OFFSHORE DRILLING AND ARCTIC TRADITIONAL FOOD SECURITY

OFFSHORE DRILLING: AN EMERGING ISSUE IN ARCTIC FOOD SECURITY

A REVIEW

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Abstract

Background: Due to global climate change, the melting of arctic ice has increased geopolitical interest in the land due to newly accessible oil reservoirs on the continental shelf. With the imminent rise in offshore gas drilling, this presents an additional threat to Arctic food security. Indigenous populations living in the circumpolar north face many challenges in accessing adequate and nutritional food sources. One of the most significant factors impacting food security is the availability of traditional food.

Objectives: To critically examine existing data and literature to discuss the impact of offshore gas drilling on traditional marine food sources. Additionally, the cultural, spiritual and physical health aspects of traditional food consumption will be determined.

Methods: Arksey and O'Malley's scoping review framework was adopted to examine the effects of offshore drilling activities on marine fauna. Furthermore, a literature review was used to determine the significance of traditional food to Canada Arctic Aboriginals.

Conclusions: Offshore drilling activities may impact the four dimensions (access, availability, utilization and stability) of food security, therefore threatening food security in the Canadian Arctic.

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Lists of all Abbreviations

EAR: Estimated average requirements

FAO: Food and Agriculture Organization

ILO: International Labour Organization

NEB: National Energy Board

NORMS: Normally occurring radioactive materials

PAH: Polycyclic Aromatic Hydrocarbons

PTS: Permanent threshold shift

PW: Produced water

TTS: Temporary threshold shift

3D: Three dimensional

2D: Two dimensional

USGS: U.S Geological Survey

Declaration of Academic Achievement

The following is a declaration that the content of the research in this document has been completed by Meghan Brockington and recognizes the contributions of Dr. John Eyles, Dr. Christina Moffat and Dr. Niko Yiannakoulias in both the research process and the completion of the thesis.

1. Introduction

Due to global climate change and the increase in earth temperature, ice in the Arctic is melting. As a result, geopolitical interest in the land has increased because of the potential accessibility of oil on the continental shelf. These undeveloped oil resources have one of the world's largest quantities of oil (World Wildlife Fund, 2009) and it seems inevitable that oil drilling projects will expand in the future. Many concerns arise from the subject of arctic drilling, primarily surrounding the health and rights of the Arctic Aboriginal Peoples and the health and sustainability of the fragile arctic environment.

The Arctic Aboriginal population has undergone significant social change throughout the last several decades. One of the most significant issues remote Aboriginal communities face is food insecurity. This is a major Canadian public health concern because the Aboriginal peoples have the highest prevalence of diet-related disease due to dietary transition, poverty and climate change (Statcan, 2008; Wallace, 2014). An important aspect of food security in the arctic is the availability and access to traditional food sources (Earle, 2015; Lambden, *et al*., 2007; Powers, 2005). These food sources are not only nutritionally beneficial but are also key to the maintenance of cultural identity (Powers, 2005). Oil and gas related activities are extremely invasive to the environment and thus threaten the security of traditional food, cultural identity and physical health.

There are several methods in which oil and gas drilling activities can have chronic impacts on the environment, human health and traditional cultures (O'Rourke & Connolly, 2003). Firstly, oil reserves are identified by remote sensing and seismic testing. Seismic testing can have population level impacts on local fisheries, change migration patterns of marine mammals or displace marine populations. Secondly, drilling activities introduce contaminants and pollutants through discharge and produced water (PW). These contaminants can bioaccumulate and biomagnify, thus polluting the sources of food that communities subside on. Thirdly, drilling technologies deployed under sea ice that are not landfast may increase the risk of oil spill (Wilkinson, Wadhams, Hughes, 2007). Moreover, the remote location of the drilling sites may increase spill response time, increasing environmental impact (WWF, 2009).

Aboriginal health is holistic in nature (NAHO, 2008). Consequently the well-being of the population relies on the health of the environment and its resources, for physical, mental, spiritual and cultural health. As a result, there is an acute need to view the dimensions of Aboriginal health, environmental health and well-being as interactive (NAHO, 2008). It is essential that Aboriginal health needs are met by incorporating traditional and cultural values to improve health outcomes before, during and after Arctic extraction projects.

2. Rationale and Research Questions

The expected rise in Arctic drilling projects may affect food security in the Canadian North. Despite the high rate of food insecurity, high prevalence of diet-related disease, and the vulnerability of Aboriginal communities to environmental degradation from resource development, action plans fail to fully account for Aboriginal perspectives or traditional methods of food acquisition. Therefore, the primary purpose of this thesis is to investigate the potential impacts of offshore oil and gas drilling on the Arctic marine traditional food supply and to discuss the effects in terms of the four pillars of food security (FAO, 2008). Secondarily, this thesis aims to contribute to the knowledge of food security issues, in Canada, that are conceptualized *within* an Aboriginal context (Powers, 2005).

This thesis recognizes that food security is a complex issue with several determining factors and acknowledges that offshore drilling is one of many factors such as socioeconomic status, population growth, the sustainability of fisheries and ecosystems and climate change. Moreover, this thesis understands that offshore drilling and the potential effects on the marine environment is a transcontinental issue. However this thesis will focus on the impacts in terms of Canadian Arctic food security and will discuss recommendations, opportunities and future research needs that can occur and begin in Canada, regardless of transcontinental agreements.

2.1.1. Research questions

This study aims to firstly (1), summarize and disseminate the research findings presented in this paper and was undertaken to, secondly (2), explore the effects of offshore drilling activities on marine mammals and animals and discuss the potential impact on Arctic food security. Specifically, this research aims to investigate the following research questions:

1. How will offshore gas drilling impact traditional food security of Canadian Arctic Aboriginal People?

2. How does offshore gas drilling impact marine sources of food?

3. What is the importance, culturally, spiritually and physically, of traditional food in the Canadian Circumpolar North?

This thesis will be composed firstly of a literature review to determine the significance of traditional food to the Arctic Canadian Aboriginals and secondly of a scoping review to examine the effects of offshore drilling on marine fauna. Finally this thesis will discuss the effect of offshore drilling on food security using the four dimensions of food security (FAO, 2008)

3. Population distribution and characteristics

3.1.1. Population distribution

For the purpose of this thesis, the Canadian Arctic includes the following regions: Nunavut, Northwest Territories, Yukon, Nunatsiavut, Northern Labrador and Nunavik, and Northern Quebec.

The Aboriginal peoples account for the majority of the Arctic population (see Figure 1 and Table 1) (Simeone, 2008 & UNEP, 2006). For example over half of the population in the Northwest Territories and 88% of the population in Nunavut is of Aboriginal identity (StatsCan, 2006, UNEP, 2006 & Simeone, 2008). Additionally, the Aboriginal population has the youngest population in Canada with a mean age of 22 compared to 38.8 for the non-Aboriginal population (StatsCan, 2006).

Table 1: Aboriginal Population of northern Canada

Table 1: Source: Parliament of Canada, *(2008). The Arctic; Northern Aboriginal Peoples. Retrieved at: http://www.parl.gc.ca/Content/LOP/ResearchPublications/prb0810-e.htm#source1*

	First Nations	Inuit	Métis	Total (Aboriginal and non-Aboriginal)
Nunavut	100	24 640	130	29 325
NWT	12 640	4 165	3 585	41 055
Yukon	6 280	255	800	30 195
Nunavik	45	9 565	15	10 570
Nunatsiavut	0	2 160	35	2 410

3.1.2. Aboriginal Social Determinant Health Gaps: An Overview

A large discrepancy exists in the social determinants of health between Canadian Aboriginals, particularly Arctic Aboriginals, and the non-Aboriginal population. In the Aboriginal population, low income, unemployment, lower education, substance abuse, physical and sexual violence and generally poor living conditions are all experienced disproportionately compared to the non-aboriginal population (StatsCan 2001, 2006, 2008, 2012). In the Arctic Aboriginal population, specifically, 36% percent have only elementary school education compared to 3% in the non-aboriginal population (StatsCan, 2008). Approximately half of the Arctic Aboriginal population aged 15-64 has a job, compared to 90% in the non-Aboriginal population (StatsCan, 2008). Unskilled and laboring job are the most likely form of employment. Finally, life expectancy in the

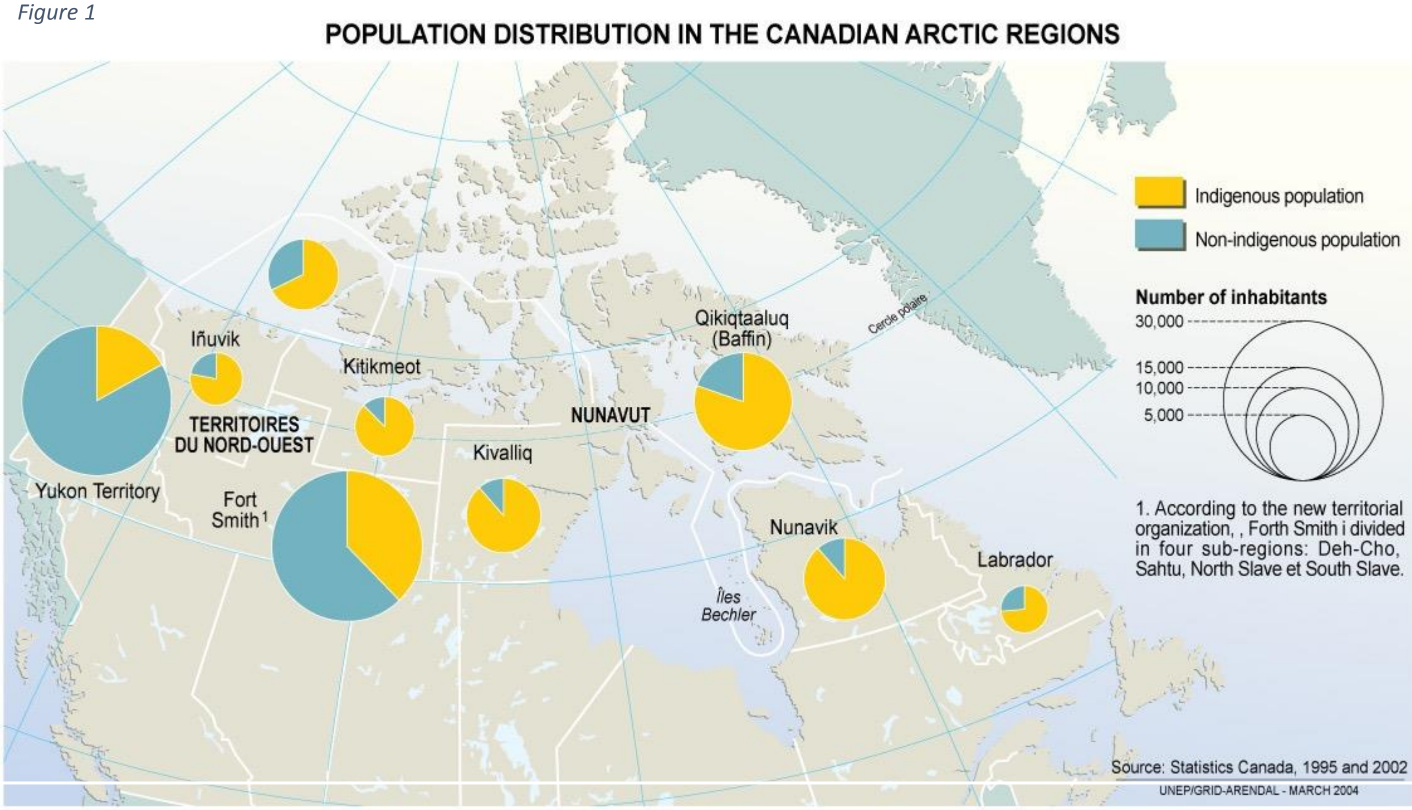
Arctic Aboriginal population is significantly lower than the Canadian average, including non-Arctic Aboriginals (Statscan 2008, 2006).

The prevalence of obesity and chronic disease is significantly higher in the Aboriginal population, compared to the non-Aboriginal population. Heart disease is 1.5 greater and tuberculosis infection is 8 to 10 times higher in the Aboriginal population (Government of Canada, 2004). Type II Diabetes, arguably a growing epidemic, has also rapidly increased in the Aboriginal population (Government of Canada, 2004). The prevalence of type II diabetes is three to five times greater in Aboriginals than in non-Aboriginals. A self-report health survey conducted in Inuit living in the Canadian Arctic found that only half of respondents reported being in good to excellent health (Wallace, 2012). Furthermore, one in four survey participants reported being diagnosed with a chronic disease by a healthcare professional (Wallace, 2012). It is important to note that chronic disease diagnosis may be higher than reported in the survey as diagnosis was reliant upon access to healthcare or a health care professional.

