Modeling the Inuit Diet to Minimize Contaminant While Maintaining Nutrient Intakes

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Abstract

The Arctic environment is changing rapidly. The purposes of this study were: 1) to predict the possible changes of diet composition and the subsequent changes in nutrient intakes as a result of environmental changes; 2) to explore the possibility of minimizing the contaminant exposure while maintaining the energy and nutrient intakes using liner modeling. It was found that a decrease of 10% or 50% of caribou or ringed seal will result in decreases for many key nutrients such as protein, zinc, and iron. It is theoretically feasible to minimize each contaminant intake while maintaining energy and nutrients at the levels of the CINE dietary survey in 2000 for Inuit in the Inuvialuit, Kitikmeot, and Kivalliq regions. However, it is theoretically infeasible for Inuit in the Labrador and Baffin regions under other hypothetical conditions. The modeling results would be useful for Inuit to make informed food choice decisions.

Résumé

L'environnement arctique change rapidement. Les buts de cette étude étaient de: 1) prévoir l'effet qu'ont les changements environnementaux sur le régime alimentaire et par conséquent sur la consommation de nutriments; 2) pour explorer la possibilité de réduire au minimum l'exposition aux contaminants tout en maintenant l'énergie et les prises d'éléments nutritifs en utilisant le modèle linéaire. On a constaté qu'une diminution de 10% ou de 50% de caribou ou de phoque aurait pour conséquence une diminution de plusieurs principaux aliments tels que les protéines, le zinc et le fer. Il est théoriquement possible de réduire au minimum chaque prise de contaminant tout en maintenant l'énergie et les nutriments comme l'indique l'enquête diététique faite par le CINE en 2000 pour les Inuits habitant les régions d'Inuvialuit, de Kitikmeot, et de Kivalliq. Cependant, il est théoriquement infaisable concernant les Inuits habitant les régions de Labrador et de Baffin suivant d'autres conditions hypothétiques. Les résultats modelants seraient utiles pour que les Inuits puissent prendre des bonnes décisions au niveau de leur choix de nourriture.

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1. Introduction

Over the past decades, Indigenous peoples have experienced tremendous changes in their traditional food system and lifestyle because of environmental changes, which include many factors, such as climate change, contaminant increases, ecological change, and economic, cultural, and political change [1-3]. All these factors are closely correlated and directly or indirectly affect their food system, and consequently affect Indigenous peoples' life and overall well-being [4, 5].

Indigenous peoples are often faced with a dilemma of whether or not to continue hunting and consuming traditional food because traditional foods, which are still their main source of nutrient, have been reported to contain various contaminants [6, 7]. It was found that environmental contaminants contained in many traditional food items may result in increased risks of adverse health effects [8, 9]. However, losing traditional food systems may lead to a loss of nutritional, social and spiritual benefits of traditional food use, and may pose Indigenous peoples at risk of nutritional deficiency or chronic diseases [10-12]. The issue of balancing the risks and benefits of traditional food use has stirred the attention of many national and international governmental or non-governmental organizations. They have expressed a need to document dietary intake data, assess benefits and risks, develop strategies and search for effective intervention programs with the goal of modifying the trend of traditional food system loss and promoting Aboriginal peoples' overall well-being [5, 13-15].

This study focused on Inuit, a group of Aboriginal people living in the Circumpolar Arctic. They were the subject of this study due to the fact that Inuit consumed the highest quantity of traditional food among the Indigenous populations in the Canadian Arctic as defined by % energy contribution and kg/day measures. In the

Yukon, the total energy contribution from traditional food in the First Nations community was 17%. Among the Dene/Metis, it was slightly higher at 21%, but was highest among the Inuit at 28%. As well, the Inuit had the highest traditional food intake in weighted measures with an annual average of 140kg/day [16, 17]. Moreover, much of their traditional food is highly contaminated [6, 7], and therefore, Inuit are facing a greater risk of toxicity caused by contaminants contained in traditional foods [5, 18-20].

The ecosystem of the Arctic is a fundamental contributor to global environmental health. The physical and biological characteristics of the Arctic ecosystem are very important for maintaining the integrity of the global environment [2, 21, 22]. As a result, it is warranted to pay closer attention to the topic concerning environmental change, traditional diet and health of Inuit, not only for Inuit but also for all populations.

2. Literature review

2.1. Inuit diet

2.1.1. Indigenous people-Inuit

"*Indigenous people* refers to a cultural group in an ecological area that developed a successful subsistence base from the natural resources available in that environment" [19].

Indigenous peoples are considered the most marginalized and disadvantaged populations according to resources needed for their well-being. The resources include food, health care, and other important factors to maintain a good quality of life [23]. Inuit (the people of the land) were previously called Eskimo (an Indian term which means eaters of raw meat). Besides living in Canada, Inuit are also found living in Russia (Siberia), Alaska and Greenland. According to the 2001 census conducted by Statistics Canada, there are about 45,070 Inuit or 5% of total self-identified aboriginal populations in Canada, with 86% of Inuit living in the north and 14% living in the rest of Canada [24].

2.1.2. Inuit traditional food system

"*Traditional food system* refers to all food from a particular culture available from local natural resources and culturally accepted. It includes sociocultural meanings, acquisition/processing techniques, use, composition, and nutritional consequences for people using the food".[19]

The Inuit traditional food system is comprised of over 300 species of marine and land mammals, plants, and birds, including caribou, ringed seal, narwhals, beluga, arctic char, polar bear, berries, etc.[25]. Based on previous studies, Inuit consumed the highest quantities of traditional foods among the Indigenous peoples in Canada. Even though traditional foods are not main contributors of energy (only 28% of energy came from traditional foods among Inuit), they are still main contributors of many essential nutrients, such as protein, omega 3, iron, zinc, copper, selenium, vitamin E and vitamin A [23, 26]. For example, traditional foods contributed nearly 50% of weekly protein, iron and vitamin A intake in Nunavik women under the age of 45 [27].

2.1.3. Dietary pattern among Inuit

A number of reports concerning the pattern of food use have been published. In summary, the results of these reports include: 1) southern communities consumed more market food than northern communities; 2) men consumed more traditional food than women; 3) older generations consumed more traditional food than younger generations; 4) food sources of diet were greater from animals than from plants; 5) traditional food was the primary source for some nutrients, including vitamin A, vitamin E, protein, omega 3 fatty acids, iron, zinc, and magnesium; 6) market food contributed the majority of fat, saturated fat, carbohydrate, sodium, calcium, and vitamin C; 7) food intakes and consequent nutrient/contaminant intakes varied by region, sex and age group. These conclusions were consistent with the other Canadian Aboriginal peoples [17, 19, 28-32].

2.1.4. Nutritional adequacy assessment among Inuit

The four methods of nutritional assessment include dietary methods, laboratory/ biochemical methods, anthropometric methods, and clinical methods. When assessing an individual or a population's diet, one goal is to determine if the person or the population's usual intake is likely to be adequate. Dietary Recommended Intakes (DRIs) are standard values that are currently used for nutritional assessment. For Inuit, pattern of food use (traditional food and market food consumption), nutritional and sociocultural benefits and risks of traditional food use were relatively well documented; however, studies focusing on assessing adequacy of nutrient intakes were limited.

Two consistently low nutrients in diets of all ages and genders among Aboriginal peoples were calcium and vitamin A [31, 33, 34]. The traditional portion of dietary fat exceeded 40% of the total energy intake for Inuit, whereas, the Sahtu diets contained only 20% [35]. The ratios of omega 6 to omega 3 fatty acid in the Baffin Inuit food profile were 0.26 for women and 0.29 for men which were the inverse of recently proposed ratios (4:1 to 10:1) recommended by Health and Welfare Canada (1990) [35]. Fediuk et al reported that dietary intake of vitamin C (60±8mg/d) from both market foods and traditional foods among Inuit women aged 20-40 in 2002 was below the recommended level (75mg/d) [36]. Egeland et al estimated vitamin A intake in 18 communities representing 5 Inuit regions and found that the prevalence of vitamin A deficiency was the predominant nutritional concern rather than excessive exposure. Public health education campaigns were recommended particularly for younger generations [37]. Kuhnlein et al concluded that Inuit were likely adequate for vitamin D and inadequate for vitamin E [38]. Berti analyzed the data collected during 1987-1988 in the Baffin region for evaluating adequacy of nutrient intakes among children and adolescents. Calcium and vitamin A intakes were inadequate for all age groups. Total and saturated fat intakes were close to the recommended levels, while sucrose intakes were higher than the recommended values [39].

Nutritional assessment for Inuit (as well as for all the Arctic peoples) was limited and incomplete if including all essential nutrient items and all gender and age groups of peoples. This failure might be due to lack of data, difficulties in accurate data collection of dietary intake and food composition, especially for fat-soluble vitamins, and the constraints of the inadequacy assessment using the DRIs procedures. Moreover, the significance of the unusual phenomenon of high fat intake and the inversed omega 6 and omega 3 ratio are unknown [40, 41]. In order to achieve a more accurate and complete nutritional assessment, a huge knowledge gap needs to be filled in future research, including the impact of ethnic differences on nutritional requirement, and effective methods to improve the accuracy of collecting dietary intake data collection, biochemical data and clinical data.

2.1.5. Nutrient and contaminant sources

It is important to identify the sources of key nutrients and contaminants for the risk groups to allow for informed food choices. Consuming the food items which have higher target nutrient levels may help improve nutrient intakes. Conversely, consuming less of the food items which have higher contaminant levels may help prevent further excessive contaminant intakes.

Intakes of contaminants or nutrients depend on the amount of each country food consumed by the individual and the concentration of contaminants or nutrients in that food [7]. For example, the concentration of mercury is not high in caribou, but caribou is still a main contributor of mercury because of the high quantity consumed by Inuit [25].

Nutrient and contaminant sources among Inuit traditional foods have been reported [5, 25]. Marine mammal blubber is the main contributor of fat, monounsaturated fatty acids, and fat-soluble vitamins, such as vitamin A, vitamin D, and vitamin E [42]; land animal fat is the main contributor of saturated fatty acids; animal liver is a good source of vitamin A [20]; rich sources of vitamin C are raw fish eggs, raw whale muktuk, ringed seal liver and blueberries [36]; caribou ribs, caribou bone and head, whitefish head and moose bone are good sources of calcium [43].

Regarding contaminant contributors, caribou, arctic char and ringed seal were main contributors for heavy metals such as mercury, lead, cadmium, and arsenic, while marine mammals were main contributors of organochlorines such as polychlorinated biphenyls (PCBs), chlordane and toxaphene [6, 7, 25].

2.1.6. Factors affecting decline and/or promotion of traditional food use

Food availability, which provides a basis for people to choose food, is a major factor of food use. If a type of food is not available, the full freedom to choose is hindered because a choice can only be made from those foods which are available. Consequently, factors determining food availability and food choice would affect the decline and/or the promotion of food use. Food is a carrier of nutrients as well as contaminants. Identifying the factors that affect food availability and food choice is important for public health professionals to address how to improve nutrition related health conditions.

The relationship of food availability and health risks has generated attention in Hungary. In the second half of the 1990s, the cancer mortality rate in Hungary was the highest in Europe. Additionally, the availability of fats in Hungary was found to be the highest and the availability of vegetables and fruits in the Hungarian population was one of the lowest in Europe [44]. It was considered that the insufficient intake of vegetables and fruits presented in the nutrition of Hungarians played a role in the development of a variety of cancers, such as esophagus, lung, stomach, colon and rectal cancers. It is also a probable risk factor in the development of pancreatic tumors [45]. Through this case, the question, what can government and industry do for human health, needs to be critically considered.

Since the first store opened in Hudson's Bay at the turn of the 20th century in

Arctic Canada, traditional foods contributed less to total energy among Indigenous peoples compared with 100% of total energy from traditional foods of prior centuries. Parallel to these changes, the morbidity of diabetes, obesity, and cardiovascular diseases were reported to be increasing [46, 47]; for diabetes, the morbidity was even higher than the average of the Canadian population [48].

The Arctic ecosystem has been undergoing tremendous changes over the past decades due to climatic changes such as global warming [49, 50]. The beluga travels north later than usual; the populations of polar bear and seal are declining; new bird species are present [51]; the routes of caribou migration are changing [52]. All of these factors would directly influence traditional food availability for Inuit, who still heavily rely on wild animals and plants from the local environment for their survival.

Generally speaking, determinants of food choice could be categorized as food-internal factors or food effects and food-external factors or non-food effects. An example of a food-internal factor is the sensory aspect of food. Examples of food-external factors include: the physical environment and social factors, including cognitive information from public health programs and/or media, cultural, personal belief, social-economic status, health condition, and the level of education of consumers, consumers' concern of weight control, price, health, safety, and convenience, among others [53].

Personal factors are a specific class of non-food factors, including food preference, demographic factors, physiological and psychological needs and traits (e.g. gender, age, sex, and belief) [54]. For example, people's food choices progressively change with ageing as a result of both physiological and psychological factors. Elderly people likely choose easy-cooked and familiar foods [54]. Nutritional surveys also proved that elderly people indeed consumed higher traditional foods than the younger generation [31]. Socio-economic factors were relatively well documented. Low socio-economic populations likely consume high energy and low nutrient-dense foods, and have higher obesity, overweight, and diabetes morbidity [55-57]. Ricciuto L. et al found that households where the reference person had a university degree, purchased significantly more fruit and vegetables, and less meat in comparison with the households with the lower education level; households with children purchased greater quantities of milk products [57]. Some researchers studied even further about personal factors, such as food neophobia and food involvement, and the relationship between them. Food neophobia predicted that people prefer to eat familiar foods rather than novel foods [58, 59]. It was also found that people with a high level of food involvement would likely be able to make finer sensory discriminations between food items [60]. In addition to personal factors, environmental factors, such as food advertisement and peer influence, are also important, especially for adolescents [56, 61, 62].

All the above food use determinants (factors influencing food availability and food choices) would affect general populations as well as Inuit; however, for Inuit and public health workers, they may face greater challenges in nutrition and health promotion due to complex political, economical, environmental, and contaminant issues. As mentioned earlier, less availability of some traditional foods, increasing access to low-quality market foods, influence of western cultural to Inuit populations, and more reports about contaminants in local media, lead to a tremendous decline of traditional food use among some Indigenous peoples [17]. Promoting traditional food use is not solely considering health benefits but also considering economic benefits as up to 78% of households reported that they would not able to afford their food needs if there is no traditional food available [25]. Therefore, when considering a traditional food promotion plan, the following questions need to be answered: Are there sufficient traditional foods available? Is the environment safe for Inuit to access those traditional foods? Is the usual daily intake level of contaminant from traditional food considered safe for their health, especially for children and childbearing age women, so that they can continue consuming traditional foods without doubt?

2.2. Environmental contamination

2.2.1. Priority contaminants

Environmental contaminants such as organochlorines (OCs) and heavy metals have been consistently acknowledged as critical in the Arctic environment because of the underlying risks to human health. These contaminants could be transported through long-range atmospheric and oceanic currents following their release at industrial sites. They can affect human health by entering the food chain, and particularly, some of these pollutants can be bioaccumulated and biomagnified [7, 63]. Because humans are at the top of the food chain, potential health effects on Indigenous peoples are a concern, and as stated earlier, Arctic Indigenous peoples are still consuming a considerable amount of marine and land mammals as their food sources.

Toxaphene, chlordane, polychlorinated biohenyls (PCBs), and mercury are the primary contaminants of concern among Inuit [5, 7, 25].

Toxaphene (chlorinated bornane) was one of the most extensively and widely used insecticides in North America during the 1960s and 1970s. It was estimated that total global use of toxaphene was 1.2 billion kg [64]. The production of chlordane in North America began in 1947, and peaked at approximately 5000 tons/year by 1974. Chlordane was first applied in Canada in 1949 however its use was prohibited after 1995. Although chlordane is no longer registered in North America, various chlordane-related contaminants still persist in the environment [5]. Polychlorinated biphenyls (PCBs) were among the presumed chemical hazards at the Distant Early Warning (DEW) sites [65]. DEW sites might be a major source of PCB pollution; however a more hazardous source of PCBs and other residues is an extension of global contamination by both air spread and transportation in ocean currents, subsequently entering the food chain [65]. Mercury naturally exists in the earth's crust, however humans may increase its release into the environment through several activities, such as industrial emissions, coal burning, and trash incineration [66]. Organic mercury, methylmercury (MeHg), is more toxic than non-organic mercury. Non-organic mercury can be methylated by organisms in fresh and marine water concentrated through the food chain, and accumulated in fish and marine mammals. Traditional foods, such as fish and sea mammals, are considered the primary environmental pathway for MeHg for Arctic peoples [7, 67].

All of these contaminants may cause toxic effects to human health. For example, long-term exposure to MeHg can permanently damage the brain, kidneys, and developing fetus [68]. Although the effects of chronic dietary exposure to PCBs on the central nervous system and the immune system and on the carcinogenic risk in humans still remain unclear. Experimental animal model studies have shown a number of pathologies due to exposure to dietary PCBs [69, 70]; chlordane and toxaphene may cause toxic effects such as suppression of immune responses, endocrine-disruptive capacity and carcinogenic effects [5, 71-73]. The health effects of newly discovered contaminants, such as polybrominated diphenyl ethers (PEDEs) and polychlorinated naphthalenes (PCNs), also have potential health effects, however the impact it has on Inuit is unknown [74].

Over the past decades, even though toxicologists and nutritionists have done considerable work in documenting contaminant composition of traditional foods (contaminant exposure study), identifying biomarkers of toxicity, and dose-response studies (epidemiological and toxicological studies); knowledge gaps still remain about the adverse effect of certain contaminants to humans. The difficulties regarding risk assessment include: 1) multiple contaminant effects make it difficult to establish a relationship between toxic effects and specific contaminants; 2) interaction between nutrients and contaminants and between contaminants may result in toxic effects antagonism, additivity, or synergism; 3) most toxicological studies were conducted in animals, so the results would be less applicable to humans; 4) safety factors (uncertainty factors) may exceed 1000-fold; 5) new contaminants; 6) inconsistent results of contaminant risks; 7) small population size; 8) genetic factors; 9) other health factors confounded with contaminant toxic effects; 10) the differences between technical contaminant and actual human exposure [5].

2.2.2. Contaminant issues in the Arctic

It has been widely recognized that the degradation of the world's ecosystems is caused by the increasing global industrialization, more specifically over the last 50 years. The distant pristine northern lands of Indigenous peoples have also been affected [32]. The sources of these contaminants for the Arctic are from both distant and local environment, such as mineral extraction [32].

Dietary exposure assessment and blood or hair sample studies have shown that peoples of some northern communities have elevated levels of contaminant exposure [6, 14, 75, 76]. Dietary exposure levels of mercury exceeded the Provisional Tolerable Daily Intake (PTDI) for over 50% of residents (83% for men, 73% for women) living in the Inuit community. In comparison, in the Dene/Metis communities, less than 1% of the population had usual intakes exceeding the PTDI for mercury [77]. Blood levels of mercury exceeded the guideline of 20μg/L for approximately 20% of Dene and 57% of

Inuit tested in the North West Territory (NWT) [78]. Total toxaphene residues detected in maternal blood samples from Inuit was 0.74ppb which was 10-fold higher than Caucasians living in the Arctic [5]. It was estimated that the mean intake of chlordane in Qikiqtarjuaq in 1998 was about 0.62μg/kg bw/day, and high consumers were thought to reach up to 5μg/kg bw/day of chlordane residues [5]. There was considerable variation in PCB intake. A pilot study conducted in an Inuit community (Broughton Island) in 1985 illustrated that 18.9% of the 312 respondents consumed more than TDI (1μg/kg bw/day) used by Health Canada [65].

