Establishing community-based safety guideline to protect Inuit from mercury originated from consuming lake trout

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CHARS Annual Project Report

Project Title: Establishing community-based safety guideline to protect Inuit from mercury originated from consuming lake trout.

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Project Team (Regional Partners): **Sylvie Ricard**, Nunavik Regional Board of Health and Social Services (NRBHSS), Nunavik Hunting Fishing and Trapping Associations (NHFTAs), Hunter Support Programs (HSPs).

Abstract: Between January and March 2015, a total of 149 lake trout were collected from 9 water systems near 5 Nunavik communities. The fish were analyzed for mercury and selenium at Nunavik Research Centre in Kuujjuaq. Fish length, weight and age were also measured for all fish, and a sub-sample, analyzed for omega-3 concentrations at the CHUL. Over 73% of lake trout exceed Health Canada mercury safety guideline for fish (> 0.5 ug/g wet weight). Over 22% exceed 1.0 ug/g wet weight. This is very similar to the findings of a previous study carried out in 2006/2007. Although statistically significant positive correlations between fish age/ length and mercury concentration were found in fish from most water systems studied, the rate of increase in mercury accumulation with fish age and size varied from one water system to another. The fish ages corresponding to the 0.5 ug/g guideline varied between 7 and 13.8 years old. The fork lengths corresponding to the 0.5 ug/g guideline varied between 34 and 56cm, and the number of fish collected with gillnets (the type used by Nunavimmuit) below 56cm were relatively few. The limitation of the gill nets (4 inch mesh) normally used by communities for subsistence harvest in catching smaller lake trout truncated the size distribution. This limited our ability to evaluate mercury levels at the smaller, younger end of the distribution. Although smaller fish would never be commonly harvested with gillnets, they are often caught by line fishing. Important factors such as natural background mercury levels, ecological niches, especially the diet and food chain position of lake trout can vary from one water system to another, and may explain the significant variation in mercury accumulated by lake trout between watersheds. These can have a decisive influence on such growth parameter – mercury bioaccumulation relationships. Lake trout is a good source of selenium and omega-3 fatty acids, and like mercury, presented significant variations between watersheds. Notably, lake trout from rivers that are close to the marine environment are exceptionally rich in omega-3 fatty acids and have a significantly lower mercury concentration. The extent to which lake trout consumption contributes to the total dietary mercury intake in Nunavimmuit was assessed by surveying the fish-eating

habits of residents of the five Nunavik communities involved in the study. In most cases, lake trout consumption in winter tends to increase since other, often more preferred fish species such as arctic char, salmon and brook trout become less available. After a detailed consultation with the Nunavik Regional Board of Health and Social Services (NRBHSS), it was concluded that it is not possible to establish fish length and age guidelines that can universally be applied to Nunavik, since the fish below 0.5 ug/g would be too small to be caught with a gillnet. Instead of disseminating public health messages to the general public of Nunavik, the NRBHSS suggested that interventions should be taken on a case-by-case basis and targeted to at-risk women (pregnant women and women of childbearing age), when high blood mercury levels are detected through blood screening tests during early pregnancy and/or when and where consumption of high mercury country foods (e.g. beluga meat, lake trout) is particularly frequent. The present study provided important data in villages where no previous information was available and will be very useful at community level and for prenatal dietary counseling.

Key Messages:

- Larger and older lake trout often contain higher concentrations of mercury. Hence one should consume smaller and younger lake trout in order to minimize dietary mercury intake; although, this does not guarantee that the consumer will stay under the Health Canada guidelines for safe fish consumption.
- Like many fish species harvested in Nunavik for subsistence consumption such as arctic char, brook trout, whitefish and salmon, lake trout is a good source of both selenium and omega-3 fatty acids. However, mercury concentration in lake trout is often significantly higher than that in these other fish species. Nunavimmuit should consider consuming less lake trout when other fish species are available. This recommendation is particular relevant for the pregnant women, women of childbearing age and young children.
- At this stage it is not possible to pinpoint precisely the fish size and age above which the Health Canada's fish mercury guideline is breached. And still, considering the size of the fish commonly caught with gillnets, the technique used by Inuit for most of their subsistent harvest, getting fish that are small enough to be low in mercury (<56cm) is less common and is mostly confined to line fishing.
- As a result of our consultation with NRBHSS, our conclusion is that intervention regarding lake trout consumption should be targeted to at-risk women on a case-by-case basis when evidence of high blood mercury levels is found and/or excessive consumption of country foods that are known to

accumulate high concentrations of mercury (e.g. beluga meat, lake trout) is a concern.