3.1.3. Economic structure

The contemporary economic structure of Northern Aboriginal communities is recognized as a mixed-subsistence economy. This system is comprised of two components: First, harvested and hunted traditional food and second, the consumer-commodity market. Over the last several decades the traditional subsistence based

Figure 1



economy has transitioned to a mixed economy due to modernization and globalization. As a result, Northern Aboriginal Communities now require a diversity of tools and methods necessary for optimal nutrition (Harder and Wenzel, 2012).

Traditional hunting and harvesting activities in terms of economic worth is poorly understood and often not reflected accurately in national statistics (Simeone, 2008). It is difficult to quantify the monetary worth of traditional food and its contribution to the Northern Aboriginal economy. As a result typical methods to capture economic value neglect to understand its societal importance of traditional food. Statistics Canada (2001) conducted a study on the harvesting activities in the Arctic and calculated the approximate worth of traditional food to be $40 million dollars annually (StatsCan, 2001). However the worth of the subsistence component of the economy far exceeds its monetary value. This component plays an important role in cultural, societal, familial and nutritional health and well-being. Furthermore, a partial subsistence based economy is essential for families that do not make enough money to purchase nutrient-rich market foods (Usher, *et al*., *et al*, 2002). Thus they must acquire necessary dietary requirements through traditional food sharing systems and from the land and/or ocean (Usher, *et al*., 2002, Harder and Wenzel, 2012).

In a subsistence based economy the household has a more important role than in a modern market-based economic system (Usher, *et al*., 2002). In a mixed economy, production and consumption occur at the household level compared to market systems, where production occurs in a factory and consumption occurs in the household (Usher, *et al*.,, 2002). Subsistence social and economic relations are determined by kinship relationships. These kinship principles determine who is responsible for resource allocation and the formation of hunting groups and camps, for example. It is these rules that determine social ties with extended households. The presence of social ties is what differentiates a subsistence economy from a market-based economy (Usher, *et al*., 2002). In a market system, accumulation and commodification are the determining elements and production and consumption can exist without social ties (Usher, *et al*., 2002). Traditional food and food sharing systems in a subsistence economy reinforce Inuit identity by creating social bonds through kinship principles (Collings, *et al*.,1998).

3.1.4. Food Insecurity and Nutrition Transition

3.1.4.1. Definition of Food Security

For the purposes of this thesis, food security will be defined by the Food and Agricultural Organization (FAO). The FAO defines food security as:

> *Food security exists when all people, at all times, have physical and economic access to sufficient, safe, and nutritious food to meet their dietary needs and food preferences for an active and healthy life.*

This definition can be further dissected into four pillars:

1. *Availability*
2. *Access*
3. *Utilization*
4. *Stability*

3.1.4.2. Arctic Food (In) security

In 2012, the Canadian Aboriginal Peoples Survey determined that 41% of Inuit had experienced food insecurity over the 12 month survey period. The prevalence of food insecurity in the Inuit population is four times greater than the rest of the Canadian population (8% food insecure) (Wallace, 2012). As evident by the Canadian Aboriginal Peoples Survey, food insecurity in the Canadian Arctic is an acute public health issue and is disproportionately more prevalent compared to the Canadian average.

Food security in the Canadian Arctic Aboriginal population is contingent upon the access, availability, utilization and stability of both market and traditional food. However many factors threaten food security in the Arctic. The security of traditional food is vulnerable to numerous factors including climate change, the high price of hunting equipment, environmental pollution and Arctic expansion (Sharma, 2010). These factors may decrease species abundance and biodiversity, contaminate food sources, and change migratory patterns thus displacing populations of key food species (Duerden, 2004). In terms of market food consumption, low income, dietary transition, lack of knowledge on healthy market food choices and the high cost of market foods promote dietary inadequacy and food insecurity.

3.1.5. Nutrition transition

“Nutrition transition” is defined as change in a population’s dietary habits. Typically this is a change away from a traditional diet to the diet of another culture (Popkin & Gordon-Larsen, 2004). In the Canadian Arctic, for example, acculturation has caused as shift in diet from a traditional subsistence diet to westernized diet. This western-style diet is characterized as being high in saturated fats, sodium, sugar and refined carbohydrates and low in essential micro-nutrients (Gordon-Larsen, 2004; Sharma, 2010). This transition is commonly accepted to be connected with an increased prevalence of obesity and diet-related disease in the Arctic Aboriginal Peoples (Popkin & Gordon-Larsen, 2004; Sharma, 2010).

Over the past several decades, the Arctic Aboriginal communities have experienced substantial social change and acculturation. As a result, commercialized market food systems have been introduced into this population (Sharma, 2010). Traditionally, the Arctic Aboriginal Peoples were active hunters and gatherers with high dietary adequacy. However due to the increased availability and the high cost of healthy market food options, this population has transitioned to a highly nutrient insecure and sedentary society. The movement away from a hunter-gatherer subsistence has contributed to the decline in physical activity and by consequence, the increased prevalence of obesity and co-morbidities (Sharma, 2010, Young, *et al*., 2000). In addition, low incomes and lack of knowledge concerning healthy market options, have promoted the consumption of cheap, low-nutrient foods. Nutrition studies in the Arctic Aboriginal Peoples has described the population as highly food insecure and the diets as severely inadequate in nutrients (Egeland, *et al*., 2011), As discussed earlier, there is a high burden of obesity and cardiovascular disease in this population and life expectancy is significantly lower than the average non-Aboriginal Canadian. The inadequate consumption of micronutrients and the over-consumption of refined carbohydrates, saturated fats, sugar and sodium may significantly contribute to the disproportionate burden of chronic disease.

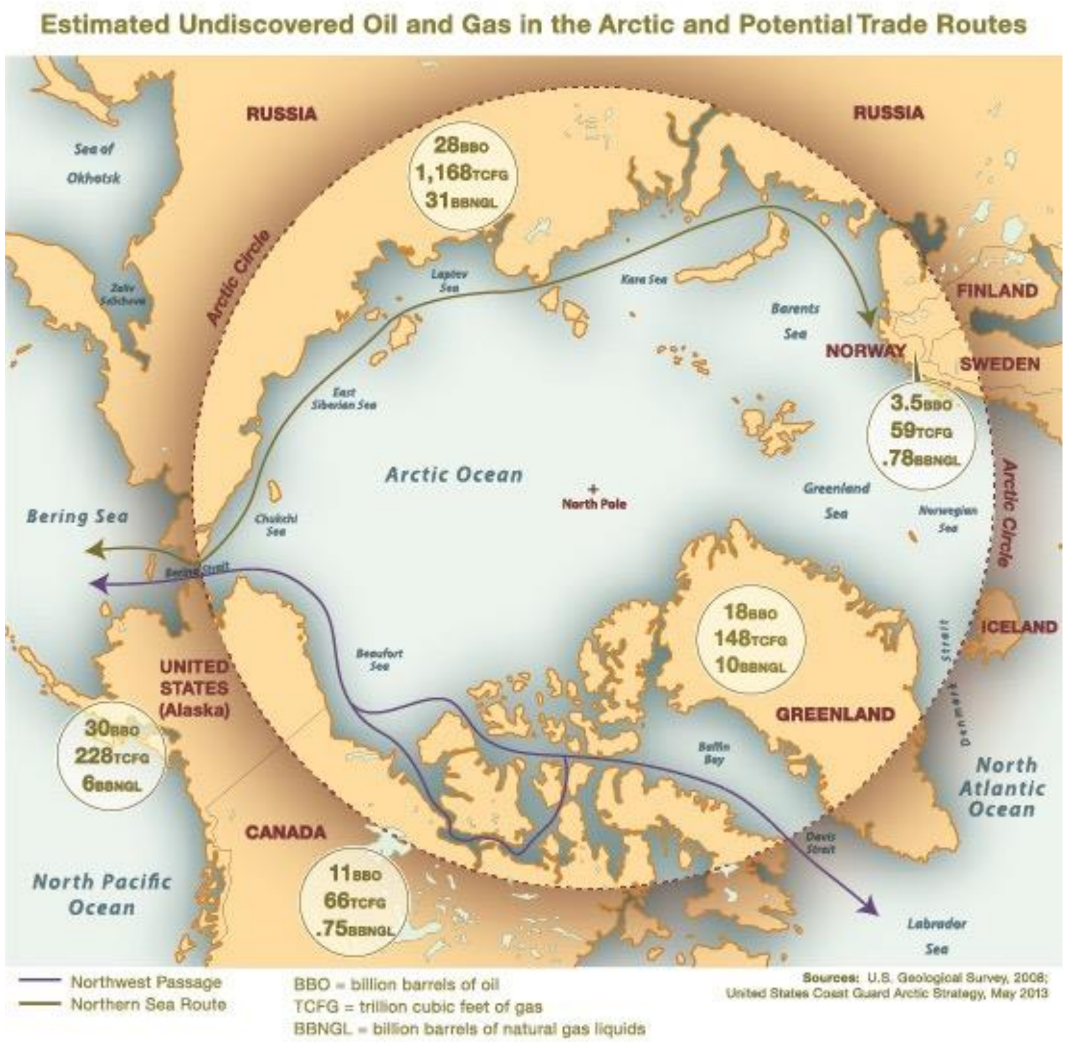
4. Increasing Resource Development in the Arctic

There are several factors related to the increasing interest in the Arctic's resource potential. Firstly, the Arctic has a large quantity of unexplored oil and/or gas stores. Numerous inland oil and gas fields have previously been discovered and explored for petroleum resources. In Canada, Russia, and Alaska, 400 oil and gas fields have been exploited, which accounts for approximately 10 percent (240 billion barrels of oil equivalent) of the known global oil and gas resources (Bird, *et al*., 2008). Even though the Arctic's onshore resources have already predominantly been exploited, the largest quantity of available oil and gas remains in the Arctic's offshore stores that has not been extensively explored or exploited. One third of the Arctic surface area is comprised of continental shelves (Budzik, 2009). The continental shelf is the landmass that extends from a continent into the ocean. This land mass results in shallow water of less than 500 meters deep. This largely untapped resource makes the Arctic the most unexplored and largest petroleum resource on the planet (Bird, *et al*., 2008) (Figure 2.).

In 2008, The US Geological survey, conducted a survey assessing the Arctic for undiscovered and recoverable oil using current extraction technology. The survey performed quantitative assessments on Arctic countries that were expected to have over a 10 percent probability of having a large quantity of accessible oil and/or gas deposits (Bird, *et al*., 2008). A large quantity was defined as 500 million barrels of oil or 300 billion cubic feet of gas (Bird, *et al*., 2008). In addition, countries were only assessed if it contained more than three kilometers of sedimentary rock, which is the accepted minimum thickness to produce a significant volume of petroleum (Bird, *et al*., 2008). The survey thus assessed the 25 remaining Arctic countries that fit the inclusion criteria. The survey stated that approximately 30 percent, of the earth's natural gas and 13 percent of its oil, 412 billion barrels of oil equivalent, are located within the Arctic Circle (Bird, *et al*., 2008). The majority of these resources (84 percent) are predicted to be located on the continental shelf (Bird, *et al*., 2008). Specific quantities of crude oil and natural gas per Arctic country and province is shown in Figure 2.

Secondly, climate change has increased access to the Arctic's unexplored petroleum resources. The global temperature has risen 0.8 degrees Celsius due to both natural causes and anthropogenic activity (Carlowicz, 2010; Hansen, *et al*., 2006). It is hypothesized that impacts from the global temperature increase could be magnified in the arctic regions by a multiple of three to five times (Comiso, *et al*., 2015). This occurs due to an ice-albedo effect. It has been documented by satellite data that perennial ice has been declining at an average rate of 13 percent per decade and sea ice has been decreasing at a rate of five percent per decade (Comiso, *et al*., 2015 & Comiso, *et al*., 2008). Submarine data from ICEsat indicates that summer ice thickness has decreased by 62.5 percent between 1980 and 2007 (Kwok & Rothrock, 2009). As a result, ice retreat is occurring for longer periods during the warmer Arctic months, thus, allowing for better access to oil and gas reserves for extended periods of time.

Figure 2



The final contributing factor is the global growth in oil and gas demands. It is estimated that global energy consumption will increase by 39% percent by 2030 (Finley, 2012). Driving the rising global energy consumption are two main forces: Firstly, the global population is continuing to grow. By 2050 the population is anticipated to exceed 9 billion people (UN, 2015). Secondly, the economy, specifically in emerging countries, is also projected to increase (Finley, 2012). Therefore, despite the high risks and high costs of Arctic drilling, extraction projects appear to be imminent.

