treating the research relationship as a collaborative partnership at all stages of the project and of consulting frequently for community feedback and approval. Several research and management frameworks have since emerged to foster more productive and beneficial research relationships (e.g. Smith 1999; Wilson 2001; Menzies 2004; Louis 2007; Fletcher 2003; Castleden et al. 2008).Today, all university researchers wishing to engage in academic research with an Indigenous community in Canada must abide by Chapter 9 ('Research involving the First Nations, Inuit and Métis Peoples of Canada') of the updated Tri-Council Policy Statement (TCPS 2014). The responsibilities for researchers outlined in Chapter 9 include a requirement to consult with their partner community and collaborate on a research agreement, which is enforced through the ethics review process of each research institution.

The field of climate change research has collectively begun to recognize the existing and potential contributions of Indigenous knowledges to research on regional mitigation strategies and climate policy (e.g. Turner & Clifton 2009; Turner and Singh 2011; Herman 2016) impacts at the local scale (e.g. Riedlinger & Berkes 2001; Nichols et al. 2004; Gearheard et al. 2010; Weatherhead et al. 2010), and frameworks for assessing vulnerability and developing effective adaptation strategies (e.g. Ford & Smit 2004; Green et al. 2010).[9] The IPCC Fifth Assessment Report (IPCC 2013) included Indigenous Peoples extensively in their discussion of climate change impacts, observations and adaptation opportunities. This is a reflection of the field's growing awareness of the importance of Indigenous Knowledge for climate change research, and of the increasing number of climate change studies being led by or including Indigenous communities. This awareness comes about largely because Indigenous Peoples have fought to have their contributions recognized in climate change dialogue (Doolittle 2010).

It is therefore becoming widely recognized how valuable the knowledge and wisdom of Indigenous Peoples can be in contributing to our understanding of this global struggle, and how important it is to facilitate it (Turner et al. 2009). For research to take place, however, it needs to be done in a way that serves one's Indigenous research partners as well as advances knowledge in the field. Non-Indigenous climate change researchers, potentially eager to engage Indigenous Peoples in research partnerships, often do not

[9] The ability to "mitigate" the severity of climate change is not related to Indigenous groups' direct influence over greenhouse gas levels but rather to the lifeways, worldviews, and wisdom that could benefit planners, policy-makers and individuals in their pursuit of sustainable solutions to environmental crises (Turner and Clifton 2009; Herman 2015).

have training in social sciences, qualitative research design, or methodologies for culturally appropriate research with Indigenous Peoples (Hall and Sanders 2015). Graduate students in particular may be uncertain of what to expect (or what is expected of them) in relation to engaging in research with Indigenous communities, the benefits of doing so, and the opportunities and challenges involved.

My co-supervisor Dr. Monica Mulrennan encouraged me to write this Chapter because it might prove useful to other students and researchers (particularly those studying climate change) hoping to engage in work with Indigenous communities but unsure about how to do so or even *if* they should do so.[10] What follows is a short review of some of the problematic legacies and current-day issues associated with conducting research alongside Indigenous communities. I then outline the common themes of several frameworks currently being employed for meaningful research in collaboration with Indigenous communities, and draw on the literature as well as my own experience in graduate school to discuss some of the ways in which these frameworks are facilitated or impeded by formal academic processes.

3.1.1 Research is the dirtiest word

Academic research involving Indigenous communities has historically often taken place in a context of profound inequality and negligence on the part of researchers to properly consult, involve, and report back to their Indigenous partners when conducting research in their territory. When Linda Tuhiwai Smith wrote the words "Research is probably one of the dirtiest words in the Indigenous world's vocabulary" (1999, 1), she articulated the severe consequences of the deeply problematic and colonial relationships that have been repeatedly imposed upon Indigenous Peoples worldwide by western academic scholars.

In some cases, the western academic community's transgressions include the characterization of Indigenous groups as "other" and the positivist falsehood that researchers' accounts of them are true to life and universally acceptable (Smith 1999). In propagating accounts of Indigenous Peoples within a western framework of reality

[10] For this reason, I rely extensively on quotations from authors whose work is prominent in the field. This chapter might serve as an introduction to this literature for some, and I therefore aim to preserve the authors' voices rather than paraphrasing in many instances

without respectfully consulting them or making room for their worldviews, researchers denied them their rights to self-determination.

Within this context, some Indigenous communities have expressed dissatisfaction with and distrust of the western academic research process. O'Neill et al. (2012), for example, document the Warraber Torres Strait Islanders' reasons for rejecting future climate change research in their community in spite of their island territory's high exposure to current and future climate change impacts. Through a series of interviews, researchers identified recurrent themes in peoples' perceptions of research conducted by outsiders: inaction (failure to derive lasting benefits from the research, such as government investment in identified solutions); cultural erosion (past researchers did not take cultural erosion seriously as an impact of climate change even though it was identified by the majority of participants as of high concern); failure to consider local knowledge (community knowledge was not given equal weight in analyses or as basis of policy recommendations); and mistrust (the researchers were perceived to have hidden agendas not communicated in their research aims).

Torres Strait Islanders, like so many Indigenous communities, have had their affairs controlled and dominated by outsiders since contact (O'Neill et al. 2012). According to Mulrennan (1992) and Arthur (2007), and many research institutions, information flow back to the community has been disparagingly low and research aims have been repeatedly miscommunicated. Given these critical oversights and the themes outlined above, it's no wonder that one participant said in their interview with O'Neill et al. (2012) that researchers are like seagulls, because they "fly through the Strait making a lot of noise about local concerns, and fly off without doing anything to help" (1112). Studies like O'Neill et al.'s (2012) give practical insight into the mistakes that researchers can all too easily make in their work with Indigenous communities, especially if a perceived lack of social science training prevents them from approaching the community for their input (Castleden et al. 2012).

In addition to the danger that western researchers will fail to conduct meaningful, beneficial research guided by community concerns, many communities perceive research as a risk to their intellectual property. Menzies (2004), in his research negotiations with the Gitxaala, was posed the following question by Gitxaala (a Ts'msyen community) Treaty Coordinator John Lewis: "So Charlie, what happens with your notes after you die?" (16). Menzies, a member of the Gitxaala, reflected on the colonial legacy of knowledge misappropriation that has resulted in the ethnographic records of the Ts'msyen people being the copyrighted property of various institutions, rather than the property of the communities whose knowledges they contain. Scholars who have used Ts'msyen hereditary chief William Beynon's notes without community approval, for example, are seen as having stolen the knowledge of the contributing Ts'msyen individuals, houses, or communities (Menzies 2004). Mutually agreed-upon research protocols, discussed in Section 3.2 below, are crucial instruments in ensuring that both community and researcher expectations are articulated, communicated, adjusted, and accepted.

Elders and other respected community members, when they met with Menzies' project team during negotiations, were very concerned not only about intellectual property rights, but also about their natural resources property rights (Menzies 2004). They articulated many experiences of researchers' misuse of community knowledge. A government-sponsored research project into the health and location of Northern Abalone populations, for example, was framed as benefiting the local community. Commercial dive boats began visiting the harvesting grounds shortly after this information was shared with researchers, resulting in the degradation of harvesting grounds and the decimation of abalone populations. Coastal communities (including the Gitga'ata) have been banned from harvesting abalone for at least twenty-five years because it is now listed as an endangered species. In the words of Menzies (2004):

> Many researchers may recognize the genre of oral stories to which the abalone story belongs. The details of particular stories may vary. The specific facts may become merged or elaborated from telling to telling. Yet, the essence of these stories is unassailably true: outsiders have come, they have preyed upon the good hearts of their Aboriginal hosts, and then they have left often leaving nothing behind but new headaches and difficulties. This is the living legacy of colonialism as experienced by many Indigenous communities. (22)

Menzies makes use of this cautionary tale to remind researchers of the links in many community members' minds between contemporary researchers and the betrayals and injustices carried out by scholars in their past experience. Researchers may not immediately see how they are associated with those wrongdoings, but Menzies reminds us that regardless, it is the responsibility of us all to make sure that they don't happen again.

3.1.2 The Mixed Roots of Contemporary Research Practices

Although the histories and perspectives described above are of crucial importance in understanding the context of academic research with Indigenous communities, the research experience for communities involved in academic research has been largely uneven. Not all research with Indigenous communities has been solely detrimental, nor all research relationships unconstructive (Mulrennan et al. 2012).

Culturally appropriate research strategies that result in community benefits are not really a new concept. The same ethnographic expeditions that appropriated Indigenous knowledge and documented cultural practices for academic interests in the Pacific Northwest in the 1800s, for example, also generated insider-outsider researcher partnerships of an extremely close, enduring, and reciprocal nature (Newell 2015). Newell outlines the insider-outsider partnerships that took place between anthropologists and their Indigenous field assistants. Through examples of these research pairings, such as that of Franz Boas (a German-born American anthropologist) and George Hunt (born in the Kwakiutl village of Tsaxis in Fort Rupert, from a Tongass Tlingit noble woman from Alaska and a White trader) from 1886 to 1993, she demonstrates the way that each of the partners mutually informed each other's research practices in their documentation of the Northwest Coast (Kwakwaka'wakw) Peoples. Newell stresses that these evolving and respectful relationships sometimes resulted in the Indigenous field researcher gaining just as much recognition (or more) for their work as outsider expert ethnologists did.

Similarly, present-day anthropologists are concluding that the "true authors" of these accounts are the Elders interviewed and the previous generations whose collective wisdom was captured in ethnographic texts (Newell 2015).[11] In conveying the importance that these texts have for contemporary First Nations communities, Newell cites the example of the Nuxalk Nation, who presently recognize both Thomas McIlwraith and their own ancestors in gifting them "a tool with which to rebuild and renew that which was almost lost or forgotten" (Newell 2015, 9).

The ethnographic accounts collected through these partnerships have been of crucial importance to Indigenous legal territory claims, land claims negotiations, and continuation of cultural practices (e.g. Ermine et al. 2010; Newell 2015). The Torres Strait Islanders in Australia have benefited from several volumes written by marine zoologist and ethnologist Haddon in 1890, which provided meticulous documentation of their territory, cultural practices, and worldviews. The text also provided accounts of the overexploitation of marine resources by non-Indigenous fishermen and persisting negative impacts on Islander life, the investigation of which was then taken up in more targeted research (Mullins 1995). Recently, Haddon's records were used extensively in the Torres Strait Regional Sea Claim, much of which was approved in the federal court in 2010 ("Akiba on behalf of the Torres Strait Islanders of the Regional Seas Claim Group v State of Queensland" 2010) and the contested portions of which were approved in 2013 ("Akiba on Behalf of the Torres Strait Regional Seas Claim Group v Commonwealth of Australia [2013]" 2016).

The James Bay Cree, too, have had mixed experiences with external researchers. Though not without their share of "disappointments", positive research relationships with Cree communities date back to the early 20th century, when anthropologist Frank Speck advocated for the protection of Cree tenure systems threatened by Euro-Canadian trappers (Mulrennan et al. 2012). Beginning in the 1970's, the hydroelectric development projects proposed by the provincial government were also catalysts for support from external researchers, who aided the Cree in their political struggles and legal negotiations to gain protection of their ancestral lands and waters (Mulrennan et al. 2012).

Researchers could draw on these examples to identify some of the essential factors in

[11] It is important to remember, however, that most ethnographic texts remain the legal property of museums or academic institutions to this day (Menzies 2004).

determining whether communities considered research to be positive. Of key importance in these partnerships were close and reciprocal relationships; research products that the communities identify with as having been generated by their own people; and tangible benefits to community members.

Furthermore, many Indigenous groups have drawn on their past experiences to identify what they do (and do not) want from academic research. Given the context of "research fatigue" wherein many communities have taken part in so many (often coinciding) projects that they feel exhausted (Castleden et al. 2008), Indigenous communities can and should be selective about research taking place on their territories. Many of the Ts'msyen Nations, for example, have developed a sophisticated set of Protocols outlining the conditions for research to gain approval (McDonald 2004; Menzies 2004). The Torres Strait Islanders have collaborated on a similar document (Nakata and Nakata 2011). Though the James Bay Cree haven't drafted an official Research Protocol, they assign priority to research that will deliver community benefits and they have identified specific expectations for collaboration and consultation throughout the research process (Mulrennan et al. 2012).

Communities are making decisions regarding research related to their knowledges or territories, and these are largely guided by community values and visions for their future (Mulrennan et al. 2012). Though the negative research relationships explored in the previous section might discourage individuals from engaging in research with Indigenous communities, other examples demonstrate that it is possible (and desirable) to forge new relationships– if they are respectful and result in positive outcomes for the community.

3.1.3 Can we? Should we?

To this end, many Indigenous scholars do not discourage non-Indigenous people from engaging in research with Indigenous communities, but stress only that if the work is to take place it must be a conscious part of the decolonizing movement (e.g. Louis 2007; Menzies 2001; Whyte 2015; Wilson 2001). On speaking to non-Indigenous researchers, in fact, Louis (2007) says, "We need help... we need allies" (137).

This aligns with Menzies' (2001) message that to withdraw from work with Indigenous

Peoples is a non-response to these critical issues. Some researchers have learnt of these critiques and have disengaged from all research with Indigenous communities, whether to save themselves the trouble of striving for culturally appropriate research strategies, or out of discomfort.[12] Menzies claims that such a response, however, is "ultimately a refusal to confront the colonial arrogance of the [anthropology] discipline's history in any meaningful way" (26).

Menzies (2001) also stresses the very real academic and socio-political benefits that can result when the research is done the right way, including more robust, detailed, and accurate research results. Meanwhile, communities benefit (and have benefitted) from research that is planned, conducted, and published with guidance from community values, worldviews, and ideas (Menzies 2004). As discussed below in Section 3.2, meaningful research outcomes are a tangible and very positive part of conducting culturally appropriate research.

According to Menzies (2001), researchers from all academic fields working with Indigenous Peoples have a choice to make. One could continue "research as usual" practices that have them engaging with their "subject" communities at arms' length without meaningful consultation, collaboration, or communication, simply going through the motions and even possibly signing a research agreement with the community that they have no real interest in adhering to (Menzies 2001). These people continue to embrace the mainstream paradigm while rejecting the notion that they have any responsibility to anything beyond so-called objectivity. Menzies says of these researchers, "one can only assume that these individuals self-consciously reject the need to accord real respect to Indigenous Peoples and that they continue to benefit from the subjugation of Indigenous Peoples" (21).

Alternatively, one could engage in "self-consciously committed, cooperative, and/or community-based research" (Menzies 2001, 26) and not only accept the responsibility to cease their academic field's contribution to colonialism, but welcome it as an opportunity to do something positive where there has been real harm done in the past.

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[12] I wonder if respect for Indigenous communities' right to conduct their own research (Smith 1999) would be a viable reason for such a response.

In the next section, I outline the main features of some of the research paradigms being explored by western scholars seeking to engage in reciprocal and lasting research relationships with Indigenous communities. In the following section I explore the various struggles that researchers might face in formal academic institutions (in my case, as a graduate student) that can act as impediments to following any one of these research paradigms, but I also discuss opportunities.

3.2 Frameworks for meaningful research

Before exploring the processes that most culturally appropriate research strategies have in common, I would like to review some important underlying principles. The overarching idea, consistent throughout all of these different research strategies, essays, and critiques, is that any use of TEK needs to empower its holders in some way, and that any work taking place *with* a community ultimately has to be (at least in some key aspects) *for* the community. “The most important elements are that research in Indigenous communities be conducted respectfully, from an Indigenous point of view and that the research has meaning that contributes to the community. If research does not benefit the community by extending the quality of life for those in the community, it should not be done” (Louis 2007, 131)

To this end, most Indigenous scholars stress the importance of respect, responsibility, and of keeping an open mind. Indigenous communities need to have their worldviews and knowledge systems respected if any sharing is to take place with outsiders. Two-Eyed Seeing, "an Indigenist pedagogy, research practice, and way of living that incorporates western and Indigenous knowledges" (Iwama et al. 2009, 3), is a framework that requires the individual to seek out and open one's mind to alternative ways of knowing. Each of these ways of knowing will interact with each other but neither can be allowed to take prevalence over the other. Understanding the principles of Two-Eyed Seeing can support the practices outlined in the rest of this section. The goal is not unity but diversity, and is more than just an intellectual research exercise, but rather a way of relating to each other and to the world:

"Two-Eyed seeing grew from the teachings of the late spiritual leader, healer, and chief Charles Labrador of Acadia First Nation, Nova Scotia, especially these words: ‘Go into a forest, you see the birch, maple, pine. Look underground and all those trees are holding hands. We as people must do the same.’” (Iwama et al. 2009, 3)

A major theme in Indigenous discussion of research is the idea of relational accountability (Wilson 2001; Menzies 2004; Louis 2007; Whyte 2015). This term “...describes the concept that Indigenous Peoples share about their dependence on everything and everyone around them” (Louis 2007, 133), and implies a very real responsibility that rests upon the shoulders of any researcher working with Indigenous communities. The concept of relational accountability has its basis in the paradigm that “knowledge is [a relationship] shared with all of creation” (Wilson 2001, 176-177) and emphasizes the need for a researcher to “fulfill” the relationships that he or she has taken on. This includes relationships with the research topic, with the environment that the research relates to, and, of course, relationships with Indigenous research partners. These responsibilities and relationships need to be continually fulfilled. Wilson encourages all researchers to ask themselves the following questions:

> What is my role as researcher, and what are my obligations? Does this method allow me to fulfill my obligations in my role? Further, does this method help to build a relationship between myself as a researcher and my research topic? Does it build respectful relationships with the other participants in the research? (2001, 178)

This is in line with Whyte’s (2015) recommendation that western scientists shift their understanding of themselves away from objective observers and towards participatory experiencers.

The frameworks that I outline next are Indigenous Research Methods (Wilson 2001; Louis 2007), Collaborative Research Methods (Menzies 2001; Menzies 2004), Community Based Participatory Research (CBPR; Castleden et al. 2008; Mulrennan et al. 2012; Castleden et al. 2012) and the Multiple Evidence Base (MEB) approach (Tengö et al. 2014). I refer to them collectively as ‘culturally appropriate research strategies’ (Louis 2007) or alternatively as ‘frameworks for meaningful research’. Though far from an exhaustive sample of culturally appropriate research strategies, they are all to some extent designed to ensure that "research on Indigenous issues is accomplished in a more sympathetic, respectful, and ethically correct fashion from an Indigenous perspective" (Louis 2007, 133).

Though I explore different approaches, I emphasize what they most have in common. Most culturally appropriate research strategies have provisions for the starting point, process, and outcome of research with Indigenous communities. Appendix 3.A gives a brief summary of significant points in each of the frameworks reviewed. It is important to remember that, as these methodologies are "fluid and dynamic" and emphasize "circular and cyclical" approaches (Louis 2007, 133); the themes identified need to be present and occurring at all stages of the research process. Though I categorize these principles as most relevant at a certain stage in the research in order to more easily organize this review, I recognize the on-going, non-linear nature of these methods and of Indigenous epistemologies in general.[13]

3.2.1 Starting point

The starting point of culturally appropriate research must always include a research agreement (Menzies 2004; Louis 2007; Mulrennan et al. 2012; Castleden et al. 2012; Tengö et al. 2014). This set of research protocols "clearly identifies the rights, responsibilities, and obligations of research partner and researcher" (Menzies 2001, 21). Whether the researcher approaches the community or vice-versa, the consideration of Indigenous end-goals for research cannot be emphasized enough. This is evidenced by Whyte's (2015), Smith's (1991) and Wilson's (2001) argument that there is a moral imperative to consider the value of the research to community planning and governance. One way for western researchers to fulfill this obligation is by signing a research protocol written by or with the community that lays the groundwork for "respectful research relations" (Menzies 2001, 21). At this stage and all that follow, the researcher must be

[13] Castleden et al. (2012) discuss critiques of the conventional research process itself (research design to data collection to data analysis to knowledge transfer), in that this model propagates "socio-historical circumstances" that undermine Indigenous autonomy. They write that they use this model to advocate Community Based Participatory Research in the hopes that it will empower, rather than undermine, Indigenous struggles for control in academic research.

aware of the colonial context in which their research takes place and must follow an approach that accommodates community concerns, and in so doing avoid replicating the conditions that have led to distrust and polarization between communities and researchers (Menzies 2014).