Objectives: (1) To examine the relationships between fish growth parameters (fish length, weight and age) and mercury accumulation in lake trout harvested from a number of waterbodies in Nunavik. The findings might be useful for NRBHSS to explore the possibility in working out recommendations in terms of fish size smaller than which mercury is not a health risk. (2) To provide updated data for a closer assessment of the role of lake trout in contributing to the total dietary mercury intake in Nunavimmuit. (3) To determine two beneficial nutrients in lake trout: omega-3 fatty acids and selenium – in order to balance considerations of the risks and benefits of lake trout consumption.

Introduction: The "Qanuippitaa? How are we?" Nunavik Inuit Health Survey conducted by Laval University and NRBHSS in 2004 had identified that methylmercury exposure by Nunavimmiut is amongst the highest in the world. Human mercury exposure was found to vary significantly between Nunavik communities. Based on a detailed dietary survey that took into account regional variations in country food consumption profiles and mercury monitoring data of all country foods, a recent collaborative study between Laval University and Nunavik Research Centre (Lemire, et. al. 2015) concluded that beluga meat is the most probable cause of the exceptionally high mercury exposure, particularly in the Hudson Strait villages. Subsequent studies following the Qanuippitaa Health Survey, identified lake trout as a potentially important source of methylmercury intake with total mercury concentrations often comparable to beluga meat and marine mammal livers. In other regions of Canada, research demonstrates that older lake trout often accumulate mercury at concentrations well above the Health Canada safety guidelines; although there are considerable regional variations in mercury concentration (Depew et. al. 2013).

Community consultation at the outset of this project (May – June 2014) established that lake trout is indeed harvested by many Nunavik communities. However, the importance of lake trout as a food source varies amongst communities, depending largely on the availability of other, often preferred fish species such as arctic char, salmon and brook trout. In many parts of Nunavik, accessibility to arctic char, salmon and brook trout is restricted in the winter months. A more in-depth dietary survey on the lake trout consumption patterns of all Nunavik communities is needed before we can assess the importance of this fish species in contributing to the very high mercury exposure experienced by Nunavimmuit. Previous research on country food consumption, did not gather data specifically on lake trout and so, actual consumption levels of this fish species in Nunavik is unknown.

The rationale of this project is based on the simple fact that mercury concentration in lake trout increases as the fish grows older and larger (Kwan 2006). Hence, by establishing the growth rate – mercury accumulation relationship, we could examine the possibility of developing safety guidelines based on fish length that are practical to implement and can easily be used by the Nunavik population to gauge if certain sizes of harvested lake trout are safe to eat. A myriad of important variables might complicate the picture: Physicochemical characteristics of the water system; the ecological niche of the lake trout especially its diet and its food-chain position, as these can vary from one water system to another; fish behaviour such as migratory vs. resident lake trout; background mercury level of the bottom sediments; and the extent of influence of marine/estuary environment to the lake trout habitat. All these can vary from one water system to another and can have an important influence on fish growth rate and/or mercury accumulation (Phillips and Rainbow. 1993). An earlier investigation of the spatial variation of mercury in Nunavik lake trout carried out almost a decade ago, found that fish growth rate and mercury accumulation can vary significantly from one water system to another (Kwan 2006).

Activities in 2014 – 2015: The project first began with the first consultation with the Nunavik Nutrition and Health Committee (NNHC) which took place in mid-November 2014. Since the findings of the project are directly relevant to the public health activities regarding contaminants in country foods, a close collaboration with and endorsement from the NRBHSS is imperative (the NNHC is part of the larger organizing structure of the NRBHSS). The NRBHSS is the only authority in Nunavik that issues public health messages to Nunavimmuit regarding food safety. It is essential that the NNHC is fully consulted and approves all communications to communities regarding the findings from this project.

Consultation with the local Hunters Fishers Trappers Associations (HFTA) of the five communities took place between mid-November and mid-December 2014 to identify the most important lake trout fishing spots for these communities. Initially, five Nunavik communities planned to participate in the project: Puvirnituq, Umiujaq, Kuujjuaraapik, Salluit and Inukjuak. In January 2015, Umiujaq and Kuujjuaraapik were not be able to collect lake trout for the study and decided to withdraw. They were replaced by Kangiqsualujjuaq and Kuujjuaq. For these NRC community consultations, copies of a plain language summary of the original project proposal in Inuktittut were prepared and presented to members of local HFTA and other interested parties (see appendix 4). Discussion between the project's principal investigators and local HFTA members confirmed the concerns expressed by communities regarding high mercury levels in lake trout. More importantly, Nunavimmuit's perception of lake trout as a country food and its level of consumption at different times of the year by different communities were discussed. For each community, a local coordinator and fishermen were identified and were trained by technicians from NRC on specifics related to the lake trout collection protocol. With the help of local fishermen, two completely separate water systems frequented by locals for subsistence harvest were identified for each of the five communities collecting fish samples.