5. The Social and Environmental Cost of Oil and Gas Production

The oil and gas extractive industry provides numerous benefits to society at both the communal and national levels. Firstly, the extractive industry positively impact macroeconomic growth. Extraction resources are a critical commodity in foreign exchange that fund the import of goods and services (Sigam & Garcia, 2012). Over the last decade, Canada has experienced irrefutable economic benefits from the expansion of its oil and gas industry (Pearson, 2015). In some countries, such as Saudi Arabia and Iran, the extractive industry accounts for over 80% of the total national exports and is therefore critical source of the country’s economic sustainability (CIA World Factbook, 2013).

Secondly, the extractive industry creates significant employment opportunities. The oil industry, specifically, employs more than two million individuals in both the production and refining stages (ILO, 2002). Additionally, The International Labour Organisation (ILO) (2002) states that for every one job in production and refining, one to four indirect jobs are created. Thus, the oil industry generates between four million and eight million jobs annually (ILO, 2002; O’Rourke & Connolly, 2003). For instance, in 2009, in the United States, over five million jobs were induced by the oil and gas industry (Sigam & Pearson, 2012). The extractive industry, therefore, is a considerable source of employment in many countries. Thirdly, oil is a substance with many functions and is moderately simple to transport. The energy dense substance has endless uses and benefits to society. Petroleum heats buildings, fuels vehicles and provides electricity. Additionally, petroleum has less obvious uses. For example, petroleum is used in pain solvents, cosmetics, cleaning products and waxes. The seemingly malleable nature of this substance makes it one of the most important liquids to modern-day society.

Although petroleum and the extractive industry offer several benefits, numerous negative impacts to human health, environmental health, culture and human rights are a product of resource development. Governments and review boards are continually striving to determine more effective technologies and policies to mitigate the impact of resource development on human and environmental health and well-being.

Often, oil and gas exploration and extraction occurs in some of the most remote locations on the planet that are home to many Aboriginal communities. Remote Aboriginal peoples are intimately linked to their surrounding environments (Colins & Murtha, 2010). The land is not only a source of substance but also an expression of traditional culture. Current approaches that aim to weigh the benefits versus risks of hydrocarbon development typically consider these in a cost-benefit analysis. These current approaches fail to consider the elements of traditional well-being that cannot be commodified, such as the cultural significance of land (Colins & Murtha, 2010). Heinberg (2014) calls this approach “the (false) binary choice”, where you have “jobs and economic growth on one hand and climate protection on the other” (Heinburg, 2014 pg. 124,). These cost-benefit analyses may be able to account for the market value of fisheries in a production area, for example, but fail to account for the cultural significance of a whale hunt and or harvest. Additionally these analyses, when considering the impact on the environment and associated wildlife, fail to consider the indirect impact of resource extraction on larger fauna (Pearson, 2015). For instance, extraction activities often do not directly or significantly harm larger fauna, such as whales. Instead the whales will change migratory patterns or displace. The analyses do not account for the direct link that the Aboriginal communities have to these large mammals, for both survival and cultural reasons. To ensure Aboriginal well-being, maintenance of culture and survival of subsistence communities, it is imperative that analyses incorporate traditional and cultural values to improve health outcomes before, during and after Arctic extraction projects.

6. Traditional Food

6.1.1. Value of Marine Food Resources

Traditional marine foods, such as beluga, whale blubber and fish, are an irreplaceable component of the Arctic Aboriginal subsistence lifestyle. These food sources are not only consumed often but are also excellent sources of micro and macro nutrients. The importance of the ocean's resources to the Northern Aboriginal communities is best illustrated through a quote by an Inuit representative at a roundtable meeting with the National Energy Board (NEB) in 2010:

> "The ocean feeds us, the ocean is our road, it's our path. The Inuvialuit way of life, traditions, and culture is dependent on the Arctic Ocean. The Inuvialuit would like to continue our way of life, traditions, and culture…" (NEB, 2011)

According to the Nunavik Inuit Health Survey (2004), marine food sources were the most frequently consumed type of traditional food, followed by land animals. Arctic char was the most consumed type of sea food and beluga whale was the most frequently consumed marine mammal (Blanchet, 2008). On average, during the course of the Inuit health survey, seafood sources were consumed three times a week and marine mammal meat was consumed once per week (Blanchet, 2008). Similarly, food frequency questionnaires conducted in Northern Aboriginal communities indicate that marine food sources are consistently a large contributor to the traditional diet (Blanchet, 2002; Gagne, *et al*., 2012). In northern Quebec, Arctic red char and white whale were among the top four most frequently consumed traditional food species in Nunavik Inuit women (Blanchet, 2002). Furthermore, among Northern Aboriginal children, the most frequently consumed traditional foods at home were caribou and arctic char. In daycare, baked salmon and skinless arctic char and trout were the most consumed. Over half (54%) of the total energy intake from traditional food came from shellfish, fish and marine mammals (Gagne, *et al*., 2012).

In addition to the frequency of consumption, marine food resources offer many health benefits. Bowhead whale blubber, for example, are a significant source of essential Omega-3 fatty acids (Reynolds, *et al*., 2006). Moreover, in certain species of marine mammal and fish, Omega-3 fatty acids may account for 15% to 45% of all fatty acids in the species (Malcolm, *et al*., 1996). Ringed seal fat, white whale fat and fish are an exceptional source of dietary vitamin D, while marine mammal tissue and seal liver are food sources high in iron. Marine mammal tissue is high in selenium and zinc and fish offer an excellent source of magnesium (Blanchet, 2002). As depicted, a diet consisting of traditional marine food can provide nutrients that are essential for optimal health. In a population that is undergoing rapid nutrient transition, marine food resources are an excellent way to increase nutrient intake.

A literature review was performed to understand the cultural and nutritional significance of traditional food sources in Arctic Aboriginal society. Terms such as “marine ecosystem”, “marine mammals”, “marine fishes” AND “traditional food”, “country food”, “food”, AND “Northern Aboriginal people”, “Aboriginal”, “Aboriginal peoples”, “Arctic Aboriginal Peoples” were used to scan the literature. The following are the four main themes extracted from the review: (1) Traditional food is a significant source of micronutrients, (2) nutritional transition is a contributor to an increased prevalence of obesity and diet-related disease, (3) nutritional transition is a component of arctic food insecurity and (4) Traditional Food is culturally significant. Table 2 summarizes the themes and associated studies.

Table 2: Aboriginal Peoples in Canada and Traditional Food Literature Review

	Nutrient Intake	**Market food and Obesity**	**Nutritional transition is a contributor to Arctic food insecurity**	**Traditional food as an expression of culture and a preferred food source**
First Author and Date	Blanchet, 2002	Downs, *et al*., 2009	Egeland, *et al*., 2011	Lambden, *et al*., 2007
	Reynolds, *et al*., 2006	Kuhnlein, *et al*., 2004	Lambden, *et al*., 2007	Pufall, *et al*., 2011
	Sharma, 2010	Sheikh, *et al*., 2011	Powers, 2008	Powers, 2008
	Kuhnlein, *et al*., 2004	Zotor, *et al*., 2012		
	Huet, *et al*., 2011	Hopping, *et al*., 2010		
	Egeland, *et al*., 2004 & 2011	Kuluguqtuq, 2009		
	Kolahdooz, *et al*., 2013 & 2014	Young, *et al*., 2000		
	Zotor, *et al*., 2012	Galloway, *et al*., 2012		
		Galloway, *et al*., 2010		
		Galloway, et al., 2012		

6.1.2. Physical health and Traditional Food

Over the last several decades, the Arctic Aboriginal population has experienced a nutrition transition, changing from a traditional diet to a diet consisting in imported and packaged food (Sharma, *et al*., 2010). Although traditional food remains a culturally and nutritionally important food source, market foods that are high in sugar, fat and refined carbohydrates have become a substantial source of total daily calories (Sharma, *et al*., 2010; Kolahdooz, *et al*., 2013 & 2014; Zotor, *et al*., 2012). It should be noted that market foods are not inherently unhealthy. Many types of imported foods, such as fruits and vegetables, are extremely nutrient dense, however healthy, fresh market foods in the Arctic are approximately double the price compared to southern Canada (Ford, 2008; Lawn & Harvey, 2003). Thus, cheaper and nutritionally insufficient foods, such as chips and soda, are purchased as opposed to healthier options (Huet, *et al*., 2012).

6.1.3. Nutritional Transition in the Canadian Arctic

Nutrient inadequacies as a result of the nutritional transition in the Canadian Arctic is heavily documented in the literature (Kolahdooz, *et al*., 2014 & 2013; Sharma, *et al*, 2010; Egeland, *et al*., 2004 & 2011; Hopping, *et al*., 2010). Many studies recognize the nutritional benefit of incorporating traditional foods in food security initiatives (Kolahdooz, *et al*., 2014 & 2013; Sharma, *et al*, 2010; Egeland, *et al*., 2004 & 2011; Hopping, *et al*., 2010; Huet, *et al*., 2012; Reynolds, *et al*., 2005), as the market foods that are being frequently consumed are low in nutritional value. Several studies that assessed the daily dietary intake of communities in the Canadian Arctic reported that non-nutrient dense imported foods were most commonly consumed, particularly in the younger age groups (Kolahdooz, *et al*., 2013&2014; Hopping, *et al*., 2010). Hopping, *et al*., 2010, used 24 hour diet recalls to assess the dietary intake in the Canadian Arctic and determined that the foods consumed most frequently were tea, coffee, and juice. The next most consumed food was bread followed by sugar, caribou, lard, sweets and carbonated drinks. Hopping, *et al*., (2010) discussed that traditional food was a significant contributor to dietary iron and protein, while non-traditional foods were the primary sources of sugar, carbohydrates and fat. Similarly, Kolahdooz, *et al*., 2014 and Zotor, *et al*., 2012 found that non-traditional foods were the highest contributors to energy, fat, carbohydrates, sugar, sodium and fiber.

The dietary shift being experienced in the Arctic has a significant impact on the nutrient adequacies of the Arctic Aboriginal Peoples. This population is consuming insufficient amounts of fiber and vitamin A, C, D, E, calcium and folate (Hopping, *et al*., 2010, Koldahooz, 2013&2014, Sharma, 2010, Egeland, *et al*., 2011). Currently dietary energy, saturated fat, sodium and sugar surpass the limits recommended for healthy living (Koldahooz, 2014). In summary, these studies found that when traditional foods were consumed, a higher intake of protein, iron and micronutrients was ingested, whereas when more market food were consumed, a higher intake of carbohydrates, saturated fat, sugar and sodium were consumed (Egeland, *et al*., 2011, Sharma, 2010, Hopping, *et al*., 2010, Koldahooz, 2013, 2014).

Egeland, *et al*., (2004) found low vitamin A among the general Canadian Inuit population. Over half the population (15-40 years of age) studied were below the estimated recommended average. Vitamin A deficiencies in the older generation of Inuit people over 40 years old, were significantly lower than the younger generations. The authors found that the large difference in vitamin A intake between the older and younger generation of Inuit people can be attributed to the difference in traditional food intake. Older Inuit diets continue to consist largely of traditional foods, whereas the younger generation is consuming low-nutrient market foods. Additionally, Kolahdooz, *et al*., (2013) found low dietary adequacy of vitamin D and calcium in women of child-bearing age in the Canadian Arctic. The study determined that only 18% of women who were traditional food consumers were not meeting their estimated-average-requirements (EAR) for calcium, while 35% of non-traditional food consumers did not meet the EAR for dietary calcium (Kolahdooz, *et al*., 2013). Furthermore, traditional food eaters consumed significantly more vitamin D compared to women who did not eat traditional food (Kolahdooz, *et al*., 2013).

The studies mentioned all identify the acute need for nutrition interventions. The consumption and integration of traditional food sources was acknowledged numerous times as a culturally appropriate and nutritionally sufficient element in food security initiatives.

6.1.4. Obesity and Diet-Related Chronic Disease: A rising epidemic

The nutrition transition away from traditional food in the Canadian Arctic has increased the prevalence of obesity and diet-related disease. Before the rapid diet transition, the consumption of traditional foods provided an overall healthy diet that may have protected the population against chronic disease (Bjerregaar, *et al*., 2004). A rapid social change has been seen in the Arctic Aboriginal populations throughout the past several decades. As a result of this social change, many communities have transitioned away from a hunter-gatherer way of life to a community that acquires food from imported sources. As previously mentioned, due to the high price of healthy market food options, many Arctic Aboriginal people consume cheaper, low-nutrient market foods. The consumption of these low-nutrient options has contributed to the increased prevalence of diet-related disease and higher BMI (Hopping, *et al*., 2010, Galloway, *et al.,* 2010). The literature emphasizes that the high prevalence of diet-related chronic disease, such as type 2 diabetes, cardiovascular disease, and obesity is a critical public health concern.