Differences in sampling strategies may effect the conclusion on time trend of contaminants, but for Inuit, there were two similar dietary intake measurements in Qikiqtarjuaq, Nunavut taken in 1987-1988 and 1999. It was shown that mercury exposure data were similar; however, reported intakes of the organochlorines (OCs) were higher in the latter survey. It was stated that this was due to a higher reported consumption of narwhal muktuk and blubber in the community [79].

Traditional food is a critical vector of contaminants, including heavy metals (Hg, Pb, As), organochlorines (PCB, chlordane, toxaphene, dioxin, DDT) and radionuclides (137Cs, 134Cs, 90Sr, 210Po, 210Pb). Canadian Arctic Contaminants Assessment Report (CACAR-1) derived from the first phase of the Canadian federal Northern Contaminants Program (NCP-1,1991-1997) focused on spatial pattern studies and reported that contaminant intakes were higher on the eastern coast than the west. CACAR-II reported the temporal trends of contaminants and the impacts and risks to human health that may have resulted from the current levels of contaminant intakes [5]. Muir et al reviewed spatial and temporal trends and effects of contaminants in the Canadian Arctic marine ecosystem. Higher mean concentrations of mercury in ringed seals and beluga were reported in more recent samples (1993/1994) than in the earlier samples (1981-1984 in eastern Arctic, 1972-1973 in western Arctic), and higher accumulation rates for mercury in present day animals than 10 to 20 years ago. Declining concentrations of PCBs and DDI-related compounds in ringed seal blubber and sea birds were also found. For other persistent organochlorines (OCs), such as chlordane and toxaphene, few significant declines in concentrations in marine mammals or sea birds based on limited data were shown [80].

Several methods, such as changing the method of food preparation (e.g. boiling) and changing dietary composition (e.g. marine vs. terrestrial, fat vs. flesh, old fish vs. young fish), can be considered to reduce contaminant ingestion [18, 32, 48, 81].

2.2.3. Effects of contaminants on Inuit populations

Seeing that fish and marine mammals are important components of traditional diet in the Arctic, Arctic Indigenous peoples in Canada are among the most exposed populations to persistent organic pollutants (POPs) and several heavy metals, such as mercury [48].

A relationship was found between the decrease in birth size and the increase in PCB concentrations, according to the initial results from an ongoing cohort study among the Inuit population of Nunavik. The results of this birth cohort study have also shown a possible link between contaminants and immune deficits in Inuit infants [5]. Dallaire et al reported that there might be a possible association between prenatal exposure to OCs and acute infection in early life in the same Inuit population [82]. Walker et al reported the average body burdens, in Baffin and Kivalliq women who participated in a maternal blood study, were associated with immunological effects and infant weight changes [83]. These findings suggested that, for certain traditional food consumers especially for those high-end (95th percentile) consumers, contaminant intakes at the current level may be sufficiently high as to warrant attention and several intervention plans are needed.

Contaminant distribution differs in human or animal tissues due to its chemical attributes. For example, it is clear that marine mammal fat contains a high concentration of organochlorines due to its lipophilic nature [7], and trans-nonachlor and oxychlordane account for more than 90% of the chlordane residues found in human milk samples [5]. This information would help Arctic Indigenous peoples identify susceptible tissues or animal organs, and make informed food choices. It would also help if public health professionals provide valuable advice on breast-feeding.

Contaminant issues in the Arctic have affected Arctic people's food choice. Hunters might reject their capture due to fear of contaminants [5]. The consequent dietary change (less traditional food and more market food) would definitely decrease contaminant intakes; however, Arctic Indigenous peoples would meanwhile suffer from the loss of a number of benefits of traditional food use, including nutritional, cultural, and spiritual benefits [17]. Contaminant issues in the Arctic played a role in the transition of traditional food and the loss of traditional lifestyle.

2.3. Environmental change

2.3.1. Global environmental change

The concept of the environment comprises the ecological environment, as well as the social, economic and political environments, which may influence the health of ecosystems and the well-being of humans [1]. Environmental change may be anthropogenic or non-anthropogenic [84-86].

The global environment has experienced remarkable changes over the past century, including climate change, loss of biodiversity, the decreasing supplies of freshwater, land degradation, and stresses on food-producing systems [87]. In essence, continued stability of a global ecosystem is the foundation of long-term good health in populations [88, 89]. Unfortunately, the increasing effects of human activities on structures of ecosystems and climate have enhanced both the magnitude and degree of environmental changes.

For example, in China, the pressure on the environment is continuously increasing due to the increasing population, relatively limited resources, and accelerated economic development [90]. Environmental degradation and environmental threats, including air pollution, water pollution, deforestation, sand depositing, soil degradation, and floods, etc, have become worse than they were years ago. Eighty percent of the rivers in China are polluted, and acid rain covers 30% of China [90]. Many populations lack access to fresh water [91]. In 1998, Duan estimated that the annual economic burden of air pollution, water pollution, land degradation, and excessive deforestation would be total about 90 billion U.S. dollars [92]. It was anticipated by scientist that losses from environmental degradation might far surpass economic progress [90].

In Norway, a European country, many sectors, including agricultural productivity, forestry, erosion, and fisheries have been affected by the changing global environment. It was projected using downscaled models that annual mean temperatures would probably increase between 1□ and 2.5□ for 2030-2049 as compared to 1980-1999 [93, 94]. Studies also showed that an increased future warming might have positive impacts on agricultural yields in the North [95, 96]. An increase in the frequency and magnitude of storms stirred concern along Norway's coast. In January 1992, the strongest storm recorded in Norway hit the western part of the country and resulted in an estimated cost of approximately 300 million U.S. dollars. Similarly, heavy snowfall in northern Norway in the winter of 1997 imposed an estimated 23.9 million Norwegian Kroner (NOK) within the transport sector [97].

The degree and the extent of exposure, sensitivity, and adaptation capacity in a certain area would determine the vulnerability of this area to climate change, and hence, it is clear that the vulnerability will vary between different regions, or even vary within regions [98]. A vulnerability assessment is needed in order to establish effective intervention plans. Adaptation capacity is dependent on a number of institutional, economical, social, and governmental conditions [99, 100]. It was found that the process of vulnerability assessment is complex as the potential thresholds and indirect effects may be more important than the direct effects [98, 101, 102].

2.3.2. Environmental change in the north

Inuit observation of natural environmental changes:

The Arctic Climate Impact Assessment Report summarized numerous examples of the Arctic's natural environmental changes, including climate change and Arctic ecosystem change, primarily focusing on the change of weather, season, sea ice, wind, and animals. For example, in the Kitikmeot region of Canada, "warmer temperatures; unpredictable weather; late autumn; early spring; more extreme hot days; spring melt came earlier than in the past in the 1990s; earlier snow melt", were changes observed in the weather. The following changes were reported in animals: "caribou changing migration routes due to early cracks in sea ice; changes in vegetation types and abundance affecting caribou foraging strategies; caribou deaths due to exhaustion from extreme heat and attempts to escape more mosquitoes; new birds seen for the first time such as the robin and unidentified yellow songbird" [103].

Inuit observation of social environmental changes:

"Daily activities no longer had to struggle with the basics of food, shelter, and clothing. Hunting and fishing was replaced by going to the Hudson's Bay Company store. Sewing clothes of animal skins was replaced by buying fabric clothing at the store...... Increased federal government interest brought in more outside community leaders in the form of teachers, doctors, nurses, welfare officers, and government administrators. Local Inuit leadership was totally replaced, creating confusion, uncertainty, frustration, suspicion and resentment. Handouts in a region of malnutrition and sickness resulted in a people's loss of confidence and self-pride" [104].

Over the past decades, the Arctic has undergone dramatic natural environmental change, including climate change and social environmental change. It was reported that the rate of climate change in the Arctic is almost twice as fast as that experienced in the lower latitudes, and climate change is the most important issue in the Arctic [105]. Observed changes include increasing temperature, sea-ice drift, decreasing ice cover, longer melting season, change in hydrology and change in ocean currents and water mass distribution [87]. It has been proven that temperatures have increased at an unprecedented rate over the past century, and warming will be inevitable and particularly evident in the North [106]. It was predicted by Kattsov that a mean warming over the Arctic region by the end of 21st century would be twice the global average (5-7□) [98]. As a consequence, climate-related risks, including greater unpredictability of environmental conditions, geophysical hazards, and changes to marine and terrestrial ecosystems, that already pose and will continue to pose greater challenges to the Arctic communities [107, 108]. For example, warming in the Arctic has lead to the decrease of ice cover and, for some areas annual ice may be significantly reduced or probably entirely lost in the future [109]. Coastal erosion may worsen due to increased amounts of open water in the Arctic Ocean, coupled with rising sea levels [110]. These changes may severely disrupt fundamental parts of Arctic people's life, including transportation and housing, as well as traditional subsistence practices. Shifts in the abundance and distribution of marine and terrestrial species such as caribou, seal, salmon, and moose have already been documented [52, 111]. Polar bear and many other mammals will tremendously decline to such sever levels that it may impact upon the very survival of Inuit [112]. It is extremely probable that a reduction in sea ice will impact reproductive habitats of polar bears, walrus, and ice-dwelling seals, possibly leading towards extinction [50, 113]. It is clear that the impact of these changes could undermine the whole Inuit way of life, culturally, spiritually and nutritionally, since Inuit are still close to the land and rely on the land for survival.

Even though there are many definitions in the literature for vulnerability to climate change, it is widely agreed that it refers to the susceptibility to harm in a system relative to a stimulus. There are two major perspectives of vulnerability: biophysical and social [2]. Biophysical perspective refers to the likelihood or frequency of the physical event exposed to humans, and the system's sensitivity to the impacts of particular events; the social perspective primarily refers to the drivers of vulnerability, including the social, political, and economic conditions (e.g. marginalization, inequality, and poverty) that make exposure unsafe or challenging [3, 4]. With regard to vulnerability to climate change, many researchers have focused on the socioeconomic aspect that constrain the ability to cope with climate hazards [114-116].

It is generally agreed that Arctic peoples, especially Arctic Indigenous peoples, following traditional lifestyle, are especially vulnerable to climate-related risks [115, 117-119]. Historically, Indigenous communities have demonstrated adaptability to deal with a variety of stress and change; however, their adaptable abilities have undergone considerable strain due to recent climatic and environmental changes being unpredictable and traditional knowledge not as useful as it previously was [120, 121]. For example, the increasing unpredictability of the weather and the shift in the timing of the break up of the ice have been particularly problematic for hunters to access traditional foods, and has been a great source of danger [122]. Cultural and social changes, including the loss of traditional knowledge about the local environment and traditional skills, the increase of wage-basis economy, acceptance of westernized lifestyle among younger generations, and an increasing dependence on assistance from the outside, have also weakened community coping capacity [116, 123].

More importantly, the potential thresholds and indirect effects may be more important than the direct and sectoral effects. A particular effect is the underlying health risk of the changing nutritional structure because of the declining traditional food use due to environmental changes [17].

It is a challenge to predict how climate change will alter the transportation of contaminants to the Canadian North [124-131]. However, it is clear that since contaminants enter global systems and are transported through the atmosphere and water, various environmental changes will definitely alter contaminant pathways. This will alter the flux and concentrations at given sites in a number of obvious ways, and consequently affect human contaminant exposure mainly through traditional food consumption [87, 132].

2.3.3. Impact on animal populations

It was generally agreed that across the biosphere, the factors, including land use, climatic change, and atmospheric composition, primarily driven by anthropogenic forces have influenced the biodiversity and sustainable portion of ecosystem goods which are important for humans [133, 134]. It is very important to understand these factors as well as interactions between plants, herbivores and carnivores; the interactions and all factors stated above will influence the degree of genetic variability of component species in a particular environment through the process of natural selection [135-140]. The fact that the changing environment may influence interactions between species, through the number of population and strength among themselves, was recognized [89, 141]. In addition, ecosystem performance is dynamic and is often non-linear interrelations between populations of plants, animals and microorganisms [142].

Many factors could possibly influence the survival of plants, primary and secondary consumers. These factors could be modified by humans, such as levels of soil nitrogen, humidity, phosphorus, calcium and PH, etc [143, 144]. Changes in these constraints would favour a few species, but meanwhile, would make other species suffer [145-147]. Knowledge about physiological characteristics of ecologically important species may help to clarify how a group of species will interact with competitors or predators, and how environmental change affects adaptation and survival [148]. Obviously, the population of a specific group of species will be determined by the living environment (food availability and temperature, etc.) and the physiological and genetic adaptation capacity through effective evolution for reproduction and survival [149-151].

2.3.4. Impact on food accessibility and availability

As stated earlier, the Inuit traditional food system is comprised of over 300 species of land and marine mammals, birds, and plants. Natural environmental change is a key determinant for traditional food availability/accessibility and distribution. The available traditional foods the Inuit can choose to consume (if factors influencing hunt, such as hunting techniques and materials, are not considered) is dependent on the Arctic ecosystem. Shifts in climate or weather patterns can disrupt the regular seasonal cycle of available plant and animal species [32]. Decreasing amounts of polar bear, caribou, seal, and other marine mammals due to environmental change directly reduces traditional food availability [50, 113].

On the other hand, social and political conditions that result in relocation, migration, and urbanization may create change in the types and quantities of food availability. For example, because of acculturation and modernization (also called urbanization and/or westernization), market foods became available in the Arctic at the turn of the 20th century [17]. Since then, market foods have become convenient and easy to access in certain areas. This may in part explain why Indigenous people living in the southern areas or the areas which are closer to cities consumed a significant amount more market foods than those living in the northern rural areas [17].

Many factors may affect food accessibility, such as snowfall condition, thickness of sea ice, the number of stores and the distance to those stores. For example, a secondary data analysis conducted using the 1996-97 national food stamp program survey concluded that easy access to supermarket shopping would be associated with an increased household consumption of fruits [152]. It was found that shorter winter seasons plus decreased snowfall may lead to the decrease of the people's ability to hunt and trap, and consequently reduce access to traditional resources [153]. In July 2000, 52 hunters fell into the ocean due to a large section of ice breaking loose from landfast ice off Arctic Bay. Even though all the hunters were rescued, the incident indicated not only the increasing difficulty of accessing traditional food due to warming weather conditions and thinning sea ice, but also indicated the unpredictability and additional dangers posed by changing climate [120, 154].

2.3.5. Impact on food choice

Besides personal factors, environmental factors, such as the media are major determinants of food choice. In addition, environmental factors may influence food choice through influencing personal factors.

Over the past century, Inuit experienced considerable social environmental changes, such as increasing political stress on constrained hunting, switching from traditional economy to a wage-basis economy, and the increasing media influence [5, 116]. Nowadays, instead of hunting, more Inuit are purchasing market foods from stores, especially the younger generation [17]; on the other hand, it is well known that fear of contaminants, particularly the organochlorine contaminants and heavy metals, has caused a great deal of concern among Arctic peoples, and has potentially affected their food choice, therefore, increased market food consumption has been reported [5, 35].

Food availability/accessibility and food choice may change because of environmental changes, so, the food system of Inuit is changing from a full traditional food system to a mixed traditional food and market food system [5, 35].

2.4. Risk-Benefit of traditional food use

2.4.1. Risks and benefits of traditional food use

Risks of traditional food use refer to the adverse effects caused by contaminants contained in traditional foods. Traditional food benefits have been well documented and discussed in the literature. Seen as a major source of nutrients, for example, fish and many other sea foods contain ample protein, omega fatty acids, and antioxidants such as selenium and vitamin E, which may contribute to the link between fish consumption and reduced risk of coronary heart disease. Besides its nutritional values, the traditional food diet is also a source of spiritual and cultural strength; it can promote an active lifestyle and food security, and increase in food diversity. Previous studies also demonstrated that traditional food might prevent some chronic diseases, such as diabetes [19, 20, 155-158]. In essence, not only is traditional food crucial for the physical aspect, but also for the social and mental health benefits of individuals and communities. All these benefits have been widely recognized by traditional food consumers and researchers [5, 18, 48].

On the contrary, reduced traditional food consumption in northern Indigenous populations, along with decreased physical activity and increasing market food consumption, has been reported to be associated with the increasing morbidity of obesity, dental caries, lowered resistance to infection, etc. [48, 159, 160].

Northerners state: "Inuit foods give us health, well-being and identity. Inuit foods are our way of life…Total health includes spiritual well-being. For us to be fully healthy, we must have our foods, recognizing the benefits they bring. Contaminants do not affect our souls. Avoiding food from fear does."[5]

2.4.2. Relationship between traditional food and chronic diseases

A number of studies have demonstrated that components of northern traditional diets, which are rich in fish and marine mammals, could protect individuals against certain chronic diseases, such as cardiovascular diseases (CVD), diabetes and certain cancers [161-164]. It is generally agreed that the beneficial effects may be attributed to the n-3 fatty acids or some ample minerals, such as selenium, obtained from traditional foods. Studies showed that plasma concentrations of n-3 fatty acids were high among Inuit populations [161, 165-167].

Land based activities such as hunting and fishing were previously an important part of their life, and it has be demonstrated that these physical activities can help to maintain a normal weight and prevent metabolic disorders [25, 168]. However, among many Aboriginal populations, it appears that the trend is towards a more sedentary lifestyle which is considered to be associated with the increasing prevalence of obesity, diabetes and CVD [47, 169].

Therefore, it is the function of negative environmental influences on the availability and access to those important traditional food sources, with the increasing availability and ease of access to low quality market food, plus the loss of traditional lifestyle, that pose the risk of losing traditional food-related benefits. Studies have shown that the increasing intake of energy, especially in the form of simple carbohydrates, is associated with type 2 diabetes among numerous Aboriginal populations, and might be attributed to a more sedentary lifestyle as well as a decreased intake of the traditional diet [26, 170].

2.4.3. Balancing risks and benefits of traditional food use

Increasing Arctic awareness of contaminant issues has driven attention to balancing risks and benefits of traditional food use [14, 81, 171, 172]. There were a number of discussions regarding how to weigh and balance risks and benefits of traditional food use. It is a critical question that needs to be addressed to resolve the Inuit's confusion about facing the dilemma of contaminant risks while maintaining nutritional, and other spiritual and social benefits of traditional food consumption.

As previously mentioned, due to safety factors, animal studies and inconsistent dose-response results, etc, the assessment of contaminant risk is complex. If a group of population's contaminant intake was below the guideline levels, it would be acceptable, even though the long-term low dosage exposure remains unclear [173]. However, if it is higher than the guideline levels, it would be difficult for public health professionals to give advice on traditional food use, particularly for those who rely heavily on traditional food for survival. Egeland and Middaugh questioned the wisdom of applying the new reference dose (RfD) for MeHg in 1996 (0.1μg perkilogram per day) developed by the

U.S. Environmental Protection Agency (EPA) by discussion of the establishment process of those guideline values and their prediction value in several studies on fish consumption [66]. The toxic effects of contaminants to human health are full of uncertainties. On the contrary, the benefits of traditional food consumption are concrete with certainty [19, 32].

Concerning balancing risks and benefits, it is important to know that obtaining as much technical and non-technical information as possible, crossing many disciplines including toxicology, nutrition, environmental policy, and public health practice, is crucial for the comparison of risks and benefits. Large gaps in the research need to be filled in the future [5, 18].

3. Rationale

It was recognized that environmental degradation is an increasing concern among Arctic populations, and it has had a profound impact on various aspects across Arctic Canada, including the changing migration routes of caribou, extinction of some mammals, and retreating icebergs. All of these factors would affect the holistic health of Arctic peoples due to the changing traditional food availability and accessibility as well as the loss of traditional lifestyle. On the other hand, it was stated that the northern environment is the sentinel of the global environment [22]. Therefore, understanding the importance of the factors related to environmental change, diet, nutrients and health in the North is crucial.