Indigenous Research Protocols are a way of ensuring that misuse of an Indigenous individual's or community's knowledge does not occur as a result of collaborative research with outsiders. By outlining the terms of the research and of knowledge ownership, they set the framework within which all research activities are to occur. Charles Menzies writes that three levels of approval need to be sought by researchers hoping to engage in research with an Indigenous community: the Band Council/ legislative/ administrative approval, approval from hereditary chiefs and matriarchs, and approval from individual community members (Menzies 2004). Throughout the approval process, you must constantly evaluate and re-evaluate your project based on feedback:

> The task undertaken by the community Elders was one that went beyond agreeing to or approving our project; it involved instructing us on how best to conduct ourselves throughout the research process. Without the instruction and ultimately support of those at the meeting the success of the interview and research aspect of the project would have been in jeopardy. (23)

Not all research agreements need to take the form of contractual Research Protocols. The James Bay Cree draw on their own guidelines for use in collaborative projects of all kinds, which they developed in response to instances in the past where external actors would arrive in the community and carry out their own agendas (Mulrennan et al. 2012). Since adopting these guidelines,

> Sound relationships have been generated through the collaborative visioning of projects [...], together with a culture of transparency, a sense of local ownership and purpose, and the expectation of moving forward at a pace that feels right to local participants (in contrast to an all-too-familiar instance in which external agents, driven by such factors as fiscal year-end and their own job descriptions, felt compelled to push their own timetables). (252)

The exact contents of a research agreement will vary by community, but issues commonly addressed include research goals; intellectual property and knowledge ownership; community endorsement of final products before widespread dissemination or publication; procedures for transferring research materials during the research and after the research has concluded; provisions for decision-making; and the research approach to be taken, among many others. Needless to say, the research agreement takes place at the starting point for a reason. It must continually form the basis for all research activities and relationships that follow, and must be respected fully by both parties in order to be beneficial—even if this requires some sacrifices or discomfort on the researchers' part (Menzies 2001).

One element of this agreement and the research that follows, for example, is the duty to respond to community needs before strictly academic ones (Menzies 2004; Louis 2007; Mulrennan et al. 2012). This central issue faced by academic researchers engaging in projects with Indigenous communities, discussed more in Section 3.2, often takes the form of timeline clashes for academic deadlines or funding applications (Menzies 2004). It is important that researchers abide by the practices outlined in the research agreement, and recognize that the community research agenda must take precedence. It is "an important first step in decolonization to accord the 'subject' of research a place at the table of decision-making" (24).

3.2.2 Process

One important part of conducting meaningful research is ensuring that your research team makes full use of Indigenous participation, through the formation of a collaborative group that includes both scientists and community members as primary researchers and community members as research assistants wherever possible (Menzies 2004; Louis 2007; Mulrennan 2012; Castleden et al. 2012; and Tengö et al. 2014). This helps to secure knowledge within the community (Menzies 2004; Louis 2007; Castleden et al. 2012), facilitates knowledge transfer (Menzies 2004), and decreases community reliance on external resources (Menzies 2004).

Related to this is Louis' (2007) challenge to "position" the Indigenous community members and researchers differently than in the current dominant discourse of "researcher", "subjects", and "informants", which marginalize participating community members rather than empowering them. "Collaborators" or "partners in theorizing" are terms that not only paint a more accurate picture of the people who are choosing to share their knowledge and wisdom for the sake of the research, but that point to the type of relationships and power balance that researchers should be striving for.

A large part of how a researcher positions themselves in relation to their Indigenous partners is also relevant to how they treat the knowledges they document. Rather than operating on the assumption that one is "better", researchers need to begin by accepting the validity of the Indigenous knowledge (Whyte 2015) and to consider them equally. This is not to say that they should be treated identically, as pointed out by Nadasdy (1999) in his discussion of the compartmentalization and distillation of Indigenous knowledge into western frameworks. Rather, they should be brought together in parallel, without distorting them.

This is the foundation of the Multiple Evidence Base (MEB) approach (Tengö et al. 2014), which could be a potential framework in which researchers approach a rudimentary practice of Two-Eyed Seeing (Iwama et al. 2009). Rather than incorporate TEK into scientific knowledge by "validating" it through scientific means, MEB brings together multiple knowledge systems and affords them equal and transparent consideration from the outset (Tengö et al. 2014). This requires respect for differences in underlying worldviews and the different approaches taken in understanding social-ecological systems. MEB therefore strives for complementarity of knowledges and these knowledges are seen to be researched "in parallel" rather than to have one dominating the other.

Benefits of this approach are that stronger confidence is placed in conclusions where knowledges converge, while disagreements generate new insights or hypotheses to be explored. Conflicting evidence, rather than being concealed or downplayed, should be transparently and honestly addressed as a natural consequence of engaging with two separate knowledge systems.

The MEB approach is more than a good step to ensure that the researchers represent the knowledge properly and include it in their analyses appropriately, but also contains provisions for all three steps of the research process. The three stages of such an approach are to first reach an agreement with one's partner community on the problems and goals to be pursued by the research; then, to bring the knowledge together equally and with consideration to the strengths and weaknesses of both; and finally, to develop and implement joint analyses and evaluation of knowledge and insights, identifying knowledge gaps, new hypotheses, and further areas for collaboration. If a researcher were to truly carry out all three stages, then they would indeed find every aspect of their research shaped by Indigenous worldviews. In fact, "the MEB is an approach for dialogues leading to changing mental models and widened perceptions of how knowledge systems can cross-fertilize among all knowledge holders" (Tengö et al. 2014, 10). This is taken further by Indigenous scholars like Smith (1999), Louis (2007) and Whyte (2015) who stress the importance of actively moving through a process of opening one's mind and striving to allow Indigenous values to shape the research at every opportunity.

Louis (2007) further specifies that in order to constitute as Indigenous research methodologies, researchers must actually advocate for Indigenous knowledges, which are "poly-rhetorical, contextually-based, and rooted in a specific place and time. Moreover, metaphysical phenomena are highly regarded and are integral to the learning process" (134). She acknowledges the difficulty with which academic researchers would accomplish this, and recommends that at the very least they incorporate the "Indigenous voice" into their work, sometimes through co-authorship with community scholars.

Bi-directional knowledge sharing was also identified to be an important part of the process in culturally appropriate research strategies (Menzies 2004; Louis 2007: Castleden et al. 2008; Mulrennan et al. 2012). Making sure that all archival research is available to the community is critical, especially in cases where the research originated in the community itself (Louis 2007)! The research that has "left" the community needs to be returned to them wherever possible, and the researcher (unfortunately) cannot assume that the community is aware of a report or dataset pertaining to their territory or knowledge, as they often are not. Additionally, all literature, analyses, tools, and other resources afforded to the researcher should be disseminated within the community (Menzies 2004; Louis 2007).

Another way to ensure bi-directional knowledge sharing is through shared experiences and undertakings. Castlededen et al. (2012) said that for communities, this includes

> [...] opportunities to learn new knowledge from social, natural, and health scientists; procedural research skills, including data collection and analysis; and also communication skills through writing reports, manuscripts, poster presentation, and conference presentations. For researchers, there are opportunities to learn from Indigenous knowledge as well as procedural community-specific skills including cultural protocols, ceremony, and relational ethics, or, to put it another way, a richer meaning of "respect" in Indigenous CBPR [Community Based Participatory Research] (162)

Mulrennan et al. (2012) outlined the various platforms through which they and the James Bay Cree have facilitated a "cross-fertilization of knowledge" (253), such as through usual research channels like semi-structured interviews and group workshops but also collaborative field surveys, biennial meetings of partners, spatial modelling, a website devoted to the project, and joint participation in workshops and conference symposia. This "commitment to knowledge exchange at philosophical, methodological, and practical levels" and the "radical differences in the ontological, epistemological, and ethical premises that underpin Cree socio-environmental management sciences" (253) ultimately led to a reconsideration of power dynamics and to a shift in "consideration of how scientific paradigms and models might be recast in relation to Cree notions of relationship, respect, and responsibility" (253).

3.2.3 Outcomes

The current trend of scholars from various scientific backgrounds conducting research alongside Indigenous communities has been critiqued for an overall lack of accountability on the part of researchers to prove that they have done anything more than engage haphazardly in "interdisciplinary research" (Hall & Sanders 2015). According to this critique, the importance of the research outcomes has been overshadowed by the good intentions involved in churning out "relevant" research documenting the latest in the science/social science grey zone of climate change impacts research, and there are no checks in place to ensure that these researchers are really doing anything beneficial at all.

As is increasingly the experience of academic researchers engaging in projects with Indigenous communities, however, the communities themselves are readily supplying their own checks (Castleden et al. 2012). Not all communities have drawn up their own Research Protocols, but many of them have (Menzies 2004). In order to obtain institutional ethics approval, in fact, proof of a research agreement with one's partner community has to be supplied, in accordance with Chapter 9 of the Tri Council Policy Statement on the Ethical Conduct for Research Involving Humans (TCPS 2014). The research agreements, if followed, are designed to produce meaningful and positive outcomes, and some Indigenous people regard research as a waste of time if it does not do so (Louis 2007).

In general terms, the most desirable outcome from culturally appropriate research is one that is beneficial to both community and researcher (Louis 2007; Castleden et al. 2008; Mulrennan et al. 2012; Whyte 2015). According to Menzies (2001), "establishing research policies that respect Indigenous values and simultaneously create research and publication opportunities is a crucial goal toward which we should strive" (25).

One important aspect of ensuring a mutually beneficial outcome is to share the final product(s) of the research before disseminating them in academic circles or through publication (Menzies 2004; Louis 2007; Mulrennan et al. 2012). Community endorsement of findings is necessary to ensure that the researcher and community share an understanding about the value of the research and its outcomes (Louis 2007, 135). Sending the finalized or pre-published version is also an incredibly important step (Mulrennan et al. 2012) that allows the community to screen these documents for items of potential concern in relation to what knowledge ends up being shared and how it is represented. One member of the Gitga'ata, when asked whether he had concerns about sharing his knowledge of traditional foods with non-Gitga'ata visitors, said:

> More—believe it [or] not—on a scientific basis than I do on a cultural basis. I think people will take away the cultural aspects: Oh, I saw them pick seaweed... I don't have a concern about that. But I do have a concern

> when scientists or researchers come in and then publish papers that may in fact have unique cultural, Aboriginal traditional knowledge that could somehow be used by others or somehow taken advantage of. (Turner 2010, 114)

This highlights the duty of the researcher to ensure that all matters of intellectual property and/or cultural ownership outlined in the research agreement are respected (Menzies 2004; Louis 2007; Castleden et al. 2008; Mulrennan et al. 2012), and if not specified by the agreement and if in doubt, researchers must be wary of making assumptions and should approach these instances on a case-by-case basis (Castleden et al. 2012). This, in itself, could be considered a primary benefit of the research process, after so many years of having their knowledges appropriated (Menzies 2004). Another important benefit to communities is the advancement of self-determination opportunities that accompanies research (Whyte 2015), such as its use in Aboriginal Rights and Title negotiations (Menzies 2001).

Other positive outcomes can be measured by evaluating the tangible benefits resulting from the research. Mulrennan et al. (2012) list the examples of opportunities for co-authorship, inclusion of local voices in published materials, making results available and accessible through appropriate language and presentation styles, training opportunities, opportunities for mobilizing community knowledge, and capacity building or social learning. Finally, the completion of the research objectives, whatever their nature, is an important outcome of any research project.

Enduring and positive relationships can be seen as another desirable research outcome (Mulrennan et al. 2012). The identification of further areas of collaboration (Tengö et al. 2014) enables the research experience to continue in a cyclical process reminiscent of Indigenous epistemologies (Louis 2007). As Wilson (2001) states, “research is not just something that’s out there: it’s something that you’re building for yourself and for your community” (179).

Though the frameworks examined above have their differences, they also have in common many provisions for researchers to abide by throughout research with

Indigenous communities. In the next section, I examine some of these provisions in relation to formal academic structures and to my experience as a graduate student.

3.3 Engaging in meaningful research with Indigenous communities as a graduate student

3.3.1 Research in Gitga'ata territory

The Gitga'ata are a coastal Ts'msyen First Nations community who continue to depend on their traditional territory for their food, transport, and cultural practices (Gitga'at Nation 2004). They are strongly involved in a struggle against Enbridge's proposed Northern Gateway pipeline and associated tanker traffic in their territory, are actively engaged in various research projects that benefit them and their lands and waters, and have been aware of (and adapting to) anthropogenic climate change impacts for over a decade (Turner 2005). Their participation in western scientific research began, like so many other Aboriginal communities, with ethnographic studies.

Ts'msyen ethnographer William Beynon, along with anthropologists Marius Barbeau and Franz Boas, are key contributors to existing oral histories detailing Gitga'ata origins, migrations, harvesting, social structure, and traditions. Their texts, published in the years between 1890 and 1988, recorded the knowledge of Gitga'ata individuals who were only one generation removed from those who had inhabited Old Town before the move to Metlakatla, and who recounted much about pre-contact occupation of the territory (Campbell 2011). The sharing of these oral histories is probably the first instance of research conducted with the Gitga'ata. As recently as 1984, an edited volume ('The Ts'msyen: Images of the past; views for the present) was published that included chapters dedicated to Hartley Bay's history and Gitga'ata feast names, in addition to including them in chapters reviewing Ts'msyen ethnographic history, social organization, worldview, and material culture (Seguin 1984). The Gitga'ata have relied on these and other documents to support their right to Aboriginal title, and to provide evidence at the Joint Review Panel for the Enbridge Northern Gateway proposal for impacts that oil tankers would have on Gitga'ata valued cultural sites and harvesting camps.

In the years since colonization, the Gitga'ata never stopped harvesting their traditional resources (Gitga'at Nation 2004), and have maintained their stance on the importance of securing Aboriginal rights and title, which they have pursued since the late 1800s (Campbell 2011). However, some traditional foods have since been lost because of mismanagement on the part of newcomers and the introduction or imposition of new foods, as well as laws that eroded self-determination and cultural identification, resulting in declining usage of these foods and inter-generational loss of knowledge (Turner & Turner 2008; Turner et al. 2012).

Research in some cases has played an unfortunate part in these detrimental losses, as evidenced through the decimation of Northern Abalone (*Haliotis kamschatkanaa* or ***bilaai*** is a cultural keystone species for the Gitga'ata; Garibaldi and Turner 2004), which in Gitga'ata territory came about when they shared the location of abalone with the Department of Fisheries and Oceans (DFO) who then allocated licenses to outsiders (Turner 2010). Another concern for the Gitga'ata, in their consideration of research that is to take place in their territory, are the petroglyphs that line the beach at one of their cultural sites, which is the largest site of petroglyphs in North America (Turner 2010). Over the last century, many of those have been taken by visitors from the beaches and have ended up "in hotels in Europe and all over the world" because people have been "going through our territory and just taking them. Not knowing the cultural significance that they had. And yet, this sounds really stupid, knowing exactly the cultural significance that they had. They were special enough to take." (Turner 2010, 116).

These cases were two of the driving forces behind establishing specific protocols for any research that takes place in Gitga'ata territory (Turner 2010). The Gitga'at Research Protocol has been in use for over ten years and stipulates the conditions for research in very specific and contractual terms, stating plainly that the researcher must take every opportunity to involve community members in their research and that the research should be mutually beneficial.

There have been many positive and enduring research partnerships with the Gitga'ata. Nancy Turner began researching Gitga'ata traditional uses of plants in 2001 as one of many researchers involved in the Coasts Under Stress Research Project, and has engaged in or contributed to over twenty separate projects with them over the years, including her role as committee member for the Social and Cultural Impact Assessment prepared for the Joint Review Panel for the Enbridge Northern Gateway pipeline. At the time of Dr. Turner's introduction to the community in 2001, several research projects were already underway related to surveys of the community's working history, career development for students, a historical study reviewing ethnographic records, letters of collaboration with environmental groups and with the King Pacific Fishing Lodge, and negotiations with forest companies. Dr. Chris Picard, current Science Director and research liaison person for the Gitga'ata, was taking part in fisheries research. These projects took place in the context of major clashes with the federal Department of Fisheries and Oceans over seafood harvesting licenses, which were not made widely available to all community members who were fishers.[14]

The Gitga'ata are adept at navigating the research process and have initiated various major projects relating to their territory. Dr. Picard serves as Science Director and research liaison for all projects taking place or under discussion, and of those that are initiated or proposed by outsiders, the community reaches an agreement on whether the work should go ahead and what changes should be made for it to result in community benefits. Indeed, in February 2014 the Gitga'ata hosted the Gitga'at Research Network and Strategy Workshops, which took place over several days. At these workshops, community members and researchers were invited to present proposed or on-going research projects, which sparked discussion and focus groups. Research topics included tanker noise impacts to marine life, the monitoring of bio-toxins in shellfish digging areas, the impact of sea level rise on important cultural-archaeological sites, community progress on climate change adaptation measures, the creation of a community Knowledge Bank, and the status of salmon, shellfish, and berry resources. The topic of climate change was a common thread that ran through most of these discussions.

[14] Nancy Turner, email to author, January 23, 2016

I am a white, female, university-educated graduate student in the Department of Geography, Planning and the Environment at Concordia University.[15] My experience with the Gitga'ata began as a research assistant to my current co-supervisor in 2012, when he alerted me to an opportunity to contribute remotely to a climate change adaptation project initiated by the Gitga'at Nation in coastal British Columbia. He had learned of this opportunity through Dr. Nancy Turner. The Gitga'ata were in the first year of a Climate Change Adaptation Program (CCAP), funded by Indigenous and Northern Affairs Canada (INAC) and aimed at developing a values-based climate change adaptation plan for the community (Reid et al. 2014). The Gitga'at CCAP was headed by the Hartley Bay Band Council in partnership with researchers from the University of Victoria and EcoPlan International. Over the course of nine months I compiled a literature review outlining the then-current academic literature on potential and already-occurring climate change effects in the region encompassing Gitga'ata territory. Upon completion of this project in spring 2013, I was accepted into the MSc program in the department and began formulating a research topic with Chris Picard. My project documents Gitga'ata knowledge of climate change impacts in their territory, so as to compile these experiences and observations for future inclusion in a Knowledge Bank project currently under development in the community, and to provide local-scale estimates of historical climate change in the territory and assess which climate variables are changing the most. Together, these two sources of knowledge potentially help to inform planning initiatives or to focus future research.

3.3.2 Case study of MSc research with Gitga'at Nation: Challenges and opportunities

The frameworks outlined above all encourage real measures to overcome the deeply problematic research relationships with Indigenous communities that the academy is built on. "Geographers engaging in research involving Indigenous Peoples are encouraged to critically reflect on their own practices to better address the history of unethical research that has, for decades, plagued Indigenous communities" (Castleden et al. 2012).

[15] I am aware that geography is a "disciplinary product of colonialism" (Castleden et al. 2012) and therefore thought it an important part of my position as a researcher

However, a review of researchers' perceptions of their Community Based Participatory Research (CBPR) experiences with Indigenous communities showed that "with the pressures of the academy as well as those stemming from partnering Indigenous communities bearing down on researchers, we see evidence that CBPR in practice is much more challenging to operationalize than CBPR in theory" (172).

Klocker, in her essay "Doing Participatory Action Research and doing a PhD: Word of encouragement for prospective students" (Klocker 2012), outlines some of the unique challenges faced throughout her PhD work with marginalized communities in Tanzania. She reviews writings that frame the combination of Participatory Action Research (PAR) and graduate dissertation as incompatible, complicated, and downright difficult. Academic culture, with its focus on deadlines, funding, and need for publications, is said to exist in constant tension with the principles of PAR – that is, moral responsibility for research outcomes, collaboration at all stages of the research, and meaningful representation of marginalized voices. She argues, however, that the two are not always as polarized as common literature on the subject would have us believe.

In this section I outline some of the difficulties discussed by Indigenous and non-Indigenous scholars who advocate for meaningful frameworks for research with Indigenous communities, and I examine some of the constraints and opportunities that I encountered in my own Master's research.

3.3.2.1 Starting point: The Research Protocol and navigating university timelines

> The key difficulty for researchers lies with the multiple level of approval necessary to achieve a respectful research relationship. As described above, three different levels of approval were required to clear the way for research to proceed [....] Refusal and redefinition is possible at every level. This is further complicated by a changing and evolving political context within which it is often necessary to renegotiate approval while the project is ongoing. All of this is then exacerbated by the wider history and legacy of colonialism that is a constant backdrop to any engagement in an Indigenous community" (Menzies 2004, 25).

Castleden et al. (2012) write that in an ideal situation, it is the community who approaches a researcher with a specific project in mind, although Menzies (2001) writes that dialogue can be initiated by the researcher, as long as they are willing to be flexible in accommodating community needs. As summarized earlier, my own experience began in 2012 when I learned that the Gitga'ata were looking for a researcher who could compile literature into a report, to be included in one of the stages of a Climate Change Adaptation Plan (Reid et al. 2014). This was how I first learned about the Gitga'ata, and in January 2013, when I visited the community to present preliminary results and obtain feedback, I met community members for the first time. Several months later I entered into my Graduate program at Concordia with no firm idea of a research project beyond that it would probably involve working with the Gitga'ata and that it would also be to do with climate change.

The research agreement was at the forefront of the initial stages of discussion related to my potential MSc work. Even before being accepted into my program (and long before we had settled on a particular topic) I had been given a copy of the Gitga'at Research Protocol to look over and to make adjustments to as necessary. The Protocol included stipulations on: confidentiality; intellectual property; mutual respect; community employment opportunities and training; information sharing and community endorsement; publication (to which my Master's document was exempt but to which any journal submissions would be subject); sensitive information disclosure; representations; and dispute resolution. The (ideally collaboratively developed) research activities were to be included as an appendix, and the research liaison (Dr. Picard) was to obtain community approval before signing it.

Since communication with the community at this point was very low (Dr. Picard understandably being incredibly busy), I can't claim to have worked closely with them to develop a research design at that stage, and spent the first two semesters of my graduate studies reading up on some of the literature pertaining to Canadian First Nations communities and climate change, while completing my course work.