An increased prevalence of obesity in Arctic Aboriginal populations is well established in the literature (Galloway,*et al.,* 2010 & 2012, Hopping, *et al*., 2010; Kuhnlein, *et al*., 2004, Downs, *et al*., 2009; Sheikh, *et al*., 2011). Kuhnlein, *et al*., (2004) found that the obesity prevalence in Arctic Aboriginal people far exceeds the Canadian national average. As poverty is a social determinant of obesity, Kuhnlein, *et al.,* (2004), compared obesity prevalence in the Arctic Aboriginal population to the adjusted prevalence from the lowest income and education level in Canada. Obesity continued to exceed the national rates even when prevalence was adjusted to survey only the lowest income and education percentage of the national population (Kuhnlein, *et al*., 2004). Parallel to Kuhnlein, *et al*., *et al*., (2004), Sheikh, *et al*., (2011) compared dietary assessments from 1998-1999 and 2007-2008 to assess BMI change over time. This study determined that BMI increased significantly ($p<0.05$) between the years of 1998 and 2008. The BMI increase is concurrent with the transition from nutrient dense traditional foods to nutrient-insufficient market foods. Galloway *et al.,* (2010 & 2012) reported a high prevalence of obesity in Inuit preschool children. The study conducted in 2012 found that the prevalence of obesity in children was higher in Nunavut compared to Nunavik. This may be due to socioeconomic and geographical determinants. For example, in the more remote geographical regions, food insecurity was higher in Nunavut (36%) compared to Nunavik (33%), which is moderately less remote. This result is concurrent with the higher prevalence of obesity in children in Nunavut. In 2010, Galloway, *et al.,* found that obesity prevalence in children was higher than previously reported and was occurring at an earlier age (preschool). This study, however, using a regression analysis, found no association between dietary and socioeconomic factors and obesity. Through further diet analysis, it was found that Inuit children were consuming food and beverages that were high in energy density and thus the study recommended further research on the impact of cultural and socioeconomic factors on Inuit childhood obesity (Galloway, *et al.,* 2010). Finally, in a rural subarctic community, obesity in Cree children was investigated (Downs, *et al*., 2009). It was determined that 64% percent of the children in this community were overweight or obese. The foods that contributed to the most energy intake were high in sugar, fat and carbohydrates with low nutritional significance. All mentioned studies discuss the importance of improved access to traditional food and affordable nutrient dense market foods.

In addition to the increased prevalence of obesity in Arctic Aboriginal Peoples, type 2 diabetes is growing to epidemic proportions in Canada's Aboriginal population (Young, *et al*., 2000). According to the First Nations and Inuit Health Survey, 8% of men and 13% of women are diabetic. This is 3.6 and 5.3 times higher, for men and women respectively, than the general Canadian population (Young, *et al*., 2000). In females aged 10-19, type 2 diabetes is at a prevalence of 3.6% (Dean, *et al*., 1998).

Diabetes in the First Nations and Inuit community was rare until approximately two decades ago (Young, *et al*., 2000), and although a connection between diet and diabetes is inconsistent in the literature, a decline in traditional lifestyle is widely accepted to be the fundamental cause of the growing epidemic (Young, *et al*., 2000). An increase in the prevalence of obesity and a decrease in activity due to a societal transition from hunter-gather to sedentary lifestyle are vital risk factors for type 2 diabetes (Young, *et al*., 2000).

6.1.5. Cultural and Spiritual Health and Traditional Food

Numerous studies explore the role of traditional food in food security, food safety, and nutrition; however few studies assessed the value or perception of traditional food to Inuit society. However, Lambden, *et al*., (2007) and Puffal *et al*., (2011) evaluated the preferences and safety concerns of traditional food in Inuit society. Both studies yielded similar results. Participants in both evaluations perceived traditional food as healthy, tasty, fresh, offering variety and was seen as inexpensive (Puffal, 2011; Lambden, *et al*., 2007). Additionally the participants discussed that they thought traditional foods provided them with essential nutrients with no additives (Puffal *et al*, 2011).

The future safety of traditional food is a common concern among Canadian Arctic Aboriginal Peoples. As human expansion increases in the north, Arctic communities fear that the pollution from dumps and pipelines will hinder the quality, health benefits and safety of their traditional resources (Puffal, et al., 2011). Furthermore the Inuit have noticed a change in taste from fish and bivalves that had been exposed to oil and gas (Pufall *et al*, 2011). Ten per cent to 38% of participants in the study conducted by Lambden, *et al*., (2007) have already experienced changes in traditional food quality due to climate change and arctic expansion.

It can be seen that traditional food is a preferred food source with perceived health benefits. In addition to value of traditional food as a preferred and nutritious food source, traditional food is an extremely valuable expression of culture. The acquisition, consumption and sharing of traditional food is an irreplaceable aspect of northern Aboriginal culture and is essential to health and survival of their identity (Powers, 2008; Lambden, *et al*., 2007). The literature indicates that traditional food is an important aspect of Arctic Aboriginal cultural, mental, spiritual and physical health (Pufall, 2011; Lambden, *et al*., 2007; powers, 2008). Over 85% of participants in the study by Lambden, *et al*., (2007) established that traditional food held important cultural qualities and the evaluation piloted by Pufall, *et al*., (2011) indicated that participants described traditional food as a way to be connected to their land, history and culture. Elaine Powers (2008) in her review of Aboriginal food insecurity in Canada emphasized the significant role that traditional food plays in the maintenance of culture, identity and spiritual health by proposing that we consider "cultural food security" for Aboriginal people that goes beyond just the fundamental aspects of food security. . It can be seen that traditional food remains an important aspect of Inuit society, however Arctic expansion and climate is a major concern for the conservation of traditional food resources that hold the key to the history, spirituality, identity and culture of the Arctic Aboriginal Peoples.

6.1.6. The role of traditional food in Arctic food security

Traditional food has been recognized as an important aspect of Arctic food security. The majority of Canadian public food security initiatives have been developed outside the context of Aboriginal lifestyles (Powers, 2008). However, given that food insecurity has a disproportionately greater impact on Canadian Aboriginals (Aldeson, 2005), it is imperative that food security strategies are developed within an Aboriginal context and that they consider the unique aspects of Aboriginal lifestyle, such as culture, food sharing, poverty and identity.

The Nunavut Food Security Symposium Priorities for Action (2013) identified access to traditional food as one of the keys to Arctic food security. The symposium recognized the importance of food sharing, the availability of wildlife for food, and the transfer of traditional knowledge to the younger generation as essential elements of improving food security in Arctic Aboriginal communities. Furthermore, Lambden, *et al*., (2007) describes arctic food security as “contingent upon access to these [traditional] foods”. Finally, due to the high price of healthy market food options, many individuals and families consume the cheaper, low-nutrient market foods (Huet, *et al*., 2012). Promotion of traditional food programs that provide hunting gear, community freezers and traditional knowledge translation (Nunavut, 2013) are significant elements to decrease low nutrient diets, obesity and diet-related disease (Egeland, *et al*., 2011).

6.1.7. Summary

The literature review provided an overview of the role of traditional food in the Arctic Aboriginal society. The following bullet points provide a summary:

- Traditional food is nutritionally dense and those who consume it are often healthier
- Market food is expensive and thus, cheaper, low-nutrient dense foods are consumed instead of healthier options
- Traditional foods are often preferred
- Traditional foods are important to preserving culture and identity
- Traditional food provides a spiritual connection to the land
- Incorporating traditional food in food security strategies may be a key to reducing Arctic food insecurity
- Marine sources of traditional food, such as whales, seal and fish, are consumed most often and are important sources of micro and macro nutrients

7. Oil spills, Chemical Discharge, Produced Water and Seismic Testing

Growth in industrial Arctic projects are accelerating at a rapid pace. Aboriginal communities that inhabit the land have many concerns surrounding the deterioration of traditional land and marine ecosystems that provide food. The Bering Strait, for example, provides 2688.5 lbs of food annually per household to the Inupiat, Yup'ik and St. Lawrence Island Yupik peoples (Gadamus, 2013). As summarized in Section 6, *Traditional Food*, traditional food is preferred, more nutritious and an important constituent of cultural identity. A study conducted in Alaska, in the Bering Strait region, studied the perceived risk and vulnerability of Aboriginal marine harvesters to industrial activity (Gadamus, 2013). Population displacement, food safety and protection of traditional ways were the main concerns of the marine mammal harvesters. These perceptions are significant because, although aspects of marine harvesting cannot be commodified or properly accounted for in an environmental assessment, the significance of traditional lands and foods clearly have meaning beyond market value and thus the health of the marine ecosystem is key to cultural and physical survival. The following section will discuss and define aspects of oil exploration that have the capacity to negatively impact human and environmental health.

7.1.1. Seismic testing in a Marine Environment

Seismic testing and surveying, and its impact on the marine environment is one of the primary concerns. Seismic testing is one of the first stages in oil and gas development and occurs in the exploration phase. Used to discover new oil and gas reserves, seismic testing utilizes reflective technology that maps rock formations below the ocean floor (Peterson, 2004). Tests are conducted off surveying ships that tow selections of airguns. The airguns discharge loud bouts of compressed air towards the ocean bottom. The speed at which the sound waves reverberate off the floor are recorded by hydrophones (Peterson, 2004). As sound travels faster in water than in air, these airgun blasts can be heard 100 kilometres away from the source (Peterson, 2004).

Two dimensional (2D) and three-dimensional seismic surveys are the most commonly used in oil and gas exploration. Two-dimensional surveys are used to gather general data about a broad geographical area, whereas three-dimensional surveys are used to gather data from specific and small interest areas (Peterson, 2004). Therefore, often 2D surveys would be used first in geographical areas where oil and gas reserve data is scarce, to fill in geological knowledge gaps of the area.

Seismic testing has introduced some of the most intense anthropogenic sounds into the marine acoustic environment. As a result, many concerns arise in terms of environmental impacts, specifically from communities that subside by the sea. There are four primary methods that can effect marine mammals and fish: (1) physically /physiologically, (2) behaviourally, (3) increased stress and (4) indirect impacts (Gillespie, *et al*., 2001). Physically, seismic testing has the potential to cause tissue and/or organ damage (such as damage to the swim bladder in bony fish), from the pressure exerted during the blast, whale stranding and auditory damage. In the literature, auditory damage is the most commonly discussed physical impact. In most developed marine animals, hearing is a vital sense in an ocean environment, and thus many species of marine animals have developed extremely sensitive hearing throughout evolution (Gillespie, *et al*, 2001). Marine animals may experience temporary threshold shift (TTS), which can take minutes to hours to recover from, or permanent threshold shift (PTS), which causes permanent damage to the inner ear.

Behaviourally, seismic testing can cause an array of changes. Whales use “singing” as the main source of communication. Studies have documented reduced or complete cessation of whale singing during exploration periods (Goold, 1996, Bowles, *et al*., 1994). Change in migratory patterns (Malme, *et al*., 1988), avoidance, population displacement, and abandonment of foraging grounds has been recorded in the literature (Gillespie, 2001). Behaviour change can have potentially harmful impacts at the population level. Chronic exposure to intense noise can increase stress by elevating the adrenocorticotrophic hormone (ATCH) (Gillespie, 2001). The elevation in this hormone is known to induce behavioural shifts, change in respiration patterns and compromise the immune system in mammals (Gillespie, *et al*, 2001). Finally, seismic testing may indirectly impact marine animals, specifically predators, because airgun blast can reduce availability and abundance of prey and change or damage their habitat.

7.1.2. Contaminants

The oil and gas industry produces significantly large quantities of liquid and solid waste. Approximately 20 percent of this waste is nonhazardous, however the majority of discharge occurs in the form of *produced water* (PW) *(*O'Rouke & Connolly, 2003)*.* PW is the water that is extracted from the ground and is forced into wells to transport remaining oil and gas in the reserve to the surface. This water can contain injection and condensation water and the naturally-occurring chemical substances in the PW will likely mirror that of the well (Bakke, *et al*., 2013). In addition to naturally-occurring substances, PW will also contain, polyromantic hydrocarbons (PAH), heavy metals (barium, arsenic, cadmium chromium, and mercury) naturally-occurring radioactive material, inorganic salts, acetic acid, propionic acid, sulphur and sulfide (Baake *et al*, 2013). Produced water that is not injected into the oil wells are discharged into the ocean. PW is also estimated to contain four times the concentration of sodium than the ocean (Clark & Veil, *et al*., 2009). In the United States, 15 billion barrels of PW was produced and over 90% of this was reinjected into the wells or discharged into the surface waters (Clark & Veil, *et al*., 2009).