The environment will be inevitably changing [98]; however, the extent of the impacts and their implications for the nutritional well-being of individuals and communities in the Arctic is not yet fully understood. Caribou and ringed seal were among the most important species consumed by Inuit [25], therefore it would be meaningful to focus on the impact on the nutrient intakes with the decline of the availability of these two species.

Regarding risks-benefits balancing of traditional food use, previous studies were all based on qualitative methods; no quantitative studies addressed this issue. Furthermore, a safe diet is essential for physical health. There is no known definition for a "safe diet"; however contaminant free or below the risk level should be a criterion of a "safe diet". Tolerable Daily Intake (TDI) and/or Provisional Tolerable Daily Intake (PTDI) are currently used as standard values for contaminant exposure assessment. The necessity of traditional food promotion is not only based on the consideration of health benefits but also on the consideration of economic aspect. Therefore, it would be ideal that the goal of minimizing contaminant exposure while maintaining energy and nutrient intakes from traditional food at reasonable levels could be achieved through the adjustment of food items and intake of traditional foods. A linear model could be developed to test the possibility of achieving the objective of the present study. TDI/PTDI can be used as an upper bound of contaminant intakes. In this study, contaminants in market foods were not taken into consideration, seeing that market food is regulated by Health Canada. Additionally, preliminary findings from Canadian "Market Basket" surveys indicated very low PCB levels in market food [65, 174]. Foetuses and infants are particularly susceptible to contaminants due to prenatal or postnatal contaminant exposure through cord, blood or breast milk from their mothers during the stage of rapid development of their physical and neural systems. It was found that Arctic women consumed greater than acceptable levels of organochlorines [175]. A significant proportion of reproductive age women among Inuit were reported to have lead and mercury concentrations in their blood that exceeded the levels that have been reportedly associated with subtle neurodevelopmental defect in other populations [176]. Hence, additional attention must be directed to the childbearing age women in Inuit communities. The present study will contribute to gaining a better understanding of the impact of environmental changes on nutrient intakes, as well as to provide a novel method to explore the issue of balancing risks and benefits of traditional food use.

4. Questions and objectives of the study

The key questions of the present project are: 1) What would be the extent of indirect impact of environmental changes on nutrient intakes? 2) Could we suggest a diet that can minimize contaminant intakes to less than or equal to the TDI/PTDI while maintaining energy and nutrient intakes from traditional food at reasonable levels?

The objectives of the study are: 1) To evaluate the impact of decreasing harvest on nutrient intakes; 2) To develop a theoretically safe diet that will minimize contaminants to less than or equal to TDI/PTDI and maintain nutrient intakes from traditional food at reasonable levels.

5. Materials and methods

5.1 Ethics

Even though the study only involved secondary data analysis, the ethics approval was obtained from the McGill ethics committee as a supplement component of the original project, "Impact of climate change on food security". The ethics form is attached as Appendix A.

5.2 Data source

5.2.1. Traditional food intake database

The dietary intake data collected by Centre for Indigenous Peoples' Nutrition and Environment (CINE) from 1997-1999 were used in the current study. Five regions and 18 communities were covered in order to achieve geographic representation (Figure 1). This is the most current and complete data describing the Inuit food system.

Regional workshops were held for each participating region to identify participating communities based on factors such as the diversity of the local food system, community size, existing health concerns, and budget limitations of the project. Random sampling of 10% of households in each community took place using household or utility lists. In small communities containing 25 households or less, all households were selected for the interview. The participation rate was high, with a regional participation average equal to or greater than 75% of households and individuals. Survey instruments included 24-hr recalls, food frequency questionnaire, socio-cultural questionnaire, weight and height measurements, and 7-day recalls. For 17% of all the participants, second 24-hr recalls were collected on a non-consecutive day. Approximately 200 samples of food samples were collected for food component analysis.

The data derived from 24-hr recalls were used in the present study, as the 24-hr recall is a valid method to estimate a population's usual intake. Individuals who consumed at least one kind of traditional food per day were selected. A total of 997 individuals and 133 traditional food items were involved in the present study. Table 1 represents the age and gender distribution of the different participants. Pregnant and lactating women were not included in this secondary data analysis.

Figure 1. Participating Inuit regions

Table 1. Listing of age and gender distribution

	Gender	Age group	No.of participants
Inuvialuit	Female	15-19	9
		20-40	54
		41-60	26
		>60	16
	Male	15-19	11
		20-40	49
		41-60	20
		>60	10
Kitikmeot	Female	15-19	4
		20-40	52
		41-60	25
		>60	9
	Male	15-19	5
		20-40	39
		41-60	21
		>60	8
Kivalliq	Female	15-19	4
		20-40	47
		41-60	33
		>60	19
	Male	15-19	4
		20-40	42
		41-60	22
		>60	11
Baffin	Female	15-19	10
		20-40	77
		41-60	58
		>60	21
	Male	15-19	8
		20-40	54
		41-60	58
		>60	16
Labrador	Female	15-19	8
		20-40	44
		41-60	45
		>60	11
	Male	15-19	6
		20-40	39
		41-60	43
		>60	10
		Total	1048*

*Holman community belongs to both Inuvialuit and Kitikmeot, where there were 51 responses, so in total there were 997 participants (1048 minus 51).

5.2.2. Food composition database (nutrients and contaminants)

The composition data of nutrients and contaminants used for this study were taken from the CINE database. Most composition data derived from published reports or from food sampling analyses of the CINE survey2000 [25, 41, 177-179]. When conducting nutrient and contaminant analysis, there should be no missing values for any food items (species*part*preparation); therefore, for some food items, if the composition values of these food items were missing, substitutions had to be considered according to their order of priority.

5.2.3. Assumptions and data substitutions

There were no missing values for nutrient composition in all traditional food items in the CINE food composition database; however, there were several missing values for contaminant concentration. The order of priority for this study was defined as follows: When the data for processed food were not available, data for raw food items were used and vice versa; when the data for some species were not available, the data from the same category species were used; when the data for a part of a species were not available, the data for a similar part were used. For example, PCB concentration data for raw caribou fat existed, however there was no PCB concentration data for raw caribou liver; although there was PCB data for raw caribou flesh, PCB concentration in liver was substituted by PCB concentration in fat. This was done because the organochlorine concentration of liver would be more similar to fat rather than flesh. Appendix B lists all the substitutions included in this study.

Finally, food preparations were combined by using the nutrient and contaminant concentration data of raw species and parts of flesh for all preparations of the respective species and parts in order to include less food items and achieve a more applicable result.

The dietary data used in this study does not separate sea-run char and landlocked char, therefore the Hg data used was the average of both.

Appendix C lists the contaminant composition data used in this study.

5.3. Scenario projection

Four scenarios were evaluated for their impact on nutrient intakes: a 10% and 50% decrease in harvested caribou, and a 10% and 50% decrease in harvested ringed seal. Even though any change in percentage could have been proposed, 10% and 50% were selected to reflect a relatively low and high percentage of change. These were simple scenario projections to describe the impact of food availability change on nutrients. In reality, when one food source declines, people will naturally search for another source to obtain enough energy for survival. For example, if hunters are unable to hunt caribou, they would therefore hunt more fish if possible, or buy affordable market foods. However, it is beyond the scope of this thesis to consider the impact on nutrient intakes involving both market food and traditional food choices.

For the purpose of the present research, the following assumptions were made: 1) if harvested caribou or seal decreased, no other food could be consumed; 2) if harvested caribou or ringed seal would decrease by a certain percent, all food items available for consumption from these species such as caribou liver and caribou kidney would decrease by the same proportion; and 3) the other food consumption patterns would remain unchanged from those identified in the CINE dietary survey carried out in 2000.

5.4. Linear modeling

5.4.1. Establishment of three scenarios

The objective of the linear modeling was to determine whether contaminant intake could be minimized to below the guideline levels (TDI/PTDI) while maintaining energy and nutrient intake from traditional foods at reasonable levels among childbearing age women (15-19 yr and 20-40 yr). Essentially, this is a mathematical equation; however, there was a critical question about nutrition: what are the reasonable nutrient levels that should be maintained in the mathematical model. Simply speaking, since we are aware that the mean intakes of several contaminants have exceeded TDI/PTDI for some contaminants among Inuit, we need to explore the possibility of finding a more acceptable and applicable/usable traditional level of food intake without compromising nutrient requirements, while minimizing contaminants.

Before conducting this quantitative study, it is crucial to understand that nutrients and contaminants are invisible, whereas the required traditional food intakes (in order to achieve that goal) are visible and appreciable by humans. The food property, rather than nutrient, is associated with food acceptability and applicability. Food acceptability and applicability will eventually determine if the goal of balancing the risks and benefits of invisible nutrients and contaminants could be achieved. In other words, if we state that a "nutrient and contaminant" study is hard science [180], a "food" study is beyond hard science because food intake is associated with factors influencing food availability and food choice. More specifically, the latter relates to unquantifiable factors such as culture and levels of education, etc. (section 2.1.6). Therefore, it is evident that a more acceptable and applicable traditional "food" level of intake might not be solely found through a quantitative study; however using this quantitative study as a first step in the topic of balancing nutrient and contaminant intake through adjusting the amount of traditional food intake, would provide a valuable basis and insight of Inuit food consumption.

It is known that most Inuit consume both traditional and market food, and nutrient intake from traditional or market food varies by sex, gender, age, season and region (geography); also, "For most nutrients (except food energy), group mean intake must exceed the Recommended Dietary Allowance (RDA) for there to be an acceptably low prevalence of inadequate intakes...[181]." Due to higher risk of nutritional inadequacy and based on current nutritional assessment studies, several nutrients, such as vitamin A and calcium may need to be given more attention to the specific age, gender or region among Inuit. Only a few studies illustrated the adequacy of many of the other nutrient intakes among Inuit. Hence, firstly, it is reasonable to consider the possibility of maintaining nutrient mean intakes from traditional food at the "current" levels based on the CINE dietary survey in 2000, while minimizing each contaminant intake; secondly, it would be interesting to see if it is possible for Inuit to obtain all of their energy and nutrients solely from traditional food at the levels of Estimated Energy Requirement (EER)/Recommended Dietary Allowance (RDA)/Adequate Intake (AI) (when RDA is not available) while minimizing each contaminant; thirdly, there is a certain portion of nutrients that come from market food, which reflects market food acceptability and affordability among Inuit. There is a possibility that there might be some nutrient intakes from both market food and traditional food equalling more than the RDA/AI, therefore it would be reasonable to consider that the excessive nutrient intake could be reduced by lowering the traditional food intake which would definitely benefit to decrease contaminant intakes. Thus, the nutrient intake levels from traditional food could be set at the levels of the difference of EER/RDA/AI and the energy and nutrient intakes from market food.

This part of the study focused on childbearing-age women (15-40 yr). Baffin and

Labrador diet patterns were very different; whereas Inuvialuit, Kitikmeot, and Kivalliq were relatively similar. Therefore this part of the study was conducted separately for Baffin, Labrador, and Inuvialuit, Kitikmeot, and Kivalliq combined.

5.4.2. Mathematical model:

In order to minimize contaminant intakes to less than or equal to the guideline levels (TDI/PTDI), the amount of high contaminated traditional foods must be reduced, and the corresponding nutrient decrease has to be replaced by non or less contaminated traditional food items for all scenarios.

This is precisely a "linear programming" problem [182]. Linear programming is one of the fundamental problems in operations research. "In mathematics, linear programming (LP) problems are optimization problems in which the objective function and the constraints are all linear. In other words, given a polytope (for example, a polygon or a polyhedron), and a real-valued affine function $f(x_1, x_2, \ldots, x_n) = a_1x_1 + a_2x_2 + \cdots a_nx_n + b$ defined on this polytope, the goal is to find a point in the polytope where the function has the smallest (or largest) value. Such points may not exist, but if they do, searching through the polytope vertices will guarantee to find at least one of them...Many practical problems in operations research can be expressed as linear programming problems. ....Linear programming is heavily used in microeconomics and business management, either to maximize the income or minimize the costs of a production scheme" [183]. However, this is the first time that a mathematical concept has been employed into a nutritional study. The SAS (version 8.02) program, "PROC LP", was employed to operate the linear programming process. "PROC LP: The linear programming procedure in SAS/OR software solves liner programming problems by using the simplex method, a well-established technique for solving linear programs.....SAS optimization can add insight, innovation, and credibility to the decision-making process in virtually any enterprise" [184]. "There are no restrictions on the problem size in the LP procedure. The number of constraints and variables in a problem that PROC LP can solve depends on the host platform, the available memory, and the available disk space for utility data set" [185]. However, the number of decision variables in the present study should be more than or equal to the number of the equalities because there will not be a solution when the number of decision variables is less than the number of equalities, which is the basic rule of mathematics. Therefore, the number of the selected key nutrients which is attempted to maintain, should be less than the number of traditional food items consumed in each group of people in this study. Interactions among nutrients were considered neglectable in this study.

There are three key elements in any optimization problem: "**Decision variables,** representing decisions or choices that are available to you"; "An **objective** that you're trying to achieve (i.e. maximizing profit or minimizing distant of traveled)"; "**Constraints**—requirements or rules that place limits on how you can pursue your objective by placing limits on the values of the decision variables" [184]. "The purpose of an optimization is to achieve the objective within the limits established by the constraints" [184].

"Every such problem can be presented in the following form:
Min $\{ c^T x | A x \geq b, x \geq 0 \}$. Here the vectors $c^T=(c_1,.......c_d)$, $b^T=(b_1,......b_m)$, and the m x d matrix a constitute the input, and $x=(x_1,......x_d)$ is the vector of variables to be optimized. Usually, one assumes that all input numbers are integers or rationals. The goal is to find an optimal x if such exists, and if not, to determine that the problem is unbounded (i.e., the minimum is $-\infty$) or infeasible (i.e., there is no x satisfying all the constraints)" [186].

The basic equations for the present study were as follows:

$$\text{Energy/Nutrient} = \sum_{i=1}^{n} food_i weight \times \ Concentration\ of\ nutrient\ in\ food_i$$

(Equalities for selected nutrient items and energy)

$$\text{TDI/PTDI} \geq \sum_{i=1}^{n} food_i weight \times Concentration\ of\ contaminant\ in\ food_i$$

(4 inequalities for selected contaminant items: mercury, PCB, chlordane, toxaphene)

Here, food $_i$ weight is the decision variable x. Dependant variables of energy and nutrients could be set to be equal to the mean nutrient daily intake from traditional foods (CINE survey in 2000) for scenario 1; or be set to be equal to the levels of EER/RDA/AI for scenario 2; or be set to be equal to the levels of the difference of EER/RDA/AI and the energy and nutrient intakes from market food for scenario 3. Energy, protein, omega 3, omega 6, iron, zinc, copper, selenium, vitamin D, vitamin E, and vitamin A were selected to be covered in scenario 1 and scenario 2. Energy and 17 nutrients (including carbohydrate, protein, fat, saturated fat, polyunsaturated fatty acid, monounsaturated fatty acid, omega 3, omega 6, iron, zinc, copper, selenium, calcium, vitamin C, vitamin E, vitamin D, and vitamin A) intakes from market food were calculated. If the intakes from market food were equal to or higher than EER/RDA/AI, the energy or nutrient items would be cancelled in the model. Therefore, the number of equalities of energy or nutrients would vary among the three groups of people in this study. Dependant variables of contaminants were set to be less than or equal to the tolerable daily intake (TDI) or provisional tolerable daily intake (PTDI). The following levels established by Health Canada were used for this study: 0.71μg/kg/d for mercury, 0.05μg/kg/d for chlordane, 1μg/kg/d for PCBs, and 0.2μg/kg/d for toxaphene. The unit of μg/kg/d was converted to μg/d for each guideline level by multiplying the mean body weight of childbearing age women in each region. The contaminant intake (dependent variable) should be greater than or equal to zero (cannot be negative). Hence, four additional inequalities were set up to control contaminant intakes greater than or equal to zero. On the other hand, the independent variable which is food intake was not considered to be negative. Therefore, a special dataline was used to constrain the independent variable to a value greater or equal to zero. The number of equalities and inequalities were listed together for the three groups of people, including Baffin, Labrador, and Inuvialuit, Kitikmeot, and Kivalliq combined. An additional dataline set was included in the model as input addressing the objective of the study: to minimize each involved contaminant. There are two formats for an input dataset: a dense format and a sparse format. A dense format was used in this study. Appendix D shows the PROC LP program of the Labrador region as an example, and the explanation for the related syntax.

6. Results

6.1. Scenario projection of decline of caribou and ringed seal consumption

Table 2 and Table 3 list the percentage of decrease in nutrient intake from CINE's dietary survey intake levels in 2000, if harvested caribou and ringed seal decreased by 10% or 50% respectively. Nutrient decrease varied by region, sex, and age group. If there was no decrease after rounding, zero was not displayed in the tables.

If harvested caribou decreased by 10% (Table 2a), for females aged 15-19 years living in the Inuvialuit region, all the covered nutrients would decrease by more than 4%; similarly, for males in the same age group and region, energy and most nutrients would decrease by more than 4% (carbohydrate, protein, fat, saturated fat, polyunsaturated fatty acid, monounsaturated fatty acid, omega 3, omega 6, iron, zinc, copper, calcium). Selenium, vitamin E, vitamin D, and vitamin A were exceptions to this decrease. Interestingly, nutrients decreased as age increased for both genders in the Inuvialuit and Baffin regions for all of the nutrients covered. For example, iron would decrease by 8%, 5%, 5%, and 4% for males aged 15-19, 20-40, 41-60, and >60 years living in the Inuvialuit region; similarly, iron would decrease 7%, 3%, 2%, and 2% for males in the same age groups living in the Baffin region. However, for the other regions, there was no obvious trend as there was like in the Inuvialuit and Baffin regions. For females aged 15-19 and 41-60 years living in the Kitikmeot region, most of the key nutrients including protein, omega 3, omega 6, iron, copper, zinc, calcium, and vitamin E decreases would be greater than the other two age groups. For example, protein and copper would decrease 7% and 8% for females aged 15-19 years and 41-60 years; however, protein and copper would decrease less than 6% and less than 7% for the other two age groups. For males aged 15-19 years and >60 years living in the Kitikmeot region, all the nutrient decreases would be greater than the other two age groups. For example, iron, copper, and zinc would decrease by 10%, meaning that almost all of these nutrient intakes came from caribou; in comparison, iron, copper, and zinc would decrease less than 6% for males aged 20-40 and 41-60 years. For females aged 15-19 years living in the Kivalliq region, most key nutrients, including protein, monounsaturated fatty acid, omega 3, calcium, vitamin E, and vitamin A, would decrease at a higher percentage than the other age groups. For example, protein, omega 3, vitamin E, and vitamin A would decrease by 7%, 7%, 7%, and 10% respectively; however, these nutrients would decrease by less than 6%, 2%, 4%, and 3% respectively for the other three age groups of females. For males living in the Kivalliq region, nutrient decreases would increase with age. For example, protein decrease would be 3%, 4%, 5%, and 6% for males aged 15-19, 20-40, 41-60, and >60 years respectively; likewise, zinc decrease would be 3%, 4%, 5%, and 7% for males aged 15-19, 20-40, 41-60, and >60 years respectively. For both males and females living in the Labrador region, nutrient decreases would be greater for the middle age groups (20-40 and 41-60 years) than for the youngest and oldest age groups. For example, protein would decrease by 6% and 4% for males aged 20-40 and 41-60 years; however, for males aged 15-19 and >60 years, protein would decrease less than 3%. Similarly, zinc would decrease by 6% and 7% for females aged 20-40 and 41-60 years; however, zinc would decrease to less than 5% for females aged 15-19 and >60 years. The key nutrients, including protein, polyunsaturated fatty acid, monounsaturated fatty acid, omega 6, iron, zinc, copper, and vitamin E decreased by more than 5% in the vulnerable groups.