Opportunities to jointly develop a research design came about only infrequently, and meanwhile my graduate research seminar course required that I move forward with specific assignments related to the development of my research topic. In February 2014, I was given a wonderful opportunity to present my proposed research ideas at the

Gitga'ata's Research Networks and Strategy meetings, along with ten to fifteen other researchers, including Dr. Turner. My presentation received little feedback (which might have something to do with the volume of my voice, which diminishes quite remarkably with anxiety) and I spent the two days being treated kindly by everybody that I had the pleasure of meeting or dining with, being given a fantastic boat tour of the territory with the other researchers by Marven Robinson and Christopher Stewart, and listening to other researchers' and community members' presentations and comments during the workshops. I took note of community members' recommendations for future climate change research, but most of these required technical expertise and a scientific background, neither of which I can claim with any confidence to possess.

The timing of my formal academic requirements was therefore somewhat out of sync with community availability. When I developed and presented a research proposal for my committee in June 2014, it was a proposal informed by the literature that I'd read and my understanding that my work would somehow end up contributing to the Knowledge Bank project, but without official approval from Dr. Picard, who had in fact responded to my document the previous day with an assertion that we should talk *more* about various research options. This discomfort of presenting something academically without first having received approval from the community is something that Klocker (2014) struggled with as well. Because PhD students need to submit research proposals and ethics applications early in the course of their program, they are often laying out a plan for how the research will unfold before they can benefit from collaborative planning processes. Though uncomfortable with participating in university processes that reflected her own timeline and proposed research activities rather than the community's, she found that she could incorporate flexibility into the research proposal by outlining her current uncertainties. Similarly, I outlined Dr. Picard's concerns to my committee when I presented my research and they told me I could change the research project to accommodate new ideas.

Working on a community's timeline, as Menzies (2004) points out, will sometimes mean pushing off your field research in spite of academic pressure to move forward. Over the course of the year 2014 I remained in sporadic communication with Dr. Picard, whose involvement in the Gitga'ata struggle against the proposed Enbridge Northern Gateway project and other admirable work that he takes on as Science Director left him short on time to correspond. It was clear that summer and autumn were both such intense periods of activity in the community that there would be little sense in planning my field research for these months. As a Master's student, I was lucky in that I was relatively free to conduct my field research during any semester, but for faculty researchers whose main window for fieldwork is summertime, this can be an important issue (Castleden et al. 2012). In the meantime, I was required to submit periodic reports to my funding contributors, to justify the delay and to update them on my plans.

At times I became frustrated by my own lack of research background or ability that would really be of use the Gitga'ata. Dr. Picard proposed different ideas in conference calls and through emails, some of which I didn't really have the scientific or archaeological background to follow through on, and others which I looked into but found impossible to pursue any further due to external circumstances (such as the Gitga'ata archival records being re-organized, and hence unsearchable, in the period corresponding to my research). In the end, the Research Protocol was signed in early January 2015 and a research project roughly pertaining to my original proposal was approved, though with changes to my methodologies.

Once the Protocol was signed, things began moving very fast, and this time university processes (specifically, my ethics approval) couldn't keep up. My research was set to begin on March 1st and 2nd, when I was to present my topic at the March Community Meetings. My ethics application had been hinging on having the signed Research Protocol, so I completed my application soon after receiving it. However, research involving Indigenous Peoples is considered to be "above minimal risk" and the procedure involved the Board reviewing my application at their monthly meeting on January 15th and issuing their recommendations, which I was to incorporate and send back for review at the meeting one month later. Although I did so, a technicality prevented me from receiving my full approval right away; I had neglected to include my funding sources on my Participant Consent Form. This, combined with the slow turnover of emails and decisions from my reviewers, meant that I received ethics approval only just in time for my scheduled interviews. Needless to say, it was stressful.

There are several main themes outlined in the frameworks reviewed earlier that became very significant at this stage in my research. The Research Protocol or research agreement process, as evidenced through the document's highly structured and instructional contents, is indeed a powerful tool for Indigenous communities to protect themselves. The way that researchers feel about this process varies. Castleden et al. (2012) documented some researchers' views that the protocols are "quasi-legal documents" that aren't useful (171). Menzies (2001) wrote that "some researchers consider this an infringement on their rights as individuals in a democratic society. Others see it as inappropriate control over the pursuit of knowledge. Perhaps, if researchers thought of this more as a form of peer review, they might not take issue with having their work reviewed by First Nations or other community groups in the first place" (23). I have to agree with Menzies here; why should researchers object to communities having the final say over work that takes place in their territory and involves their knowledge systems?

Another issue confronted at this stage was that of timing. In the frameworks above, I review research methodologies that endorse the reality that community timelines and research agendas need to take precedence over those of the researcher and university. Certainly this was something that I encountered while I waited for formal approval to begin my research. I spent an extra year in my program over the two that students are typically encouraged to take to graduate. I vividly recall a phone conversation with Dr. Picard that occurred in early January 2015 after we had already discussed dates in March and when the Research Protocol was on the cusp of being signed, and my ethics application was due in a day and a half if I wanted to get approval in time to conduct my field research in March. It was a perfect storm of timing, with everything hinging on whether the Protocol was signed the next day. Dr. Picard pitched a few fundamentally different methodologies and ideas over the phone and I remember flat-out panicking. I wouldn't have time to incorporate new methodologies into my ethics application! When I said as much, Dr. Picard told me that his concern was with representing community needs, not with university paperwork. That was a moment of some pretty intense reflection for me. It reminded me who this research was for. I could have begun a Master's project in climate modelling or any other topic that didn't involve an Indigenous community, but I chose this research because I admired the Gitga'ata's initiative in proactively gathering information about climate change and planning adaptively, and I wanted to help. After visiting a few times, I was even more personally invested because the people I met spoke so passionately about their way of life and their determination to protect it. Needless to say, you could have fried an egg on my face, I was so embarrassed.[16]

Related to this experience was that I was beginning to understand the paucity of community benefits that would arise from combining community knowledge with climate science for increased understanding of recent environmental change, when direct research into effects on harvested species or on viable adaptation measures would be so much more useful. In hindsight, I can see that the inertia of my academic progress, the overall lack of regular correspondence, and a feeling of relative isolation from the community (understandably considering that we were on opposite sides of the country) resulted in a curious sort of "time pinch". The feedback loop between the community and myself was functioning so slowly that I wasted a lot of time on a topic that was not ideal in the dual belief that it was satisfactory and that there was no time to change it, when I could have been working toward a better one, had I only had a clear idea of what it was and how much time I had to pursue it.

There are many researchers facing institutional timeline clashes in upholding their responsibilities to their Indigenous research partners, however. Issues of funding deadlines, of the pressure to produce results and publications, and of ethics applications are frequently encountered (Menzies 2004; Castleden et al. 2012; Klocker 2014).

> That is, the lack of funding certainty and then the rush to complete project deliverables on time [...] compels researchers to focus on results readily producible, that do not challenge funding agencies, and that rarely advance the state of knowledge [...] we were nonetheless intent on

[16] In the end, the Protocol was signed the next day anyway, as Dr. Picard seemed to decide that no change was necessary.

> maintaining a process of respectful research relationships that fully incorporated not simply the external funding agency's changing expectations, but also met the expectations of our community partners in terms of research protocol. Though our efforts resulted in effective community relationships it ultimately undermined our administrative effectiveness from the perspective of the funding agency. (Menzies 2004, 18)

Similarly, one researcher found it difficult to rationalize to their university Dean that they hadn't published from their research yet because they "spent the first year drinking tea" (Castleden et al. 2012, p 168). The fact is that building relationships based on trust and mutual respect takes time, and that the data collection process will often begin many months after an initial informal research agreement, regardless of funding or timeline concerns (Menzies 2004; Castleden et al. 2012).

Another issue was confronted during that phone call when my eagerness over obtaining institutional ethics approval resulted (somewhat ironically) in a lack of given priority to the community's agenda. The institutional ethics process sometimes clash with the participatory, consultative, and practical considerations of one's responsibilities to their partner communities (Klocker 2014). For instance, Klocker's work with children was difficult to rationalize to her university ethics board, while her PAR training strongly emphasized how unethical it would be not to consult with and engage children whose lives she was researching. She found this tension very difficult to negotiate, as the stakes were impacts that would be felt in real peoples' lives. Along a similar vein, one CBPR researcher interviewed by Castleden et al. (2012) needed to fight their institutional ethics review board over their decision to identify all knowledge-holders by name, because the review board was encouraging anonymity while community members wanted their knowledge contribution acknowledged.

In my case, a separate conflict arose between the community's agenda and the ethics review board's requirements regarding my consent forms, and it was easy to criticize this disparity when the lack of a funding logo that no Gitga'ata member would ever care about nearly prevented me from working within the community's timeline. This corresponds to research that shows that the rigid nature of the consent process can sometimes be counterproductive in conducting culturally appropriate research (Sherman et al. 2012). However, it needs to be acknowledged that the Tri-Council Policy Statement for Ethical Research Involving Humans as well as the institutional ethics boards that enforce it are in the interest of protecting communities from further harmful research practices and knowledge appropriation, and are powerful tools in doing so (Castleden et al. 2012).

The Research Protocol process, in recapitulation, is absolutely crucial in conducting research with Indigenous communities (Menzies 2004; Louis 2007; Castleden et al. 2012; Mulrennan et al. 2012; Tengö et al. 2014). Though it will often involve sacrifices and pressures on the researcher's part, it is necessary in the pursuit of decolonized methodologies.[17]

Furthermore, the process benefits the researcher greatly. In my case, waiting on the Research Protocol, working on a community timeline and being guided by an experienced research liaison person meant attending a two-day event where I was able to get to know community members before even beginning my research; being able to submit a newsletter article before conducting my field research that familiarized the community with my project before arriving; presenting at Community Meetings that gave me further opportunity to introduce myself and my research and get acquainted with community members and potential participants; and ultimately receiving community support through Dr. Picard's work in getting the research agreement signed. In the end, wherever my field research went smoothly, it was because of this very important antecedent process. As Menzies (2004) said, "without this instruction and ultimately support of those at the meetings the success of the interview and research aspect of the project would have been in jeopardy" (23) or else "would not have been possible at all" (26).

3.3.2.2 Process and Output

The latter two stages of the process in my case have also been framed to some extent by

[17] As culturally appropriate research partnerships with Indigenous communities become more commonplace and Indigenous scholarship more present in academic institutions, moreover, a shift may occur toward institutional acceptance of the timelines and commitments involved (Louis 2007)

elements of the frameworks discussed above, but to a lesser degree. The research activities outlined in the Protocol made it clear that in the analysis and writing stages, for instance, I could proceed alone (as long as participants and community representatives had a chance to give their approval before my thesis was submitted).

At the "Process" stage, nothing was more important to my research than working with a community-appointed research assistant. The importance of having your research team include community members has been established (Menzies 2004; Louis 2007; Mulrennan et al. 2012; Castleden et al. 2012; Tengö et al. 2014), and my fieldwork was no exception. I was pretty thrilled when Dr. Picard appointed Spencer Greening, a community member (and now Band Councilor) and Master's student at the University of Northern British Columbia, as Research Assistant. Aside from the fact that he was always really friendly over the phone (and that we made fast friends in person), I began to think of him as a research partner extraordinaire from the moment we started working together. He always had wonderful suggestions of who would be available and willing to be interviewed, was an active participant in interviews and often asked questions that never would have occurred to me, and could always be counted upon to lug four or five sizeable maps of the territory to each interview just in case the community member being interviewed wanted to anchor their observations in space (two did). This is in agreement with observations that collaboration with a community member is essential to a successful research experience. Though some also caution that engaging community members can have socially complex and potentially negative repercussions (Castleden et al. 2012), this certainly wasn't the case with Spencer. Between him and Dr. Turner (who was also present for some interviews and was a wonderful mentor) and the research participants themselves, who were incredibly accommodating and knowledgeable, my field research went better than I had anticipated.

Elements that influence my research at the "Output" stage can be addressed relatively easily, and have presented few challenges in my experience as a graduate student. On matters of intellectual property, I will abide by the Protocol agreement and acknowledge individual contributors and the community in general wherever possible. I don't expect to experience any academic difficulties in doing so, though some university researchers who have secured funding or are pursuing publication are faced with research regulations dictating that they must retain ownership over the research and all data collected (Menzies 2004). Euro-Canadian law apparently states that a taped interview is the property of the interviewer, but I will be acknowledging the Gitga'ata's cultural ownership of these materials, as is increasingly (though unfortunately, not always) the case for researchers working with Indigenous communities (Menzies 2004).

Keeping sensitive cultural information confidential is also of great importance to any project involving human subjects, and it is important to be mindful of topics that participants may share during an interview with an individual but would not be comfortable sharing publically. Several participants shared the location of valued resources to provide context for their stories, and while they were happy to allow me to include this knowledge in my project, they asked that the location not be mentioned. This ties back to the perceived dangers of sharing information with researchers (sections 3.1.1), and underscores the need to provide the community with a chance to look over all materials before they are shared or published.

The community knowledge-holders who granted me interviews were given the opportunity to look over their interview transcripts and return them with any desired changes, though only a few did so.[18] The draft of my thesis was sent to Dr. Chris Picard, to each participant, and to Spencer Greening for review so that I could incorporate any of their changes along with my academic committee's, and to request their endorsement. This is an important gesture when the research is drawing to a close (Menzies 2004; Louis 2007; Mulrennan et al. 2012; Castleden et al. 2012) but can be a source of anxiety for researchers, as it places control over whether or not your research moves forward into somebody else's hands (Castleden et al. 2012). "It may be difficult for academic scholars to be 'judged' by both a panel of Indigenous community members and by a group of their peers, and it might be even more difficult to write adequately for both audiences, but it is necessary to do so" (Louis 2007, 135).

In the interest of knowledge sharing, I recognize that a Master's thesis over one hundred

[18] This is possibly due to the length of time that passed between the interviews and sending them to participants for feedback

pages long is not the best way to benefit community planning and future projects. I plan to summarize my findings in a more accessible report (and potentially a poster or pamphlets) to send back to the community, as is encouraged in Community Based Participatory Research (Castleden et al. 2008; Mulrennan et al. 2012). I will also send all transcriptions, data, relevant analyses, and literature collections that I utilized in this research.

Whether or not my research has had, or will have, a beneficial outcome is difficult to judge. More than the thesis itself, I feel the interview recordings and my method for organizing them by topic could be of value for informing climate change planning and focusing future climate change studies. As well, the inclusion of the interviews in the ongoing Knowledge Bank and/or Old Town projects will be quite special, as there were absolutely wonderful stories shared with me that weren't included in my thesis.

Finally, I regret that I cannot claim to have fully taken on the position of advocate for Indigenous Knowledge or engaged in Two-Eyed Seeing, because my methods were pretty conventional and weren't shaped by Indigenous epistemologies. However, my work in the community was a learning experience for which I will forever be grateful and I've tried, wherever possible, to use quotations to preserve the integrity of the knowledge gained through my interviews (Louis 2007). Both before and after conducting my fieldwork, I felt uncertain about whether or not I had done everything possible to produce something of value to the community, and I began reading about frameworks for meaningful research in earnest. This chapter is the product of that endeavor, and is meant to introduce other students to these important frameworks, while signaling to them some of the challenges involved and the importance of remaining open to a research approach that is more dynamic and flexible than what is typically encountered (or encouraged) in graduate research.

3.4 Discussion and conclusion

My hope is that readers of this chapter will come away with an increased understanding of the standards for which we all need to strive in our research with Indigenous communities, and of the very real benefits that result from doing so. Menzies' (2001) account of scholars who withdraw from work with Indigenous communities because they're intimidated by potential critiques of (or undue constraints on) their research is a reminder that trying and failing is better than not trying at all. Klocker's (2014) greatest source of frustration in her PAR research was not the timeline complications or the dual sources of oversight, but the overly harsh and judgmental literature that separated work that perfectly aligned with the PAR structure into "morally good" research and work that didn't into "morally bad" research. As Wilson (2001), Menzies (2004) and Louis (2007) point out, the academic field needs researchers who are actively trying to change it. If we are to "decolonize the academy" (Louis 2007), we need to encourage students to engage in this work, rather than scaring them off it, facilitating "a new generation of scholars who recognize the value of working towards a more engaged, community-centered research agenda" (Mulrennan et al. 2012, 254).[19] As Dr. Mulrennan told me (and as Klocker herself was told when discouraged by the criticism of her peers), "everybody has to start somewhere".[20]

For researchers who would like to conduct work that specifically involves Indigenous communities and climate change, this is a quickly growing field (Hall & Sanders 2015). Indigenous Peoples' struggles to have their voices and concerns recognized in climate change discourse have resulted in an increased awareness of the links between and potential applications of Indigenous lifeways and climate change research (Doolittle 2010), and the IPCC AR5 (2013) is tangible proof that researchers are engaging with Indigenous knowledges alongside western scientific sources of climate understanding. Hall and Sanders (2015) argue these are like metaphorical wolves in sheep's clothing, because they draw on conventional methods and do very little to take on changing research practices while widely disseminating their essentially colonial research within interdisciplinary research networks. Maybe this is true of some studies, but I have also

[19] That being said, there are also systematic changes that could be made at the institutional level to make the process easier and more encouraging for students. An Indigenous Research Methods course in the curriculum (Louis 2007) and increased training opportunities (Castleden et al. 2012) are examples.

[20] Indeed, I only began researching these frameworks and their applicability to my research after I had already finalized my research design and completed my fieldwork, and the application of the principles outlined in this chapter to my own research (Chapter 4) is highly incomplete. Dr. Mulrennan's advice is a reminder that the act of truly moving away from conventional western scientific frameworks is a difficult (but worthwhile) one, requiring practice.

read many in Canada alone that are based on long-standing relationships with their partner communities and are taken on in collaboration with them (e.g. Nichols et al. 2004; Ford et al. 2006; Turner & Clifton 2009; Weatherhead et al. 2010; Gearheard et al. 2010). These researchers allow Indigenous values and knowledges to shape their research (e.g. Turner and Clifton 2009; Weatherhead et al. 2010), bring their knowledge together in equal consideration with scientific data (e.g. Gearheard et al. 2010), and engage in the identification of areas for adaptation planning (e.g. Ford et al. 2006).

There are struggles involved in being a non-Indigenous researcher working with Indigenous communities, but any difficulties come hand-in-hand with unique opportunities and do not compare to the struggles that Indigenous communities have endured from non-consultative research practices. There is room for real change within the academy, and it has to come about as a result of a willingness to engage alternative research strategies, even if done imperfectly. “Commitment to truly decolonised research must be more than fine words: it must be an act and demonstrable in practice.” (Menzies 2004, 17)

CHAPTER 4

"THE BATTLE OF THE WEATHERS": COMMUNITY OBSERVATIONS AND DOWNSCALED CLIMATE DATA OF CHANGES TO THE WEATHER IN GITGA'ATA TERRITORY, BRITISH COLUMBIA

Abstract

The Gitga'ata are a Ts'msyen First Nations community located on the north coast of British Columbia. There have been community-led initiatives to document and respond adaptively to observed environmental changes occurring throughout their coastal territory over the past five years. This research draws on Gitg'ata knowledge and downscaled climate data from the ClimateBC software to discuss climatic changes that have taken place in Gitga'ata territory over the past century. I present a discussion of temperature, precipitation, snow, wind, storms, and general changes to weather patterns guided by interview and workshop analyses, and I analyze 137 variables related to temperature, precipitation and solar radiation for temporal trends using regression analysis. I then identify areas of agreement and discrepancy between these two knowledge systems, before discussing the merits, challenges and limitations of this type of research.

4.1 Introduction

Indigenous Peoples are often disproportionately impacted by climate change because they are frequently (though not uniformly) at a geographical, social, political, or economic disadvantage (Salick and Byg 2007). In spite of these disadvantages, Indigenous communities are not passive victims of climate change. Many, including the Gitga'ata, a Ts'msyen group of northern coastal British Columbia, are striving for ways to mitigate and adapt to the impacts of climate change on their way of life (Reid et al. 2014). Indeed, the Indigenous Peoples of Western North America have faced and responded to environmental change throughout their very long histories in their territory (Turner and Spalding 2013; Turner 2014).

The Gitga'ata have long inhabited their coastal territory. As a community they have taken initiative in recording observations and participating in research related to climate change impacts on their territory, and my graduate project was an extension of that work. In this chapter, I first provide a short review of the applications of TEK in climate change research, discuss climate-modelling results for the region, and introduce the Gitga'ata and their territory. I then present Gitga'ata knowledge of weather and environmental change in their territory and discuss this knowledge in relation to climatic trends from data analysis.

4.1.1 TEK AND CLIMATE CHANGE STUDIES

Berkes et al. (2000) describe Traditional Ecological Knowledge (TEK) 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 things (including humans) with one another and with their environment." (1252). TEK develops from sustained intimacy and engagement with the environment, when people are integrated with their environment on many different levels (such as spiritually and physically; Kimmerer 2002, 2013). It is holistic, adaptive, accumulated over generations and incrementally in one's life, formed through practical experience, tested through trial-and-error, and transmitted orally or by shared experience (Berkes et al. 2000). It is also nested- none of the components of TEK can be isolated from the context within which they have developed (Berkes 2008; fig. 2.1). Although this knowledge is grounded in traditional practices and relationships with the territory, it is by no means static, but is dynamic and evolving (Berkes et al. 2000). New information and practices are continually being incorporated and these knowledges adapt to present circumstances while anticipating future change.