Numerous cases of acute and chronic health conditions have been intrinsically linked to oil and gas development. Humans can be exposed to harmful contaminants in several ways. Radioactive materials can be pushed to the surface of the water, water supplies can become contaminated or bioaccumulation and biomagnification of heavy metals and/or PAH can occur in fish or mammals that humans consume. Bioaccumulation is the process by which an organism consumes a toxin at a greater rate than is metabolized whereas biomagnification is the process of increased toxin accumulation at each higher trophic level. Heavy metals and PAHs have the potential to bioaccumulate and biomagnify.

The ingestion of contaminants is of particular concern to subsistence communities. The precise acute and chronic effects of PAHs on human health is debated, however one of the most researched toxicity endpoints is cancer. Furthermore, prolonged exposure to heavy metals in known to have deadly effects on human health (Singh, *et al*., 2011).

7.1.3. Oil Spills

Oil spills can have detrimental acute and chronic effects on the marine environment. The transportation of oil has caused several large oil spills each year throughout the world. Large scale spills are well publicized and have notable environmental consequences; however, smaller spills, that occur regularly, do not receive as much attention. The cumulative impact of the small spills may degrade the environment more than the large spills (Williams, 2012). Spills occur most frequently in maritime transportation and are released in the form of bilge and fuel oil (O'Rouke &

Connolly, 2003). Large oil spills occur one to three times annually and will spill over 10 million gallons of oil each time. However, cumulative leaks and small spills from bilge and fuel oil alone, release a quantity of oil approximately five times greater yearly than a large spill. Consequently, small spills and leaks must be accounted for when considering the amount of fuel that enters the ocean due to the extraction industry.

The marine environment is impacted the most from oil spills and leaks. The size and location of the spill influence the magnitude of impact, however some ecosystems are more fragile than others such as coral reefs, polar bear habitats, Arctic ecosystems and salt marshes (O'Rouke & Connolly, 2003). Furthermore, spills can impact human health through the consumption of contaminated marine food sources or contaminated water supplies. Fisheries can experience chronic impact from oil spills and may take years to recover (Burger, 1997)

In the Arctic, the harsh and variable climate may increase the likelihood of an oil spill and response time may be delayed due to the remote nature of the locations. Increasing spill response time could potentially increase the detrimental effects of the oil spill on the Arctic marine environment. Many Aboriginal communities subsist on resources from the sea and loss of these resources could negatively affect several communities' ability to survive.

8. Scoping Review Methods

This study conducted a scoping review of Arctic studies that focused on the effects of offshore drilling activities on marine sources of traditional food. A scoping review technique was adapted for the purpose of this study for its ability to rapidly chart relevant information from many sources and study designs. Additionally, a scoping review aims to map key concepts in areas of research that are broad, complex and scarcely researched, regardless of study design quality (Arksey and O'Malley, 2005). This methodological design provides an opportunity to address the complex nature of the proposed research questions by incorporating a large range of studies that focused on the health and environmental effects of offshore drilling activities. The use of a scoping technique allows this study to investigate the effect of offshore drilling activities on marine sources of traditional food and to discuss the findings as it pertains to the four pillars of food security. The present scoping review outlines research from peer-reviewed sources to map out key concepts underlining the research questions.

Arksey & O'Malley (2005), published a five step methodological framework for completing a scoping review: (1) Identify the research question, (2) Identify relevant studies, (3) Study selection, (3) Charting the data and (4) Collating, summarizing and reporting the results. In addition to the five step framework, Arksey & O'Malley (2005) presented four circumstances in which a scoping study is useful: (1) To examine the extent, range and nature of research activity, (2) to determine the value of undertaking a full systematic review, (3) to summarize and disseminate research findings and (4) to identify research gaps un the existing literature.

8.1.1. Search terms and databases

Five databases were searched for articles between the years of 2000-2015: PubMed, Web of Science, Science Direct, JSTOR and the Mendeley internal database were used to obtain articles from the health sciences, environmental sciences and the social sciences. In addition to the articles chosen from the five databases, hand-selected articles were included from other review papers. Literature on Arctic Aboriginal traditional food was scanned to select search terms. Table 2 shows selected words in four categories: Offshore gas drilling (1), traditional food (2), Arctic Aboriginal People (3), marine food sources (4).

Table 3: Keywords and Search Term

Table 3, Keywords Search Terms			
Offshore Gas Drilling	**Traditional Food**	**Arctic Aboriginal Peoples'**	**Marine Food Sources**
Gas drilling Extractive projects Extractive industry Oil and gas drilling	Food Country food	Northern Aboriginal Northern Aboriginal Aboriginal Arctic Aboriginal Peoples' Inuit Indigenous Arctic Indigenous Canadian Arctic Indigenous OR Aboriginal First Nations	Marine ecosystem Marine mammals Marine ecosystem Marine fishes

A search strategy was developed to scope English journal articles between the years of 2000 and 2015. The scoping strategy was refined as familiarity with the available data increased. Due to the broad and scarcely researched nature of the study question, search hits, after narrowing search terms, often generated over 1000 hits. To ensure all data was included, all articles were scanned for title relevance.

After reviewing the abstracts, a set of inclusion and exclusion criteria (Table 3) for literature selection was created *post hoc (*Arksey & O'Malley*)*. Rationale for exclusion of articles was as follows: (1) No focus on drilling OR extraction activities AND marine mammals OR fishes OR marine environment, (2) No focus on drilling OR extraction activities AND traditional food, (3) an exclusive focus on climate change, renewable energy sources, measurement models or law (4) "perceived risk" or "opinion studies" and (5) study methods were not clearly indicated.

8.1.2. Assessment and analysis (charting, collating and summarizing the data)

A spreadsheet in Microsoft Excel was used to chart the data that was extracted from the selected sources. First author and year, publication source, country of study, study questions and/or aims, methods overview, results and conclusions were recorded. Data was extracted based on relevance to study questions. After data was recorded on the spreadsheet, themes were identified and colour coded.

Table 4. Selection Criteria	
Inclusion	**Exclusion**
Study clearly indicated its method of research	Perceived risk or opinion studies
Primary or secondary outcomes focused on oil drilling OR extraction projects OR seismic testing/surveys AND Marine food sources (whales, fish, crustaceans, Bird, *et al.*,s etc..)	Language other than English
English	Study focus was climate change, renewable energy sources, measurement models or law
Study published from 2000-2015	Study did not focus on aboriginal sources of marine food
Study included Aboriginal natural food sources (traditional food, country food)	

9. Results

9.1.1. Description of Studies

My electronic database title search for articles, after duplicates were removed, resulted in 784 articles. An abstract scan was performed and 221 articles were identified for full-text screening. Articles were excluded (n=563) based on irrelevance to study objectives. The inclusion and exclusion criteria, that were created *post hoc*, were applied for the full text scan which identified 19 articles to be used in the scoping study. Additionally, four hand selected articles were included in the scope (see Figure 4 for PRISMA diagram of the study selection process)

9.1.1.1. Countries

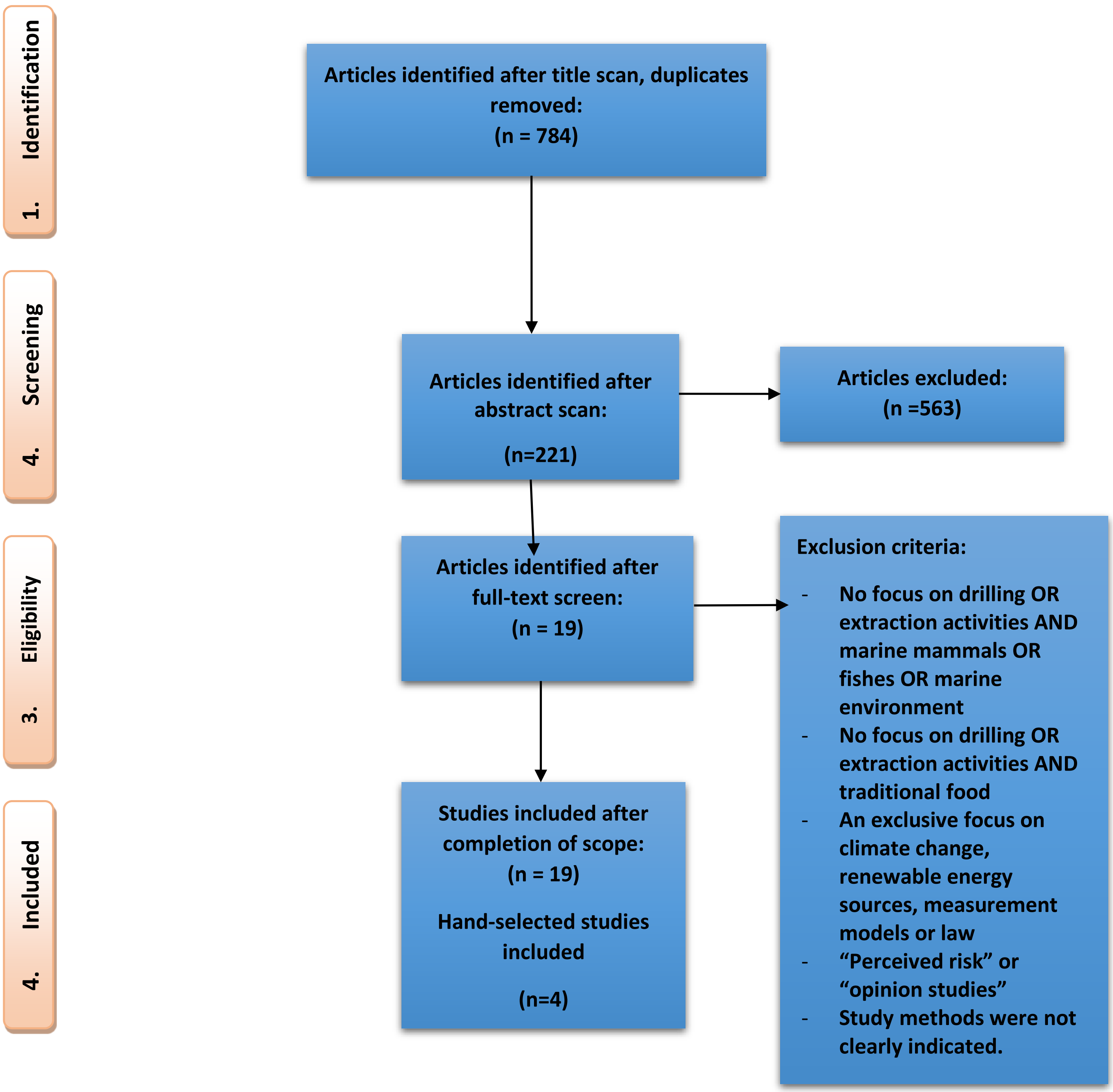
The 23 studies selected for the scope represented six of the seven continents. 20% of the studies were conducted in North America, 15% in Europe, 15% in Asia, 10%

in South America, 5% in Africa, 5% in Oceania and no study was found in Antarctica. Studies were included from multiple continents to understand how offshore drilling has impacted marine traditional food sources globally. Additionally, 10% of the studies had no country because they were conducted in a laboratory setting (see Figure 5 for a breakdown of the continent representation).