The same trend of nutrient decreases were observed when harvested caribou decreased by 50% and 10% (Table 2a and Table 2b). The difference is expressed as the percentage. The key nutrients, including protein, polyunsaturated fatty acid, monounsaturated fatty acid, omega 6, iron, zinc, copper, and vitamin E decreased by more than 25% in the vulnerable groups.

Ringed seal consumption would not be as severely affected, except for the people living in the Baffin region. If harvested ringed seal decreased by 10% (Table 3a), energy and all nutrient decreases would increase with age from 1% to as high as 7% as was found with iron among the male participants living in the Baffin region. For example, omega 3 would decrease by 1%, 3%, and 4% for males aged 20-40, 41-60, and >60 years living in the Baffin region; likewise, iron would decrease by 4%, 6%, and 7% for males aged 20-40, 41-60, and >60 years in the same region. As shown in Table 3a, ringed seal is a good source of protein, omega 3, iron, zinc, copper, calcium, and vitamin A for the elderly in the Baffin region.

Nutrient decreases followed the same trend when harvested ringed seal decreased by 50% and 10% (Table 3a and Table 3b) for the people living in the Baffin region. The difference is expressed as the percentage. Protein, omega 3, iron, zinc, copper, calcium, and vitamin A would decrease from 4% to as high as 36% as was found with iron among the males aged >60 years living in the Baffin region. Table 7b also shows that nutrient decreases would be more evident for the middle age groups (20-40 and 41-60 years) than the youngest (15-19 years) and the oldest (>60 years) in the Inuvialuit, Kitikmeot, Kivalliq, and Labrador regions. For example, nutrient decreases were almost zero for people aged 15-19 and >60 years, when compared to nutrient decreases which were more than 1% for people aged 20-40 and 41-60 years living in the Inuvialuit, Kitikmeot, Kivalliq, and Labrador region.

6.2 Linear modeling: three scenarios

The statistical analysis software (SAS) program, "PROC LP", provided the following output: contaminant, nutrient intakes, and required traditional food intake, when aiming to minimize each contaminant intake while maintaining energy and nutrient intakes at any selected levels. If it was theoretically feasible as shown in the PROC LP, this means that a polygon could be formed and the vertices could be found. The values of the variables (traditional food intakes in this study) would determine the place of the vertices of the polygon in the space. There would be 4 groups of values when minimizing mercury, PCB, chlordane, and toxaphene. If it was theoretically infeasible, as shown in the PROC LP output, this would mean that a closed polygon could not be formed and the vertices could not be found. However, PROC LP can also provide us theoretically best result which could mostly meet the constraints, and infeasible constraints could be identified （new nutrient and contaminant intake information in this case）[185], however, it is unclear how it can interpreted in the polytope.

6.2.1. Scenario 1: Setting the energy and nutrients at the levels of the CINE dietary survey 2000

It would be theoretically possible to minimize each contaminant intake while maintaining energy and nutrient intakes at the levels of the CINE dietary intake levels in 2000, if analyzing for the three regions combined (Inuvialuit, Kitikmeot, and Kivalliq regions).

Table 4a represents that the 4 contaminants could be decreased by 57%-94% and reach the minimized level of 4.4μg/d, 19.8μg/d, 1.3μg/d, and 3.5μg/d for PCB, mercury, chlordane, and toxaphene respectively when aiming to minimize each of them.

Table 4b represents the traditional food intake change with minimizing each contaminant. It is obvious that the continued consumption of marine mammals would not be recommended; in comparison, when aiming to minimize any contaminant, consumption of some land mammals and seafood would be suggested in much higher amounts than before. The increase in traditional foods are highlighted in the respective tables including Table 4b, Table 5b, Table 6b, Table 7b, Table 8b, Table 9b, Table 10b, Table 11b, and Table 12b.

When aiming to minimize PCB, whitefish flesh, pacific herring egg, and caribou blood would be recommended to be consumed 12, 21, and consumed 4 times more than previou intakes. Caribou flesh, caribou fat, caribou liver, and muskox flesh would be recommended to be slightly increased. Most of the birds, plants, marine mammals, half of the land mammals and seafood would no longer be recommended.

When aiming to minimize mercury, caribou head, blueberry, ringed seal blubber, and caribou blood would be recommended to be consumed 40, 44, 5, and consumed 6 times more than previous intakes. Caribou bone marrow, caribou liver, muskox flesh, Arctic hare flesh Arctic char flesh, and whitefish flesh would be recommended to be slightly increased. It would be suggested to cease consumption of most of marine mammals, half of the land mammals, birds and seafood.

When aiming to minimize chlordane or toxaphene, the results would be similar to those of PCB. There were only several food changes that differed with PCB. For example, intake of pacific herring egg was recommended to be increased, if aiming to minimize PCB; however, intake of the same food would be recommended to be decreased if aiming to minimize toxaphene. Energy and the nutrients could be maintained with the suggested traditional food composition (Table 4c).

It would be theoretically impossible to minimize each contaminant while maintaining energy and nutrient intakes by adjusting traditional food composition for childbearing age women living in the Baffin region. PROC LP can also provide us with the theoretically best result which could meet the majority of the constraints; however it is unclear that it was the true result, or the system limitation that the results were the same when minimizing PCB, mercury, chlordane, and toxaphene. Table 5a illustrates that mercury could be reduced by 72% (from 154.5μg/d to 43.7μg/d, PTDI is 43.7μg/d for mercury), chlordane by 92% (from 38.7μg/d to 3.1μg/d, TDI is 3.1μg/d for chlordane), PCB by 80% (from 99.6μg/d to 20.2μg/d, TDI is 61.6μg/d for PCB), and toxaphene by 94% (from 198.9 to 12.3, PTDI is 12.3μg/d for toxaphene). Table 5b shows traditional food intake changes. Cisco flesh and Arctic cod flesh were recommended to be consumed up to 26 and 52 times higher than the previous intakes. Blueberry was especially recommended to be consumed 1400 times higher than previous intakes. Other traditional foods, including ringed seal flesh and blubber, walrus flesh and blubber, arctic char, beluga flipper, etc., were recommended not to be consumed, or to be increased or decreased slightly to a certain degree. Table 5c lists the nutrient changes. Protein, iron, and zinc had to be decreased by 34%, 38%, and 45% respectively. The nutrients which could not be maintained were highlighted in the respective tables including Table 5c, 6c, 7c, 8c, 9c, 10c, 11c, and 12c.

Similarly, for childbearing age women living in the Labrador region, it would be infeasible to maintain nutrients at the levels of the CINE dietary survey in 2000 while minimizing each contaminant. Table 6a shows that mercury and toxaphene intakes could be reduced by 50% (from 58.3μg/d to 28.9μg/d, PTDI is 47μg/d for mercury) and 83% (from 17.1μg/d to 2.9μg/d, PTDI is 13.2μg/d for toxaphene) respectively. Previous intakes of PCB and chlordane were less than TDI, and new intakes were also below TDI. Table 6b shows the traditional food changes required for the reduced contaminant intake. It was recommended to consume blueberry 69 times more than previous intakes. Caribou head, Barren-ground caribou (caribou_B) flesh, and Arctic char flesh were recommended to be slightly increased. Other traditional food would have almost been suggested to decrease to zero. Energy, protein, omega 3, omega 6, iron, and vitamin D could not be maintained at the levels of the CINE survey traditional food intakes in 2000 (Table 6c) with the suggested diet composition change.

6.2.2. Scenario 2: Setting the energy and nutrients at the levels of Estimated Energy Requirement (EER)/Recommended Dietary Allowance (RDA)/Adequate Intake (AI)

The results of setting the nutrient intakes at the levels of EER/ RDA/AI are listed in Table 7 for the Inuvialuit, Kitikmeot, Kivalliq regions combined, Table 8 for the Baffin region, and the Table 9 for the Labrador region.

It would be theoretically infeasible for the three groups of people to obtain energy and nutrients at the levels of EER/RDA/AI while minimizing each contaminant.

For the Inuvialuit, Kitikmeot, Kivalliq regions combined, contaminant intakes could be controlled at the levels of less than or equal to TDI/PTDI (Table 7a). The traditional food consumption of the beluga flipper, blueberries, caribou blood, caribou bone marrow, caribou liver, pacific herring egg and flesh would be recommended to be consumed from 2-1000 times higher than the previous intakes. It would be suggested that other traditional foods would be decreased from 47% to 100% below the levels of the previous intakes (Table 7b). Omega 6, zinc, and vitamin E could not be maintained at the levels of RDA/AI (Table 7c).

For the Baffin region, contaminant intakes could be controlled at the levels less than or equal to TDI/PTDI (Table 8a). It would be suggested that Beluga flesh, walrus flesh, and ringed seal liver would be consumed 1-4 times higher than previous intakes, and particularly, caribou fat and blueberries would be recommended to be consumed 40 and 10000 times higher than the previous intakes. Other traditional foods would be suggested to be decreased from 58% to 100% (Table 8b). Energy, protein, omega 6, iron, zinc, and vitamin E could not be maintained at the levels of EER/RDA/AI (Table 8c).

For the Labrador region, contaminant intakes could be controlled at the levels less than or equal to TDI/PTDI (Table 9a), as well with the suggested traditional food consumption. Regarding the traditional food intake change, as shown in the Table 9b, the traditional food consumption of cranberries, grenadier flesh, porcupine flesh, salmon flesh, and caribou-B flesh would be suggested to be increasingly consumed, and other traditional foods would be recommended to be decreased to zero. Especially, grenadier flesh and cranberries would be suggested to be consumed at 35 and 90 times higher than the previous intakes. Energy, omega 3, omega 6, iron, vitamin E, and vitamin A could not be maintained at the levels of EER/RDA/AI (Table 9c).

6.2.3. Scenario 3: Setting the energy and nutrients at the levels of the difference of EER/RDA/AI and the energy and nutrient intakes from market food

The results of setting the nutrient intakes at the levels of the difference of EER/RDA/AI and the energy and nutrient intakes from market food are listed in the Table 10 for the Inuvialuit, Kitikmeot, Kivalliq regions combined, Table 11 for the Baffin region, and the Table 12 for the Labrador region.

It would be theoretically infeasible for the three groups of people to obtain energy and nutrients at the levels of the difference of EER/RDA/AI and the energy and nutrient intakes from market food while minimizing each contaminant.

For the Inuvialuit, Kitikmeot, Kivalliq regions combined, contaminant intakes could be controlled at the levels of less than or equal to TDI/PTDI (Table 10a). Beluga oil, blueberries, caribou blood, and caribou bone marrow would be recommended to be increased, and especially, caribou blood, caribou bone marrow, and blueberries would be recommended to be consumed 26, 52 and 556 times higher than previous intakes. Other traditional foods would be suggested to be decreased from 57% to 100% (Table 10b). Omega 6, calcium and vitamin E could not be maintained at the levels of the difference of RDA/AI and the nutrient intakes from market food (Table 10c).

For the Baffin region, contaminant intakes could be controlled at the levels of less than or equal to TDI/PTDI (Table11a). An increase in blueberries, blackberries, and ringed seal liver would be recommended, and blackberries in particular would be recommended to be consumed 134 times higher than previous intakes. It would be recommended to decrease other traditional foods from 68% to 100% (Table 11b). Energy, omega 6, iron, zinc, calcium, vitamin D and vitamin E could not be maintained at the levels of the difference of EER/RDA/AI and the energy and nutrient intakes from market food (Table 11c).

For the Labrador region, contaminant intakes could be controlled at the levels of less than or equal to TDI/PTDI as shown in Table 12a. It would be recommended to increase traditional food consumption of blueberries, blackberries, fowl hen spruce flesh, and salmon flesh, while recommendations of other traditional foods to be decreased to zero. Especially, the consumption of blueberries and blackberries would be recommended to be consumed 75 and 900 times higher than previous intakes (Table 12b). Energy, omega 6, calcium, and vitamin A could not be maintained at the levels of the difference of EER/RDA/AI and the energy and nutrient intakes from market food (Table 12c).

6.2.4. Summary of the recommended traditional foods

Table 13. Summary of the suggested traditional food

The group of people	Traditional food
Inuvialuit, Kitikmeot, and Kivalliq combined	Bearded seal intestine Ringed seal blubber Beluga oil flipper Caribou fat, liver, blood, bone marrow, flesh, and head Muskox flesh Arctic hare flesh Pacific herring eggs and flesh Arctic char flesh Whitefish flesh Blueberries berries
Baffin	Narwhal muktuk skin only Ringed seal liver and broth Walrus flesh Beluga flesh Caribou fat Cisco (with herring) flesh Clams contents no shell Arctic cod flesh Fowl ptarmigan flesh Blueberries berries Blackberries berries

Labrador	Caribou heart Caribou-B flesh Porcupine flesh Fowl hen spruce flesh Arctic char flesh Salmon flesh Grenadier flesh Blueberries berries Blackberries berries Cranberries berries

The recommended traditional foods in these three scenarios are summarized in Table 13. Since the traditional foods listed above are recommended in one or more scenarios, they must be promoted. However, this does not imply that other traditional foods should be reduced, because there are a number of underlying problems which need to be further explored in the future concerning this topic.

7. Discussion:

With respect to the results of section 6.1 (Scenario projection for the impact on nutrient intakes of the decline of caribou and ringed seal consumption), the impact was shown to be prevalent and severe if caribou decreased by 10% or 50%, because caribou is a nutrient-dense species containing a variety of nutrients, and was reported to be highly consumed among Inuit [25]. In comparison, a decrease in ringed seal would primarily pose a nutrient loss to the Baffin region. This is because ringed seal is a key marine species for Inuit in the Baffin region, however it is not for Inuit in the other regions [25].

The essence of the model is to predict nutrient intake change based on food harvest data; however, food choice factors may change with the environment, which may cause a proportional or disproportional decrease in traditional food items. On the other hand, traditional food composition may also change with the natural environment. All of these factors may limit the predictive value of this model. Nonetheless, the model highlights that in this situation an alternative strategy has to be considered to prevent Inuit from the increasing risks of nutritional deficiency, especially for those vulnerable groups of people whose consumption of key species is high. Furthermore, the following questions need to be considered: 1) How can the harvest exercise be improved if the species is still available in the local environment? 2) Are there other traditional foods or high quality market foods available? Are they affordable and acceptable? 3) How necessary is it to implement strategies like food fortification, and how much? 4) What could the government do once these changes occur?

As for the results in section 6.2 (minimizing contaminant intake by changing traditional diet composition among women of childbearing age), it is important to understand that a number of considerations need to be taken into account when applying this method to all Indigenous peoples' regarding this topic: balancing risks – benefits.

To do so, we conducted an optimization research by employing PROC LP, which is a mathematical method, helping us find extreme values (minimization) while maintaining energy and nutrients at reasonable levels. It is very clear that contaminant intake should be less than or equal to TDI/PTDI; however, the reasonable energy and nutrient intake levels from traditional food remains unclear. We tested three scenarios which maintained energy and nutrients at different levels. The strengths and weaknesses of each scenario are summarized below:

Table 14. Strength and weakness of each scenario

Scenario	**Strength**	**Weakness**
Scenario1	Contaminant intakes were higher than the risk guideline levels for many contaminants based on the CINE dietary survey in 2000, so it is appropriate to employ PROC LP because the "conflict" is obvious.	Energy or several nutrient intakes may still be higher than the guideline levels even though they were not maintained at the previous levels (theoretically infeasible results: Table 5c, Table 6c).
Scenario2	Based on the idea that traditional foods need to be promoted, it would be desirable for Inuit to obtain entire required energy and nutrients from traditional foods.	Traditional food only contributed 20+% energy of EER according to the CINE dietary survey in 2000. If we set the energy to be maintained at the level of EER, which means 5 times higher than previous energy would come from traditional food only. Fat and meat are good contributors of energy. However, they are very high in

		contaminants. These contaminants need to be controlled at the levels less than or equal to TDI/PTDI in the model. Hence, intakes of low energy-dense and low contaminant-dense food such as berries need to be increased (Table 7b, Table 8b, and Table 9b). This would definitely result in more unacceptable (unusable) results compared with setting the energy and nutrient intakes at the levels of the CINE dietary survey in 2000.
Scenario3	The current market food intake reflects market food affordability and acceptability. It is reasonable to consider obtaining energy and nutrients from traditional food at the levels of the difference of the guideline level of EER/RDA/AI and energy and nutrients obtained from market food. Thus, energy and nutrient intakes could be adequate and the opportunity of the excessive contaminant intake could be reduced.	The difference is very small (Table 10c, Table 11c, and Table 12c). The contaminant exposure due to the small portion of energy and nutrients needed from traditional food may destine less than or equal to TDI/PTDI. There may be few possibilities of excessive contaminant intake, so it might be inappropriate to employ PROC LP in this case.

As shown in the Tables 4-12, the general results reflected the fact that marine mammals are the main contributors of OCs and mercury. The changed direction (increase or decrease) and changed degree might be interpreted with the contaminant concentration. For example, beluga blubber contains high amounts of contaminants: 80ng/g for mercury, 2000ng/g for chlordane, 3636ng/g for PCB, and 6120ng/g for toxaphene, therefore beluga blubber would not be recommended to be consumed when aiming to decrease contaminants in any scenario. However, based on the model, a number of recommended traditional food dietary changes are difficult to fathom. For example, blackberries, which contain low contaminants, were recommended to be consumed less (Table 5b).

Regarding the results of the three scenarios, nearly one out of the three traditional food items, which were all important nutrient sources and played an important role in Inuit peoples' life, would be recommended not to be consumed for all regions. Meanwhile some traditional foods would be recommended to be consumed 2 times to as high as thousand times of previous intakes in order to minimize each contaminant while maintaining a certain level of energy and nutrients. The questions raised are: "Would there be sufficient traditional foods available to meet this suggestion?" and "Is this acceptable for individuals or communities with different food preferences and cultural levels? The study provided a theoretical diet for Inuit; however, many applicable considerations need to be taken into account in real life, including food availability, acceptability, cultural aspects and beliefs. On the other hand, we cannot expect one type of theoretically feasible diet to be applied to every person in that region. Inter-personal variability, including food preference and food habit, needs to be considered in future work. PROC LP can be run by individual if we have related data.

Diet changes seem to be necessary due to the evidence showing that contaminant intakes are higher than the guideline levels. The current diet definitely reflects many realistic conditions such as food availability and food preference. If we draw an axis and the current diet is displayed as the origin, then, the closer the new diet to the origin, the more applicable it would be in reality as it changes a little; on the contrary, the further the new diet to the origin, the more difficult (making less sense) it would be in reality as it changes too much. However, it is hard to say beyond which cut-off point the new diet would not make sense in reality because the applicability of the new diet is determined by several factors that influence food availability and food choice (see section 2.1.6). The new intakes which were 10 times higher than the previous intakes were marked with stars as they were easily identified to make not much sense from a common view (Table 4b, 5b, 6b, 7b, 8b, 9b, 10b, 11b, and 12b). Many realistic considerations, such as how to deal with the rest of the caribou meat if only caribou bone marrow is recommended, are beyond the scope of this mathematical model. What the results of this model are able tell us is that Inuit will benefit from reducing contaminant intakes below or equal to levels of risk (TDI/PTDI), while maintaining nutrients at a certain level, seeing as to whether they follow the recommended diet. With respect to the reality of applicability, it is clear that many model and non-model factors need to be considered in future research.

It is important to note that 0.71μg/kg body weight/day as a guideline level of total mercury used in this study. This level was established by Health Canada for PTDI of total mercury daily intake for the general population, and there is no guideline level of total mercury for childbearing age women; therefore, it might underestimate the risk of mercury to women of childbearing age among Inuit in this study. However, if 0.2μg/kg body weight/day (the newly established guideline level for methylmercury for childbearing age women) was used, the risk of mercury would be overestimated as the concentration of mercury from CINE's contaminant composition database was reported as total mercury rather than that of methylmercury. Since the percentage of methylmercury varies in different traditional food items, it is not possible to recalculate the intake of methylmercury only.