Houde (2007) similarly describes TEK as having six "faces", of which factual observations is only one. The other faces are management systems; past and current territory uses; ethics and values; vectors for cultural survival; and beliefs and cosmology. Within the "factual observation" component, there exist many different "types" of observational knowledge that are indicative of a deep engagement with all aspects of the surrounding environment. This includes empirical observations; classifications; nomenclature and place-names; descriptions of ecosystem components; understanding of interconnections and linkages; identification of spatial and population patterns; and observation of ecosystem dynamics and changes. Lantz and Turner (2003) describe the Traditional phenological indicators that many Indigenous Peoples rely on to gauge the distribution, health, or life stage of important plant and animal species through careful observation of an indicator species.

There has been a growing awareness of the merits of these localized knowledges within the scientific community in recent years (for example, Huntington et al. 2004; IPCC 2014; Krupnik and Ray 2007; and Moller et al. 2003). Furthermore, as scientific awareness of the value of such knowledges increases and tools for mutually beneficial collaboration emerge, the potential for Indigenous experts to be included in the research process in ethical and respectful partnerships is now increasingly acknowledged (Mulrennan 2013).

One of the ways in which TEK may be of particular importance to climate researchers is through a provision of "direct knowledge and insights relating to weather, environments, species and habitats" (Turner and Clifton 2009, 185). This can emerge through many applications of relevance to this research.

First, local-scale observations and understandings, such as in relation to changes in sea ice, wildlife, permafrost, or weather, can inform scientific research with complex detail of local environmental processes and knowledge of long-term trends (Riedlinger & Berkes 2001). Turner and Clifton (2009) have suggested that the specific nature of their observations in space and time allow the Aboriginal groups in coastal British Columbia to recognize odd years as distinct from long-term trends and to differentiate between fluctuations within expectations of natural variation from occurrences that are considered truly unusual (also discussed in Barnhardt 2005; Peloquin and Berkes 2010; and Ignatowski and Rosales 2013). In Gitga'ata territory, one particularly important detected weather trends is a shift away from May sunshine, which has traditionally been relied upon to provide clear weather for picking edible seaweed *(Pyropia abbottia*; ***lha'ask)*** during the spring low tides when the seaweed is just right for picking, and for warming the rocks enough to dry seaweed on. Since the late 1990s, weather in May has generally become overcast and rainy, making it difficult for the Gitga'ata to anticipate a window in which to harvest and dry this valued food (Turner et al. 2006; Turner and Clifton 2009).

Second, TEK can provide a source of climate history and baseline data at a scale not usually explored in climate studies (Riedlinger & Berkes 2001). Seasonal calendars and similar knowledge depicting the "normal" timing, duration and intensity of weather events can offer substantial insight into the baseline climate of a region, informing communities whether current changes are normal or outside the range of historical natural variability. Seasonal calendars are often inextricably linked with phenological indicators depicting the seasonal onset of resource availability, animal behaviors, or life stage of a particular plant (Lantz and Turner 2003). The Gitga'ata make use of weather patterns to reliably predict the seasonal "growth, development, reproduction, and migration of organisms" (Turner and Clifton 2009, 184). Recent shifts away from the normal timing of weather events and associated phenological events have resulted in a loss of reliability in some of the indicators that they use to determine the readiness of valued species.

Third, TEK can act as a starting point for new research questions and hypotheses, such as whether observed changes are beyond the natural range of variation, or whether there is an increase in extreme weather events (Riedlinger & Berkes 2001). TEK, for instance, can provide insights and generate research hypotheses about possible causal mechanisms of change that scientists might not think to explore (Huntington et al. 2004; Weatherhead et al. 2010). An example of this is when Helen Clifton, Gitga'ata Matriarch, remarked upon the possibility that berry bushes were failing because increased spring rains were affecting pollinators (Turner and Clifton 2009).

Table 4.1 introduces studies of TEK in relation to climate change as examples of the three applications described above, and identifies which types of observational knowledge described by Houde (2007) were drawn on in each study (though these are often never explicitly named).

Climate change researchers' acknowledgement of TEK is evident in the Fifth Assessment Report (AR5; IPCC 2014), which engages with TEK on the theoretical level as well as regarding Indigenous peoples' observations of change with high consideration and confidence in their discussion of detected climate changes.[21] The report's endorsement of the use of TEK in climate change studies is reflective of a large body of literature that frames the integration and co-production of TEK and western science as valuable for studies of climate change impacts, as well as the fields of historical climatology; adaptation; natural disaster mitigation; biodiversity science; and sustainability (Salick and Ross 2009; Hall and Sanders 2015).

Table 4.1. Examples of three of the applications of TEK to climate change studies discussed by Riedlinger & Berkes (2001; left column), study examples (middle column), and the types of observational knowledges drawn on (Houde 2007; right column)

Application	Study Description	Type(s) of Observational Knowledge
Local-scale processes and long-term trends	Inuit hunters often have intricate knowledge of what landscape features influence wind patterns, how to forecast wind conditions, and how winds influence weather. In Nunavut, many hunters have remarked on changes to wind variability, direction, and speed, and on the effects that these changes were having on sea-ice, glaciers, and snow conditions. Researchers obtained wind speed and direction data from Environment Canada and found that while some of the observations were also detected by scientific instruments, Inuit assessments cover larger, more topographically complex areas, thereby offering insight into local-scale processes not detected by wind stations. (Gearheard et al. 2010)	Empirical observations; description of ecosystem components; understanding of interconnections and linkages; identification of spatial and population patterns; observation of system dynamics and changes
Climate history or baseline knowledge	The Samoan calendar, constructed around the onset of weather events as well as other indicators (such as the arrival and departure of seasonal species in their territory) was recorded. It was found that Samoan people can accurately forecast weather changes based on cloud	Empirical observations; classifications; nomenclature; description of

[21] The lack of chapter authorship related to Indigenous research, however, has been criticized (Ford et al. 2011)

	formations, wind characteristics, and animal behavior. (Lefale 2010)	ecosystem components; understanding of interconnections and linkages; observation of system dynamics and changes
New research questions and hypotheses	The Inuit of Baker Lake have noticed a change in the accuracy of their weather forecasting since the 1990s. When interviewed about climate change, they identified not a long-term trend in any given variable but rather a new lack of "weather persistence", or "coherence of weather patterns". Researchers, following this lead, calculated weather persistence and found that it has shown a decreasing trend since 1984, with marked decreases after 1990 (Weatherhead et al. 2010)	Empirical observations

4.1.2 Climate modelling

Major global climate changes are expected to take place within the next century, due to the high level of greenhouse gases continually being added to the atmosphere. These changes include temperature increases, extreme weather events, regional re-distribution of precipitation patterns, sea level rise, ocean acidification, and numerous other phenomena (IPCC 2013). Climate models are valuable tools in investigating future or hypothetical climate system responses to changes occurring at a multitude of scales (Flato et al. 2013). They are useful simplifications of the climate system, its components, and exchanges between them. By manipulating these exchanges in a model (e.g. by simulating an increase of the exchange of carbon from the land surface to the atmosphere) users can obtain spatially and temporally specific data depicting the resulting changes in climatic variables such as temperature, precipitation, and atmospheric circulation as well as derive numerous sub-variables (such as frost-free periods) through calculations (Le Treut et al. 2007).

The global environmental changes noted above are manifesting themselves in vastly different ways at regional and local scales. Also, it is very difficult to apply global climate model results for a large grid cell in a global climate model to a location within that grid cell with a high degree of confidence (Sobie and Weaver 2012). The process of estimating local climate changes from coarse-resolution model simulations is known as downscaling, in which spatially interpolated data (such as from global climate models or climate station interpolation) have been superimposed (Wang et al. 2012), statistically correlated with (Sobie and Weaver 2012), nested (as in the case of regional climate models (Laprise 2008), or otherwise geospatially linked with high- resolution surfaces to enable finer estimates. As a consequence, downscaled climate data is associated with whatever uncertainties were inherent in the original large-scale data as well as additional uncertainties emerging from the downscaling process (Wang et al. 2012).

Climate model data for the region encompassing Gitga'ata territory on British Columbia's coast shows that there have been significant climate changes that have already occurred. Examples of these are decreases in the number of frost days (Frich et al. 2002), increases in seasonally averaged minimum temperatures (Rodenhius 2009), earlier spring arrival (Bonsal and Prowse 2003), increases in precipitation frequency (Vincent and Mekis 2006), volume (Zhang et al. 2000), and intensity (Groisman et al. 2005), and a decrease in precipitation falling as snow in spring months (Zhang et al. 2000).

The implications of such changes are substantial, though not altogether predictable, and isolated coastal communities such as the Gitga'at'a will face significant exposure to future changes, as climate continues to be modified by anthropogenic emissions. Consequently, it is important to assess what is known about changing climate conditions in Gitga'ata territory, so as to provide a benchmark for anticipated future changes and to inform the community's ongoing efforts to adapt to these changing climatic conditions and associated environmental impacts.

4.1.3 Research Aims

In this chapter I investigate the potential for TEK and downscaled climate data to be brought together in an overlapping narrative of climate change. To identify major climatic changes in Gitga'ata territory in the years that participants have spent living or harvesting in their territory, I draw on local observations by members of the Gitga'at'a Nation who have retained connections with their complex coastal territory and have acquired detailed knowledge of wildlife, weather and other conditions. I also use the downscaled climate dataset from ClimateBC (Wang et al. 2012) to discuss temperature and precipitation trends for the years 1901-2013. After outlining the results of the analyses, I explore the compatibilities and discrepancies of community observations with downscaled climate data for their ability to increase confidence in individual conclusions, to fill knowledge gaps, and to generate hypotheses that might not otherwise have been explored.

4.2 Gitga'ata

A member community of the Southern Ts'msyen First Nations cultural group, the Gitga'ata people have inhabited the Northwest Coast since time immemorial and are stewards of the lands, waters, and resources on their territory. The Gitga'ata are a relatively small community of 630 people. One hundred and eighty of this number live in Hartley Bay village on the territory (fig. 1.1), and 450 live in Prince Rupert (140 km to the north) and elsewhere in British Columbia or abroad. While English is the predominant language today, many Elders continue to speak the coast Ts'msyen language of ***Sm'algyax,*** which is taught at the village school in Hartley Bay (Gitga'at Nation 2004).[22]

Gitga'ata territory at sea level is located within the Coastal Western Hemlock biogeoclimatic zone, characterized by mountainous topography and ocean adjacency, and at higher elevations within the Mountain Hemlock zone (Krajina 1959). Ample available atmospheric moisture combined with orographic lifting therefore contributes to a climate that is mild and wet (Egan 1999). The coastal location of the community is significant; the Gitga'ata's long-term habitation in this zone signifies a deep and collectively accumulated history of understanding and engaging with coastal processes, environments

[22] In the past, the Gitga'ata spoke the Southern Ts'msyen dialect, but during colonization began to favor the more widely-used Coast Ts'msyen (Halpin and Seguin 1990).

and resources, as well as an on-going capacity for adapting to change (Turner et al. 2006; Mulrennan 2014).

Since first contact with Europeans, the Gitga'ata have retained many of their traditional ways and continue to rely on various harvesting sites throughout their territory (Gitga'at Nation 2004). They have maintained two permanent harvesting camps. Old Town (or ***Laxgal'tsap***) is where they harvest berries *(**maay**)*, Chum *(Oncorhynchus keta; **gayniis**)* and Pink *(Oncorhyncus gorbuscha; **stmoon**)* salmon among other resources. Old Town was the site of their winter village before the move to Metlakatla, and is situated 19 km north of Hartley Bay along the Douglas Channel, in the Kitkiata inlet. Kiel (or ***K'yel***), for spring seaweed *(Pyropia abbottiae*; ***lha'ask)*** picking and halibut *(Hippoglossus stenolepsis; **txaw**)* fishing (as well as other seafood harvesting), is located on the northwest part of Princess Royal Island (or ***Lax'a'lit'aa Koo***) approximately 40 km to the south of Hartley Bay, in Whale Channel. The Gitga'ata have also built a hatchery for their Coho enhancement project along their main river at Hartley Bay, which is a salmon-spawning stream and lake system. They operate each year while also fishing the stream for Coho *(Oncorhynchus kisutch; **wüüx**)* and other salmon species.

The Gitga'ata rely heavily on seasonal harvesting of plant and marine resources for subsistence. Many families have multiple stand-alone freezer units where they store their traditional foods. Sharing of foods among extended Gitga'ata family members is still identified as being of vital importance by many community members (Satterfield et al. 2011). Many community members take part in one or more of fishing, hunting, and gathering activities. Edible Red Laver seaweed *(Pyropia abbottiae*; ***lha'ask)***, Western Red-cedar *(Thuja plicata; **smgán**)*, different varieties of salmon ***(yeeh, müsoo, stmoon, wüüx, gayniis**),* cockles *(Clinocardium nuttallii; **gaboox**)* and Northern Abalone *(Haliotis kamschatkana; **bilaa**)* continue to act as cultural keystone species for the community, in that people identify strongly (and indeed are associated by others) with these species, and their significance is maintained through their intensity of use, contribution to trade, role in ceremonies and narrative, and other elements (Garibaldi and Turner 2004; Turner and Thompson 2006; Turner et al. 2012).

4.3 Materials and Methods

4.3.1 Workshop observations

The Gitga'ata Climate Change Adaptation Program (CCAP), funded by the former federal ministry of Indigenous and Northern Affairs Canada (INAC), is aimed at developing a values-focused climate change adaptation plan for the community (Reid et al. 2014). This work, initiated by the community in 2012 as a response to observed climate changes on the territory, took place over four consecutive years. The CCAP team, comprised of external researchers, planning consultants, and community members developed outreach activities as well as organized five community workshop series in November 2012, January 2013, May 2013, August 2013 and February 2014. The workshops were intended to encourage community feedback about the project and to discuss and record key exposure potential to social, cultural, and physical impacts. The most recent workshops served as a space to explore Gitga'ata adaptive capacity and level of resilience to these changes, and to develop concrete measures for mitigation and adaptation to impacts in the short, medium and long term. A key component of identifying vulnerability to climate change was the identification of community observations and insights related to changes already taking place.

I compiled the content of these documents into Excel tables by theme (Appendix 4.A). These themes then formed the basis of my own interview guide (Appendix 4.B) and the observations were integrated into my analysis along with my coded interviews.

4.3.2 Interviews and optional exercises

4.3.2.1 Arranging interviews and recruiting participants

The beginning date of my field research had been scheduled to coincide with community meetings taking place on March 1st 2015 in Prince Rupert and March 2nd in Hartley Bay. At these meetings, with support from Spencer Greening, I gave short presentations, where I introduced my research project (to some, for the first time), explained the proposed interview process, and answered community questions. I had a chance at these meetings to pass around a sign-up sheet for those who felt comfortable discussing environmental changes in the territory and who would be interested in participating or in learning more, and I made an effort to secure interviews with all of those who signed up, though for some scheduling made it impossible. Ten out nineteen participants were recruited this way. For all other interviews, it was Spencer Greening (appointed community research assistant) or Dr. Nancy Turner (my committee member and long-time research partner to the Gitga'ata) who identified knowledgeable (and available) members of the community to approach and who made contact on my behalf, having access to most peoples' phone numbers.[23]

Eight women and eleven men participated. Ten of the participants chose to be interviewed in pairs, for a total of fourteen interviews. All participants were over the age of thirty-five, and I estimate the median age to be over sixty. Of those who participated, nearly all have been making the annual journey either to Kiel (where activities include seaweed picking, fishing, and/or drying seaweed and halibut), or to Old Town (where activities include gathering berries or fishing salmon in the Quaal River), in several cases since they were children (see also Turner et al. 2012). Many are adept at navigating the waterways on boats, some while fishing for herring, crabs or halibut, and many also reported annual digging for cockles and clams. Though hunting is less common than fishing, seaweed picking, or digging for shellfish, there were several participants who spoke about animal trapping or about hunting for deer, moose, or seal. Though there was a slight tendency toward gendered division of these activities (with men interviewed more likely to report hunting, fishing, and digging for shellfish, and women more likely to report berry picking, seaweed picking, and halibut processing), each activity was identified with by both men and women. The dependence on reliable weather patterns in order to take part in these activities signifies a meaningful level of expertise related to environmental conditions. The timing and success of these activities is often closely associated with environmental conditions related to the tides, winds, precipitation and/or temperature.

[23] All individuals who signed up or who were recommended to me but whom I was unable to meet with for were taken note of for future reference.

4.3.2.2 Interview process

I conducted all interviews in person. In Hartley Bay (nine interviews), they most often took place in the home of the participant(s), though two took place in the Band Office and one along the boardwalk leading up to the lake. In Prince Rupert, three took place in a private room of the library of Northwest Community College, one in a participant's home, and one at a participant's workplace. Each interview lasted between one and two hours.

Spencer Greening, community-appointed research assistant, was present at and participated in all interviews except two, while Dr. Turner attended seven before departing for Victoria. The interviews typically began with a short recap of the project aims and a few examples of potential discussion topics, and permission for video or audio recording was solicited. The interviews were very loosely structured and mostly driven by participants' own exploration of themes and topics that they were most interested in discussing. We only drew on the interview guide (Appendix 4.B) if we sensed that the participant was more comfortable with a more directive approach, or when a participant seemed to run out of things to say.

Additionally, I designed two optional written exercises. One of these was a table of trends where a participant could specify the existence and direction of a climate trend (precipitation intensity, for example) in general or in a given month or season (Appendix 4.C). Another was a blank seasonal calendar where the participant could depict the traditional timing of notable weather events and associated harvest (Appendix 4.D). I included these as optional exercises for anybody who enjoyed structuring their ideas in such a manner. Seven participants (or pairs of participants) accepted one or both of these exercises and three have completed and returned them.

4.3.2.3 Interview analyses

Four participants declined to have their interview recorded, and the analyses for these interviews were based on notes taken by myself, by Dr. Turner, or by Spencer. For those interviews that had been recorded, I transcribed them using NVivo for Mac, a data management software for qualitative analyses.

Transcriptions (or interview notes) were sent off to participants for their review using the email address that they had provided at the time of the interview.[24] Participants could specify what they meant by a given statement, could mark off sections for non-inclusion within my analyses, and could also add new thoughts or observations that either hadn't occurred to them in the interview or had transpired in recent months. Most participants didn't respond with any changes, and their interview notes or transcriptions have been used as originally recorded.

I coded the interview transcriptions using NVivo. From here, the interview content was explored by theme and organized in a file for my reference, as well as compiled into Appendix 4.E wherever participants mentioned a change that signified a trend over the longer term (identified at the time of the interview as having changed in their lifetime).

4.3.3 Climate data

4.3.3.1 ClimateBC software

The web-accessible ClimateBC software, developed by the University of British Columbia's Centre for Forest Conservation Genetics (CFCG), is a valuable source of free downscaled climate data for the coordinates of a user's choice (Wang et al. 2012). The program downscales data from climate records to provide more accurate estimates of localized climates in topographically complex areas, such as in the mountainous coast of British Columbia.

The methods are described in Wang et al. (2012). The developers of the program began with a spatially continuous temperature and precipitation dataset averaged over the years 1961-1990, obtained from the Parameter-Elevation Regressions on Independent Slopes

[24] Two participants didn't leave an email address but chose instead to receive their transcriptions in the care of Spencer, who could go over the documents with them

(PRISM) climate group. This dataset is based on weather station data, digital elevation models, and expert knowledge of climate patterns. After employing techniques to transform this 1961-1990 averaged dataset into a more high-resolution reproduction of temperature and precipitation over the province, they used the delta approach to superimpose historical (from a database) and projected (from the CMIP5 climate model ensemble) deviations from the 1961-1990 average onto the *downscaled* 1961-1990 baseline. A ClimateBC user can therefore obtain a data value for any given variable (e.g. December precipitation) in any given year and location that will be based on a much higher-resolution surface than if they accessed data directly from the PRISM climate group. For historical estimates, they found that this greatly increased the accuracy in matching historical station data for individual locations (though they had more success in increasing accuracy for temperature than for precipitation variables, and they found that accuracy increased the most for years following 1960).

The software allows a user to specify coordinates and to select a historical year (1901-2013) or historical thirty-year period (such as 1971-2000) if they are interested in viewing past climate data for a particular region. Alternatively, one can specify a future thirty-year period (such as 2010-2039), climate model ensemble, and greenhouse concentration scenario (Van Vuuren et al. 2011) in order to obtain estimates of future climate based on different climate models or rates of global emissions. The output is a collection of 23 annual variables, 56 seasonal variables (fourteen variables calculated for every season), and 168 monthly variables (fourteen variables calculated for every month). Examples of these variables are 'annual number of frost-free days', 'mean winter temperature', or 'August precipitation'. Some of these variables are directly measured data (as in monthly maximum temperatures) and some are derived through simple calculations (such as the frost-free period). Figure 4 is a screenshot of the web-accessible version of the ClimateBC user interface (available from http://cfcg.forestry.ubc.ca/projects/climate-data/climatebcwna/#ClimateBC).