Communities started collecting and shipping lake trout samples to NRC in mid-January 2015. In two months time, a total of 149 lake trout were collected. Total mercury concentration was determined by cold vapour atomic absorption spectrometry (CVAAS) and selenium concentration by graphite furnace atomic absorption spectrometry (GFAAS) at NRC in Kuujjuaq. All analyses were subjected to an established quality assurance/quality control (QA/QC) protocol using Certified Reference Materials (CRM) from the National Research Council of Canada. The trace metal analytical lab at NRC has been a participant of the Inter-laboratory QA/QC program of the Northern Contaminants Program since 1998. Fish age was determined by reading the otoliths extracted from the lake trout. Fork length, fresh weight and stomach contents were recorded for all samples. Subsamples of belly meat from 23 lake trout were shipped to Quebec City for omega-3 fatty acids determination at the CHUL.

Three presentations were given each by the three principal investigators of this project at the NNHC meeting in Kuujjuaq on 24th March 2015. The first presentation was delivered by M. Kwan titled "Mercury and Lake Trout in Nunavik. 2015 and 2006/07 studies." (Appendix 1) which directly addressed the objectives identified at the outset of this project. The presentation combined the results of the present study with those from an earlier study (Kwan 2006) funded by the Northern Ecosystems Initiatives (NEI). A total of 349 lake trout were studied in the two studies combined (200 from the 2006/07 study and 149 from the present study)– the largest and most completed dataset of mercury in lake trout harvested in Nunavik to date. The presentation highlighted the relationships between various growth parameters and mercury concentration in lake trout and the spatial variation in fish growth rate and mercury accumulation in different waterbodies. The second presentation was given by M. Lemire (Appendix 2), which specifically examined the potential human health implications of mercury in Nunavik lake trout by calculating the provisional tolerable daily intake (pTDI) for the consumption of lake trout with low, high and very high concentrations of mercury based on the data of this project. Lake trout as a good source of omega-3 fatty acids was also discussed. The third presentation, which titled "Reported Fish Consumption in Pregnant Inuit Women from Nunavik." was presented by C. Pirkle (Appendix 3). This is a study funded by other sources. However, it is relevant to the CHARS funded project since apart from arctic char and mollusks, lake trout is the only fish species regularly consumed by pregnant Nunavik women more than once a month, according to a detailed food frequency questionnaire. This study also highlighted that the extent to which lake trout consumption by pregnant women varies from community to community and the research directly sampled the population most at risk of the adverse effects of mercury exposure. As mentioned previously, existing data of country food consumption did not contain information specifically about lake trout consumption.

Together with detailed dietary survey data from the other research study, mercury data from the Nunavik lake trout project will provide the NRBHSS the necessary information to assess the importance of this fish species in contributing to the total dietary mercury intake in Nunavimmuit. Subsequently, public health messages regarding consumption of lake trout can be formulated. A discussion of the findings at the present stage during the 24th March NNHC meeting is summarized in Appendix 5 ("Preliminary Results Summary for the Mercury Lake Trout Projects" by Lemire *et. al*. 2015).

Results: For all the results generated with the funding from CHARS between 2014 and 2015 fiscal year please see Table 1 (mercury and bio-data) and Table 2 (omega-3 fatty acids and selenium) below. The Powerpoint presentations in Appendices 1* and 2 give a more detailed analysis of the findings.

(* Appendix 1 presentation is a combination of the present CHARS – funded project and an earlier study (Kwan 2006) undertook by one of the principal investigators).

Table 1. Mercury concentration and bio-data of 149 lake trout from 9 Nunavik waterbodies collected between January and March 2015

INK-1, Inukjuak site 1
INK-2, Inukjuak site 2
Sal-1, Salluit site 1
Sal-2, Salluit site 2
PUV-1, Puvirnituq site 1
PUV-2, Puvirnituq site 2
GL, Kuujjuaq site 1
TLK, Kuujjuaq site 2
PH, Kangiqsualujjuaq

sample ID	mercury concentration ug/g w.w.	age	sex	full length, cm	fork length, cm	weight, g	stomach content
INK-1-1	0.707	12	f	55	52	1625	digested unidentified fish
INK-1-2	1.330	17	f	56.5	53	1675	sticklebacks
INK-1-3	0.560	7	m	48.5	45	1150	empty
INK-1-4	0.650	10	m	50.5	47	1150	empty
INK-1-5	1.000	11	f	54.5	50.5	1250	empty
INK-1-6	0.605	8	f	48.5	45.5	1125	empty
INK-1-7	1.070	12	f	54.5	52	1475	sticklebacks
INK-1-8	1.417	17	m	66	61	2500	empty
INK-1-9	0.483	8	m	49.5	46	1100	empty
INK-1-10	0.833	13	m	63	59	2250	empty
INK-1-11	0.609	9	m	52.5	49.5	1225	empty
INK-1-12	0.883	10	m	56	52.5	1150	sticklebacks
INK-1-13	0.919	16	m	58	54.5	1625	empty
INK-1-14	1.310	17	f	60	57.5	1625	empty