Validity of TDI/PTDI as a boundary constraint for this model is very important. The establishment of valid TDI/PTDI is an ongoing process. For example, some studies on monkeys regarding the mutagenicity and carcinogenicity of toxaphene will be useful for reassessing the toxicity and PTDI of this chemical [5]. As mentioned in the literature review, there are many difficulties involved in the process of establishing TDI/PTDI and conducting contaminant exposure assessments. Several examples are: unclear multiple contaminant effects, interaction and correlation between contaminants, between nutrients, and between nutrients and contaminants, safety factors used from animal studies to humans as well as inconsistent dose-response study results. Furthermore, contaminants, like excessive nutrients, circulate through the human body and may cause toxic effects at different levels of tissues or organs. If intakes exceed certain levels, effects can range from minor biochemical changes to severe clinical symptoms. Therefore, TDI/PTDI is comparable with Tolerable Upper Intake Level (UL) in regards to nutrients, and similarly, biomarkers can be identified at different levels. However, the level of effect (within the homeostatic or not) caused by the nutrient or contaminant intakes, would be related to many factors, such as enzymes or the strength of interactions with other chemicals [187]. For example, environmental degradation of PCBs, including that by "animal" enzyme systems, can alter the properties of the original PCB mixture [188]; however, enzyme systems, which are determined by genes, may vary among species of animals, and ethnic groups among humans [189-191]. Genetic differences between ethnic groups of people, due to environmental adaptation, needs to be emphasized when establishing TDI/PTDI for toxic assessment. On the other hand, it was known that some nutrients may have a protection role, such as selenium on MeHg toxicity; however, the mechanisms remain unclear, and the results were inconsistent in showing the relationship between a specific nutrient and a contaminant. Further studies are needed to explore the influence of dietary components to toxicity of contaminants, and nutritional therapy may be an effective method to treat contaminant intoxication [192]. Based on this knowledge, it needs to be mentioned that it may be possible that the high intake of fish and marine mammals in Inuit diet, which contribute to high selenium and essential mineral intakes, could affect the validity of TDI/PTDI for Inuit.

A lot of basic research is required prior to this kind of study, such as the establishment of TDI/PTDI. The upper bound of decision variables can be supplemented in the model once we know the acceptable maximum traditional food intake based on favourite foods and food availability. For example, acceptable berry intake levels must vary by individual and by region; however, we have no data on the acceptable berry intake to indicate the upper bound in the model, therefore all the decision variables were considered infinite by default in this study. Hence, it is understandable why many traditional foods would be suggested even thousands of times higher than previous intakes. "Once you have found a solution, you need to implement it in the situation that you are modeling—and it may happen that you find that the solution cannot really be implemented.... In this case, you would go back to the model and add a restriction that it must consider .... This kind of give and take between the model and what it is representing is natural. It is how models are improved"[184].

As a fundamental problem in operations research, LP has been studied and developed since it was formulated in 1940s [186]. It was stated that it might be the most widely used optimization model in the world regarding the problems in economics, industry, military, etc. It was a valuable exploration to employ LP into a nutritional study. However, it should be noted that some fundamental properties of LP and its algorithms are still not fully understood [186], and thus it would be interesting to understand the following paragraph: "That is not to say that we all succeed at optimization. We experience varying degrees of success, influenced by a number of factors. We might not have the freedom to take the actions that really produce the best results. We might have incomplete or incorrect information on how various actions interact with each other, how they are limited by our circumstances, or how they influence the outcomes. There may be so many choices of possible actions that it is impossible to evaluate them all. We might not even have a reliable way to determine if the outcome we produce is remotely close to being the best outcome " [184]. Numerous mathematical research can be found relating LP. For example, Ron Shamir questioned the efficiency of the simplex method [186]; an approach which can be used to analyze of improper problems of linear programming [193]; and how to analyze and solve infeasibility [194].

The present research can be improved with the development of mathematical knowledge. How the model can be improved and how usable the results are will depend on how much and how accurate the related information we have is.

On the other hand, it is important to note that in reality it might not be necessary to minimize the contaminant intakes. It would be sufficiently safe to decrease contaminant intakes to less than or equal to TDI/PTDI if the TDI/PTDI is reliable. Thus, the group of those equations (energy and nutrients, dependent variables which can be set to be equal to certain levels) and non-equations (contaminant intakes, dependent variables which can be set to less than or equal to TDI/PTDI) could already be a useful tool. For such a group containing equation and non-equation, there are infinite groups of solutions, meaning that there are infinite combinations of different food amounts and food items which could meet the constraints: maintaining nutrient intakes at certain levels while decreasing contaminant intakes to less than or equal to TDI/PTDI (not minimize). Currently, there is no mathematical software through which the output can provide us with a possible solution since there are infinite solutions. However, we may pre-input reasonable daily intakes of some foods. The number of input of food items must be the difference of the number of variables and the number of constrains in equality. This is based on the mathematical rule that there might be a solution group when the number of variables equals the number of equations. The input of food items and amount could be dependent on different priorities. For example, we may input lower risk (low contaminant concentration) traditional food into the group and then calculate the intakes of the higher contaminated (relatively high contaminant concentration) traditional food items, or input those most preferred or most available traditional food intakes, and then calculate how much other food intakes should be adjusted. And meanwhile, contaminant intakes should be controlled to below TDI/PTDI levels while maintaining nutrient intakes at certain levels. This process can be redone until a more applicable result can be obtained. Scenarios can be projected in future research to test the usage of the group, of the equalities and inequalities if a group of levels of fixed reasonable energy and nutrient intakes from traditional foods need to be maintained. However, the fixed reasonable energy and nutrient intakes from traditional food remains a problem.

In addition, it may not be necessary to maintain energy and nutrient intakes at fixed levels. For example, the energy and nutrient intakes from traditional foods can be set between the differences of EER/RDA/AI and the energy and nutrient intakes from market foods, and the differences of Tolerable Upper Intake Level (UL), and the nutrient intakes from market foods. Meanwhile, the contaminant intakes can be set in the same range: less than or equal to TDI/PTDI and greater than or equal to zero. If we have related data, food intakes (independent variables) can also be restricted in a certain range. For example, if we know that people living in the Labrador region usually consume a minimal amount of 10 g of blueberries per day and a maximum amount of 50 g per day based on blueberry availability and food preference, then we can add one more inequality to the group of inequalities. It is obvious that the solvability of the group of inequalities will decrease while the number of constraints increases. There might be some kinds of mathematical and statistical software which may be employed to solve the group of inequalities such as matlab and SAS.

Nonetheless, the analysis represents a preliminary and exploratory attempt to evaluate the utility of the linear program model in identifying ways of encouraging traditional food consumption while minimizing contaminant exposure. This established novel method will provide a valuable mathematical tool and consequently will provide researchers and policy makers a basis for understanding the contaminant risks related to the nutrient benefits of traditional food use. Additionally, the current work will contribute to provide more information for informed decision making regarding food choice at the public health and individual levels.

Figure 2 illustrates the holistic outline presented in this study, regarding the relationship between environmental changes, food systems, guideline levels of contaminants and nutrients, physiological responses to contaminant and nutrient intakes, genetic differences, and health. The first vertical arrow on the top can be demonstrated by sections 2.3.4 and 2.3.5. Three arrows from traditional food depicted in Figure 2 represent traditional foods' risk (contaminant) and two main benefits (social culture and nutrients); Nutrients from both traditional foods and market foods will determine Inuit nutrient intakes. TDIs and DRIs are standard values used for contaminant and nutritional assessment, and they are located between food use and physiological response. Accurately, TDIs and DRIs should be determined by people's internal environment (gene) reflected by biochemical changes and clinical symptoms, as illustrated in the box. This is a critical element, which may in part explain the twin phenomenon of increasing global food supply existing side- by-side with the increasing nutrient deficiency and excess nutrient intakes [195, 196]. This might be because the food supply mismatched the nutrient

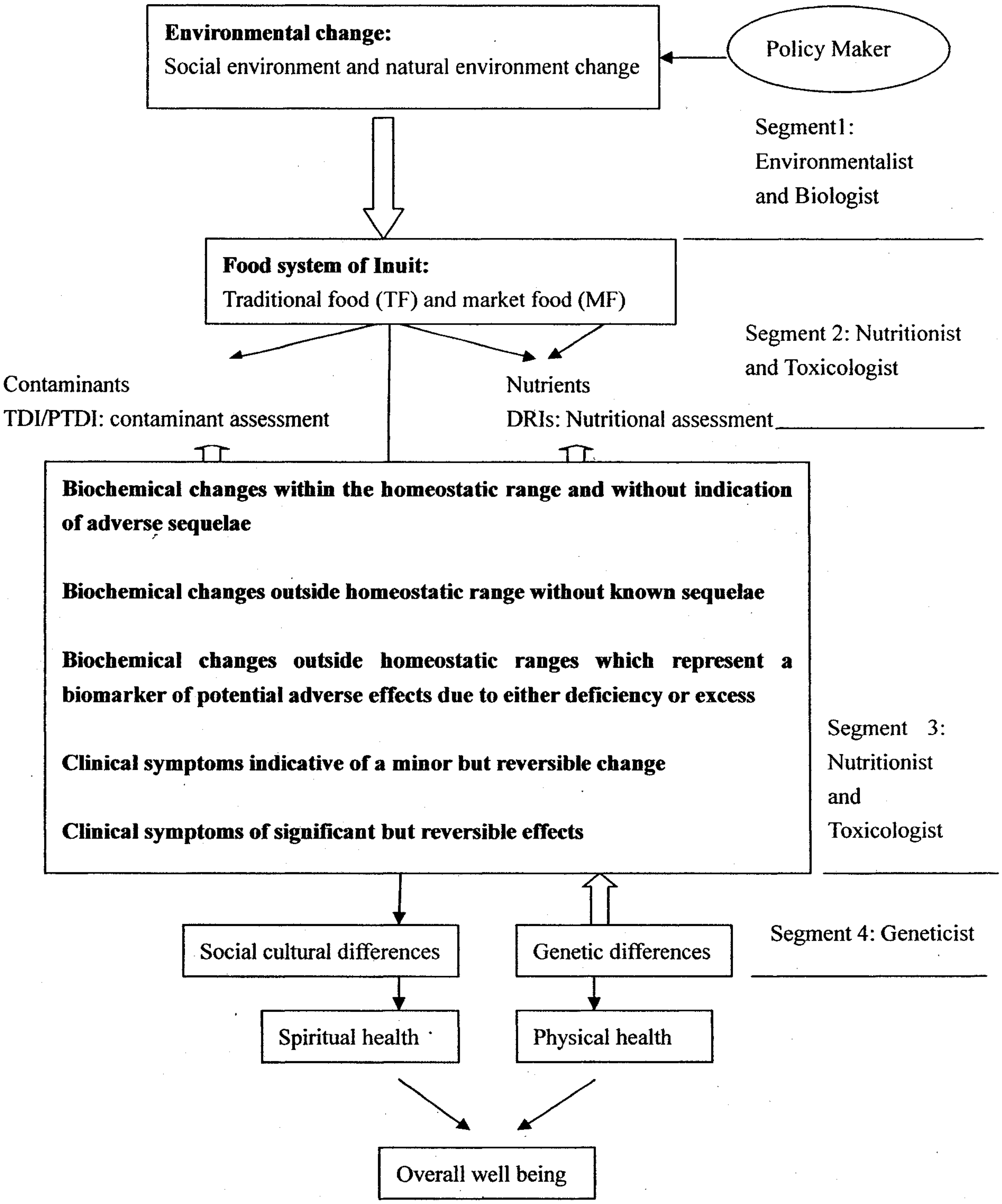

Figure 2. Environmental change, food system, ethnic difference, and health

requirements. The bottom of the figure illustrates that health includes two aspects: spiritual/emotional health and physical health. It is clear that traditional food plays an important role for Inuit's overall health when observing the entire figure. Key players are in each segment on the right hand side.

Dietary transition may be associated with adverse health effects [17, 197, 198]. On the contrary, in Australia, a remarkable improvement in carbohydrate and lipid metabolism was shown among diabetic aboriginal people who temporarily returned to their traditional food and lifestyle [156, 199]. Through a nutritional perspective, it is the proper ratio between each nutrient and amount of each nutrient (which fit a specific group of people's nutritional requirement and metabolic characteristics) that play an important role for human health [200], regardless of the source of the nutrients. For this case, the preventative property of traditional foods might be explained by low simple carbohydrate content in traditional foods alleviated insulin resistance. Therefore, if traditional food availability is inadequate or traditional food has to be reduced due to contaminant risks according to reliable risk guideline levels, the alternative is to supplement nutrient loss through market foods. The chosen market foods should have a similar nutrient structure (ratio and amount of nutrient) to the traditional foods.

Finally, it needs to be emphasized that stopping emissions of persistent pollutants into global environments is the only reasonable and permanent solution to eliminate contaminants. The collective effort of all key players, including geneticists, nutritionists, toxicologists, anthropologists, biologists, environmentalists, policy makers/governors and educators is warranted for finding adaptation and intervention strategies against environmental changes.

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Tables:

Table 2- Table 12

Table 2a. Percentage changes of nutrient intakes if harvested caribou decreases by 10 %

Region	Gender	Age group	Energy	Cho	Prot	Fat	Sfat	Pufa	Mufa	Omeg3	Omeg6	Fe	Cu	Zn	Ca	Se	VitC	VitD	VitE	VitA
Inuvialuit	Female	15-19	-6	-4	-7	-5	-6	-5	-5	-6	-5	-7	-8	-7	-6	-4	-5	-4	-8	-10
		20-40	-5	-4	-5	-4	-5	-4	-3	-2	-5	-4	-5	-6	-3	-3	-3		-4	-1
		41-60	-5	-5	-5	-3	-5	-4	-2	-1	-6	-5	-6	-5	-1	-1	-2		-3	
		>61	-5	-2	-5	-3	-5	-3	-3	-1	-5	-5	-6	-7	-2	-2	-1		-3	
	Male	15-19	-7	-4	-8	-6	-8	-7	-6	-4	-8	-8	-8	-8	-4	-2	-3		-6	-1
		20-40	-6	-4	-6	-5	-5	-5	-4	-3	-6	-5	-6	-7	-4	-2	-3		-5	-1
		41-60	-5	-3	-6	-4	-6	-4	-4	-2	-6	-5	-6	-6	-3	-3	-3		-4	
		>61	-3	-1	-4	-1	-3	-2	-1	-1	-3	-4	-5	-5	-1	-1			-1	
Kitikmeot	Female	15-19	-6	-1	-7	-6	-5	-4	-5	-4	-4	-6	-8	-7	-6	-4	-1		-6	
		20-40	-6	-5	-6	-5	-6	-4	-4	-2	-6	-6	-7	-7	-4	-4	-3		-6	-1
		41-60	-6	-9	-7	-5	-7	-5	-4	-2	-8	-7	-8	-8	-3	-5	-7		-9	-10
		>61	-4	-3	-4	-4	-5	-3	-3	-1	-5	-3	-6	-5	-2	-1	-2		-5	-2
	Male	15-19	-8	-10	-9	-7	-9	-7	-6	-4	-9	-10	-10	-10	-5	-10	-8		-9	-1
		20-40	-5	-2	-5	-3	-4	-3	-2	-2	-4	-4	-6	-6	-3	-3	-2		-5	
		41-60	-4	-6	-4	-3	-4	-3	-2	-1	-5	-5	-6	-5	-3	-3	-3		-5	-2
		>61	-9	-7	-9	-9	-9	-7	-8	-4	-9	-10	-10	-10	-6	-8	-5		-8	-5
Kivalliq	Female	15-19	-7	-10	-7	-7	-8	-8	-9	-7	-8	-7	-7	-6	-7	-4	-7		-7	-10
		20-40	-5	-7	-5	-6	-7	-5	-5	-2	-6	-5	-6	-5	-4	-1	-1		-4	-2
		41-60	-6	-7	-6	-5	-7	-5	-4	-2	-8	-6	-8	-6	-5	-1	-2		-4	-1
		>61	-5	-10	-5	-5	-7	-4	-4	-1	-7	-8	-7	-7	-3	-4	-4		-6	-3
	Male	15-19	-2	-10	-3	-1	-4	-1	-1		-5	-2	-5	-3	-2		-1		-3	
		20-40	-4	-7	-4	-4	-6	-4	-3	-2	-6	-5	-6	-4	-4	-1	-1		-3	-2
		41-60	-5	-5	-5	-4	-6	-4	-3	-1	-6	-5	-7	-5	-4	-1	-1		-3	-1
		>61	-6	-7	-6	-6	-7	-4	-4	-1	-7	-6	-8	-7	-4	-3	-4		-7	-4
Baffin	Female	15-19	-5	-7	-5	-5	-7	-6	-5	-3	-7	-4	-7	-5	-4	-1	-1		-4	-1
		20-40	-3	-4	-3	-2	-5	-2	-1	-1	-5	-2	-4	-4	-1		-1		-2	-1
		41-60	-3	-4	-4	-2	-4	-2	-1		-5	-2	-5	-4	-2		-1		-1	-1
		>61	-3	-6	-4	-2	-4	-2	-1	-1	-6	-2	-5	-5	-1	-1	-1		-2	
	Male	15-19	-6	-9	-7	-4	-6	-4	-4	-1	-7	-7	-7	-7	-6	-3	-7		-6	-4
		20-40	-5	-8	-4	-5	-7	-3	-4	-1	-6	-3	-6	-5	-2	-2	-4		-4	-2
		41-60	-3	-5	-4	-3	-5	-2	-2	-1	-5	-2	-5	-4	-2		-1		-3	-4
		>61	-3	-6	-4	-2	-4	-2	-1		-5	-2	-5	-5	-2	-1	-1		-2	-1
Labrador	Female	15-19	-3		-4	-3	-4	-3	-3	-3	-3	-3	-4	-5	-2	-3	-1		-3	
		20-40	-5	-3	-5	-4	-6	-4	-4	-2	-6	-5	-6	-6	-3	-3	-3		-5	-2
		41-60	-6	-2	-6	-5	-7	-6	-6	-3	-7	-5	-6	-7	-2	-3	-1		-5	
		>61																		
	Male	15-19	-3		-3	-2	-3	-2	-2	-1	-3	-3	-4	-4	-1	-2	-2		-4	
		20-40	-6	-4	-6	-5	-6	-5	-5	-3	-6	-6	-6	-7	-3	-5	-4		-6	
		41-60	-4	-3	-4	-3	-5	-3	-3	-1	-4	-4	-4	-5	-1	-2	-2		-4	-1
		>61	-2	-1	-1	-2	-3	-1	-3	-1	-2	-1	-2	-2			-1		-1	

Table 2b. Percentage changes of nutrient intakes if harvested caribou decreases by 50 %