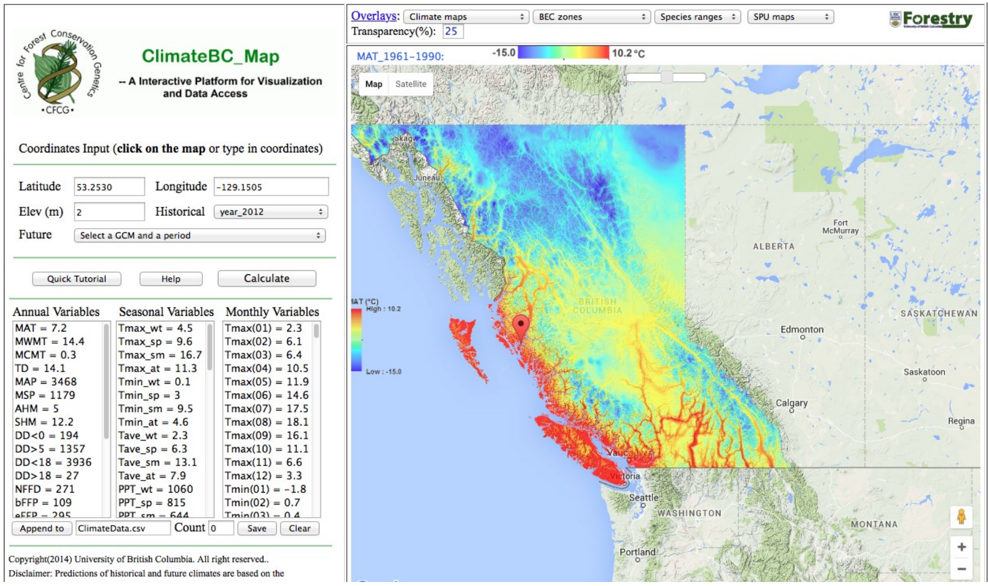

Figure 4.1. A screenshot of the input and output fields of ClimateBC for the coordinates corresponding to Hartley Bay. The user in this case has chosen to obtain downscaled climate data for the year 2012. The output consists of 23 annual, 56 seasonal and 168 monthly variables and can be downloaded in an Excel file (Wang et al. 2012).

4.3.3.2 Data analyzed

As an initial test of the reliability of the ClimateBC data, I performed a graphical comparison with an Environment Canada station available for the same coordinates. The Environment Canada data spans the years 1974-1995 but is quite patchy, as a marine weather buoy (whose incidence in the waters near Hartley Bay has been sporadic) was used to collect the data. I selected six variables from Environment Canada that had data for all of the years between 1974-1995 and that had corresponding ClimateBC equivalents. The results of the graphical comparison (fig. 4.2) show that both temperature and precipitation variables from ClimateBC (blue line) and Environment Canada (red line) tend to co-vary over time, though much more closely for temperature than for precipitation. This is not surprising, given the limitation described by Wang et al. (2012) about the accuracy of their precipitation data. The Environment Canada data was also quite limited, however, in that several years did not contain data for all twelve months, and the average for the year will therefore be inaccurate. Environment Canada years with four or more months missing were marked on the graphs as a reminder of the less reliable nature of these years' data.

4.3.3.3 ClimateBC regression analysis

To explore changes in temperature and precipitation variables over time, I performed regression analyses for each of my chosen climate variables as a function of time in years (1901-2013) using R (version 3.2.1), a free statistical computing software. I recorded the t-statistic and the significance level of each of these, in order to glean which climate variables had changed between 1901 and 2013, what the nature of each change was, and how pronounced it was.

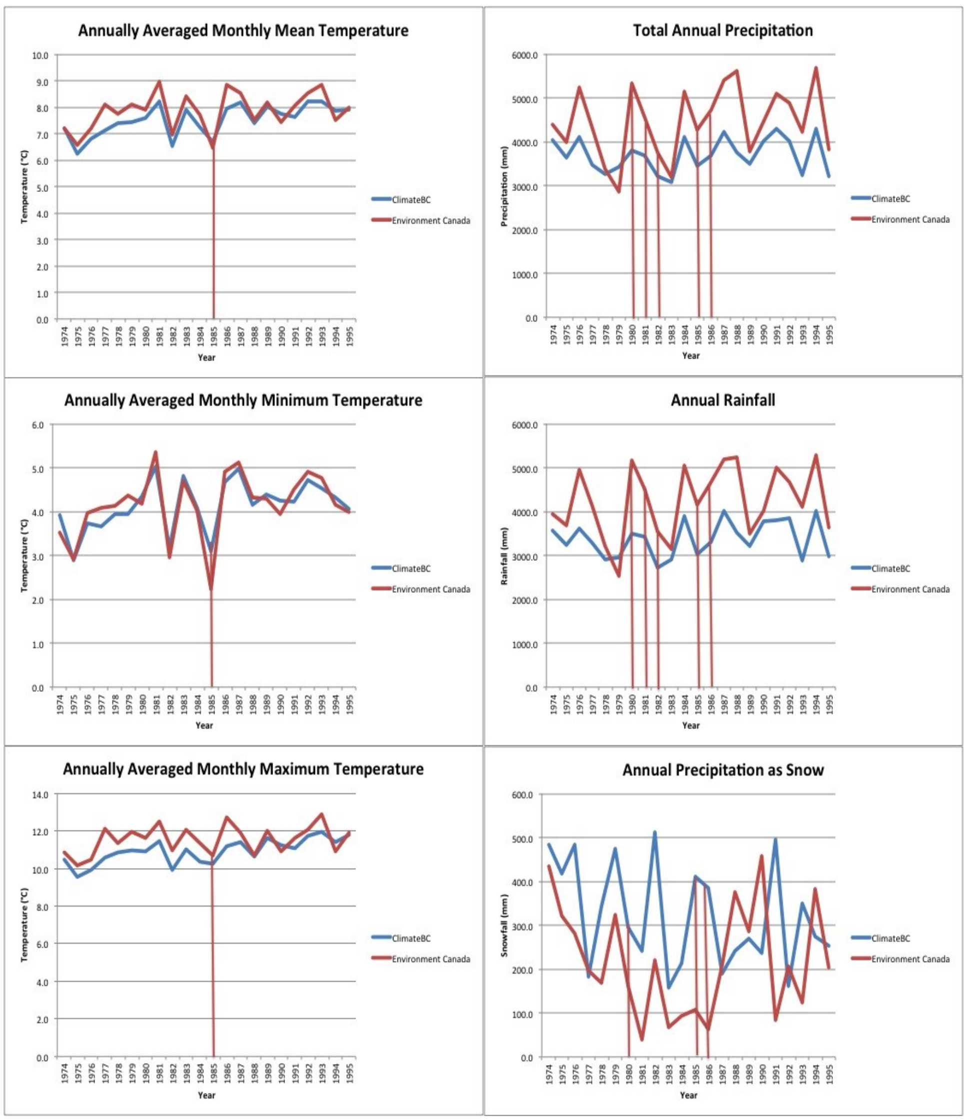

Figure 4.2. Comparison between ClimateBC downscaled data and historical Environment Canada data 1974-1995 for three temperature variables (left) and three precipitation variables (right). Years with incomplete Environment Canada data are indicated by red bars.

4.4 Results and discussion

4.4.1 Interview observations of climatic changes in Gitga'ata territory

A summary of the general trends mentioned by each participant can be viewed in Appendix 4.E. These are strictly limited to climatic changes, however, and I draw more on the context surrounding these observations for the discussion that follows below.[25] This study's focus on weather has largely omitted discussion of Gitga'ata knowledge of important species and ecosystem dynamics not related to climate or weather, and this has resulted in limited opportunities to present the underlying worldviews, institutions, and management practices of Gitga'ata knowledge systems.[26] Wherever possible, I have attempted to include these as direct quotations from participants, but this discussion focuses mainly on the observational knowledge of the Gitga'ata as it relates to detecting climatic trends, outlining the baseline climate of the territory through understanding of seasonal weather patterns and associated harvesting activities, and generating hypotheses related to some of these changes.

4.4.1.1 Temperature

Participants identified winter, spring, and autumn as being warmer than in the past, though some described May as cooler. Some identified the month of September in particular as "hot and dry", with additional participants citing more extreme hot days in the autumn months.

Observations of summer temperatures were more variable – at least two participants claimed that summer temperatures are lower now, and another specified that they seem to be lower in the morning at Old Town. Another participant said that the warm days have

[25] Participants who chose to remain confidential do not have their names mentioned in the discussion.

[26] Despite my discussion of literature condemning the separation of knowledge from its context, for example, I found my attempts at including these elements from my interviews continually challenged by the sheer volume of in-depth knowledge to convey in a single chapter. Further to this, I worried that my own understanding of the species, ecosystem processes, management systems, social institutions, and worldviews discussed in interviews would be too limited to represent these knowledges with any grace, and in fact encountered this uncertainty even in relation to weather, of which participants' discussion was rich and complex.

become hotter, indicating that while he didn't sense an overall difference in summer temperature, he found that the days considered hot were getting hotter.

The methods through which participants observed or described these changes sometimes involved a straight-forward detection of change (such as when Kyle Clifton told us "we don't get the big cold snaps in the wintertime [anymore]" or when Darryl Robinson joked that he didn't need to observe snow volume to tell him that winters are becoming warmer, because it's "really evident with the kids walking around in shorts and T-shirts"). Examples also abound of the observed effects that these temperature changes have had on daily activities (such as that in May, the rocks are no longer hot enough to dry seaweed on), and of locally-generated hypotheses that provide astute possible explanations for the changes. One participant noted that the boardwalk around the village and up to the lake didn't last as long anymore, and wondered if it was because the grains in the cedar planks weren't as tightly knit, due to accelerated growth from increased temperatures.

Increased winter temperatures, observed by at least nine participants, were evidenced not only through decreased snowfall (discussed in section 4.4.1.3 below), but in the waters of the territory. Mary Reece remembered a time when they would fill in the outdoor basketball court with water in the winter to make a skating rink, and said it's been a long time since they've been able to do so. Similarly, Darryl Robinson as well as a CCAP workshop participant said that the lake wasn't freezing over anymore, and that it hadn't been safe to skate on it for many years.

Nicole Robinson recounted the change in Old Town winter temperatures: "It's kind of cold up there but not like it used to 'cause the river would freeze just about down to Man Made [Island] and now it doesn't". Archie Dundas remembers advice that his father used to give him. "Even around here I guess at Union Pass my dad said it used to freeze up right between Union Pass. 'Cause he always told us to watch out when we'd go up there in the winter, because we might get stuck in there, 'cause of the ice."

Chief Ernie and Lynne Hill described how cold the air in the Channel used to get: "We [haven't] seen, you know, not for a long time, the whole channel would be smoking, literally smoking! Well I guess it [wasn't] smoke. But it's so cold, and the ocean is so warm, [that] maybe a hundred feet above the water, maybe more, you [couldn't] see! You [couldn't] even see the whitecaps anymore [...] It [was] really dangerous."

Many have also noticed a change in temperature around their fishing activities. Mary Reece told us that September needs to be cool in order to properly smoke the fish, but that it has been hot in recent years. David Robinson and Darryl Robinson both said that the fish are swimming deeper to avoid warmer surface temperatures, making it more difficult to catch them, and one participant said that the shellfish populations are also moving downslope in the intertidal zone. Darryl Robinson said that one year, there was actually an over-escapement (i.e., too many fish reaching the spawning grounds) in the river but that they were much harder to catch anyway. At the Coho hatchery in Hartley Bay, they're seeing incredible changes in the life cycle of their salmon. The eggs usually develop eyes in late January or early February, and they hatch at the end of March or beginning of April. When I conducted my fieldwork in early March 2015, they had already hatched − in January. Forty percent of the eggs perished before they could hatch, afflicted by the fungal diseases that warm water temperatures help to spread.

Many people were eager to discuss the past couple of years in particular; one participant explained that there have been "crazy different" temperatures in the past five years. The winter in which I visited (2014-2015) was described by every participant as being unusually warm. Mary Reece remembered a very cold July 2013 at Old Town, followed by a significantly warmer September 2013. One participant described summer 2013 as the hottest summer in Hartley Bay in her memory. Cam Hill remembers bullhead fish dying in the river that summer, a function of warm temperatures as well as very little rainfall. In 2014, the Coho salmon at the hatchery needed to be released in late spring rather than early autumn, because the water level was so low and the water becoming so warm. One participant watched anxiously as river temperatures first went up to 17°C, then 20°C the next morning, and 25.5°C the day after− this was the hottest he had ever seen them, and salmon fry begin to die if temperatures are sustained above 20°C.[27] Unfortunately, they don't currently have the means to regulate the water temperature at the hatchery. Their only option when temperatures get too hot is to release the fries when

[27] Interview with author, March 2015

they are still young and vulnerable, so that they can seek the shade and coolness of deeper stream waters.

Not all participants believed that temperatures are showing lasting trends. One participant asserted that temperature has shown year-by-year variability but no long-term trend, while another acknowledged a recent trend but with the belief that it will get very cold again one day. One workshop participant said that there have always been temperature cycles over 40-50 year time periods. This individual may be referring to the Pacific Decadal Oscillation (PDO), which has shown regime shifts every 20-30 years over the past century. Incidentally, the PDO switched onto a warm phase in spring 2014, signaling that sea surface temperatures have become warmer in the tropical and Northeast Pacific. At the same time, we began a new positive El Niño phase this spring (NOAA 2015).

4.4.1.2 Rain

Quite a few participants mentioned that it rains more often, and several believed that rainfall is getting heavier, with one participant informing us that "you see it splash two feet off the boardwalk". Several people talked about more frequent landslides behind the village, which they said were probably caused by heavier rains. Four people explicitly said that winter rain has increased, though this was also implied through discussion of negligible snowfall compared to in the past (section 4.4.1.3 below). Several participants observed increased spring rain volume and intensity, with some specifying that it had increased in the month of May. More frequent and intense rainfall in the autumn was discussed as well. Two people specified that it's particularly intense in September and that the overall volume has increased the most in October, and one participant said that it seems like the autumn rains are coming later every year.

It's a bit more difficult to discern a pattern in peoples' discussion of summer precipitation. One person described it as becoming more intense and shorter in duration, claiming that it now rains like "cats and dogs" in the summer months. Another participant said the summer rain seems to have become more mild in intensity, and that he doesn't go through his rain gear as quickly as he used to when he's out on a boat all day. Three others mentioned an increase in August rain, the time at which they're supposed to be able to hang Chum and Pink salmon on cedar branches to dry in the wind at Old Town during sunny periods. When asked about summer rain, most people referred to the more recent years of 2013 and 2014, when conditions were unusually dry. People spoke about the river drying up enough to cross it on foot, fish dying in the creeks, and the emergency release of salmon in 2014.

Discussion of rain was closely linked with river levels. It's clear that in the summer, the interacting factors of temperature, rain, and the previous winter's snowfall determine the health of the river system. Mary Reece said that in the summer that she could walk across the river, the preceding winter (2012-2013) hadn't even been as warm as the current (2014-2015) one was, and she was worried about the river levels for fish that year.

In autumn, on the other hand, the rains are so heavy that they are causing flooding of one to three feet by Coho creek, where a shack by the hatchery needed to be tied down last year to avoid it being swept away. These rainy autumns are also causing heavy erosion in the little river by Chief Ernie and Lynne Hill's house, which their son Cam Hill worried might undercut and destabilize the bank that their house rests on. Cam had an idea to try to stabilize the bank with rocks, possibly carving them with petroglyphs first, a skill he had been learning and practicing.

At Old Town, the rivers are not fed by a lake (as in Hartley Bay), but rather by snow and precipitation run-off through the mountains. Archie Dundas thought it had become more rainy there, " 'cause I remember long ago when I used to go up there with my dad we used to have to be draggin' our boats up there, but now you don't have to drag unless we get stuck up there and the tide goes down. We don't really ever have to drag the boat anymore."

One of the most frequently repeated concerns was that it was raining more often during the drying season at Kiel. These are the months in May when the edible red laver seaweed, *Porphyra abbottiae*, is picked from the rocks at low tide and the halibut is fished (Turner et al. 2006). The seaweed is then laid on the hot rocks in squares, where they are dried in the sun for about three hours on each side. The halibut is cut into thin strips called ***wooks*** and hung to dry in the wind and sun, also being turned and adjusted to ensure even and thorough drying (Appendix 4.D). In the past twenty years, however, there has been more rain in those weeks around May when these activities take place. In addition to interview and CCAP participants who referred to rainier springs, four people mentioned increasingly rainy May months at the CCAP workshops, and three people talked about it in interviews as well. People are finding it necessary to freeze their seaweed until July or later, when it can be dried, and one participant even mentioned that there is so much moisture in the air it now takes her two or three days to dry seaweed even in the summer months. The possible associated shifts in prevalent May winds that brings these rainy periods is discussed below in section 4.4.1.4.

4.4.1.3 Snow

Of those who discussed snowfall, there wasn’t a single participant who didn’t recount their memories of Hartley Bay winters in the old days (Appendix 4.D). Stories of snow piled up to rooftops, of twenty-five feet falling in a season, of children sledding off their houses, and of the never-ending job of shoveling the boardwalks were nostalgically communicated during ten of my interviews, and at three of the four CCAP workshops.

On the use of cross-country skis and snowshoes, Lynne Hill said “Well we used to use them every year. It was a winter thing that we would go out and cross-country ski all over the place here. That hasn't happened [lately]... And they were just taking up space in the school, so...”

One recurrent theme in these discussions was the amount of work and collaboration that used to go into keeping the village clear of snow. “Families shoveled snow together”, said Helen Clifton. Darryl Robinson told us, “I remember when my dad and them used to shovel the road in Hartley Bay. They were going 24/7. Like they'd shovel the road in the morning get it cleared off for the kids to get to school, lunchtime, just before lunch they're shoveling again so the kids could get home for lunch, and then after school they're doing it again, and then after supper they're doing it. After our fathers finished shoveling the roads, we used to take those shovels and dig tunnels. Tunneling through the village." Lynne Hill remembers that "People would be out, everybody would shovel together, the roads. Well the cohesiveness of people doing that together hasn't happened for a while, either, but there hasn't been the need to do that. I don't mind, I hate the snow!"

Another indication of snowfall, though just as closely related to annual temperature as to snow volume, is that the snowpack on the mountain directly across from Hartley Bay is disappearing faster in the summer months, whereas it used to remain well into the summer. In 2012, one workshop participant said that it seemed to them that the mountain snowcaps had been re-building in recent years. In our early March 2015 interview over two years later, however, Nicole Robinson said that the week previously the mountain had been completely devoid of snow. "Grandma used to say 'Kids can't go swimming 'till all the snow has melted off the mountain across', so we'd be sitting here in the summertime, like I was about 7 or 8 then, and we'd be watching all the kids swim [...] So we'd have to sit there and I'd always watch the mountains across, the snow melt. And I was thinking of that last week because there was no snow on the mountain and I got kind of giggly thinking, 'the kids can go swimming now'! [...] See the snow pack used to last right into the summer, then, because I remember it would be about July or something before we were allowed to go swimming [...] It's getting less and less."

The volume of snowfall and the depth of the snowpack are closely related to the health of important harvested species. Without the slow spring melt to ensure a continual feed of cool water to the rivers, the fishing streams heat up and remain lower than in the past, once or twice drying up altogether in the past ten years. Several participants mentioned the negative impact that this has on the fish, which require cool and well-flowing waters.

Not only is there less snow in winter, but the snow season used to extend much later than it does today (Appendix 4.D). Darryl Robinson recounted the years when they would still have many feet of snow for Easter. "When Easter celebrations would come along, some years we'd be lucky that we'd get a southeast before and the snow on the field would be gone but most of the time, everybody's 'Well what are we gonna do? There's no place to play the games! [To] have the races!' So we'd shovel two, four, five feet of snow, off of the area maybe the size of this college, shovel it right into the ocean. So we'd have a kind of place to play the games for Easter celebrations!" Though not as common as these snowy Easter weekends, Chief Ernie Hill recalled that they would sometimes get large dumps of snow as late as April. "I remember [a] time in late April when they were doing repairs on the school, the guy laid out all his stuff, it was a beautiful day, and the next day he was gonna start, we got two feet of snow. Everything was buried, all his equipment..."

Hartley Bay and Prince Rupert do still sometimes get unexpected snow later in the season, but these snowfall events tend to happen when spring has begun early. A few people mentioned the damaged seaweed tips that occur when it snows or hails at low tide and the seaweed is growing. Kyle Clifton was talking about spring blossom times in 2015 when he voiced his concerns about late snows. "Beginning of March and there's flowers, salmonberry flowers, around. A little bit of a warm winter and it's starting early. But that's a bit scary 'cause we had that a few years ago where everything started early like this and then towards the end of March we had a foot and a half of snow in Rupert. We had these blackberry bushes in our backyard that are dead, they're gone, just from that one snowfall. They were starting to grow and then the whole thing died." Another participant said that it seems that the snow is starting later, but then is followed by an unexpected and sudden spring. The timing of seasons is discussed more in section 4.4.1.6.