9.1.1.2. Species

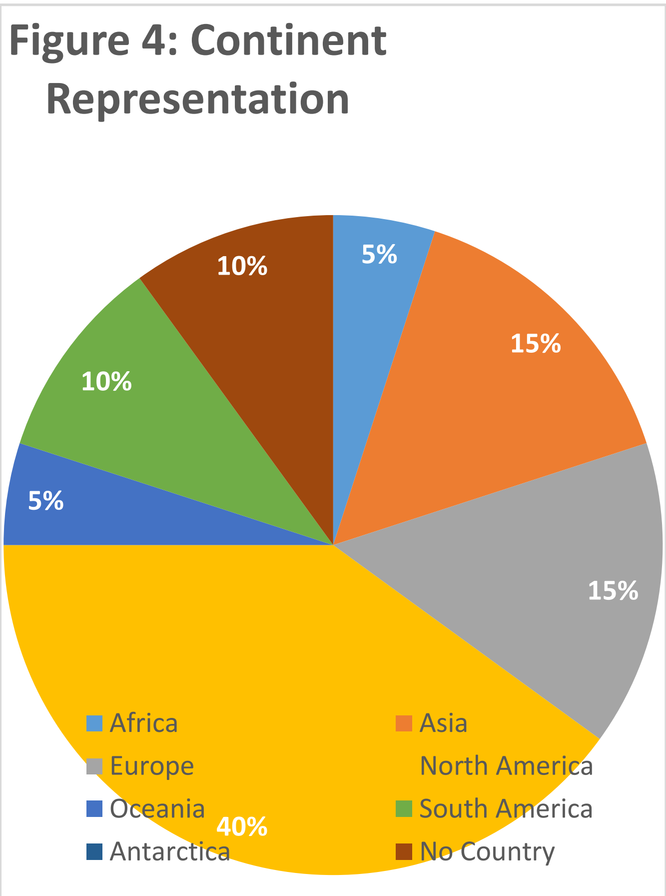
For the use of this study, species were distributed in three categories: 1) marine mammals, such as whales, seals and otters, 2) Fishes and 3) Benthic micro and macro organisms, which include but are not limited to bivalves, crustaceans and echinoderms (see Figure 6 for species distribution). Marine mammals represented 50% of the included studies, 25% of the studies focused on fishes, and 20% studied benthic organisms. Five percent of the studies included were categorized as “other” because the focus was on marine

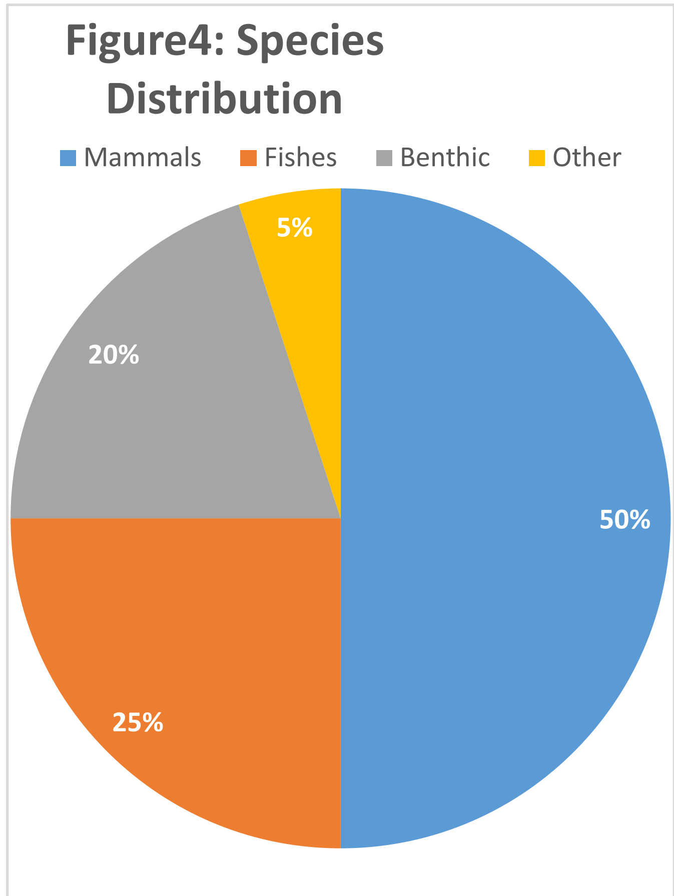
Figure 3. PRISMA Diagram



9.1.1.3. Themes
Based on this scoping reviews' research questions, included articles were categorized into four broad themes:

1) Seismic testing,
2) Toxicity and contamination
3) Oil spills
4) Other.





9.1.2. Effect of Seismic Testing on the Marine Environment

Seismic surveys are loud enough to search for oil and gas reserves that are hundreds of kilometers underground. During periods of seismic testing, the marine acoustic environment becomes 100 times louder (IWC, 2005 & 2007) and this can impact marine mammals and fishes at the population level. Seismic surveys can cause hearing impairment, change in behaviour, avoidance and population displacement and disrupt whale singing activity. The following section will discuss various aspects of seismic noise and its effect on marine fauna (See table 5 for a summary of included studies).

9.1.2.1. Hearing Impairment

Due to the hearing sensitivity of marine mammals and fish, seismic pulses can cause Temporary Threshold Shift (TTS) or Permanent Threshold Shift (PTS). Gedamke, *et al*., (2011) and Popper, *et al*., (2005) studied the impact of seismic testing on hearing impairment in marine mammals and fish, respectively. Popper, *et al.,* (2005) found that in a laboratory setting, young and adult northern pike and broad whitefish experienced statistically significant hearing loss that was recovered 24 hours later. The study noted that although fish recovered from TTS in 24 hours, in the wild, 24 hours with impaired hearing ability could affect the fish’s ability to survive. This study did not perform necropsies and thus could not discuss the possible permanent damage to the structure of the inner ear. In mammals, Gedamke, *et al*., (2011) found that whales that approach seismic vessels between 1-1.2 km were exposed to noise levels sufficient enough to cause TTS. The results from this study indicated that marine mammals, in addition to fish, are vulnerable to TTS (Gedamke, *et al*., 2011).

Table 5

Table5 Seismic Testing Studies Included					
Species	Country	Source	Range	Behaviour	First Author and Date
Cetacean	Brazil	103 surveys conducted using 2D technology and 83 using 3D technology	N/A	decrease in number of cetacean (p=0.048) during periods of high seismic activity in 2000-2003	Parente, *et al*., 2007
Humpback whales	Brazil	103 surveys conducted using 2D technology and 83 using 3D technology	N/A	Increased number of whale stranding's during periods of high seismic activity (2000-2003)	Engel, 2004
Seals	Alaska, USA	3D seismic surveys	150m-250m	Local avoidance, no dramatic displacement	Harris, *et al*., 2001
Young, *et al*., pike, broad whitefish and adult pike	Canada, Mackenzie River Delta	laboratory setting	N/A	24 hour TTS	Popper, *et al*., 2005
Humpback whales	Angola	N/A	N/A	Decrease in breeding singing activity	Cerchio, *et al*., 2014
Seals, porpoises, gray and minke whales	California, USA	2D seismic surveys	150m-70km	All species exhibited avoidance behaviour, some species from 70 km away from source	Bain & Williams, 2006
Gray whales	Russia	3D seismic surveys	5km-20km	Displacement noted between pre-seismic and seismic periods. Population will displace from feeding grounds	Weller & Burdin, 2002
Cetacean	Laboratory Setting	computer simulation	1-1.2 km	It is likely that whales that approach seismic noise sources within a kilometer are susceptible to TTS	Gedamke, *et al*., 2011

9.1.2.2. Behaviour Change

The majority of the studies found that marine mammals exhibited avoidance behaviour and population displacement (Parente, *et al*., 2007; Engel, 2004; Harris, *et al*., 2001; Bain & Williams, 20006; Weller & Burdin, 2002). In Brazil, a period of high seismic activity occurred between the years 2000 and 2003. During this period, Parente *et al*., (2007) compared whale sighting data with periods of high seismic activity. It was observed that there was a significant decrease (p=0.048) in whale sightings during periods of high activity. In addition to a decrease in whale sightings, Engel *et al*., 2004, compared whale stranding data with periods of high seismic activity in Brazil. Similar to Parente, *et al*., (2007) Engel *et al*., (2004) found an increase in whale stranding's during periods of high seismic activity. Although causation could not be determined in either study, a relationship between population displacement and increased whale stranding's was seen during periods of high seismic activity.

In Russia, Weller & Burdin *et al*., 2002 studied the impact of seismic testing on gray whales and discussed comparable results to the studies conducted in Brazil. During feeding season, whales were observed and counted from platforms during pre-seismic, seismic and post-seismic periods. Population displacement was noted between the periods of pre-seismic and seismic and thus concluded that whales will displace during seismic testing despite having to displace from feeding grounds. This can hinder breeding patterns and create malnourished populations. In seals, however, Harris, *et al*., (2001) found that this genus only exhibited local avoidance and no dramatic displacement was observed. Although no major displacement was seen, Harris, *et al*.,

(2001) discussed that because seals did not move from the noise source, it is possible that the population will experience physiological impacts.

Contrarily to Harris, *et al*., (2001), Bain & Williams *et al*., (2015) studied the long range effect of seismic noise on seals, porpoises and whales. This study noticed that all species exhibited avoidance behaviour from 70 km away from noise source. Although only a small sample size was used, this study speculated that avoidance behaviour suggests that animals are displacing from their habitat which could result in population-effects.

9.1.2.3. Singing Activity

Singing for whale survival. Often singing is used in whale mating rituals and seismic testing can impede on these rituals, thus decreasing breeding success. One study in this scope observed a decrease in humpback whale singing during breeding season when seismic surveying activities were occurring (Cherchio, 2014).

9.1.3. Effect of Contamination and Chemical Discharge on the Marine Environment

Eight studies in this scoping review were categorized in this theme and of the eight, seven focused on hydrocarbons and/or polycyclic aromatic hydrocarbons and one studied the impact of drill cuttings on benthic fauna (See Table 6 for a summary of included studies).

9.1.3.1. Bioaccumulation and Human Risk

Bioaccumulation is the build-up of chemicals or toxins being absorbed at a rate faster than metabolized. It reflects the risk of biomagnification by predation (Hellou, *et al*., 2006). Four studies in the scope explored bioaccumulation as either the primary or secondary study outcome (Hellou, *et al*., 2006 ;Formigaro, *et al*., 2014; Zhao, *et al*., 2014; Danion, *et al*., 2011). Formigaro, *et al*., (2014) investigated organochloride and PAH in the diet of captive whales. Whales were fed a diet of wild fish. The study found that the organochlorides and PAHs found in the fish samples were mirrored in the orca blood samples at similar concentrations. The study concluded that a diet high in fish was a significant source of PAH contamination. Hellou, *et al*., (2006) determined that concentration of PAH exposure to fish populations near petroleum developments varied depending on size, sex and lipid content. In fish species with a higher lipid content, such as herring, had a higher concentration of PAH in the internal organs. The study recommended further investigation into the fate of PAH overtime in fish species that are commercially significant (i.e. herring). For humans who subsist on marine animal sources, PAHs in oil and gas development are of particular concern due to the carcinogenic compounds. Danion, *et al*., (2011) and Zhao, *et al*., (2014) studied the levels of PAH levels in sea bass and carp and investigated the risk to human consumers. In the study Danion *et al*., (2011) performed, sea bass were exposed to a mixture of crude oil similar to Arabian oil for 48 hours. After exposure, fish were placed in a clean environment for 15 days. After recovery in a clean environment, PAHs remained in the fish muscles. Carcinogenic PAH compounds were found in fish tissues. Zhao, *et al*., (2014) studied the residual levels of PAH in fish tissue and the risk of bioaccumulation in human consumers. PAH compounds were found in all fish tissues including the edible portions of the fish. The human risk assessment indicated that humans are at risk of induced carcinogenic effects by consuming fish that are exposed to petrogenic or pyrogenic contamination point sources (Zhao, *et al*., 2014).

9.1.3.2. Hydrocarbons and Marine Sediments

Hydrocarbons that are found in marine sediments pose a threat to benthic communities and organisms that prey upon benthic food webs (Harris, *et al*., 2011). The availability of sediment-associated hydrocarbons to benthic organisms provides an additional vector for bioaccumulation in higher trophic levels. Hydrocarbons create a highly toxic environment and toxic sediment is highly available for benthic micro and macro organisms (Harris, *et al*., 2011 & Grant & Briggs, 2002). The toxicity of this environment can also have population level impacts on benthic communities. Currie & Isaacs (2002) determined that drill cuttings in the sediments surrounding drilling sites produced a 36% decrease in benthic biodiversity and a 66% decrease in species abundance. Although the drilling activity had impacts on the benthic community structure, Currie & Isaacs (2011) hypothesized that it was unlikely to have negative impacts on higher tropic levels.