Region	Gender	Age group	Energy	Cho	Prot	Fat	Sfat	Pufa	Mufa	Omeg3	Omeg6	Fe	Cu	Zn	Ca	Se	VitC	VitD	VitE	VitA
Inuvialuit	Female	15-19	-31	-22	-33	-25	-30	-27	-26	-28	-27	-36	-42	-36	-28	-20	-27	-22	-42	-49
		20-40	-24	-20	-26	-21	-24	-19	-17	-10	-25	-21	-27	-29	-13	-13	-13		-19	-3
		41-60	-23	-27	-26	-15	-23	-18	-12	-6	-31	-26	-30	-27	-6	-4	-9		-13	-2
		>61	-24	-11	-27	-17	-26	-17	-17	-7	-24	-27	-31	-35	-9	-12	-3		-14	-2
	Male	15-19	-36	-21	-38	-31	-40	-33	-29	-18	-40	-40	-40	-41	-21	-8	-14		-32	-4
		20-40	-30	-21	-31	-25	-26	-23	-18	-13	-29	-27	-32	-33	-22	-12	-15		-25	-4
		41-60	-26	-16	-29	-20	-28	-20	-18	-8	-29	-27	-31	-31	-13	-14	-17		-22	-1
		>61	-14	-6	-18	-7	-13	-8	-5	-3	-16	-22	-23	-24	-6	-5	-1		-5	-1
Kitikmeot	Female	15-19	-32	-7	-34	-30	-23	-22	-23	-21	-22	-31	-39	-36	-28	-20	-3		-28	-2
		20-40	-31	-23	-32	-26	-28	-22	-19	-11	-30	-29	-36	-36	-22	-18	-13		-31	-6
		41-60	-32	-47	-33	-27	-34	-25	-20	-10	-40	-37	-41	-41	-16	-25	-37		-47	-49
		>61	-19	-15	-20	-18	-25	-14	-16	-4	-27	-15	-30	-27	-8	-5	-9		-23	-8
	Male	15-19	-42	-50	-43	-37	-43	-36	-30	-20	-46	-49	-48	-49	-26	-50	-38		-46	-4
		20-40	-23	-11	-25	-17	-19	-16	-11	-9	-22	-22	-28	-30	-14	-17	-8		-26	-2
		41-60	-20	-32	-22	-16	-21	-15	-11	-5	-25	-24	-29	-27	-13	-14	-16		-27	-9
		>61	-44	-36	-44	-44	-46	-35	-39	-22	-45	-49	-48	-49	-30	-38	-26	-1	-41	-26
Kivalliq	Female	15-19	-35	-50	-35	-37	-41	-38	-43	-33	-39	-36	-36	-32	-36	-18	-33		-33	-50
		20-40	-26	-37	-24	-29	-36	-23	-25	-11	-32	-23	-30	-23	-19	-5	-6	-1	-20	-8
		41-60	-30	-35	-32	-26	-37	-27	-21	-11	-38	-30	-38	-32	-23	-4	-8		-18	-5
		>61	-27	-49	-27	-25	-34	-19	-19	-7	-35	-39	-36	-36	-13	-18	-21		-31	-14
	Male	15-19	-12	-50	-17	-6	-18	-7	-6	-1	-24	-10	-24	-17	-10		-7		-14	-2
		20-40	-22	-35	-22	-22	-30	-18	-17	-8	-28	-24	-28	-22	-18	-6	-6		-16	-10
		41-60	-23	-23	-24	-21	-30	-19	-16	-6	-32	-23	-33	-24	-18	-3	-3		-16	-5
		>61	-29	-34	-29	-29	-33	-20	-20	-7	-35	-31	-39	-37	-22	-15	-22		-34	-20
Baffin	Female	15-19	-26	-36	-26	-25	-35	-28	-26	-14	-35	-19	-33	-24	-22	-3	-4		-22	-7
		20-40	-15	-19	-17	-11	-23	-10	-6	-3	-23	-10	-22	-18	-6	-2	-3		-9	-3
		41-60	-14	-20	-19	-9	-20	-9	-5	-2	-24	-10	-25	-20	-8	-2	-3		-7	-3
		>61	-16	-29	-20	-10	-19	-11	-6	-3	-28	-10	-26	-23	-6	-3	-6		-11	-2
	Male	15-19	-29	-43	-34	-19	-32	-20	-18	-7	-34	-36	-34	-33	-32	-17	-35		-32	-19
		20-40	-23	-42	-22	-25	-34	-16	-19	-6	-29	-14	-29	-27	-12	-10	-19		-20	-10
		41-60	-16	-27	-18	-14	-27	-10	-8	-3	-25	-11	-24	-20	-12	-2	-7	-1	-14	-20
		>61	-15	-32	-19	-8	-19	-9	-5	-2	-25	-9	-27	-26	-8	-4	-7		-10	-7
Labrador	Female	15-19	-17	-2	-18	-14	-20	-15	-17	-13	-16	-15	-18	-23	-11	-14	-5		-16	-1
		20-40	-26	-13	-27	-22	-30	-22	-21	-11	-29	-26	-32	-30	-13	-17	-15	-1	-24	-9
		41-60	-30	-12	-31	-27	-35	-28	-32	-16	-34	-24	-32	-37	-9	-15	-6		-27	-1
		>61	-1		-1	-1	-1	-1	-1		-1		-1	-1						
	Male	15-19	-14		-16	-9	-14	-10	-8	-5	-15	-16	-18	-22	-6	-10	-10		-19	
		20-40	-28	-20	-29	-26	-30	-25	-24	-17	-28	-29	-30	-33	-15	-25	-21		-29	-2
		41-60	-18	-13	-19	-17	-24	-15	-17	-7	-22	-21	-22	-26	-4	-8	-10		-19	-5
		>61	-8	-3	-7	-12	-15	-7	-15	-3	-9	-7	-11	-12	-2	-2	-4		-6	-1

Table 3a. Percentage changes of nutrient intakes if harvested ringed seal decreases by 10 %

Region	Gender	Age group	Energy	Cho	Prot	Fat	Sfat	Pufa	Mufa	Omeg3	Omeg6	Fe	Cu	Zn	Ca	Se	VitC	VitD	VitE	VitA
Inuvialuit	Female	15-19																		
		20-40								-1		-2				-1				
		41-60								-1		-1								
		>61																		
	Male	15-19																		
		20-40										-1								
		41-60				-1			-1	-1		-1				-1				
		>61																		
Kitikmeot	Female	15-19																		
		20-40								-1		-1				-1				
		41-60				-1			-1	-1		-1				-1				
		>61	-1		-1	-1	-1	-1	-1	-1		-6	-1	-2	-1	-3	-1		-1	
	Male	15-19																		
		20-40										-1								
		41-60				-1			-1	-1		-1				-1				
		>61																		
Kivalliq	Female	15-19																		
		20-40							-1	-1										
		41-60	-1		-1	-1		-1	-1	-1		-3			-1	-1				
		>61																		
	Male	15-19																		
		20-40																		
		41-60	-1		-1	-1		-1	-1	-1		-2			-1					
		>61																		
Baffin	Female	15-19	-1		-1	-1		-1	-1	-1		-3		-1	-1	-1		-1		
		20-40	-2	-1	-2	-1	-1	-2	-1	-2	-1	-6	-2	-2	-2	-1	-1	-1	-1	-4
		41-60	-2	-1	-2	-1	-1	-2	-1	-2	-1	-5	-2	-1	-3	-1				-1
		>61	-2	-1	-3	-2	-2	-3	-3	-4	-2	-6	-3	-2	-2	-2	-2	-1	-1	-6
	Male	15-19																		
		20-40	-1		-1	-1		-1	-1	-1	-1	-4	-1	-1	-2	-2	-2		-1	-1
		41-60	-2	-1	-3	-2	-1	-2	-2	-3	-1	-6	-2	-2	-2	-2	-1	-1	-1	-2
		>61	-3	-1	-4	-3	-2	-3	-3	-4	-2	-7	-3	-3	-4	-3	-1	-1	-1	-2
Labrador	Female	15-19																		
		20-40										-2				-1				
		41-60								-1		-2	-1			-1	-2	-1	-1	-9
		>61																		
	Male	15-19																		
		20-40							-1	-1										
		41-60																		
		>61																		

Table 3b. Percentage changes of nutrient intakes if harvested ringed seal decreases by 50 %

Region	Gender	Age group	Energy	Cho	Prot	Fat	Sfat	Pufa	Mufa	Omeg3	Omeg6	Fe	Cu	Zn	Ca	Se	VitC	VitD	VitE	VitA
Inuvialuit	Female	15-19																		
		20-40	-2		-2	-2	-1	-2	-2	-3	-1	-8	-1	-1	-1	-4	-2	-2	-1	
		41-60	-2		-1	-2	-1	-2	-2	-3	-1	-6	-1	-1		-1	-1			
		>61																		
	Male	15-19																		
		20-40	-1		-1	-1				-1		-3		-1	-1	-1	-1	-1		
		41-60	-2		-1	-3	-1	-2	-3	-5	-1	-6	-1	-1	-1	-3	-2		-1	
		>61																		
Kitikmeot	Female	15-19																		
		20-40	-2		-2	-2	-1	-1	-2	-3	-1	-7	-1	-1	-2	-4	-1	-1	-1	
		41-60	-2		-1	-3	-1	-2	-4	-4	-1	-4		-1	-1	-3	-1			
		>61	-7		-7	-6	-3	-3	-4	-4	-2	-29	-4	-8	-4	-14	-6	-1	-5	-2
	Male	15-19																		
		20-40	-1		-1	-1				-1		-5	-1	-1	-1	-2	-1		-1	
		41-60	-2		-1	-3	-1	-2	-3	-4	-1	-7	-1	-1	-1	-3	-2		-1	-1
		>61																		
Kivalliq	Female	15-19																		
		20-40	-1		-1	-2	-1	-2	-3	-5		-2			-1	-1				-1
		41-60	-3	-1	-3	-3	-1	-3	-3	-7	-1	-13	-2	-2	-6	-3	-1	-1	-1	-1
		>61																		
	Male	15-19																		
		20-40																		
		41-60	-3	-1	-3	-3	-2	-4	-4	-7	-1	-12	-2	-2	-4	-2	-1	-1	-1	-1
		>61																		
Baffin	Female	15-19	-4		-4	-3	-2	-3	-3	-5	-1	-14	-2	-3	-5	-4	-1	-4	-2	-1
		20-40	-10	-3	-11	-7	-5	-9	-6	-11	-5	-31	-10	-8	-11	-6	-4	-3	-4	-20
		41-60	-9	-3	-11	-6	-5	-8	-6	-10	-5	-27	-9	-7	-15	-5	-2	-2	-2	-4
		>61	-12	-3	-13	-10	-11	-17	-14	-22	-8	-31	-14	-10	-9	-11	-11	-4	-7	-30
	Male	15-19																		
		20-40	-6	-2	-7	-3	-2	-4	-3	-4	-3	-21	-4	-6	-9	-10	-8	-1	-3	-5
		41-60	-11	-4	-14	-8	-5	-12	-8	-14	-6	-30	-10	-10	-12	-9	-6	-4	-4	-11
		>61	-17	-4	-18	-14	-11	-17	-14	-20	-9	-36	-14	-15	-21	-13	-6	-3	-6	-9
Labrador	Female	15-19																		
		20-40	-2		-2	-1	-1	-1	-1	-2	-1	-8	-1	-2	-1	-3	-2	-1	-1	-1
		41-60	-2	-1	-2	-2	-1	-2	-2	-3	-1	-11	-3	-2	-1	-5	-8	-5	-6	-44
		>61																		
	Male	15-19																		
		20-40				-1		-1	-3	-3		-1				-1				
		41-60								-1										
		>61																		

Table 4a. The changes of contaminant intakes in the Inuvialuit, Kitikmeot, and Kivalliq regions combined

Contaminant	TDI/PTDI (μg/d)	Previous intake (μg/d)	New intake(μg/d) if minimizing PCB (%change)	New intake(μg/d) if minimizing HG (%change)	New intake(μg/d) if minimizing CHL (%change)	New intake(μg/d) if minimizing TOX (%change)
HG	44.9	78.5	32.9(-58%)	19.8(-75%)	33(-58%)	33.5(-57%)
CHL	3.2	16.6	1.3(-92%)	3.2(-81%)	1.3(-92%)	1.5(-91%)
PCB	63.3	36.3	4.4(-88%)	6.8(-81%)	4.5(-88%)	5.5(-85%)
TOX	12.7	58.3	3.9(-93%)	6.2(-89%)	4(-93%)	3.5(-94%)

Table 4b. The changes of traditional food intakes in the Inuvialuit, Kitikmeot, and Kivalliq regions combined

Category	Food name(34 variables)	Previous intake(g/d)	New intake if minimizing PCB(%change)	New intake if minimizing HG(%change)	New intake if minimizing CHL(%change)	New intake if minimizing TOX(%change)
Marine mammal	BELUGA,BLUBBER	1.1	0(-100%)	0(-100%)	0(-100%)	0(-100%)
	BELUGA,FLIPPER	0.3	0(-100%)	0(-100%)	0(-100%)	0(-100%)
	BELUGA,MUKTUK/SKIN ONLY	7.1	0(-100%)	0(-100%)	0(-100%)	0(-100%)
	BELUGA,OIL	0.7	0(-100%)	0.3(-61%)	0(-100%)	0(-100%)
	SEAL, BEARDED,FLESH	3.9	0(-100%)	0(-100%)	0(-100%)	0(-100%)
	SEAL, BEARDED,INTESTINE	1.7	0(-100%)	0(-100%)	0(-100%)	12.9(674%)
	SEAL, RINGED,BLUBBER	0.3	0.2(-34%)	1.8(486%)	0.2(-36%)	0.4(47%)
	SEAL, RINGED,FLESH	4.5	0(-100%)	0(-100%)	0.5(-89%)	0(-100%)
	WALRUS,BLUBBER	0.1	0(-100%)	0(-100%)	0(-100%)	0(-100%)
	WALRUS,FLESH	2.5	0(-100%)	0(-100%)	0(-100%)	0(-100%)
Land mammal	CARIBOU,BLOOD	0.3	1.5(421%)	2(559%)	1.4(371%)	0(-100%)
	CARIBOU,BONE MARROW	0.6	0(-100%)	2.3(288%)	0(-100%)	0(-100%)
	CARIBOU,EARS	0.6	0(-100%)	0(-100%)	0(-100%)	0(-100%)
	CARIBOU,FAT	2.4	3.4(42%)	0(-100%)	3.3(41%)	2.4(0)
	CARIBOU,FLESH	150	271.6(81%)	89.8(-40%)	273.7(82%)	255.9(71%)
	CARIBOU,HEAD	3.3	0(-100%)	136.3(3980%)*	0(-100%)	0(-100%)
	CARIBOU,HEART	1.1	0(-100%)	0(-100%)	0(-100%)	0(-100%)
	CARIBOU,LIPS	0.6	0(-100%)	0(-100%)	0(-100%)	0(-100%)
	CARIBOU,LIVER	1.1	1.6(46%)	1.8(58%)	1.6(46%)	1.4(24%)
	CARIBOU,RIBS	8.4	0(-100%)	0(-100%)	0(-100%)	0(-100%)
	CARIBOU,TONGUE	0.2	0(-100%)	0(-100%)	0(-100%)	0(-100%)
	CARIBOU-B,FLESH	55.5	28.8(-48%)	0(-100%)	27.3(-51%)	22.2(-60%)
	MUSKOX,FLESH	20.2	42.4(110%)	58.8(191%)	42.1(108%)	69.6(245%)
	HARE, ARCTIC,FLESH	6.3	0(-100%)	63.5(912%)	0(-100%)	0(-100%)
Bird	DUCK, DIVING, EIDER,FLESH	3.3	0.3(-90%)	0(-100%)	0(-100%)	3.2(-4%)
	DUCK, DIVING, EIDER, KING,FLESH	2.2	0(-100%)	0(-100%)	0(-100%)	0(-100%)
	FOWL, PTARMIGAN,FLESH	2.3	0(-100%)	0(-100%)	0(-100%)	0(-100%)
	GOOSE, YELLOW LEGS,FLESH	1.7	0(-100%)	0(-100%)	0(-100%)	0(-100%)
Fish	HERRING, PACIFIC (WITH CISCO),EGGS	0.1	3.1(2102%)*	0(-100%)	3.2(2182%)*	0(-100%)
	HERRING, PACIFIC (WITH CISCO),FLESH	0.6	0(-100%)	0(-100%)	0(-100%)	0(-100%)
	CHAR, ARCTIC,FLESH	24.5	20.7(-16%)	28.9(18%)	20.6(-16%)	23.3(-5%)
	TROUT, LAKE,FLESH	1.1	0(-100%)	0(-100%)	0(-100%)	0(-100%)
	WHITEFISH,FLESH	4.8	64.3(1241%)*	9.0(87%)	64.4(1242%)*	44.7(830%)
Plant	BLUEBERRIES,BERRIES	0.9	0(-100%)	39.2(4419%)*	0(-100%)	15.3(1665%)*

* The diet suggestion which may not make sense in reality

Table 4c. The changes of nutrient intakes from traditional food in the Inuvialuit, Kitikmeot, and Kivalliq regions combined

Nutrient	EER/RDA/AI	Previous intake	New intake	Change(%)
Energy (kcal/d)	2403*	541.5	541.5	0
Protein(g/d)	46**	95.1	95.1	0
Omega 3(g/d)	1.1***	0.9	0.9	0
Omega 6(g/d)	12***	1.6	1.6	0
Iron(mg/d)	18**	17.2	17.2	0
Zinc(mg/d)	8**	13.5	13.5	0
Copper(mg/d)	900**	1040	1040	0
Selenium(mg/d)	55**	47.8	47.8	0
Vitamin D(μg/d)	5***	7.9	7.9	0
Vitamin E(mg/d)	15**	1.9	1.9	0
Vitamin A(μg/d)	700**	391.3	391.3	0

*: The Estimated Energy Requirement (EER). Source: Adapted from the Dietary Adequacy Intakes series. National Adademics Press.Copyright 1997,1998,2000,2001,2002,2004, by the National Academics of Sciences.

**: Recommended Dietary Allowance (RDA): the average daily nutrient intake level sufficient to meet the nutrient requirement of nearly all (97 to 98 percent) healthy individuals in a particular life stage and gender group. Souce: Dietary Reference Intakes (2000): Application in Dietary Assessment.

***:Adequate Intake (AI): a recommended average daily nutrient intake level based on observed or experimentally determined apparently healthy people that are assumed to be adequate used when an RDA cannot be determined. Souce: Dietary Reference Intakes (2000): Application in Dietary Assessment

Table 5a. The changes of contaminant intakes in the Baffin region

Contaminant	TDI/PTDI(μg/d)	Previous intake(μg/d)	New intake(μg/d)	Change (%)
HG	43.7	154.5	43.7	-72
CHL	3.1	38.7	3.1	-92
PCB	61.6	99.6	20.2	-80
TOX	12.3	198.9	12.3	-94

5b. The changes of traditional food intakes in the Baffin region

Category	Food name (28 variables)	Previous intake(g/d)	New intake(g/d)	Change(%)
Marine mammal	NARWHAL,BLUBBER	7.3	0.0	-100
	NARWHAL,MUKTUK/SKIN ONLY	26.4	35.1	33
	SEAL, BEARDED,BLUBBER	1.1	0.0	-100
	SEAL, BEARDED,FLESH	2.6	0.0	-100
	SEAL, BEARDED,INTESTINE	3.9	0.0	-100
	SEAL, RINGED,BLUBBER	0.6	0.0	-100
	SEAL, RINGED,BROTH	14.1	65.6	366
	SEAL, RINGED,FLESH	74.9	0.0	-100
	SEAL, RINGED,KIDNEY	1.3	0.0	-100
	SEAL, RINGED,LIVER	1.3	5.5	320
	WALRUS,BLUBBER	3.4	0.0	-100
	WALRUS,FLESH	6.5	21.5	231
	BELUGA,BLUBBER	1.7	0.0	-100
	BELUGA,FLESH	2.6	0.0	-100
	BELUGA,FLIPPER	3.9	0.0	-100
	BELUGA,MUKTUK/SKIN ONLY	16.7	0.0	-100
	BEAR, POLAR,FLESH	20.6	0.0	-100
Land mammal	CARIBOU,FAT	3.2	24.5	655
	CARIBOU,FLESH	145.3	53.6	-63
	CARIBOU-B,FLESH	23.9	0.0	-100
Fish	CHAR, ARCTIC,FLESH	64.6	0.0	-100
	CISCO (WITH HERRING),FLESH	2.6	70.1	2609*
	CLAMS,CONTENTS,NO SHELL	3.9	26.9	592
	COD, ARCTIC,FLESH	1.3	68.9	5208*
Bird	FOWL, PTARMIGAN,FLESH	14.2	61.1	329
Plant	KELP,WHOLE	0.6	0.0	-100
	BLACKBERRIES,BERRIES	2.5	0.0	-100
	BLUEBERRIES,BERRIES	0.1	163.9	142474*

* The diet suggestion which may not make sense in reality

Table 5c. The changes of nutrient intakes from traditional food in the Baffin region

Nutrient	EER/RDA/AI	Previous intake	New intake	Change(%)
Energy (kcal/d)	2403*	760.7	760.7	0
Protein(g/d)	46**	115.4	75.9	-34
Omega 3(g/d)	1.1***	2.5	2.5	0
Omega 6(g/d)	12***	1.4	1.4	0
Iron(mg/d)	18**	34.4	21.5	-38
Zinc(mg/d)	8**	17	9.4	-45
Copper(mg/d)	900**	1065.1	1065.1	0
Selenium(mg/d)	55**	253.2	253.2	0
Vitamin D(μg/d)	5***	20.3	20.3	0
Vitamin E(mg/d)	15**	3	3	0
Vitamin A(μg/d)	700**	659.1	659.1	0

*: The Estimated Energy Requirement (EER). Source: Adapted from the Dietary Adequacy Intakes series. National Adademics Press.Copyright 1997,1998,2000,2001,2002,2004, by the National Academics of Sciences.