As with temperatures, some participants didn't believe there has been a consistent trend and instead noted that every year is different when it comes to snow. This is supported by mentions of years as recent as 2009 when they received 22 feet of snow, and the record for Hartley Bay was only fifteen years ago, when they received 29 feet. Some did acknowledge that there is less snow than there used to be but that snow, like temperatures, occurs in cycles and that snowy weather will return to the territory again.

4.4.1.4 Wind

Because prevalent winds in Hartley Bay vary on many different temporal and spatial scales, it was difficult to reconcile all the many discussions of winds and their close connection to rainfall, snow, and storms. I've drawn together discussion around several main themes from the interviews and CCAP workshops. Additionally, the seasonal weather calendar (Appendix 4.D) is a handy tool in understanding the prevalent seasonal winds and the weather that they bring.

One theme that emerged from interviews and CCAP workshops was an overall lack of predictability in winds compared to in the past. Several participants mentioned the suddenness with which the weather can change when one is out on the water, and that it is getting more difficult to read the signs. David Robinson told us that he believed winds were getting stronger and more unpredictable, and that he once went out in his boat on a beautiful day and got caught in a terrible storm.

Cam Hill talked about the shifts in local wind that have been occurring in isolated areas on the water. "It's hard to learn how to judge those [local winds]. I mean really, the only thing to do now is to expect them. And it's different, because we really haven't been taught, you know, being brought up to fish, get your gear out there, before the wind comes, leave it out there when the wind's there, go and pick it up when the wind slows done. It's getting harder and harder to judge that because sometimes the wind switches so quickly now, and it's from a different direction."

Another important theme of discussion around winds was their prevalent direction in a given month or season. In winter, for example, the cold weather and snow used to come about as a result of a north wind, which would persist for at least three weeks of winter (Appendix 4.D). Usually, according to Chief Ernie Hill, the northwest winds would blow down the channel all day, but haven't done so in some time. Darryl Robinson told us of his time growing up in Hartley Bay, "Northerly outflow, guaranteed your temperature was gonna drop 10 degrees." But these northerly winds have been replaced by more and more frequent southeasterly storms. These bring rain instead of snow, keep the weather mild, and influence the tides (the boardwalk has been flooded these past three years due to these storms). Several participants said that the shellfish harvest was negatively impacted as a result. One CCAP participant also said that the winter storms are stirring up the red tide (harmful algal blooms), which usually remain buried in these months (Appendix 4.D).

Interestingly, one participant said that they are getting more north wind in summer, causing what he calls sunny yet cold “Julanuaries”. This could be a possible explanation for the cold summers mentioned by several others.

One major theme that emerged from both my interviews and the CCAP workshops is that a shift in prevalent wind direction over the past twenty years in Kiel is what’s responsible for the rainy weather during the harvesting and drying season. As with winter, people cited increasingly southeasterly winds, which bring rain and storms. These replace northwest winds at Kiel, which typically bring clear weather and dry winds. Kyle Clifton described this shift and the effects on Kiel activities. “A lot of the times in May, one of the times you probably want to dry things in May was that you'd have the north wind that would come and bring the sun and you'd have a few days to dry halibut. There's been a lot of years that we haven't had the northwest. It ends up being southeast the whole time, and it makes things a lot harder having to dry halibut and seaweed in the house 'cause it doesn't come out the same as drying it in the sun. Seaweed starts collecting in the flavors in the house and the smoke from the fire so it ends up tasting different than if it was dried in the sun and then put it away properly. And the quality of the halibut's different being dried in the house, too.”

Another impact observed was the increasingly severe erosion of the beach at Kiel and at Hartley Bay, which a few participants said is being caused by the increase in storms from the southwest and southeast.

4.4.1.5 Storms

Most participants characterized storms as events with high winds and heavy rain. The review of wind-related observations (in section 4.4.1.4 above) made it clear that increased southeast winds in winter and in May are bringing stormier conditions. In this section, I review some of the other themes around storms that emerged through interviews and CCAP workshops.

Closely tied in with the unpredictability of winds, storms are exhibiting less predictable behavior, something that can be quite dangerous when one is out on the water. Tony Eaton told us that you always need to be cautious and very prepared when heading out on to the water, so that you have the proper fuel and equipment if bad weather should suddenly hit. One journey from Bow Point to Fin Island, for example, took him nearly eight hours instead of the usual one hour, due to strong wind and waves.

Between the CCAP workshops and my interviews, there were mixed results about whether storms were becoming more frequent and about their timing (particularly in the autumn/winter months). However, several people said that they seem to be becoming more intense in general. Two people said that the months of October, November, December, and January are seeing more intense storms. One person mentioned that the storms at Kiel from the west, southwest and southeast are not only more frequent but more intense as well. Many people discussed the Thanksgiving storm that took place on October 10th, 2010, which was so powerful that it blew off the roof of the cultural center in Hartley Bay. Darryl Robinson remembered that day as the day that he and the other employees of the King Pacific fishing lodge had to evacuate their guests to safety.

Still, many seemed not to be sure whether they were really becoming more intense or not, and one participant who spends a lot of time on the water said that storms come in cycles. He believed that some of them have gotten pretty strong lately but that it’s not indicative of real long-term change.

4.4.1.6 Changes to general weather patterns

Quite a few people, in addition to elaborating on specific changes, told us that weather just seems to be more unpredictable now. At the CCAP workshops, one participant said that the new "normal" for them was unpredictable weather.

In the sections above I outlined how storms and winds are becoming more unpredictable. Two participants also talked about how temperature extremes seemed to be occurring more frequently and more sporadically, with no regard to the season they are currently in. According to Cam Hill, "It goes from one extreme to another, with a southerly wind it's so warm, and a month later, November 11th long weekend, just pouring down rain, and when it's raining it's warm, and then it switched to frozen. And it was just within a 24-hour period you're going from +8 to -10. With all that rain saturated into the ground you've got water lines freezing, fuel lines freezing, it just happened too quick, those are the kind of extremes the weather has taken over the past 10-12 years." Nicole Robinson, who spends a lot of time at Old Town in the summer and autumn, said that on October 9th 2012 "it was 25 degrees and I was sitting there tanning. And then two days later it snowed on the mountains. It was nuts." She also remembers a day in April 2013 at Kiel when she was "lying on a log tanning again, and two days later it was really cold again".

A few people mentioned that the timing of the seasons and associated harvesting activities has shifted to occur later and later every year over the past decade. One person said that the first snowfall in Hartley Bay used to occur in late October or early November, but that it has been postponed to late November or early December.

Chief Albert Clifton noted the delayed progression from summer to autumn:

> It seems like our fall weather's not coming early enough. You expect by mid-September, you start getting a mix between [summer and fall]. And it's not happening. The summer weather is still stronger than the fall weather [...] In our language, my father used to tell us stories about the different weathers, there is the battle of the weathers. I don't remember because they were talking in [Sm'algyax] most of the time. But those guys

> that really were able to forecast weather, they understand the battle of the weather in different seasons.

Several people also mentioned the odd incongruity in timing between certain weather patterns and plant phenology. A CCAP workshop participant said that their indicators are out of sync with each other, meaning that the occurrences of two phenological events are no longer linked, limiting the extent to which they can be used to predict each other's condition. It is becoming more difficult to predict when berries and seaweed will be ready, as discussed by Turner and Clifton (2009). A few people also talked about the snow and hail that is occurring more in seaweed growing season, which damages the seaweed when it is exposed at low tide.

Kyle Clifton discussed his early-budding blackberry bushes, which were killed when it snowed toward the end of March, in section 4.4.1.3. Another participant recounted a similar phenomenon during our March interview, adding that the pollinators are out of sync with these early blooms. "Actually the plants are coming out earlier. In the last five years. They've been budding but then they get that shock of [late] winter. Winter wants to attack one more time. My cherry tree was flowered two weeks ago! And that's way too early [...] And we don't have the flies, the honey flies, the pollinators, out to pollinate them."

Three participants mentioned something that they found very odd: that the weather in Hartley Bay seems to have become “unlinked” from Kitimat's. In the past, they could rely on receiving a very similar amount of snowfall as Kitimat, situated approximately 60km northwest, at the eastern end of the Douglas Channel (fig. 1.1). Chief Ernie Hill remembers the time that they each got five feet within a twenty-four hour period, a record for the region. Yet more and more in the past five years, they don't get the same volume of snow that Kitimat does. In the 2014-2015 season, two participants mentioned that Kitimat received about 8-10 feet of snow while Hartley Bay received under 10 inches—a vast difference.

Also of note is several participants' knowledge about weather cycles over multiple timescales. Knowledge of similar phenomena in their own or their parents' (or grandparents') lifetime informs a view of climatic processes as non-linear, and therefore some of the changes to temperature, storms and snowfall outlined above are within their frame of reference for expected variability over long time scales. The El Niño and Pacific Decadal Oscillations are examples of cyclical changes that can occur within a linear trend taking place in the longer term. This corresponds to literature discussing the ability of some Indigenous groups to distinguish trends and significantly unusual occurrences from natural variability (Barnhardt 2005; Turner and Clifton 2009; Peloquin and Berkes 2010; Ignatowski and Rosales 2013). It could be an indication that for certain climatic variables, the changes that have taken place so far have not yet exceeded the range of variability experienced by those who remember or who have been told of such abnormal conditions occurring in the past. Darryl Robinson said, after acknowledging that changes are occurring, " 'Course, it's in cycles, they come back. And the Old People who were alive when it happened will tell you 'yes this is happening again'".

4.4.2 ClimateBC regressions 1901-2013

Appendix 4.F shows the direction and significance of all trends identified through the regression analyses. Of the 137 variables analyzed, 67 had significantly changed over time. Appendix 4.G is a list of variables found to be non-significant.

Many of these results were exactly as expected. All variables that showed significant changes between 1901-2012 were consistent with the expected signal of warming temperatures, as shown in Figure 4.3.

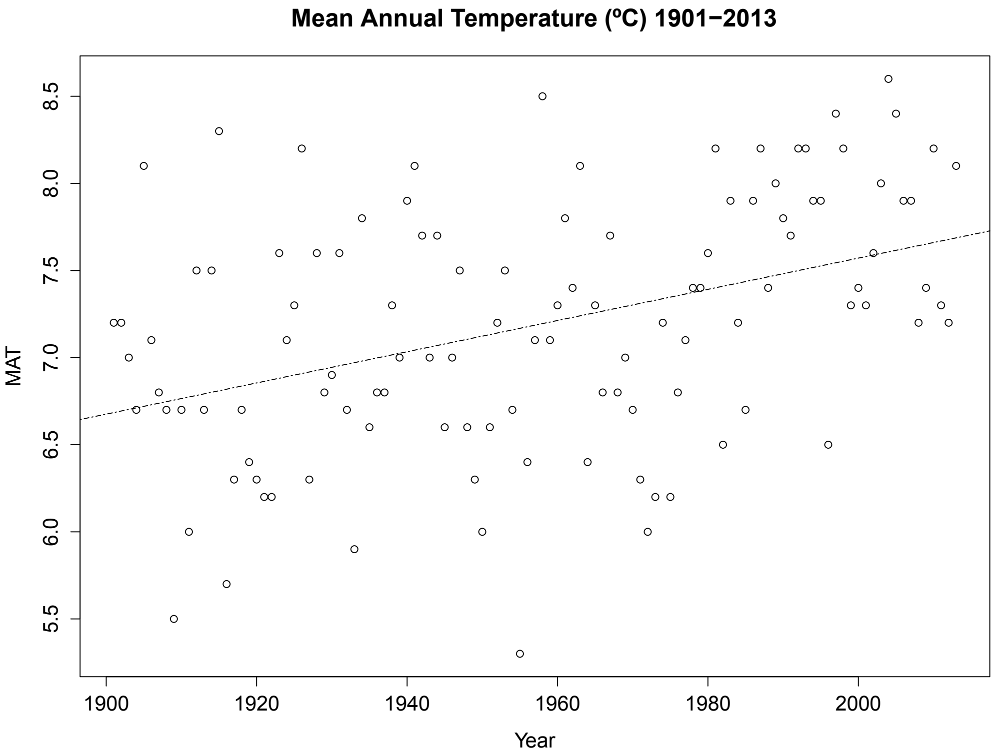

Figure 4.3. Regression plot showing the mean annual temperature response to the variable of time in years. Mean annual temperature increased significantly between 1900 and 2013. Data from ClimateBC.

The variable 'precipitation as snow' decreased significantly with time, both as a seasonal total (fig. 4.4) and also for individual months. This is consistent with the trend corresponding to the coastal region of Hartley Bay in Zhang et al. (2000), who interpolated historical climate data over the surface of Canada for the years 1950-1998. It is worth noting that snowfall trends from ClimateBC are less consistent with historical data from Environment Canada than most other variables (Figure 5). Importantly, however, this result is clearly supported by the overwhelming evidence from participants that snowfall has decreased drastically since their childhoods.

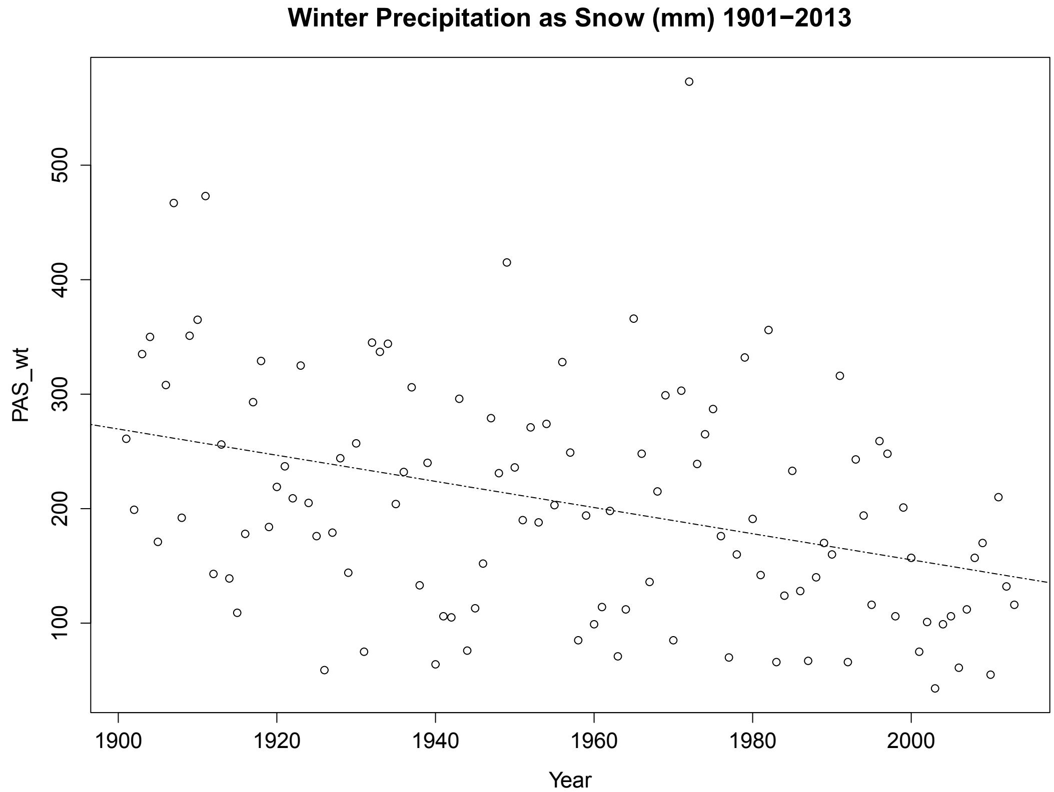

Figure 4.4. Regression plot showing the annual snowfall response to the variable of time in years. Mean snowfall decreased significantly between 1900 and 2013. Data from ClimateBC.

Minimum temperatures were more likely to show significant increases than maximum temperatures, and with higher associated significance levels, in agreement Zhang et al. (2000) and with Rodenhius (2009), who downscaled climate data for the years 1900 and 2004 for British Columbia. The frost-free period had clearly lengthened, with earlier start dates and later end dates, in accordance with Bonsal and Prowse (2003) in their historical overview of spring end and autumn arrival dates in Prince Rupert from 1900 to 1998. The season with the most significant increases in monthly average temperature was winter, consistent with the future climate projections found for the region by Christensen et al. (2007).

There were several surprising results as well. Most remarkably is that not a single precipitation variable (other than 'precipitation as snow') showed a significant trend over time. This was perhaps most puzzling in regards to the month of May, which has consistently and repeatedly been cited as increasingly rainy by those who have traditionally harvested seaweed for much of their lives− the month of May is called ***ha'li' la`x la``'a`sk***, "the month for gathering seaweed" (Turner et al. 2006; Turner and Clifton 2009).

Possible explanations for the lack of significant precipitation trends can be usefully speculated on. Firstly, pioneers of the ClimateBC program have claimed that their software less reliably models precipitation than it does temperature (Wang et al. 2012). My own visual comparison to Environment Canada data (fig. 4.2) supports this conclusion.

Secondly, the seaweed harvesting camp of Kiel is situated over an hour away from Hartley Bay by boat and seems to have a different micro-climate. For instance, Chief Ernie Hill mentioned in his interview that it hardly ever snows in Kiel, even when the village receives several feet in the winter season. When I analyzed the spring precipitation data for Kiel coordinates, however, the results were no more significant than at Hartley Bay. Wang et al. (2012) acknowledges that although their downscaled data accounts for local elevation (and thus is more high-resolution than a typical spatially interpolated dataset), small-scale topography (like slope and frost pockets) and local geographic features (like rivers and lakes) are not captured. It is easy to imagine that the intricate channels, narrow angles and local wind patterns associated with the fjord topography in Gitga'ata territory may produce precipitation patterns that are not represented in the data.

Solar radiation reaching the surface had significantly decreased in the spring season, consistent with widely cited recently-occurring lack of sunshine in the last two weeks of May in Kiel, traditionally relied upon to dry the seaweed on the rocks (and the halibut ***wooks*** on cedar poles). Solar radiation for May, however, showed no significant changes. Possible explanations are that ClimateBC doesn't reproduce solar radiation at the surface very reliably, or that the trend mentioned by participants (usually cited as occurring in the past twenty years) isn't long-term enough to be detected in the ClimateBC time series.

Immediately apparent is that the autumn months have the least significant change associated with them. Of all the seasonal variables explored, autumn was significantly associated only with 'degree-days above 5ºC', a variable that was found to be significantly positive for each one of the seasons and all of the months except October, November, and December, indicating it was September driving the significance of that trend for autumn in the first place. Indeed, when examining the monthly variables it becomes clear that while September has had a few significant changes associated with it (higher mean temperature; higher minimum temperature; fewer chilling degree-days; and an increase in growing degree-days), October and November have experienced no significant change in any of the variables analyzed, while December experienced an increase in mean temperature and nothing more. While peculiar, these findings support participant observations that Septembers have become significantly warmer.

One highly relevant and much-discussed community concern related to June-September temperatures is the lower stream levels and higher stream temperatures in the summer months/ early autumn, a trend that has resulted in an impaired ability of the salmon stock to make their way into their native streams for spawning. Though maximum temperatures in these months haven't increased, minimum temperatures have, and so have average temperatures in all months except July. Summer stream levels, however, are a function not only of temperature but also of summer precipitation (which is potentially unreliably estimated by ClimateBC) and by the preceding year's snowpack (which has decreased significantly).

Maximum temperatures in late winter, early spring, and summer also have an impact on salmon health. Specifically, the water temperatures at the Coho hatchery are important in maintaining an environment conducive to egg survival and fry endurance. The waters at the hatchery have warmed markedly in recent years, with several years (including 2014) requiring a three-month early emergency release of fry into the river so that they could reach the safety of deeper waters, and many years in which eggs are more susceptible to the spread of deadly fungus and death because of exposure to warm hatchery river temperatures. Salmon can temporarily tolerate water temperatures of 20ºC, with lethal temperatures occurring at 25ºC.[28] Maximum temperatures in January, March, and April all showed highly significant increases.

4.4.3 Benefits and limitations

4.4.3.1 Parallel knowledges

Tengö et al. (2014) suggested that researchers working with different types of knowledge should aim to bring those knowledges together in parallel and sometimes overlapping narratives, without giving priority to one or the other. They encourage the evaluation of the "strengths and weaknesses" of each type of knowledge in order to identify areas where their mutual use provides particularly rich insights. In my results and discussion, I have examined Gitga'ata interview and workshop observations both separately and together with historical downscaled climate data from ClimateBC, approximating the overlapping narrative design outlined in the Multiple Evidence Base approach (Tengö et al. 2014). Here I outline the main areas of complementarity and of agreement between these two knowledge sets.

As already noted, Wang et al. (2012) point to the fact that while their downscaling methods consistently resulted in significantly higher prediction accuracy for temperature variables, there were more mixed results with precipitation when analyzing individual years, due to the stochastic nature of precipitation events (Wang et al. 2012). Community knowledge of changes to precipitation can therefore be helpfully relied on for knowledge about changes to rain or snowfall.

Given the size of the territory and its mountainous terrain, microclimatologies do come into play in the region. When a participant asserts that a given change has occurred at Old Town, only 19 km north in the Douglas Channel, but not at Hartley Bay, that change might not be reliably detected by ClimateBC data (even if using Old Town coordinates to run the program) because it is indicative of highly local processes not captured in ClimateBC data. This points to another advantage of community observations, which is a

[28] Interview with author, March 2015.

depth of observation and knowledge for a place that is thus far impossible to capture even in the presence of an actual weather station, which can provide data at an extremely local scale (Wang et al. 2012) but which cannot describe the unique behavior of weather across a region.