Table 6: Summary of Includes Studies: Contamination and Toxicity					
Species	Location	Source	Type of Chemical	Effect	First author and Date
Sea bass		Experimental oil spill	PAH	Carcinogenic PAH compounds were found in the fish muscle after 15 days of recovery. The presence of these compounds poses a threat to human consumers	Danion, *et al*., 2011
Feral Finfish (plaice, capelin, herring, sand lace and yellow flounder)	Canada	Small scale petroleum development	PAH	Contamination was found in organs of fish. Concentration varied depending on size, sex and species. Presence of organ contamination poses risk of bioaccumulation during largescale development	Hellou, *et al*., 2006
Benthic organisms	Australia	Exploratory gas drilling operations	drill cuttings	36% decrease in biodiversity and 66% decrease in abundance.	Currie & Isaacs, 2005
Sea otters	Canada		Aliphatic and aromatic hydrocarbons from oil and gas drilling	Many levels PAHs exceeded sediment standards. PAH mixtures did not exceed standards but were close to limit. Guidelines may underestimate the toxicity of PAH mixtures	Harris, *et al*., 2011
Sediments	Hutton	drill cuttings and oil wells	hydrocarbons	Highly toxic environment due to hydrocarbon's. Toxic sediment is highly available for benthic feeding organisms	Grant & Briggs, 2002
Carp species	China	Petroleum and combustion	PAH	The human health risk assessment indicated that consumption of these fishes may induce carcinogenetic effects in humans	Zhao, *et al*., 2014
plaice, capelin, herring, sand lace and yellowtail flounder	Canada		PAH	PAHs found in the fish samples were mirrored in the orca blood samples at similar concentrations. The study concluded that a diet high in fish was a significant source of PAH contamination	Formigaro, *et al*., 2014

9.1.4. Effect of Oil Spills on the Marine Environment

In this scoping review, five articles were categorized in the “Oil spill” theme (See Table 7 for a summary of included studies). It can be seen from these articles that oil spills can have detrimental impacts on the environment and respective ecosystems (Al-Mohanna & Subrahmanyam, 2001, Kassaify, *et al*., 2009, Pineiro, *et al*., 1996, Bowyer, *et al*., 2003). Five large scale oil spills are represented: 1) Exxon Valdez, Alaska in 1989 that spilled 37, 000 tons of oil, 2) Jiyeh Power station, Lebanon that spilled 15, 000 tons of heavy oil 3) Aegean, Spain in 1992 that spilled 60,000 tons of oil 4) Deepwater Horizon, Gulf of Mexico in 2010 that spilled 60 million gallons of oil and 5) The Gulf War spill, Kuwait in 1991 that 1,500,000 tons of oil. The oil spills included here represent some of the largest spills of all time that produced numerous acute and chronic environmental impacts. Al-Mohanna & Subrahmanyam (2001) investigated heavy metal accumulation in marine blue crab a decade after the Gulf War Oil Spill. The study found a significant increase in Cu and Zn concentrations that were highly associated with the oil spill. In addition to Al-Mohanna & Subrahmanyam, (2001), Bowyer, *et al*., (2003) documented the chronic impact of the Exxon Valdez oil spill in otters. Otters found immediately after the spill showed a high concentration of hydrocarbons in the blood and tissue samples and exposure continued seven years post Exxon Valdez oil spill to a lesser extent. Both studies document the chronic impact of environmental contamination and the ability for hydrocarbons to bioaccumulation following a large scale oil spill.

In addition to chronic environmental contamination, oil spills can have several acute effects. Firstly, it is likely that in benthic communities, species abundance and biodiversity will decrease post oil spill. Although baseline data for benthic communities is relatively unknown, Valentine & Benfield *et al*., (2013) compared benthic communities in different study sites based on the Deepwater Horizon oil spill trajectory. Some species were more resilient or more vulnerable to the spill however a decrease in taxonomic richness and abundance was seen in the sites most impacted by the spill. Secondly, oil spills create a highly toxic and contaminated environment for marine organisms, which can pose a risk to humans who consume and subsist on ocean resources. Contamination in oysters, which are consumed raw by humans, was documented in a study by Kassaify, *et al*., (2009). No salmonella was found in the collected oysters, however a high contamination rate was found and the Coliform count was higher than FDA approved standards following the Jiyeh oil spill. In turbot and salmon, statistically high hydrocarbon contamination was documented succeeding the Aegean oil spill in Spain (Pineiro, *et al*.1996). The contamination rate decreased over time, however the rate was faster in the turbot compared to the salmon due to a lower lipid content.

Table 7: Summary of Includes Studies: Oil Spills					
Species	Location	Source		Effect	First Author and Date
Blue crab	Kuwait Coast	Gulf war Oil spill	Heavy metals	A decade after spill, high concentrations of Zu and CU in muscle tissue was found and largely associated with oil spill	Al-Mohanna, Subrahmanyam, 2001
Oysters	Lebanon	Jiyeh Oil Spill	Total aerobic bacteria	High bacterial contamination was found. Vibrio spp. Increase post spill. Coliform count was higher than FDA approved standards	Kassaify, *et al*., 2009
Turbot and Salmon	Spain	Aegean Sea Oil Spill	PAH	Significantly high hydrocarbon contamination post oil spill but decreased over time. Decrease occurred faster in turbot (lower fat content)	Pineiro, *et al*., 1996
Benthic organisms	USA	Deep Water Horizon Spill		Decrease in biodiversity and species abundance	Valentine & Benfield, 2013
River Otters	USA, Alaska	Exxon Valdez oil spill	hydrocarbons	High levels of hydrocarbons found in dead otters immediately following spill, exposure in otters continued 7 years post spill	Bowyer, *et al*., 2003

9.1.5. Other

One outlier study did not fit into the above three themes, however it suited the inclusion criteria (See table 8 for a summary of included studies). This study by Reeves, *et al*., (2014) compared cetacean migratory patterns and ranges with hydrocarbon development and shipping maps. A large overlap between cetacean migratory range and potentially disruptive and harmful hydrocarbon development was seen. The study determined that over 50% of cetacean ranges would be interrupted by hydrocarbon development activities.

Table 8: Summary of Includes Studies: Other

Source	Study aim	Result	First author and Date
Oil development projects	Mapping oil development with cetacean migration	A large overlap (over 50%) between cetacean range and potentially harmful human activities and development projects was observed	Reeves, *et al*., 2014

10. Discussion

Considering the Inuit economy is recognized as a mixed subsistence-cash economy and traditional foods are a vital component to cultural identity and physical health, I argue that Arctic food security is dependent upon the availability, access, utilization and stability of the traditional food supply. The following section will discuss the potential implications of offshore drilling on the security of traditional marine food.

10.1.1. Availability

Food availability exists when there is a reliable and consistent source of quality food (FAO, 2008). This dimension of food security, based on the Food and Agriculture

Organization (FAO) definition, is achieved when adequate food is accessible for all individuals at all times. The availability of marine traditional food may be compromised in areas of offshore resource development where the risk of environmental degradation, blowouts, spills and animal population displacement is high. Thus in terms of resource development, the availability of essential marine sources of traditional food that are critical to the survival of the Arctic Aboriginal population, may be significantly threatened.

The availability dimension of food security is described as the amount of adequate food that is attainable by an individual or community (FAO). Therefore, to achieve food availability, an adequate quantity of nutritious food must be obtainable at all times. For example, climate change can alter ecosystems and displace animal populations, thus reducing the availability of traditional food sources. In regards to offshore drilling activities, the availability dimension may be impacted by activities that degrade the environment or ecosystems at the population level such as oils spills and seismic testing.

Oil spills in a marine environment can have long-term impacts at the population level. Oil pollution can impact predator-prey relationships, degrade habitats and decrease productivity (Moreno, *et al*., 2013). As indicated in the results of this scope, after the Deepwater Horizon Oil Spill, a significant decrease in biodiversity and abundance of benthic organisms was seen (Valentine & Benfield, 2013). The results from the Deepwater Horizon Spill are similar to results found by (Penela, *et al*., 2009) from the Prestige Oil spill. In this study, benthic species such as crustaceans and mollusc’s, were impacted by the petroleum pollution (Penela, *et al*., 2009). Although

Valentine & Benfield *et al* (2013) did not investigate the cascading food web effects of the oil spill, it is possible that a bottom up effect can occur causing a disruption in predator-prey dynamics. After the Exxon Valdez Oil Spill, Bowyer, *et al*., (2003) collected 12 carcases of otters and determined that the deaths were due to the acute effects of oiling. Despite the small sample size used in this study, fatality due to oiling could be conclusively determined due to high levels of hydrocarbons in the blood of the otters. The susceptibility of marine mammals to oil pollution can be noted from this study.

In an Arctic climate, environmental and biological degradation from oil spills may be more impactful than in temperate or subtropical regions (Hjermann *et al*, 2007). Given that polar ecosystems are simpler than in warmer regions, change in structure or abundance of a key species can have a greater impact (Hjermann, et al., 2007). The studies on oil spills included in this scope occurred in mostly temperate regions and therefore may underestimate the effect of oil spills on marine systems in the Arctic region.

Seismic testing may also impact marine systems at the population level and thus by consequence, the availability of essential traditional food sources. Change in behaviour and migratory patterns, population displacement and hearing impairment have been documented in marine mammals and marine fishes (Bain & Williams, 2006; Cerchio, *et al*., 2014; Engel, 2004; Harris, *et al*., 2001; Gedamke, *et al*., 2011; Parente, *et al*., 2007, Popper, *et al*., 2005; Weller & Burdin, 2002). During periods of seismic testing, often whale and seal species will displace from habitat grounds regardless of the season (i.e. breeding season or feeding season) (Cerchio, *et al*., 2014; Weller &

Burdin, 2002). Movement of key food species, such as whales and seals, can have many implications to Arctic food availability. In an Arctic climate that is enduring a rapid change in sea ice, the safety of hunting trips is a substantial concern for human health and food security (UN, 2007). As documented by Bain & Williams *et al*., (2005), avoidance behaviour in seals and whales has been documented up to large distances of 70km (Bain & Williams, 2005). The large displacement of vital traditional food sources due to offshore resource development delivers an additional challenge to Arctic food availability. Therefore, seismic testing may play a crucial role in the availability of species that are central to the cultural and physical survival of the Aboriginal population.

Further implications from seismic testing include hearing impairment, disruption in breeding patterns and whale stranding's. Airgun blasts from seismic testing are known to impair the hearing of various marine species. Specifically, TTS over a 24 hour period has been seen in both whales and fish. Although hearing is often recovered after 24 hours, the capacity to hear in a marine environment is indispensable for survival, and consequently TTS could impact the survival of fisheries and marine mammals. Furthermore, the noise from seismic activity can decrease singing activity in whales, disturbing mating. A disruption in mating rituals could weaken the strength of whale populations, thus causing population-level effects. Finally, whale stranding's during periods of seismic testing has been a subject for concern (Engel, 2004). No conclusive evidence exists, however, for relationships between periods of high seismic activity and an increase in whale stranding's have been documented (Cerchio, *et al*., 2014). The above effects of seismic testing have the potential to further challenge the achievement of marine food availability in the arctic by weakening the strength of various marine species and systems.

10.1.2. Accessibility

Food accessibility refers primarily to the economic aspect of food security (FAO, 2008). The accessibility dimension considers an individual's or a community's access to sufficient resources to obtain food (FAO, 2008). Although the economies of the Canadian Arctic Aboriginal communities have experienced numerous changes, these communities continue to have meaningful relationships with their environment (Nacher, 2009). As a result, the economies of these northern communities are categorized as mixed subsistence-cash economies (Harder & Wenzel, 2012 & Nacher, 2009). In mixed-subsistence communities, food access is reliant upon food sharing networks *in addition* to the monetary access of resources. Sharing systems are based on kinship, where the most accomplished male hunter decides the allocation of food and resources (Harder & Wenzel, 2012). In households that do not hunt or have lower-income, sharing meals at one of the focal households in the community is a common way to consume culturally significant traditional food (Harder & Wenzel, 2012).

Access to food in a mixed subsistence-cash economy is not only affected by monetary influences. As discussed, in these communities traditional food is shared with relatives and communities members that do not have the resources or ability to hunt and gather. It is generally frowned upon to sell traditional food to an Inuit community member. Therefore the majority of traditional food acquired remains in the vernacular economy. For this reason, when conceptualizing Arctic food security, non-monetary traditions of food acquisition must be considered. For example, in Clyde River, Harder and Wenzel (2012) determined that on the average household's income during the months of May through August, in 2009, was $84358 dollars. A shadow price of traditional food income during this study period was determined to be $15363 dollars. Given that traditional food contributed to 20% of the economy in Clyde River, it can be clearly seen that if offshore drilling activities pollute or displace traditional food sources, *access* to food will be endangered. Although traditional food is not commodified, it remains an important aspect of the Arctic Aboriginal economy. Therefore Arctic food security is not simply dependent upon the ability to purchase food, but is contingent upon the ability to access traditional foods and share these food sources with family and lower-income households. Any disruption in this social and cultural system may increase the risk of food insecurity in Northern Canada.

In terms of contamination of nutritious marine sources of traditional food may promote mal-nutrition. As seen in Section 6, *Traditional Food*, marine food sources contribute to the largest quantity of traditional food consumed. Additionally, traditional foods provide the Canadian Arctic Aboriginal Peoples with essential micro-nutrients and may act as a protective mechanism against some diet-related disease. Given that market foods must travel great distances and are typically flown into rural arctic regions, the cost of market food generally very high (Socha, *et al*., 2012). Furthermore, poverty rates in Aboriginal communities is disproportionately higher compared to the rest of the Canada (STATSCAN, 2008). Consequently, economic access to healthy market foods is limited.