**: Recommended Dietary Allowance (RDA): the average daily nutrient intake level sufficient to meet the nutrient requirement of nearly all (97 to 98 percent) healthy individuals in a particular life stage and gender group. Souce: Dietary Reference Intakes (2000): Application in Dietary Assessment.

***:Adequate Intake (AI): a recommended average daily nutrient intake level based on observed or experimentally determined apparently healthy people that are assumed to be adequate used when an RDA cannot be determined. Souce: Dietary Reference Intakes (2000): Application in Dietary Assessment

Table 6a. The changes of contaminant intakes in the Labrador region

Contaminant	TDI/PTDI(μg/d)	Previous intake(μg/d)	New intake(μg/d)	Change(%)
HG	47	58.3	28.9	-50
CHL	3.3	2.2	1	-55
PCB	66.1	7.4	2.8	-62
TOX	13.2	17.1	2.9	-83

Table 6b. The changes of traditional food intakes in the Labrador region

Category	**Food name (17 variables)**	**Previous intake(g/d)**	**New intake(g/d)**	**Change(%)**
Marine mammal	SEAL, RINGED,FLESH	8.7	0	-100
Land mammal	CARIBOU,FLESH	115.2	76	-34
	CARIBOU,HEART	23.8	53	121
	CARIBOU-B,FLESH	58.0	131	127
	PORCUPINE,FLESH	4.3	0	-100
Fish	CHAR, ARCTIC,FLESH	17.3	35	103
	COD, ROCK,FLESH	4.3	0	-100
	SALMON,FLESH	7.3	0	-100
	GRENADIER,FLESH	0.7	0	-100
	TROUT, LAKE,FLESH	13.0	0	-100
Bird	DUCK,FLESH	6.5	0	-100
	FOWL, HEN, SPRUCE,FLESH	13.0	0	-100
	GOOSE, CANADA,FLESH	12.3	0	-100
Plant	BAKEAPPLE,BERRY	1.3	0	-100
	BLACKBERRIES,BERRIES	1.0	0	-100
	BLUEBERRIES,BERRIES	0.8	54	6895*
	CRANBERRIES,BERRIES	10.6	0	-100

* The diet suggestion which may not make sense in reality

Table 6c. The changes of nutrient intakes from traditional food in the Labrador region

Nutrient	EER/RDA/AI	Previous intake	New intake	Change(%)
Energy (kcal/d)	2403*	478.7	433.2	-10
Protein(g/d)	46**	88.5	78.8	-11
Omega 3(g/d)	1.1***	0.7	0.5	-29
Omega 6(g/d)	12***	1.4	1.1	-21
Iron(mg/d)	18**	16.8	13.9	-17
Zinc(mg/d)	8**	11.3	11.3	0
Copper(mg/d)	900**	987.4	987.4	0
Selenium(mg/d)	55**	45.1	45.1	0
Vitamin D(μg/d)	5***	10	9.5	-5
Vitamin E(mg/d)	15**	1.4	1.4	0
Vitamin A(μg/d)	700**	46	46	0

*: The Estimated Energy Requirement (EER). Source: Adapted from the Dietary Adequacy Intakes series. National Adademics Press.Copyright 1997,1998,2000,2001,2002,2004, by the National Academics of Sciences.

**: Recommended Dietary Allowance (RDA): the average daily nutrient intake level sufficient to meet the nutrient requirement of nearly all (97 to 98 percent) healthy individuals in a particular life stage and gender group. Souce: Dietary Reference Intakes (2000): Application in Dietary Assessment.

***:Adequate Intake (AI): a recommended average daily nutrient intake level based on observed or experimentally determined apparently healthy people that are assumed to be adequate used when an RDA cannot be determined. Souce: Dietary Reference Intakes (2000): Application in Dietary Assessment

Table 7a.The changes of contaminant intakes in the Inuvialuit, Kitikmeot, and Kivalliq regions combined

Contaminant	TDI/PTDI(μg/d)	Previous intake(μg/d)	New intake(μg/d)
HG	44.9	78.5	21.2
CHL	3.2	16.6	2.2
PCB	63.3	36.3	11.6
TOX	12.7	58.3	12.7

Table 7b. The changes of traditional food intakes in the Inuvialuit, Kitikmeot, and Kivalliq regions combined

Category	Food name (34 variables)	Previous intake(g/d)	New intake(g/d)	Change(%)
Marine mammal	BELUGA,BLUBBER	1.1	0.0	-100
	BELUGA,FLIPPER	0.3	6.0	2046*
	BELUGA,MUKTUK/SKIN ONLY	7.1	3.7	-47
	BELUGA,OIL	0.7	0.0	-100
	SEAL, BEARDED,FLESH	3.9	0.0	-100
	SEAL, BEARDED,INTESTINE	1.7	0.0	-100
	SEAL, RINGED,BLUBBER	0.3	0.0	-100
	SEAL, RINGED,FLESH	4.5	0.0	-100
	WALRUS,BLUBBER	0.1	0.0	-100
	WALRUS,FLESH	2.5	0.0	-100
Land mammal	CARIBOU,BLOOD	0.3	13.7	4528*
	CARIBOU,BONE MARROW	0.6	207.4	34468*
	CARIBOU,EARS	0.6	0.0	-100
	CARIBOU,FAT	2.4	0.0	-100
	CARIBOU,FLESH	150	0.0	-100
	CARIBOU,HEAD	3.3	0.0	-100
	CARIBOU,HEART	1.1	0.0	-100
	CARIBOU,LIPS	0.6	0.0	-100
	CARIBOU,LIVER	1.1	3.4	206
	CARIBOU,RIBS	8.4	0.0	-100
	CARIBOU,TONGUE	0.2	0.0	-100
	CARIBOU-B,FLESH	55.5	0.0	-100
	MUSKOX,FLESH	20.2	64.1	217
	HARE, ARCTIC,FLESH	6.3	0.0	-100
Bird	DUCK, DIVING, EIDER,FLESH	3.3	0.0	-100
	DUCK, DIVING, EIDER, KING,FLESH	2.2	0.0	-100
	FOWL, PTARMIGAN,FLESH	2.3	0.0	-100
	GOOSE, YELLOW LEGS,FLESH	1.7	0.0	-100
Fish	HERRING, PACIFIC (WITH CISCO),EGGS	0.1	24.8	17778*
	HERRING, PACIFIC (WITH CISCO),FLESH	0.6	23.7	4139*
	CHAR, ARCTIC,FLESH	24.5	0.0	-100
	TROUT, LAKE,FLESH	1.1	0.0	-100
	WHITEFISH,FLESH	4.8	0.0	-100
Plant	BLUEBERRIES,BERRIES	0.9	949.5	109504*

* The diet suggestion which may not make sense in reality

Table 7c. The changes of nutrient intakes from traditional food in the Inuvialuit, Kitikmeot, and Kivalliq regions combined

Nutrient	EER/RDA/AI	New intake	Previous intake
Energy (kcal/d)	2403*	2403	541.5
Protein(g/d)	46**	46	95.1
Omega 3(g/d)	1.1***	1.1	0.9
Omega 6(g/d)	12***	2.5	1.6
Iron(mg/d)	18**	18	17.2
Zinc(mg/d)	8**	7.5	13.5
Copper(mg/d)	900**	900	1040
Selenium(mg/d)	55**	55	47.8
Vitamin D(μg/d)	5***	5	7.9
Vitamin E(mg/d)	15**	6.7	1.9
Vitamin A(μg/d)	700**	700	391.3

*: The Estimated Energy Requirement (EER). Source: Adapted from the Dietary Adequacy Intakes series. National Adademics Press.Copyright 1997,1998,2000,2001,2002,2004, by the National Academics of Sciences.

**: Recommended Dietary Allowance (RDA): the average daily nutrient intake level sufficient to meet the nutrient requirement of nearly all (97 to 98 percent) healthy individuals in a particular life stage and gender group. Souce: Dietary Reference Intakes (2000): Application in Dietary Assessment.

***:Adequate Intake (AI): a recommended average daily nutrient intake level based on observed or experimentally determined apparently healthy people that are assumed to be adequate used when an RDA cannot be determined. Souce: Dietary Reference Intakes (2000): Application in Dietary Assessment

Table 8a. The changes of contaminant intakes in the Baffin region

Contaminant	TDI/PTDI (μg/d)	Previous intake (μg/d)	New intake (μg/d)
HG	43.7	154.5	43.7
CHL	3.1	38.7	3.1
PCB	61.6	99.6	17.1
TOX	12.3	198.9	7.4

Table 8b. The changes of traditional food intakes in the Baffin region

Category	Food name (28 variables)	Previous intake(g/d)	New intake(g/d)	Change(%)
Marine mammal	NARWHAL,BLUBBER	7.3	0.0	-100
	NARWHAL,MUKTUK/SKIN ONLY	26.4	4.9	-82
	SEAL, BEARDED,BLUBBER	1.1	0.0	-100
	SEAL, BEARDED,FLESH	2.6	0.0	-100
	SEAL, BEARDED,INTESTINE	3.9	0.0	-100
	SEAL, RINGED,BLUBBER	0.6	0.0	-100
	SEAL, RINGED,BROTH	14.1	0.0	-100
	SEAL, RINGED,FLESH	74.9	0.0	-100
	SEAL, RINGED,KIDNEY	1.3	0.0	-100
	SEAL, RINGED,LIVER	1.3	6.9	430
	WALRUS,BLUBBER	3.4	0.0	-100
	WALRUS,FLESH	6.5	20.4	215
	BELUGA,BLUBBER	1.7	0.7	-58
	BELUGA,FLESH	2.6	6.6	156
	BELUGA,FLIPPER	3.9	0.0	-100
	BELUGA,MUKTUK/SKIN ONLY	16.7	0.0	-100
	BEAR, POLAR,FLESH	20.6	0.0	-100
Land mammal	CARIBOU,FAT	3.2	134.0	4034*
	CARIBOU,FLESH	145.3	0.0	-100
	CARIBOU-B,FLESH	23.9	0.0	-100
Fish	CHAR, ARCTIC,FLESH	64.6	0.0	-100
	CISCO (WITH HERRING),FLESH	2.6	0.0	-100
	CLAMS,CONTENTS,NO SHELL	3.9	0.0	-100
	COD, ARCTIC,FLESH	1.3	0.0	-100
Bird	FOWL, PTARMIGAN,FLESH	14.2	0.0	-100
Plant	KELP,WHOLE	0.6	0.0	-100
	BLACKBERRIES,BERRIES	2.5	0.0	-100
	BLUEBERRIES,BERRIES	0.1	1232.6	1072241*

* The diet suggestion which may not make sense in reality

Table 8c. The changes of nutrient intakes from traditional food in the Baffin region

Nutrient	EER/RDA/AI	New intake	Previous intake
Energy (kcal/d)	2403*	1833.7	760.7
Protein(g/d)	46**	22.8	115.4
Omega 3(g/d)	1.1***	1.1	2.5
Omega 6(g/d)	12***	0.9	1.4
Iron(mg/d)	18**	14.1	34.4
Zinc(mg/d)	8**	4.7	17
Copper(mg/d)	900**	900	1065.1
Selenium(mg/d)	55**	55	253.2
Vitamin D(μg/d)	5***	5	20.3
Vitamin E(mg/d)	15**	8.7	3
Vitamin A(μg/d)	700**	700	659.1

*: The Estimated Energy Requirement (EER). Source: Adapted from the Dietary Adequacy Intakes series. National Adademics Press.Copyright 1997,1998,2000,2001,2002,2004, by the National Academics of Sciences.

**: Recommended Dietary Allowance (RDA): the average daily nutrient intake level sufficient to meet the nutrient requirement of nearly all (97 to 98 percent) healthy individuals in a particular life stage and gender group. Souce: Dietary Reference Intakes (2000): Application in Dietary Assessment.

***:Adequate Intake (AI): a recommended average daily nutrient intake level based on observed or experimentally determined apparently healthy people that are assumed to be adequate used when an RDA cannot be determined. Souce: Dietary Reference Intakes (2000): Application in Dietary Assessment

Table 9a. The changes of contaminant intakes in the Labrador region

Contaminant	TDI/PTDI(μg/d)	Previous intake(μg/d)	New intake(μg/d)
HG	47	58.3	11.5
CHL	3.3	2.2	0.5
PCB	66.1	7.4	7.7
TOX	13.2	17.1	6.4

Table 9b. The changes of traditional food intakes in the Labrador region

Category	Food name (17 variables)	Previous intake(g/d)	New intake(g/d)	Change(%)
Marine mammal	SEAL, RINGED,FLESH	8.7	0.0	-100
Land mammal	CARIBOU,FLESH	115.2	0.0	-100
	CARIBOU,HEART	23.8	0.0	-100
	CARIBOU-B,FLESH	58.0	74.2	28
	PORCUPINE,FLESH	4.3	37.7	771
Fish	CHAR, ARCTIC,FLESH	17.3	0.0	-100
	COD, ROCK,FLESH	4.3	0.0	-100
	SALMON,FLESH	7.3	9.4	28
	GRENADIER,FLESH	0.7	26.9	3580*
	TROUT, LAKE,FLESH	13.0	0.0	-100
Bird	DUCK,FLESH	6.5	0.0	-100
	FOWL, HEN, SPRUCE,FLESH	13.0	0.0	-100
	GOOSE, CANADA,FLESH	12.3	0.0	-100
Plant	BAKEAPPLE,BERRY	1.3	0.0	-100
	BLACKBERRIES,BERRIES	1.0	0.0	-100
	BLUEBERRIES,BERRIES	0.8	0.0	-100
	CRANBERRIES,BERRIES	10.6	965.7	9010*

* The diet suggestion which may not make sense in reality

Table 9c. The changes of nutrient intakes from traditional food in the Labrador region

Nutrient	EER/RDA/AI	New intake	Previous intake
Energy (kcal/d)	2403*	893.5	478.7
Protein(g/d)	46**	46.0	88.5
Omega 3(g/d)	1.1***	0.4	0.7
Omega 6(g/d)	12***	0.5	1.4
Iron(mg/d)	18**	8.1	16.8
Zinc(mg/d)	8**	8.0	11.3
Copper(mg/d)	900**	900.0	987.4
Selenium(mg/d)	55**	55.0	45.1
Vitamin D(μg/d)	5***	5.0	10
Vitamin E(mg/d)	15**	12.3	1.4
Vitamin A(μg/d)	700**	39.0	46

*: The Estimated Energy Requirement (EER). Source: Adapted from the Dietary Adequacy Intakes series. National Adademics Press.Copyright 1997,1998,2000,2001,2002,2004, by the National Academics of Sciences.

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***:Adequate Intake (AI): a recommended average daily nutrient intake level based on observed or experimentally determined apparently healthy people that are assumed to be adequate used when an RDA cannot be determined. Souce: Dietary Reference Intakes (2000): Application in Dietary Assessment

Table 10a. The changes of contaminant intakes in the Inuvialuit, Kitikmeot, and Kivalliq regions combined

Contaminant	TDI/PTDI(µg/d)	Previous intake(µg/d)	New intake(µg/d)
HG	44.9	78.5	27.3
CHL	3.2	16.6	0.3
PCB	63.3	36.3	5.9
TOX	12.7	58.3	4.5

Table 10b. The changes of traditional food intakes in the Inuvialuit, Kitikmeot,and Kivalliq regions combined

Category	Food name (34 variables)	Previous intake(g/d)	New intake(g/d)	Change(%)
Marine mammal	BELUGA,BLUBBER	1.1	0.0	-100
	BELUGA,FLIPPER	0.3	0.0	-100
	BELUGA,MUKTUK/SKIN ONLY	7.1	0.0	-100
	BELUGA,OIL	0.7	1.1	44
	SEAL, BEARDED,FLESH	3.9	0.0	-100
	SEAL, BEARDED,INTESTINE	1.7	0.0	-100
	SEAL, RINGED,BLUBBER	0.3	0.0	-100
	SEAL, RINGED,FLESH	4.5	0.0	-100
	WALRUS,BLUBBER	0.1	0.0	-100
	WALRUS,FLESH	2.5	0.0	-100
Land mammal	CARIBOU,BLOOD	0.3	8.1	2628*
	CARIBOU,BONE MARROW	0.6	32.4	5296*
	CARIBOU,EARS	0.6	0.0	-100
	CARIBOU,FAT	2.4	0.0	-100
	CARIBOU,FLESH	150	0.0	-100
	CARIBOU,HEAD	3.3	0.0	-100
	CARIBOU,HEART	1.1	0.0	-100
	CARIBOU,LIPS	0.6	0.0	-100
	CARIBOU,LIVER	1.1	0.3	-74
	CARIBOU,RIBS	8.4	0.0	-100
	CARIBOU,TONGUE	0.2	0.0	-100
	CARIBOU-B,FLESH	55.5	0.0	-100
	MUSKOX,FLESH	20.2	0.0	-100
	HARE, ARCTIC,FLESH	6.3	0.0	-100
Bird	DUCK, DIVING, EIDER,FLESH	3.3	0.0	-100
	DUCK, DIVING, EIDER, KING,FLESH	2.2	0.0	-100
	FOWL, PTARMIGAN,FLESH	2.3	0.0	-100
	GOOSE, YELLOW LEGS,FLESH	1.7	0.0	-100
Fish	HERRING, PACIFIC (WITH CISCO),EGGS	0.1	0.0	-100
	HERRING, PACIFIC (WITH CISCO),FLESH	0.6	0.0	-100
	CHAR, ARCTIC,FLESH	24.5	10.5	-57
	TROUT, LAKE,FLESH	1.1	0.0	-100
	WHITEFISH,FLESH	4.8	0.0	-100
Plant	BLUEBERRIES,BERRIES	0.9	483.1	55663*

* The diet suggestion which may not make sense in reality

Table 10c. The changes of nutrient intakes from traditional food in the Inuvialuit, Kitikmeot, and Kivalliq regions combined

Nutrient	EER/RDA/AI	Difference of EER/RDA/AI and energy and nutrients from market food	New nutrinet intakes from traditional food	Previous nutrinet intakes from traditional food
Energy(kcal/d)	2403*	582	582	541.5
Omega 6(g/d)	12***	2	0.28	1.6
Iron(mg/d)	18**	6.2	6.3	17.2
Zinc(mg/d)	8**	1.1	1.1	13.5
Calcium(mg/d)	1000***	1000	550.8	30.1
Vitamin D(μg/d)	5***	3	3	7.9
Vitamin E(mg/d)	15**	11.6	3.2	1.9
Vitamin A(μg/d)	700**	95.9	95.9	391.3

*: The Estimated Energy Requirement (EER). Source: Adapted from the Dietary Adequacy Intakes series. National Adademics Press.Copyright 1997,1998,2000,2001,2002,2004, by the National Academics of Sciences.