All data obtained from ClimateBC pertains to temperature, precipitation, or radiation. However, I interviewed community members about other weather variables (such as wind, storms, and timing of weather events). Participants outlined their observations with memories of specific events, with information about the usual occurrence of prevalent weather in specific parts of the territory, and with a multitude of effects that these changes have in the ecosystem of the territory. The depth and completeness of this knowledge is not something that a model or dataset could ever approximate easily or reliably.

ClimateBC, however, is able to provide unique, quantified estimates of specific climatic variables for each of the years between 1900 and 2013. In cases where the community is in need of data or analyses specific to their territory for planning or for future research, this dataset provides a valuable resource. Somebody who wanted to study phenological changes around the village, for instance, could make excellent use of the degree-day data if they knew the degree-day requirements of the plants under study, in order to understand whether the health of a valued plant species is threatened by recent and future climate change.

The ways that my ClimateBC analyses assigned significance and that a community member assigned significance to a given change are also very different. In my climate data analyses, I relied on statistical tests to determine whether a change in the territory could be deemed ‘significant’. More recent trends are unlikely to be detected, as I pointed out when speculating on the differences between ClimateBC data and interview observations for precipitation and solar radiation. Many people have started noticing climate change impacts only over the past twenty years – quite a significant period of time in somebody’s life, yet perhaps not quite long enough to be statistically detected in a regression. Arguably, an entire lifetime of reliable seasonal weather that has begun to change noticeably in the past twenty years is indeed highly 'significant'.

If one were to base the outcome of my interviews on Appendix 4.E (on-going weather trends from interview analyses) alone, it would seem that people weren't very forthcoming with changes that they've observed in the territory. This couldn't be further from the truth. Though there were only a few people who volunteered their observation of a sustained, long-term trend for each discussed variable, there was so much information conveyed during these interviews. Instances of very unusual individual years, for instance, were discussed in great detail. Ultimately, people were less likely to talk about straightforward weather trends than they were to talk about the impacts that they've felt in their daily lives. Harvesting, travel, and sociocultural impacts were discussed much more often and in much more detail than isolated weather variables, and this is another area of high complementarity between these two types of knowledge. Further work could highlight these elements rather than focusing on weather changes.

Table 4.2 shows a list of long-term trends identified in interviews and CCAP workshops, and whether or not these are supported by results from the ClimateBC regressions. Given the complementarities outlined above, tables such as these offer only limited insight into the contribution that mixed-methods analyses can provide the research community. While it is valuable to have an idea of which variables in ClimateBC are bolstered by the support of on-the-ground observations, the real advantage of drawing on different knowledges arguably lies in the areas of non-agreement.

4.4.3.2 Main benefits of this research

The Gitga'ata initiated this research, and the CCAP program, in part because they are eager to record their peoples' knowledge for future generations. The interview materials have all been given to the community for inclusion in their Knowledge Bank, for use in future research, or other applications of their choosing.

Table 4.2. Long-term weather trends from interview and CCAP analyses, and corresponding ClimateBC variable if reflected in the regression analyses. The number of participants who endorsed a trend is included, with the portion of the total from CCAP workshops included in parentheses. Since participants guided the interviews based on topics that they are particularly interested in and knowledgeable about, the number of participants listed represents the number who chose to speak on that topic. A lack of endorsement from others, therefore, is not necessarily a reflection of disagreement. (Adapted from Ignatowski and Rosales 2013).

Observation	# Participants	ClimateBC Support and Comparative Variable
Warmer **winter temperatures**	10 (1)	Yes (Tave_wt)
Warmer **spring temperatures**	3	Yes (Tave _sp)
Cooler **May temperatures**	1 (1)	No
Warmer **summer temperatures**	2	Yes (Tave_sm)
Cooler **summer temperatures**	2 (1)	No
Warmer **autumn temperatures**	3	No
Warmer **September temperatures**	2 (1)	Yes (Tave09)
Warmer **summer maximum temperatures**	1	No
Warmer **September maximum temperatures**	1	No
More **rain overall**	5	No
More **winter rain**	3 (1)	No
More **spring rain**	5 (2)	No
More **May rain**	3(2)	No
More **summer rain**	2 (2)	No

More **autumn rain**	5 (1)	No
More **October rain**	2	No
Less **snow volume**	13 (3)	Yes (PAS; PAS_wt; PAS_sp)

The main themes outlined in the discussion could serve as an important basis for planning. Though changes in Kiel have already been outlined extensively (e.g. Turner and Clifton 2009), and many of the changes discussed in interviews were previously mentioned at the CCAP workshops, my synthesis of CCAP and interview observations resulted in a few themes that haven't previously been discussed at length. Examples of these are prevalent wind directions and stream levels.

The community knowledge recorded here, taken together with the regression results, could serve as the basis of community planning activities through the provision of an up-to-date compilation of some of the current knowledge on climate change impacts in the territory.

4.4.3.3 Limitations and recommendations

There are several substantial limitations to my methodology. I relied on temperature and precipitation data from ClimateBC as my sources of climate information, but future research could obtain or calculate other climatic data as well. Wind station data, for instance, could bring further insights into the changing wind patterns of the region, but was beyond the scope of this research. A second source of precipitation data could have been useful, as ClimateBC calculated precipitation volume but not intensity, in addition to the limitations already discussed. Another interesting approach would have been to try to calculate weather persistence, as Weatherhead et al. (2010) did in their work with the Inuit in Baker Lake, Nunavut, because several Gitga'ata have mentioned the lack of weather predictability in their territory. Finally, an analysis that explores the recent shift away from weather co-evolution between Hartley Bay and Kitimat (as pointed out by several participants) might reveal some of the underlying mechanisms of Hartley Bay's main weather changes over the years.

As for my interview methodology, my interviews could have benefited from a bit more structure, purely as a means of affording more clarity to the interview content and resulting analyses. I never asked, for example, if the participant believed there *hadn't* been a trend, or if they simply didn't *know* if there was one, in a given variable under discussion (when they responded in the negative to a question about a specific change).

Finally, because the individuals speaking were not usually identified in the CCAP workshop documents, there might be some degree of overlap between participants at these workshops and in my interviews, which means that if I specify that a given trend was communicated both in my interviews and at the CCAP workshops, it may have been voiced by the same participant.

4.5 Conclusion

The changes in weather patterns taking place in the territory of the Gitga'ata are significant, rapid, and of high concern to many in the community. The salience of their stories is made stronger, perhaps, as policy-makers and governmental leaders refuse to take immediate measures to mitigate the worst of these impacts.

There exists a wide range of possibilities for continued climatic change in Hartley Bay, according to ClimateBC projections (which rely on three different climate model ensembles and three different scenarios of atmospheric concentration of greenhouse gases). By mid-century (2050), average annual temperatures could increase by anywhere between 1.4°C and 3.7°C, while annual snowfall could decrease by 4.5- 16 cm. With these climatic changes would come further impacts to weather predictability and safety out on the water, to peoples' ability to harvest and process important food species, to survival of forest and food species in their territory, and to the health of river systems, among many others.

This case study uses a mixed-methods approach to document the environmental changes taking place at the local level. As the contributions of Indigenous communities for climate change research are increasingly recognized, new research partnerships can provide in-depth and comprehensive accounts of how global climate change is manifesting itself in a multitude of localities. The Gitga'ata are knowledgeable about their territory and about the dynamics of and linkages between the climate system and their coastal ecosystem. They have detected long-term trends and occurrences so unusual that they fall outside the expected range of variability; they have a developed an adaptive understanding of the baseline climate and phenological progression of the territory; and they rely on their understanding of and connection to their territory to support hypotheses that explain changes that exceed what they have directly or communally experienced.

"The Gitga'ata have always adapted" was a constant refrain in my conversations with community members in March. Of the resourcefulness and abilities of the Gitga'ata people, there can be no doubt. Having endured the effects of colonization, the mismanagement of their communal resources by commercial fisheries and logging industries, the changes to their traditional foods and practices from modernization and globalization, and now the system-wide effects of global atmospheric greenhouse gas accumulation, they have demonstrated incredible resilience.

However, these rapid and often deleterious changes to their lifeways have not been without some damage to their knowledge systems. Many members of the community expressed fear or hopelessness when discussing their children or grandchildren's futures, because of the sheer number and scale of the changes taking place. Threats of major tanker traffic in their territory, uncertainty about fish stocks, a federal government with seemingly little interest in community well being, and other perturbations to Gitga'ata self-governance converged with the environmental changes taking place so that "climate change" became an all-encompassing term to describe everything that this community has had to deal as each new challenge presented itself.

A major concern for participants was whether these changes were too numerous and were taking place too quickly for their knowledge systems to be able to adapt, and they felt were losing the reliability with which they could make predictions about their territory.

Several participants talked about teaching their children or grandchildren the traditional ways and how it was much more difficult to do so now that so much had changed. This concern is evident in the adaptation goals developed through the CCAP, many of which centered on the strengthening of traditional knowledges and facilitation of knowledge transmission to younger generations (Reid et al. 2014). As Whyte (2015) articulated, a future shaped by community values rests largely on the strength of traditional knowledge systems.

The stories and examples shared here are illustrations of Gitga'ata TEK of their lands and waters, and are only a small subset of the vast repertoire of knowledge gained from my interviews. The Gitga'ata endeavor to make sustainable decisions as stewards of their changing territory and are taking measures to record and strengthen their knowledge for future generations, and to have this knowledge inform meaningful adaptation strategies. Our national and global communities would do well to follow their example. Cam Hill, at the conclusion of our interview, articulated his concern for his community as well as his determination that the Gitga'ata overcome the challenges currently facing them.

> It's hard to observe that stuff when you know that the change is happening. And everybody says change is good but this change isn't good. We need to arm ourselves. [...] As a people, we've all been taught to be resourceful and to deal with what comes your way, and to be able to fight through and power on and do whatever, but when you see so much happening around you, it really is scary because if there's one thing that I've been taught, you listen to nature. You don't fight it. In any way, shape or form. I think nature's pretty pissed. And we're gonna be the ones that are gonna suffer. Not because she's vindictive or mean, it's what we as a people on this whole earth have done to it, and are continuing [to do]. I mean the powers that be in governments all over the world don't really give a care. And the people that are living the lives that I believe that if everybody followed, a Gitga'at way of life, and people must get bored of me saying it, it's so repetitive [..] It's simple you just take what you need and you use what you take, no more, no less. There's no money exchanging hands, I share with you guys what we've gotten, and it'll always be there. It'll always be there to go around. But we're talking about powers that are infiltrating our way of life. [...] I'm gonna take your word for it that we're gonna be resourceful and deal with what comes our way, but this is gonna be a tough one. This is gonna be tough to deal with.

CHAPTER 5

CONCLUSION

The field of climate change is one of several that are growing receptive to Traditional Ecological Knowledge as a resource for increased understanding of ecological and physical systems. Research investigating local climate change impacts, sustainable policy solutions, or adaptation measures could benefit greatly from the insight and wisdom that can be gained through partnerships with knowledgeable Indigenous communities.

These benefits have been demonstrated in many studies and are reflected in my research. This study, initiated by and conducted with the Gitga'at Nation, a member of the Southern Ts'msyen cultural group, supports global evidence that climatic changes are occurring at an accelerated rate. The discussion of Gitga'ata observations in Chapter 4 also ties community knowledge in with modelling studies for the region. In light of the high proportion of Canadian studies examining climate change in relation to Arctic Inuit communities, this study demonstrates the significance of changes taking place in the coastal temperature rainforest territory of a First Nations community, highlighting the fact that rapid impacts are already occurring even outside of the Arctic Circle.

The joint consideration of community knowledge and downscaled climate data lends increased confidences to areas of high agreement between the two (as was the case with most temperature variables analyzed) and, perhaps more interestingly, provides insight into the ways that community knowledge can offer an understanding of complex local-scale processes that are not reliably detected through scientific investigation alone.

The benefits resulting from such a mixed-methods approach, however, should not lie only with the researcher but should contribute to community planning, governance, or knowledge strengthening. The joint development and implementation of a research plan is of vital importance, as is continued discussion and opportunities for feedback once the research is in its final stages. Indigenous concepts of two-eyed seeing (Iwama et al. 2009) and relational accountability (Wilson 2001) can be of significant value in ensuring that researchers remain flexible, open, and attentive to their responsibilities, while frameworks that address researcher best practice at the starting point, process, and output stages of research are valuable tools in planning for and conducting research that is productive and meaningful.

The strengths of this research are first and foremost the contributions of the Gitga'ata community to a field in which knowledge of local climate change impacts are scarce. Also, in adhering to community timelines and in benefitting from having Dr. Chris Picard, Dr. Nancy Turner and Spencer Greening as teachers, my approach to this research was more comprehensive, the analyses more stimulating, and the results more provocative.

A focus on the interface between western scientific frameworks and Traditional Ecological Knowledge is quickly becoming recognized for its utility in climate change studies, but communities may want to carry these studies out themselves. One potential strength of this study is that it is easily replicable. I employed a standard semi-directive interview format and made use of free, open-access downscaled climate data, which can currently be obtained for any point in North America (http://cfcg.forestry.ubc.ca/projects/climate-data/climatebcwna/). The analyses that I performed on these data were simple regressions using the free statistical software, R.

This study also has many limitations, including the number of interviews conducted. The nineteen individuals who participated are only a small number of the living experts and knowledge-holders among the Gitga'ata. Related to this, a low proportion of knowledge collected through these interviews was actually utilized for this study. This was a result of time limitations as well as a thematic focus on climatic change, but the knowledge recorded in these interviews related to cultural traditions and management practices, underlying paradigms related to the environment, inter-generational knowledge transfer, adaptive approaches, and detailed observations of changes in valued species could be of great value in further documenting Gitga'ata knowledge of environmental change or in exploring matters of adaptation and food security (e.g. Ford 2009). In addition to a report summarizing the results of this study, I plan to send all interview transcriptions in their original forms and categorized by these themes to the community.

Another limitation is the extent to which I truly engaged with the community at all stages of my research. Though I evaluate this in Chapter 3 as emerging largely from institutional challenges and from my restraints as a graduate student, I also discuss missed opportunities for the co-production of ideas and directions that resulted from insufficient communication on my part.

In order to better inform a comprehensive understanding of the climatic changes taking place in Gitga'ata territory, climate data sources other than just ClimateBC could have been useful. Data from wind stations or marine monitoring stations are examples.

The significance of this project for climate change researchers lies, on one hand, in the methodologies employed and on the other, in the results obtained. The easily-replicable methods could allow other researchers or members of Indigenous communities to initiate a similar project, though it should be remembered that this work was the extension of a more comprehensive, long term and applicable climate change adaptation plan (CCAP; Reid et al. 2014). The results outlined in Chapter 4 serve to flag some of the climate changes taking place within the coastal Pacific Northwest. Perhaps some of the broad changes identified as significant by both the community and the downscaling program could be generalized to a larger region.

Chapter 3 highlights the unique circumstances for students or climate change researchers interested in engaging in research partnerships with Indigenous communities, and this chapter could act as an introduction to some of these issues for some. Its purpose is to serve as a tool for information and support regarding Indigenous research partnerships in a formal academic context, which is currently considered by some to be a vacuum for both (Louis 2007; Castleden et al. 2012; Klocker 2013).

Community uses for this research may include its combination with CCAP and other research for adaptation planning, its application as the basis for future research, and its inclusion in community research archives. Interview transcriptions in particular could make a valuable addition to a future knowledge bank or to the Old Town project (which is being developed by Dr. Dana Lepofsky of Simon Fraser University, March Wunsch of Quadra Island, and by Dr. Nancy Turner in collaboration with the community, and which will bring multiple forms of media together in one central interactive database on the subject of Old Town).

The Gitga'ata might also make use of this study as evidence in applications for grants related to specific adaptation projects, or otherwise locate segments of the interview transcriptions that would be of use to them in their continued pursuit of Aboriginal Rights and Title.

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APPENDICES

Appendix 3.A- Table of frameworks for meaningful research

	Starting Point	Process	Outcome
Indigenous Research Methods (Louis 2007)	Rights and regulation: abide by Indigenous protocols outlining their goals and considering potential impacts of the research Honor all agreements, contracts and protocols before academic requirements	Respectful representation: listen to others' ideas and accept Indigenous Peoples' decisions about the treatment of their knowledge Indigenous collaboration and participation Knowledge sharing	Reciprocal appropriation: obtain benefits for Indigenous people and researcher Gain community endorsement of findings Intellectual property and Indigenous ownership over their knowledge
Multiple Evidence Base (MEB) Approach (Tengö et al. 2014)	Reach an agreement with one's partner community on the problems and goals to be pursued by the research	Bring the knowledge together equally and with consideration to the strengths and weaknesses of both Develop and implement joint analyses/ evaluation of knowledge and insights	Develop and implement joint analyses and evaluation of knowledge and insights, identifying knowledge gaps, new hypotheses, and further areas for collaboration

Collaborative Research Methods (Menzies 2001/2004)	Negotiation with and approval from Band Council/ administration; hereditary chiefs and matriarchs; and individual community members Honor commitment to community before academic considerations and funding or university timelines	Create research teams comprising community members to facilitate knowledge transfer, secure important community knowledge and skills, and increase opportunities for community self-reliance During writing, analysis, revision, and distribution, remain in contact, update frequently, and share all access to resources	
Community-based participatory research (Castleden et al. 2008) (Mulrennan et al. 2012)	Community-defined research agenda about project scope, decision-making, and research approach	Collaborative research process: Identify team Methodologies supporting knowledge cross-fertilization	Meaningful research outcomes: Real progress toward community goals Training opportunities Mobilizing knowledge of the land Accessible findings Capacity building and social learning Long-term relationship

Appendix 4.A- CCAP workshop observations of changes in weather

WEATHER

CATEGORY	OBSERVATION	OBSERVATION DATE(s)	Nov-12	Jan-13	Aug-13	Feb-14	LINK WITH OTHER OBSERVATIONS	OBSERVER
Precipitation								
	More moisture in the air		◆					
	Really intense rains year 2012	2012		◆	◆			
	Rain came in big downpours	2012			◆			
	Increased rains make it harder to garden	Spring	◆				PLANTS	
	Rain that used to come in early April comes in late April or May	April/May		◆				
	Dry soil to plant in	Spring		◆			PLANTS	
	Rains wash away soils		◆				PLANTS	
	Water-logged crops		◆				PLANTS	
	Waterlogged salmonberries		◆				SALMONBERRIES	
	More rain during drying season; Possibly due to winds; 20-year trend	Spring/ Summer	◆	◆			WIND; SEAWEED	
	Rain that used to occur in early spring pushed off until May; there used to be 2-3 day breaks in the rains to dry seaweed	April/May		◆			SEAWEED	
	Increased rain leads to rotten seaweed tips	Spring		◆			SEAWEED	
	Less seaweed in the past 30 years	Spring	◆				SEAWEED	
	Change in pH?		◆				SEAWEED	
	Increased rain; seaweed doesn't like freshwater		◆				SEAWEED	
	Increased hail damages seaweed at low tide		◆					

WEATHER

CATEGORY	OBSERVATION	OBSERVATION DATE(s)	Nov-12	Jan-13	Aug-13	Feb-14	LINK WITH OTHER OBSERVATIONS	OBSERVER
Weather								
	New normal= unpredictable weather;		◆			◆		HB; PR
	Dangerous/difficult travel conditions		◆					
	Can't predict timing of things like berries, seaweed etc. Indicators no longer applicable		◆				MARINE SPECIES; PLANTS	
	More extreme weather past 10 years				◆			PR
	Fewer storms, but bigger when they arrive		◆					Marven
	No storms winter 2012/2013	Winter 2012/2013			◆	◆		
	Weather patterns coming later		◆					PR
	Weather is moving south							
	Storms used to be windier		◆				WIND	Jenny
	Southeast storms preventing snowfall	Winter	◆				WIND; PRECIPITATION	
	More frequent and intense south-easterly storms influence tide; shellfish harvest impacted	Winter	◆				WIND; SHELLFISH; TIDES	
	Winter storms are stirring up red tide; normally remain buried	Winter 2011/2012	◆				ALGAE	PR
	Hail occuring in seaweed harvesting season	Spring		◆			SEAWEED	

WEATHER

CATEGORY	OBSERVATION	OBSERVATION DATE(s)	Nov-12	Jan-13	Aug-13	Feb-14	LINK WITH OTHER OBSERVATIONS	OBSERVER
Precipitation (cont'd)	More freshwater at mouth of river from bigger stream flows (increased precipitation and faster snowmelt)		◆				**SNOW; OCEAN SALINITY**	
	Causes bigger waves		◆				**MARINE ENV'T**	
	Seaweed doesn't like fresh water		◆				**SEAWEED**	
	Lots of crabapple blossoms in spring but never ripened; maybe due to rain	Spring 2012	◆				**CRABAPPLES**	
	Dirty rain over past 3 years (possibly due to fire dust)	Summer	◆					
	Wetter summers	Summer	◆					
	Very wet spring and summer, with rotten berries, but then three solid weeks of sun	Spring/ Summer 2012	◆				**SALMONBERRIES**	
	Drier summers since 2010	Summer		◆				
	Lower summer stream levels	Summer					**RIVERS**	
	No rain summer 2013	Summer 2013			◆			HB; PR
	Waterfalls and creeks all dry summer 2013	Summer 2013					**RIVERS**	PR
	September usually rainy; only 3-4 days of rain 2013	September 2013	◆			◆		
	More rain in Autumn	Autumn		◆				
	Rivers so full it's difficult to fish at old villages	Autumn					**FISH**	
	No time to dry coho; used to get two weeks of sun at end of September	Autumn					**FISH**	
	More rain in winter overall	Winter	◆					

WEATHER

CATEGORY	OBSERVATION	OBSERVATION DATE(s)	Nov-12	Jan-13	Aug-13	Feb-14	LINK WITH OTHER OBSERVATIONS	OBSERVER
Precipitation (cont'd)	Boardwalks not lasting as long; possibly due to more rain		◆					
	Soccer field flooded a few times past few years		◆					
	More slides on hills along Grenville channel and behind village, even in areas never logged; erosion from heavy rains		◆				**LANDSLIDES**	
	Increased river flow changing wave patterns and increasing erosion, landslides		◆				**RIVERS; LANDSLIDES; MARINE ENV'T**	
	More fog earlier in the year and more in summer				◆			

Appendix 4.B- Semi-directive interview guide

FLEXIBLE INTERVIEW GUIDE- WEATHER AND PHYSICAL SYSTEMS

Have you noticed a change in ____________ for a particular month or season, compared to in the past?