10.1.3. Utilization

The dimension of food utilization refers to the quality and safety of food (FAO, 2008). This dimension concentrates on adequate nutrition and the safety and sanitation of food throughout the complete food chain (FAO). The contamination of marine food sources in regions of offshore drilling development is a significant issue for Arctic traditional food security. Offshore drilling development provides an additional method of anthropogenic contamination in the arctic food web. In the exploration phase, exploratory drilling can pollute the marine environment through drill cuttings and accidental blowouts (Currie & Isaacs, 2005). Heavy metals, naturally occurring radioactive materials (NORM) and hydrocarbons may be released in the local and regional environment throughout this phase (AMAP, 2007). In the production phase, well drilling, well-production and operational wastes further pollute the local and regional marine environment with produced water (which can contain heavy metals, hydrocarbons, high levels of salt, organic and inorganic material), drilling fluids, cuttings and hydrocarbons. Drilling fluids and drill cuttings have the capacity to be stored in sediments, which is highly available for bottom feeding benthic communities (Harris, *et al.*, K, 2011 & Grant & Briggs, 2002). Due to the potential for marine mammals and fishes to bioaccumulation anthropogenic and environmental contaminants, the safety of traditional food in subsistence arctic communities is an emerging issue in food security (Powers, 2008). Offshore resource development may significantly impact the safety of traditional food, and thus the dimension of food utilization may be jeopardized.

Petroleum hydrocarbon contamination occurs in mixtures in the environment. The largest concentration occurs in the form of polycyclic aromatic hydrocarbons (Albers, 2003), which are of particular concern to human consumers due to their known carcinogenic effect (Mumtaz & George 1996). A gap in knowledge exists about the quantity of PAHs consumed by subsistence communities and the toxic impact on their health; however, the literature does recognize the risk of consuming food that has been exposed to petroleum hydrocarbons (Danion, *et al*., 2011 & Zhao, *et al*., 2014). In various fish species exposed to petroleum development, high contamination of PAHs in blood and tissue samples have been found (Danion, *et al*., 2011; Formigaro, *et al*., 2014; Hellou, *et al*., 2006). Furthermore, the presence of hydrocarbons in organs and consumable tissue indicates that there is a risk of bioaccumulation throughout the food web (Danion, *et al*., 2011; Hellou, *et al*., Zhao, *et al*., 2014). Bioaccumulation can also be seen in large marine mammals with high metabolisms. Formigaro, *et al*., (2014) fed captive killer whales wild herring that had been exposed to PAHs. PAHs present in the fish were also present in the orcas after the consumption of the contaminated fish. It can be concluded from this study that large marine mammals have the ability to be exposed to contamination indirectly through their prey, which may contaminate food sources for the Arctic Aboriginal communities. In addition, although this study was performed on orcas, it can be seen that a diet high in fish exposed to petroleum development may be a significant source of PAH contamination (Formigaro, *et al*., 2014).

Oil spills release large quantities of hydrocarbons, heavy metals and bacteria. After the Jiyeh Oil Spill in Lebanon, a high bacterial contamination rate was found in oysters which are consumed raw by humans globally. A decade after the Gulf War Oil Spill, high concentrations of Zn and Cu were found in the muscle tissues of crabs off the Kuwait coast that were largely associated with the spill. In Spain, following the Aegean Sea Oil Spill, acute hydrocarbon contamination was recorded in salmon and turbot species of fish. Finally, seven years after the Exxon Valdez Oil spill, otters continued to show exposure to hydrocarbons in blood samples. As evident by the list of oil spills above, spills contaminate key food species not only acutely but also chronically. In an Arctic Aboriginal community that subsides off of marine sources of food, the contamination of the environment due to an oil spill will considerably impact the short-term and long-term safety of their food resources. Due to the acute and chronic impacts of oil spill pollution in a marine environment, oil spills may severely promote food insecurity in subsistence Aboriginal communities.

In the past decade, a nutritional transition has occurred in the Canadian Arctic. An increase in high sugar, high fat and calorically dense market foods has increased the prevalence obesity and diet-related disease, such as type II diabetes. If essential marine ecosystems become contaminated or if populations of key species decrease or displace due to offshore drilling development, then the utilization of quality food will continue to decrease. Contamination or loss of traditional food supplies may promote consumption of unhealthy market foods thus increasing the rate of food insecurity and malnutrition in the Canadian Arctic.

10.1.4. Stability

The dimension of food stability refers to the availability, access and utilization of safe and nutritious food sources over time. The stability of food supply can be categorized into three classifications: 1) Normal, indicating a constant and sustainable supply of food, 2) transitory, indicating instability in the food supply due to natural or manmade disasters, market crashes etcetera and 3) Permanent or Chronic instability from repeated shortages or environmental damage. As discussed in the sections on the availability, access and utilization of food security, traditional food is culturally, socially, economically and nutritiously important to the Canadian Arctic Aboriginal Peoples. As a result, the impact of offshore drilling on the stability of the traditional food supply must be considered.

Seismic testing, oil spills and chemical contamination in the marine environment due to offshore drilling activities may have transitory and chronic effects on the stability of the marine traditional food supply. Acute environmental impacts from oil spills and drilling activities, such as change in the benthic ecosystem, decrease in species abundance, biodiversity and high levels of contamination can occur, potentially causing a transitory shift in the stability of the marine traditional food supply. From the scoping results, it can be seen that drilling activities and associated accidents can have a long-term impact on the environment. Hydrocarbon and heavy metal contamination in marine crustaceans, mammals and fishes was found 7-10 years following offshore development project or an oil spill, chronically effecting the food safety of traditional food (Bowyer, *et al*., 2003).

Although the short-term effects of seismic testing on the marine environment can be seen in the scoping results, a gap in the literature exists about the chronic impact of seismic testing on population displacement and behaviour change in key traditional food species. A definite time period for transitory food insecurity has not been defined; however given that exploratory and extraction activities can last for years, it can be argued that contamination, population displacement and change in the marine ecosystem structure, due to offshore drilling activities, could contribute to chronic food instability in the Canadian North.

11. Recommendation, Opportunities and Future Research Need

Traditional food and the sustainability of the Arctic Aboriginal subsistence way of life are crucial for the survival of cultural identity. Furthermore, Arctic food security and Aboriginal diet adequacy is contingent upon the sustainability and maintenance of traditional food (Egeland, *et al*., 2004, 2011; Lambden, *et al*., 2007; Powers, 2008). Given that offshore drilling can have degrading effects on the environment, it is crucial that Arctic resource development decisions consider long-term effects and are developed within an Aboriginal context. The following section will discuss opportunities and future research needs that were revealed from this review.

1. Research assessment and ongoing ecosystem based management

Comprehensive baseline data should be prioritized. Baseline data collection should include water quality, subsistence marine animal pollutant levels, biodiversity, and species abundance. Inclusive baseline data will allow for on-going and long-term evaluation of the effects of offshore drilling on the marine ecosystem and traditional food security. Additionally research and data should include and consider the effects of multiple systems on the subsistence lifestyle, such as climate change and other stressors.

Offshore drilling decisions should be formed based on rigorous research that considers the subsistence way of life. All offshore drilling projects must be established in an environmentally and culturally sensitive way and management of offshore drilling activities should be based on ecosystem management ideologies*(NOAA, 2013).

Finally, on-going monitoring of Arctic systems and the effects of drilling activities on the Arctic Aboriginal traditional food supply must be completed to guide decision making.

2. Integration of scientific knowledge with traditional knowledge

To protect the environment, traditional subsistence lifestyle, culture, health and well-being, scientific knowledge should be integrated with traditional knowledge. Traditional knowledge is comprised of hundreds of years of experience and observation that is transferred generation to generation, whereas scientific knowledge is analytical, didactic and based on the scientific method. The integration of scientific knowledge and traditional knowledge can produce a holistic understanding of the Arctic ecosystem, land and the Aboriginal way of life that can be translated into practice. For example traditional knowledge from elders, hunters and leaders can identify areas of ecological significance, times of the year and areas in which drilling activities should not occur, to protect the subsistence way life (NOAA, 2013).

3. Development of effective partnerships with the Arctic Aboriginal People

Responsible Arctic offshore drilling development is an opportunity to create meaningful and lasting partnerships with the Aboriginal community. Building trusting and effective relationships with Aboriginal leaders means including them at the beginning of the decision making process, asking for feedback often, and ensuring that decisions are transparent (CPP, 2012). Effective relationships between decision-makers and Aboriginal leaders will create empowerment in the Aboriginal community and ensure that decisions are developed within an Aboriginal context.

4. Development of Arctic-specific safety response plans

Safety response plans must be developed within an Arctic specific context. Infrastructure should be developed to withstand the harsh, fragile and unpredictable nature of the arctic climate (WWF, 2011). Furthermore, emergency response plans must consider the uniqueness of the arctic climate. Further research surrounding oil spill dispersion behaviour in an Arctic environment must be conducted for the development preparedness plans (WWF, 2011).

*Ecosystem based management recognizes that several factors influence a system, such as human interaction with an ecosystem.

5. Transparent and accessible data

To effectively develop offshore drilling plans and to monitor the environmental effects of offshore drilling, comprehensive data must be transparent and accessible. Data must be organized in a portal, for example a web-based portal, to be available to stakeholders to ensure that decisions are made from the best and newest data available (NOAA, 2012).

12. Conclusion

This thesis was conducted to explore the potential impact of offshore drilling on the security of traditional food in the Canadian Arctic, to understand the importance of traditional food on the social, cultural, mental and physical health of Canadian Arctic Aboriginal Peoples and to explore the concept of food security *within* Aboriginal context. Using the FAO's four pillars of food security, the study sought to prospectively understand how offshore drilling extractive activities may acutely and chronically effect marine sources of traditional food. Specifically this thesis sought to answer the following research questions:

4. How will offshore gas drilling impact traditional food security of Canadian Arctic Aboriginal People?

5. How does offshore gas drilling impact marine sources of food?

6. What is the importance, culturally, spiritually and physically, of traditional food in the Canadian Circumpolar North?

My thesis questions were important to explore for three reasons. Firstly, food security policies and research are often not conducted within the Aboriginal context and thus fail to fully account for the unique aspects of Aboriginal food acquisition. My thesis directly considers foods security within an Aboriginal setting. Secondly, a significant gap in knowledge exists in terms of the impact of offshore drilling on food security in the Arctic. Finally, this thesis provides an opportunity to discuss the potential negative effects of offshore drilling on the Arctic Aboriginal Peoples ***prospectively.*** Therefore relationships can be built between the Aboriginal people and decision makers before offshore drilling expands, creating the opportunity to develop effective risk mitigation programs and policies that genuinely meet the needs of the people. The following concluding chapter will discuss the study findings in terms of implications.

Food security and diet inadequacy is significantly higher in the Canadian Arctic compared to the rest of the population. Traditional food plays an important role in the social, cultural, mental, spiritual and physical health of the Canadian Arctic Aboriginals. Furthermore, traditional food is also an important factor to Arctic food security. However given that impact from extractive projects in the Circumpolar North transcends national borders, the access, availability, utilization and stability of traditional food is not limited to the extractive activities within Canada. Thus, it is necessary that decision makers and stakeholders proactively develop programs and policies that consider the impact of offshore drilling on traditional food to increase diet adequacy and food security in the Arctic. Furthermore it is imperative that these programs and policies are developed *within* a Canadian Arctic Aboriginal context to ensure inclusion of cultural and spiritual factors. In Chapter 11, the recommendations, opportunities and future research needs discussed were areas of improvement that can occur at home, in Canada. The recommendations, opportunities and future research needs do not require transcontinental agreements and may provide effective ways to limit the negative impacts of offshore drilling on traditional food security. For example, the development of effective relationships and the integration of scientific and traditional knowledge may improve program and/or policy outcomes.

Aboriginal health is holistic in nature and the health and well-being of the population depends on the health of the environment. Thus, it is important to consider how environmental impacts from oil and gas drilling activities may affect the local Aboriginal communities. Many rural Canadian Arctic communities continue to thrive off of a subsistence-based lifestyle and traditional subsistence foods are culturally, spiritually and physically important and are a key aspect of diet adequacy and food security in the Arctic. Specifically, marine sources of traditional food continue to be consumed often and are an exceptional source of essential micro and macro nutrients. If offshore drilling development expands in the Arctic, projects must be developed in an environmentally and culturally conscious manner. In Canada, it is imperative that programs and policies are developed proactively to limit the potential negative effects of offshore drilling on the Arctic Aboriginal Peoples.

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