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***:Adequate Intake (AI): a recommended average daily nutrient intake level based on observed or experimentally determined apparently healthy people that are assumed to be adequate used when an RDA cannot be determined. Souce: Dietary Reference Intakes (2000): Application in Dietary Assessment

Table 11a. The changes of contaminant intakes in the Baffin region

Contaminant	TDI/PTDI(μg/d)	Previous intake(μg/d)	New intake(μg/d)
HG	43.7	154.5	20.9
CHL	3.1	38.7	0.1
PCB	61.6	99.6	4.3
TOX	12.3	198.9	0.1

Table 11b. The changes of traditional food intakes in the Baffin region

Category	Food name (28 variables)	Previous intake(g/d)	New intake(g/d)	Change(%)
Marine mammal	NARWHAL,BLUBBER	7.3	0.0	-100
	NARWHAL,MUKTUK/SKIN ONLY	26.4	0.0	-100
	SEAL, BEARDED,BLUBBER	1.1	0.0	-100
	SEAL, BEARDED,FLESH	2.6	0.0	-100
	SEAL, BEARDED,INTESTINE	3.9	0.0	-100
	SEAL, RINGED,BLUBBER	0.6	0.0	-100
	SEAL, RINGED,BROTH	14.1	0.0	-100
	SEAL, RINGED,FLESH	74.9	0.0	-100
	SEAL, RINGED,KIDNEY	1.3	0.0	-100
	SEAL, RINGED,LIVER	1.3	4.6	252
	WALRUS,BLUBBER	3.4	0.0	-100
	WALRUS,FLESH	6.5	0.0	-100
	BELUGA,BLUBBER	1.7	0.0	-100
	BELUGA,FLESH	2.6	0.0	-100
	BELUGA,FLIPPER	3.9	0.0	-100
	BELUGA,MUKTUK/SKIN ONLY	16.7	0.0	-100
	BEAR, POLAR,FLESH	20.6	0.0	-100
Land mammal	CARIBOU,FAT	3.2	53.4	1549*
	CARIBOU,FLESH	145.3	0.0	-100
	CARIBOU-B,FLESH	23.9	7.6	-68
Fish	CHAR, ARCTIC,FLESH	64.6	0.0	-100
	CISCO (WITH HERRING),FLESH	2.6	0.0	-100
	CLAMS,CONTENTS,NO SHELL	3.9	0.0	-100
	COD, ARCTIC,FLESH	1.3	0.0	-100
Bird	FOWL, PTARMIGAN,FLESH	14.2	0.0	-100
Plant	KELP,WHOLE	0.6	0.0	-100
	BLACKBERRIES,BERRIES	2.5	343.3	13474*
	BLUEBERRIES,BERRIES	0.1	0.0	-100

* The diet suggestion which may not make sense in reality

Table 11c. The changes of nutrient intakes from traditional food in the Baffin region

Nutrient	EER/RDA/AI	Difference of EER/RDA/AI and energy and nutrients from market food	New nutrinet intakes from traditional food	Previous nutrinet intakes from traditional food
Energy(kcal/d)	2403*	961.9	595	760.7
Protein(g/d)	46**	6.8	6.8	115.4
Omega 3(g/d)	1.1***	0.4	0.4	2.5
Omega 6(g/d)	12***	4.7	0.4	1.4
Iron(mg/d)	18**	9.4	4.1	34.4
Zinc(mg/d)	8**	3.5	1.1	17
Calcium(mg/d)	1000***	584.7	22	56
Vitamin C(mg/d)	75**	9.3	9.3	19.6
Vitamin D(mg/d)	5***	3.7	2.3	20.3
Vitamin E(mg/d)	15**	12.4	4.7	4
Vitamin A(μg/d)	700**	430.8	430.8	659.1

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***:Adequate Intake (AI): a recommended average daily nutrient intake level based on observed or experimentally determined apparently healthy people that are assumed to be adequate used when an RDA cannot be determined. Souce: Dietary Reference Intakes (2000): Application in Dietary Assessment

Table 12a. The changes of contaminant intakes in the Labrador region

Contaminant	TDI/PTDI(µg/d)	Previous intake(µg/d)	New intake(µg/d)
HG	47	58.3	11.5
CHL	3.3	2.2	0.5
PCB	66.1	7.4	7.7
TOX	13.2	17.1	6.4

Table 12b. The changes of traditional food intakes in the Labrador region

Category	Food name (17 variables)	Previous intake(g/d)	New intake(g/d)	Change (%)
Marine mammal	SEAL, RINGED,FLESH	8.7	0.0	-100
Land mammal	CARIBOU,FLESH	115.2	0.0	-100
	CARIBOU,HEART	23.8	0.0	-100
	CARIBOU-B,FLESH	58.0	0.0	-100
	PORCUPINE,FLESH	4.3	0.0	-100
Fish	CHAR, ARCTIC,FLESH	17.3	0.0	-100
	COD, ROCK,FLESH	4.3	0.0	-100
	SALMON,FLESH	7.3	12.4	69
	GRENADIER,FLESH	0.7	0.0	-100
	TROUT, LAKE,FLESH	13.0	0.0	-100
Bird	DUCK,FLESH	6.5	0.0	-100
	FOWL, HEN, SPRUCE,FLESH	13.0	68.1	424
	GOOSE, CANADA,FLESH	12.3	0.0	-100
Plant	BAKEAPPLE,BERRY	1.3	0.0	-100
	BLACKBERRIES,BERRIES	1.0	871.0	90486*
	BLUEBERRIES,BERRIES	0.8	59.1	7589*
	CRANBERRIES,BERRIES	10.6	0.0	-100

* The diet suggestion which may not make sense in reality

Table 12c. The changes of nutrient intakes from traditional food in the Labrador region

Nutrient	EER/RDA/AI	Difference of EER/RDA/AI and energy and nutrients from market food	New nutrinet intakes from traditional food	Previous nutrinet intakes from traditional food
Energy(kcal/d)	2403*	600.5	585.4	478.7
Omega 6(mg/d)	12***	1.4	0.4	1.4
Iron(mg/d)	18**	8.8	8.8	16.8
Zinc(mg/d)	8**	1.8	1.8	11.3
Calcium(mg/d)	1000***	515.5	66.4	36.5
Vitamin D(μg/d)	5***	1.6	1.6	10
Vitamin E(mg/d)	15**	10.9	10.9	1.4
Vitamin A(μg/d)	700**	277.9	140.5	46

*: The Estimated Energy Requirement (EER). Source: Adapted from the Dietary Adequacy Intakes series. National Adademics Press.Copyright 1997,1998,2000,2001,2002,2004, by the National Academics of Sciences.

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Appendices:

Appendix A: Ethics form

Appendix B: Substitutions of contaminant composition

Appendix C: Contaminant composition data used in the study

Appendix D: The example of “PROC LP” program and related syntax explanation

Appendix B: Substitutions of contaminant composition

Food item to be substituted	Missing composition	Substitution food item
Boiled narwhal blubber	Hg, Pcb, Tox, Chl	Raw narwhal blubber
Baked caribou-B liver	Pcb	Raw caribou fat
Raw caribou-B kidney	Chl	Cooked carbou kidney
Raw clams contents	Hg	Boiled clams content
Raw caribou liver	Pcb	Raw caribou fat
Fried caribou liver	Pcb	Raw caribou fat
Cooked crab flesh	Hg	Boiled clams content
Cooked fowl ptarmigan gizzard	Hg	Raw fowl ptarmigan willow flesh
Raw pacific herring eggs (with cisco)	Hg, Pcb, Tox, Chl	Raw herring flesh (with cisco)

Appendix C: Contaminant composition data

SPECIES	PART	HG(ng/g)	CHL(ng/d)	PCB(ng/g)	TOX(ng/g)
BAKEAPPLE	BERRY	0	0	6	0
BEAR, POLAR	FAT	84	3168	5196	3490
BEAR, POLAR	FLESH	457	47	224	11
BELUGA	BLUBBER	80	2000	3636	6120
BELUGA	FLESH	1715	55	152	372
BELUGA	FLIPPER	800	119	288	951
BELUGA	MUKTUK/SKIN ONLY	728	119	288	342
BELUGA	OIL	80	2800	5090	8568
BIRD, FISH EATING, LOON	FLESH	500	1	50	2
BLACKBERRIES	BERRIES	29	0	6	0
BLUEBERRIES	BERRIES	8	0	6	0
CAPELIN	WHOLE	636	4	7	113
CARIBOU	BLOOD	0	3	6	1
CARIBOU	BONE MARROW	10	3	12	1
CARIBOU	BRAIN	5	3	6	1
CARIBOU	CARTILAGE	57	3	6	1
CARIBOU	EARS	57	3	10	1
CARIBOU	FAT	57	1	12	1
CARIBOU	FLESH	57	2	7	1
CARIBOU	HEAD	57	3	10	1
CARIBOU	HEART	49	3	6	1
CARIBOU	INTESTINE	125	3	6	1
CARIBOU	KIDNEY	857	3	10	0
CARIBOU	LIPS	76	3	10	0
CARIBOU	LIVER	620	0	1.5	0
CARIBOU	RIBS	137	3	10	1
CARIBOU	STOMACH	125	3	10	1
CARIBOU	STOMACH CONTENTS	61	3	10	1
CARIBOU	TONGUE	115	3	10	1
CARIBOU-B	FLESH	137	2	5	1
CARIBOU-B	INTESTINE	125	3	6	1
CARIBOU-B	KIDNEY	857	0	10	0
CARIBOU-B	LIVER	527	0	2	0
CHAR, ARCTIC	FLESH	102	12	27	76
CHAR, ARCTIC	HEAD	102	14	3	76
CISCO (WITH HERRING)	FLESH	25	1	0	113
CLAMS	CONTENTS,NO SHELL	12	1	3	1
CLAMS, STOM CONTENTS (WALRUS)	WHOLE	12	2	80	11
CLOUDBERRIES	BERRY	0	0	6	0
COD	FLESH	34	10	11	66
COD, ARCTIC	FLESH	31	4	6	39
COD, ROCK	FLESH	31	4	6	39
CRAB	FLESH	12	0	5	2
CRANBERRIES	BERRIES	0	0	6	0
DUCK	FLESH	800	34	290	2
DUCK, DIVING, EIDER	FLESH	201	9	12	2
DUCK, DIVING, EIDER, KING	FLESH	140	34	290	2
FOWL, GROUSE, SPRUCE	WHOLE (FLESH)	15	1	1	3
FOWL, HEN, SPRUCE	FLESH	15	2	2	3

Appendix C: Contaminant composition data (continued)

SPECIES	PART	HG(ng/g)	CHL(ng/d)	PCB(ng/g)	TOX(ng/g)
FOWL, PTARMIGAN	FLESH	3	1	1	3
FOWL, PTARMIGAN	GIZZARD	76	5	6	2
FOWL, PTARMIGAN, WILLOW	FLESH	76	0	2	3
GOOSE	GIZZARD	0	1	6	2
GOOSE, CANADA	FLESH	79	1	2	2
GOOSE, YELLOW LEGS	FLESH	79	1	2	2
GRENADIER	FLESH	30	9	50	113
HALIBUT (TURBOT)	CHEEKS	100	121	184	617
HARE, ARCTIC	FLESH	6	4	1	1
HERRING (WITH CISCO)	FLESH	30	8	4	30
HERRING, PACIFIC (WITH CISCO)	EGGS	25	1	0	113
HERRING, PACIFIC (WITH CISCO)	FLESH	25	6	5	113
KELP	WHOLE	106	0	6	0
MOOSE	FLESH	20	2	1	1
MUSKOX	FLESH	11	3	6	1
MUSKOX	TONGUE	11	0	10	1
MUSKRAT	FLESH	10	1	4	2
MUSSELS	CONTENTS,NO SHELL	128	0	26	3
NARWHAL	BLUBBER	130	1748	4851	8842
NARWHAL	MUKTUK/SKIN ONLY	560	32	289	11
PORCUPINE	FLESH	2	1	0	1
SALMON	FLESH	44	13	18	344
SEAL, BEARDED	BLUBBER	75	149	1230	755
SEAL, BEARDED	FLESH	270	12	220	221
SEAL, BEARDED	INTESTINE	334	1	80	11
SEAL, RINGED	BLOOD	111	6	6	1
SEAL, RINGED	BLUBBER	75	561	933	540
SEAL, RINGED	BROTH	59	6	80	11
SEAL, RINGED	FLESH	400	6	43	221
SEAL, RINGED	HEART	158	14	26	11
SEAL, RINGED	KIDNEY	2844	32	80	11
SEAL, RINGED	LIVER	1510	9	338	11
TROUT, LAKE	FLESH	846	14	51	150
WALRUS	BLUBBER	116	2203	3308	14619
WALRUS	FLESH	82	45	36	11
WALRUS	INTESTINE	82	3	80	11
WALRUS	LIVER	1430	32	80	11
WALRUS	MATTAK	27	92	77	11
WHITEFISH	EGGS	0	9	50	113
WHITEFISH	ESOPHAGUS	0	9	50	113
WHITEFISH	FLESH	149	3	21	23
WHITEFISH, BROAD	LIVER	558	0	80	113

Source: CINE contaminant composition database

Appendix D: The example of "PROC LP" program and related syntax explanation

```
/* Scenario 1: for the Labrador region*/
data newwomen5;
input _NAME_ $ COL1 _11   _19 _21 _30 _34 _78 _82 _10 _1   _42 _44 _45 _49 _54 _56
    _70 _71   _type_ $;
datalines;

sumkcal  47870     62.3 121.4      145.6      147.8      105.2      127.6      97    50.5 49.6 139.2
    72.3 151.1     132.5      245.3      87.7 127.4      149.6   eq
sumprot  88500.7   22.7 28.3 30.2 19   26.2 15.9 0.4  2    30.2 0.7  28.5 28   33.8 17.6 26.7 21.7
eq
ssumomeg3    70   0    0.1  0.1  0.1  0.7  0.3  0.6  0    0    0.2  0    0.6  0.1  0.1  0.3  0.2  1.3
eq
ssumomeg6    140 0    0.3  0.5  0.4  0.1  0.1  0.3  0    0    0.1  0    0.1  0.6  1.4  0    0.5  0.2
eq
sumiron  16800.3   4.5  8.8  4.2  0.4  19.1 0.3  0.2  0.4  0.2  0.3  10.6 10   9    0.8  4.8  0.6  eq
sumzinc  11300.2   3.8  2.3  5.3  0.4  2.1  0.5  0.1  0.5  0.8  0.2  2.8  1.1  3.9  1.6  4.4  0.5  eq
sumcopper    98740     62.1 294.2      614.7      291.6      71.2 193.8      66.6 147.9      103.1
    124.5    63.3 676.9      410.1      506.7      67.5 130.3      54   eq
sumse    45100.5   10.3 18.8 19   6.2  21.4 22.7 0.9  0.5  25.2 1.9  31.6 23.3 25.5 13   43.1 30   eq
sumvitd  10000     0    0.8  0    25.8 0    19.7 0    0    13.4 0    0    0    0    14.1 0    12.9
eql
sumvite  140  0.6  0.3  0.3  0.5  0.1  0.1  0.2  1.2  1.2  0.2  1.2  0.1  0.1  1.5  0.4  0.5  0.2  eq
sumrae   46003     40.3 8.9 0 26.2 90.7 52.6 11   3    4    3    26.4 46.9 31   6.3  0    88.5  eq
HG  47000    8    57   49   137  102  400  846  29   0    31   0    800  15   79   30   2    44   le
CHL 33000    2    3    2    12   6    14   0    0    4    0    34   2    1    9    1    13   le
PCB 66100    6    7    6    5    27   43   51   6    6    6    6    290  2    2    50   0    18   le
TOX13200     0    1    1    1    76   221  150  0    0    39   0    2    3    2    113  1    344  le
HG  0    8   57   49   137  102  400  846  29   0    31   0    800  15   79   30   2    44 ge
CHL 0    0   2    3    2    12   6    14   0    0    4    0    34   2    1    9    1    13 ge
PCB 0    6   7    6    5    27   43   51   6    6    6    6    290  2    2    50   0    18 ge
TOX0     0   1    1    1    76   221  150  0    0    39   0    2    3    2    113  1    344 ge
LOWER .      0    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0
    lowerbd
;
data objective;
input _NAME_ $    COL1 _11      _19 _21 _30 _34 _78 _82 _10 _1   _42 _44 _45 _49 _54
```

```
    _56 _70 _71 _type_ $;
datalines;
HG  47000   8   57   49   137  102  400  846  29   0    31   0    800  15   79   30   2    44
min
CHL 33000   2   3    2    12   6    14   0    0    4    0    34   2    1    9    1    13   min
PCB 66100   6   7    6    5    27   43   51   6    6    6    6    290  2    2    50   0    18
min
TOX 13200   0   1    1    1    76   221  150  0    0    39   0    2    3    2    113  1    344
min
;

Data PCB;
set objective;
    if _NAME_='PCB';
output;
Do obsnum=1 to 20;
    set newwomen5 point=obsnum;
    output;
end;
run;
Proc LP data=PCB primalout=newwomen5_PCB dualout=newwomen5_constrain_PCB;
ID _NAME_;
rhs COL1;
run;

Data HG;
set objective;
    if _NAME_='HG';
output;
Do obsnum=1 to 20;
    set newwomen5 point=obsnum;
    output;
end;
run;
Proc LP data=HG primalout=newwomen5_HG dualout=newwomen5_constrain_HG;
ID _NAME_;
rhs COL1;
run;
Data CHL;
set objective;
    if _NAME_='CHL';
```

```
output;
Do obsnum=1 to 20;
    set newwomen5 point=obsnum;
    output;
end;
run;
Proc LP data=CHL primalout=newwomen5_CHL dualout=newwomen5_constrain_CHL;
ID _NAME_;
rhs COL1;
run;
Data TOX;
set objective;
    if _NAME_='TOX';
output;
Do obsnum=1 to 20;
    set newwomen5 point=obsnum;
    output;
end;
run;
Proc LP data=TOX primalout=newwomen5_TOX dualout=newwomen5_constrain_TOX;
ID _NAME_;
rhs COL1;
run;
```

"PROC LP" statement involved in this study:

DATA= SAS-data-set
names the SAS data set containing the problem data. If the DATA= option is not specified, PROC LP uses the most recently created SAS data set.

DUALOUT= SAS-data-set
names the SAS data set that contains the current dual solution (shadow prices) on termination of PROC LP. This data set contains the current dual solution only if PROC LP terminates successfully.

PRIMALOUT= SAS-data-set
names the SAS data set that contains the current primal solution when PROC LP terminates.

RUN : start or resume optimization

ID: an alias for ROW *variable(s)*.

RHS: For the dense input format, the RHS statement identifies variables in the problem dataset that contain the right-hand-side constants of the linear program. Only numeric variables can be specified.

TYPE: The TYPE statement specifies a character variable in the problem data set that contains the type identifier for each observation. This variable has keyword values that specify how the LP procedure should interpret the observation. For the dense input format, the type variable identifies the constraint and objective rows and rows that contain information about the variables. The type variable should have no missing values in all observations. The following are valid values for the TYPE variable in an observation:

MIN contains the price coefficients of an objective row to be minimized.
MAX contains the price coefficients of an objective row to be maximized.
EQ (=) contains coefficients of an equality constrained row.
LE (≤) contains coefficients of an inequality, less than or equal to, constrained row.
GE (≥) contains coefficients of an inequality, greater than or equal to, constrained row.