- When did you first notice this change?
- Is it an ongoing trend or a one-time occurrence?

Have changes in ___________ impacted your or others' **ability to harvest a certain resource**?

Have changes in ___________ impacted the **availability, behavior, or health** of certain species?

Theme: Precipitation
Rainfall
Fog
Local snowfall
Mountaintop snow
Hail

Theme: Temperature
Seasonal
Annual
Extreme hot events
Extreme cold events
Glaciers

Theme: Storms
Frequency
Intensity
Duration

Theme: Wind
Strength
Direction
Frequency/duration

Theme: Ocean
Sea level rise
Storm surges
Tides
Currents

Theme: Freshwater
Rivers, creeks
Lakes

FLEXIBLE INTERVIEW GUIDE- RESOURCES AND BIOTA

Have there been any changes in the **abundance** of ______________ ?
Do you have a theory about why this is happening?

Have there been any changes in the **distribution** of any ____________ ?
Do you have a theory about why this is happening?

Have there been any changes in the **behavior** of any _______________?
Do you have a theory about why this is happening?

Have you noticed **new kinds** of _______________ in the territory?
Do you have a theory about why this is happening?

Theme: Marine Resources
Fish: Halibut, salmon, rockfish, others
Seafood: Cockles, clams, crabs, chiton, abalone, sea urchins
Marine plants: Edible seaweed, kelp, other

Theme: Plant Resources
Berries: salmonberry, salal berry, blueberry, other berry
Crabapple bushes
Trees: Cedar trees, orchard trees, other trees
Garden plants
Flowers

Theme: Animals Resources and Wildlife
Wildlife: Bear, deer, moose, wolves, mink, others
Birds: Songbirds, seabirds, other birds

Theme: Insects
Bees
Butterflies
Mosquitoes
Flies

Appendix 4.C- Table of trends (Optional exercise 1)

CLIMATE TRENDS

Participant Name: ______________________________

Date: ________________

Please indicate with with arrows (🡅, 🡇) whether you think a weather variable (like rainfall) has increased or decreased in your lifetime.

You can say whether it has increased (🡅) or decreased (🡇) in a certain month (put an arrow in individual boxes), in a certain season (put an arrow in a season's group of colored boxes), or overall (put an arrow in the "annual" box for that weather variable). You can indicate no change with (--).

You choose what you want to include! Some boxes can be left blank!

	Rainfall Amount	Rainfall Intensity	Snowfall	Average Temperature	Extremely Cold Days	Extremely Warm Days	Number Storm Events	Storm Intensity
December								
January								
February								
March								
April								
May								
June								
July								
August								
September								
October								
November								
Annual								

🡅= increase

🡇= decrease

-- = no change

Appendix 4.D- Seasonal weather calendar (Optional exercise 2)

Week	DECEMBER		
1	Sleet/Rain/Southeast storms (1)	Cockle digging during big tides (1); Cockles and clams when tide is right (2); Mussels, clams and cockles, tide dependent (3)	* Gathering shellfish depends on big low tides usually full moon (1)
2	Sleet/Rain (1)	Cockle digging during big tides (1)(2); Hunt seal, deer, moose depending on weather (2); Flounder jigging, weather dependent (3)	
3	Snow (1)	Pick gills at low tides (2); Cockle digging, depending on tides (2)	
4	Snow (1)	Cockle digging, depending on tides (2)	

Week	JANUARY	
1	North wind down Douglas Channel (1); -10°C temperatures (1)	Mussels, clams and cockles, tide dependent (3)
2	Snow (1)	Cockle tides (1); Flounder jigging, weather dependent (3)
3	Snow (1)	
4	Snow (1); 6-8 ft snow pile-up (1)	

Week	FEBRUARY		
1	Snow (1)	Mussels, clams and cockles, tide dependent (3)	* This month is when Nass/Skeena eulachon run appears (1)
2	Sleet (1); Melting snow (1); More rain (1)	Clam digging during big tides (1); Flounder jigging, weather dependent (3)	
3	Mix rain/snow (1)		
4	Mix rain/snow (1)		

Week	MARCH	
1	Rain (1); Regular southeast storms (1)	Rain (1); Collect herring eggs/ eulachons (2); Clams at low tide (3)
2	Rain (1)	Clam tides (1); Collect herring eggs/ eulachons (2); Clams at low tide (3)
3	Rain (1)	Kemano eulachon run (1); Trade for seaweed (1); Collect herring eggs/ eulachons (2); Clams at low tide (3); Rarely, can get abalone at right weather and tides
4	Rain (1)	Robins (1); Preserve eulachon grease (2); Clams at low tide (3); Flounder jigging (3); May get spring salmon (3)

Week	APRIL	
1	Sun/ Rain showers (1)	Growth of nettles same as seaweed (1); Abalone, spring salmon tide/weather dependent (3)
2	Sun/ Rain (1)	Hummingbirds (1); If an early spring you can get halibut, seaweed, snapper, ling cod, seal, sea prunes, chinese slipper (3)
3	Sun (1); Longer days (1)	Getting ready to move to Kiel spring camp (1)
4	Sun (1)	Gathering wood for stoves and smokehouses (prefer alder) (1); Prepare camp for Kiel (2)

Week	MAY		
1	Sun (1)	Fishing black cod, red cod, halibut, spring salmon (1); Filet and dry fish in sun (1); Low tide kitings (1); Seal (1); Halibut (3); Seaweed (3)	* Large mussels and cedar bark gathered *after* all halibut and seaweed has been dried, because it causes rain (1) (3)
2	Sun (1)	Low tide abalone (1); Low tide seaweed, picked and spread on rocks in squares 2" thick to dry, turned over 3:00 and gathered at 7:00 (1); Halibut (3); Seaweed (3)	
3	Sun (1)	Low tide seaweed, picked and spread on rocks in squares 2" thick to dry, turned over 3:00 and gathered at 7:00 (1)	
4	Sun (1)		

Week	JUNE		
1	Sun/ Intermittent showers (1); Westerly wind (1)	Finish processing of seaweed- roasted and chopped (1); Fish for sockeye to preserve in jars (2); All varieties salmon (3); Halibut, crab, abalone, berries, black cod, octopus, sea cucumbers, prawns, rock oysters (3)	* Village people move to canneries in June/July, and to the Skeena for salmon season, and still processing traditional food at home (1)
2	Sun/ Intermittent showers (1); Westerly wind (1)	Gather medicinal plants like devil's club, poison root and process, sun dry (1); Salmonberries and then blueberries and thimbleberries (3)	
3	Sun/ Intermittent Showers (1)	Gather medicinal plants like devil's club, poison root and process, sun dry (1); Pick salmonberries (1); Sockeye (3)	
4	Sun/ Intermittent Showers (1)	Mosquitos (1)	

Week	JULY	
1	Sun/ Intermittent Showers (1)	Sockeye is canned and smoked (1); Pick salmonberries (2) (3); Salmon (3)
2	Sun/ Intermittent Showers (1)	Bluberries/ Red huckleberries (1) (3)
3	Sun/ Intermittent Showers (1)	
4	Sun/ Intermittent Showers (1)	

Week	AUGUST	
1	Sun/ Southeast rains (1); Sun not as hot (1)	Move to Old Town camp (1); Geese/ Ducks/ Bear (1); Pick blueberries (2); Coho (3)
2	Sun/ Southeast rains (1)	Salaal/High bush cranberry/ Pigeonberry/ Rosehips (1); Crabapple (1)(3); Wild currents (3); Bunchberries (3)
3	Sun/ Southeast rains (1)	Coho salmon (1); Indian rice (3)
4	Sun/ Southeast rains (1)	Lot of black bear and cubs appear (1)

Week	SEPTEMBER	
1	Sun (1); Southeast rain blows into camp (1)	Fish coho for smoking and wooks (2)(3); Move back to Hartley Bay (1); May get berries (3)
2	Sun (1)	Indian summer 3 weeks (1); Crabapples (3); May get berries (3)
3	Sun (1)	Snow on mountains (1); Prepare to leave (1); Halibut (3); Crab (3); May get crabs (3)
4	Rain (1); Sun (1)	School starts (1)

Week	OCTOBER	
1	Rain (1); Sun (1)	Cockle digging, depending on tides (2) (3)
2	Rain (1)	Cockle tides (1)(2)
3	Mix fall weather (1)	Hunt deer and moose (1) Cockle digging, depending on tides (2)
4	Mix fall weather (1)	Cockle digging, depending on tides (2)

Week	NOVEMBER	
1	Rain/ Sleet (1); Few sunny days (1)	Men go trapping November/December and come back before real snow pack (1); Cockle digging, depending on tides (2); Duck hunting (2); Cockles, clams, mussles (3)
2	Sleet (1); Snow flurries (1)	Real snow pack (1); Cockle digging, depending on tides (2); White flamingoes at low tide (3)
3	Sleet (1); Snow flurries (1)	Cockle tides (1); Cockle digging, depending on tides (2)
4		Cockle digging, depending on tides (2)

Appendix 4.E- Weather trends from interview analyses

Participant	Winter Temperature	Spring Temperature	Summer Temperature	Autumn Temperature	Wind	Winter Wind	Summer Wind	Storms
A	Higher	Higher, with more extremely warm days	Lower	Higher, with more extremely warm days in September	No change			
B	Higher		Lower in morning		Stronger and more unpredictable			
C								
D								
E								
F	Higher				More outflows	More north wind		
G	Higher	Higher	Higher	Higher	More outflows	More north wind		
H								
I			Higher extreme temperatures		More unpredictable		Southerly afternoon/evening winds follow the usual morning northerly winds in the north prt of the territory	Big storms (usually mid-autumn to the end of winter) now occur mid-October to mid-November and mid-February to end of March
J								
K/L								
M				Higher in late August and September				Storms from W, SW and SE at Kiel are so intense that they're washing the beach away

Participant	Winter Temperature	Spring Temperature	Summer Temperature	Autumn Temperature	Wind	Winter Wind	Summer Wind	Storms
N	Higher							More intense/ frequent O-N-D-J
O	Higher					Less northwest wind		More intense/ frequent O-N-D-J
P	Higher							
Q	Higher	Higher	Higher	Higher				No change
R	Higher				Less north wind at Kiel in May, more southeast	Less north wind, more southeast		
S			Lower				More north wind	

Participant	Overall Rain	Winter Rain	Spring Rain	Summer Rain	Autumn Rain	Snow Volume
A	More intense	Increase, and more intense				Decrease
B						
C	More intense					Decrease
D	Increase, and more intense					Decrease
E	More intense, and shorter duration	Increase		More intense		
F	Increase					Decreased snowpack on back mountains
G	Increase					Decreased snowpack on mountain across channel
H	Increase		Increase in May	Increase at Old Town	Increase at Old Town	Decrease

Participant	Overall Rain	Winter Rain	Spring Rain	Summer Rain	Autumn Rain	Snow Volume
I	Increase			Increase in August	Increase, and more intense in September and contantly raining in October	
J				Increase in August	Increase, and more intense in September and contantly raining in October	
K/L						
M			Increase in May			

Participant	Overall Rain	Winter Rain	Spring Rain	Summer Rain	Autumn Rain	Snow Volume
N			Increase, and more intense in March and April		Increase, and more intense	Decrease
O			Increase, and more intense in March and April		Increase, and more intense	Decrease, and ending earlier in spring
P						Decrease
Q				Less intense		Decrease
R			Increase in May			Decrease
S					Later	Decrease in November/ December

Appendix 4.F- ClimateBC variables with significant trends

Category	Variable	Trend Direction	<0.05	<0.01	<0.001
Mean Temperature (ºC)	Mean annual temperature (MAT)	+	x	x	x
	Mean warmest month temperature (MWMT)	+	x		
	Mean coldest month temperature (MCMT)	+	x	x	
	Average winter temperature (Tave_wt)	+	x	x	x
	Average spring temperature (Tave_sp)	+	x	x	
	Average summer temperature (Tave_sm)	+	x	x	
	Average January temperature (Tave01)	+	x	x	
	Average February temperature (Tave02)	+	x	x	x
	Average March temperature (Tave03)	+	x	x	
	Average April temperature (Tave04)	+	x		
	Average June temperature (Tave06)	+	x		
	Average August temperature (Tave08)	+	x	x	
	Average September temperature (Tave09)	+	x	x	x
Continentality (ºC)	Temperature difference between warmest and coldest year (TD)				
Maximum Temperature (ºC)	Winter average maximum temperature (Tmax_wt)	+	x	x	x
	Spring average maximum temperature (Tmax_sp)	+	x		
	January average maximum temperature (Tmax01)	+	x	x	x
	February average maximum temperature (Tmax02)	+	x	x	x
	March average maximum temperature (Tmax03)	+	x	x	
Minimum Temperature (ºC)	Winter average minimum temperature (Tmin_wt)	+	x	x	x
	Spring average minimum temperature (Tmin_sp)	+	x	x	x
	Summer average minimum temperature (Tmin_sm)	+	x	x	x
	January average minimum temperature (Tmin01)	+	x	x	
	February average minimum temperature (Tmin02)	+	x	x	

Category	Variable	Trend Direction	<0.05	<0.01	<0.001
Minimum Temperature (ºC)	March average minimum temperature (Tmin03)	+	x		
	April average minimum temperature (Tmin04)	+	x	x	
	May average minimum temperature (Tmin05)	+	x	x	
	June average minimum temperature (Tmin06)	+	x	x	x
	July average minimum temperature (Tmin07)	+	x	x	x
	August average minimum temperature (Tmin08)	+	x	x	x
	September average minimum temperature (Tmin09)	+	x	x	x
Chilling Degree-Days	Annual degree-days below 0ºC (DD_0)	-	x	x	x
	Winter degree-days below 0ºC (DD_0_wt)	-	x	x	x
	Spring degree-days below 0ºC (DD_0_sp)	-	x	x	
	January degree-days below 0º (DD_0_01)	-	x	x	
	February degree-days below 0º (DD_0_02)	-	x	x	
	March degree-days below 0º (DD_0_03)	-	x	x	
	April degree-days below 0º (DD_0_04)	-	x		
	September degree-days below 0ºC (DD_0_09)	-	x		
Growing Degree-Days	Annual degree-days above 5ºC (DD5)	+	x	x	x
	Winter degree-days above 5ºC (DD5_wt)	+	x	x	x
	Spring degree-days above 5ºC (DD5_sp)	+	x		
	Summer degree-days above 5ºC (DD5_sm)	+	x	x	
	Autumn degree-days above 5ºC (DD5_at)	+	x		
	January degree-days above 5ºC (DD5_01)	+	x	x	
	February degree-days above 5ºC (DD5_02)	+	x	x	x
	March degree-days above 5ºC (DD5_03)	+	x		
	April degree-days above 5ºC (DD5_04)	+	x		
	June degree-days above 5ºC (DD5_06)	+	x		
	August degree-days above 5ºC (DD5_08)	+	x	x	

Category	Variable	Trend Direction	<0.05	<0.01	<0.001
Growing Degree-Days	September degree-days above 5ºC (DD5_09)	+	x	x	x
Frost-Free Period	Annual number of frost-free days (NFFD)	+	x	x	x
	Length frost-free period (FFP)	+	x	x	x
	Beginning date of annual frost-free period (bFFP)	-	x	x	x
	End date of annual frost-feriod period (eFFP)	+	x	x	x
	Winter number of frost-free days (NFFD_wt)	+	x	x	x
	Spring number of frost-free days (NFFD_sp)	+	x	x	x
	Summer numer of frost-free days (NFFD_sm)	+	x	x	x
Solar Radiation Reaching Surface (MK $m^{-2}d^{-1}$)	Spring solar radiation (Rad_sp)	-	x		
	January solar radiation (Rad01)	-	x		
	March solar radiation (Rad03)	-	x		
Precipitation as Snow (mm)	Annual precipitation as snow (PAS)	-	x	x	x
	Winter precipitation as snow (PAS_wt)	-	x	x	x
	Spring precipitation as snow (PAS_sp)	-	x	x	
	January precipitation as snow (PAS01)	-	x		
	February precipitation as snow	-	x	x	x
	March precipitation as snow	-	x	x	

Appendix 4.G- ClimateBC variables with non-significant trends

Category	Variable	Not Analyzed
Mean Temperature (ºC)	Average autumn temperature (Tave_at)	
	May average temperature (Tave05)	
	July average temperature (Tave07)	
	October average temperature (Tave10)	
	November average temperature (Tave11)	
	Average December temperature (Tave12)	
Maximum Temperature (ºC)	Summer average maximum temperature (Tmax_sm)	
	Autumn average maximum temperature (Tmax_at)	
	April average maxmimum temperature (Tmax04)	
	May average maximum temperature (Tmax05)	
	June average maximum temperature (Tmax06)	
	July average maximum temperature (Tmax07)	
	August average maximum temperature (Tmax08)	
	September average maximum temperature (Tmax09)	
	October average maximum temperature (Tmax10)	
	November average maximum temperature (Tmax11)	
	December average maximum temperature (Tmax12)	
Minimum Temperature (ºC)	Autumn average minimum temperature (Tmin_at)	
	October average minimum temperature (Tmin10)	
	November average minimum temperature (Tmin11)	

Category	Variable	Not Analyzed
Minimum Temperature (ºC)	December average minimum temperature (Tmin12)	
Precipitation (mm)	Mean annual precipitation (MAP)	
	Mean annual summer precipitation (MSP)	
	Average winter precipitation (PPT_wt)	
	Average spring precipitation (PPT_sp)	
	Average summer precipitation (PPT_sm)	
	Average autumn precipitation (PPT_at)	
	January precipitation (PPT01)	
	February precipitation (PPT02)	
	March precipitation (PPT03)	
	April precipitation (PPT04)	
	May precipitation (PPT05)	
	June precipitation (PPT06)	
	July precipitation (PPT07)	
	August precipitation (PPT08)	
	September precipitation (PPT09)	
	October precipitation (PPT10)	
	November precipitation (PPT11)	
	December precipitation (PPT12)	
Chilling Degree-Days	Autumn degree-days below 0ºC (DD_0_at)	DD_0_sm; DD_0_06; DD_0_07; DD_0_08
	May degree-days below 0ºC (DD_0_5)	
	September degree-days below 0ºC (DD_0_09)	
	October degree-days below 0ºC (DD_0_10)	
	November degree-days below 0ºC (DD_0_11)	
	December degree-days below 0ºC (DD_0_12)	
Growing Degree-Days	May degree-days above 5ºC (DD5_05)	
	July degree-days above 5ºC (DD5_07)	
	October degree-days above 5ºC (DD5_10)	

Category	Variable	Not Analyzed
Growing Degree-Days	November degree-days above 5ºC (DD5_11)	
	December degree-days above 5ºC (DD5_12)	
Frost-Free Period	Autumn number of frost-free days (NFFD)	
Solar Radiation Reaching Surface (MK m^{-2} d^{-1})	Winter solar radiation (Rad_wt)	
	Summer solar radiation (Rad_sm)	
	Autumn solar radiation (Rad_at)	
	February solar radiation (Rad02)	
	April solar radiation (Rad04)	
	May solar radiation (Rad05)	
	June solar radiation (Rad06)	
	July solar radiation (Rad07)	
	August solar radiation (Rad08)	
	September solar radiation (Rad09)	
	October solar radiation (Rad10)	
	November solar radiation (Rad11)	
	December solar radiation (Rad12)	
Precipitation as Snow (mm)	Autumn precipitation as snow (PAS_at)	PAS_sm; PAS06; PAS07; PAS08
	April precipitation as snow (PAS04)	
	May precipitation as snow (PAS05)	
	September precipitation as snow (PAS09)	
	October precipitation as snow (PAS10)	
	November precipitation as snow (PAS11)	
	December precipitation as snow (PAS12)	