INK-1-15	1.298	13	m	59.5	55.5	1800	a big whitefish
INK-1-16	1.136	14	m	60	56	1775	empty
INK-1-17	0.660	9	m	50	46.5	1050	sticklebacks
INK-1-18	0.670	11	m	53	50	1400	sticklebacks
INK-1-19	0.632	9	f	48.5	46	1075	a big unidentified fish
INK-1-20	1.230	15	f	53.5	49.5	1350	empty
INK-2-1	0.405	9	f	44.5	42	725	sticklebacks
INK-2-2	1.03	14	m	broken tail	55	1800	sticklebacks, unidentified digested fish
INK-2-3	0.569	11	f	52	49	1275	sticklebacks, ciscoes
INK-2-4	0.666	15	m	52.5	49.5	1550	sticklebacks, ciscoes
INK-2-5	0.627	14	m	49.5	46.5	1150	ciscoes
INK-2-6	0.916	16	m	56	52	1525	sticklebacks, ciscoes
INK-2-7	0.598	11	m	49	46	1125	sticklebacks, ciscoes
INK-2-8	1.205	12	f	51.5	49	1125	ciscoes
INK-2-9	1.851	20	f	90.5	84	6575	digested unidentified fish
INK-2-10	0.618	14	m	broken tail	52	1575	sticklebacks
INK-2-11	0.831	12	m	53.5	50	1150	sticklebacks
INK-2-12	0.864	11	f	broken tail	49	1200	empty
INK-2-13	1.273	19	m	87.5	83.5	7200	unidentified fish bones
INK-2-14	0.664	13	f	57.5	54.5	1825	sticklebacks
INK-2-15	1.221	14	f	55.5	52	1375	sticklebacks
INK-2-16	1.851	12	f	53.5	50	1100	empty
INK-2-17	0.552	9	f	45.5	41.5	750	caddy fly larvae
INK-2-18	0.783	10	m	49	46.5	1000	rocks
Sal-1-1 (char)	0.04	6	f	22	21	100	
Sal-1-2	0.31	13	f	50.5	48	1225	empty
Sal-1-3	0.206	13	m	38.5	37	450	empty
Sal-1-4	0.349	17	f	54	51.5	1525	a char
Sal-1-5	0.314	16	m	52	49	1300	empty
Sal-1-6	0.347	18	m	53	50.5	1425	chars
Sal-1-7	0.392	16	f	60	57	1950	empty
Sal-1-8	0.283	16	f	53	50.5	1425	empty
Sal-1-9	0.36	17	m	55	52.5	1475	empty
Sal-1-10	0.401	15	m	45.5	43.5	925	empty
Sal-2-1	0.589	20	f	49	47	1075	small unidentified fish
Sal-2-2	0.5	18	f	broken tail	52	1625	empty
Sal-2-3	0.369	15	f	44.5	43	925	two big chars
Sal-2-4	0.692	18	m	48.5	46	750	empty
Sal-2-5	0.437	16	m	44.5	42	750	small fish
PUV-1-1	0.446	10	f	49.5	47	1275	sticklebacks
PUV-1-2	0.343	8	f	broken tail	46	1200	sticklebacks
PUV-1-3	0.371	8	f	broken tail	47	1225	sticklebacks
PUV-1-4	0.401	10	f	50	48	1200	sticklebacks
PUV-1-5	0.247	8	m	broken tail	47	1250	empty
PUV-1-6	0.235	8	m	broken tail	36	550	unidentified digested fish
PUV-1-7	0.502	16	f	54.5	51.5	1700	sticklebacks
PUV-1-8	0.779	12	f	57.5	53.5	1650	a big whitefish
PUV-1-9	0.344	11	f	broken tail	50.5	1475	sticklebacks
PUV-1-10	0.521	12	m	broken tail	49	1325	empty

PUV-1-11	0.294	8	m	50	47	1250	empty
PUV-1-12	1.136	17	m	89	83	9500	two big whitefish
PUV-1-13	0.533	15	m	55	52.5	1800	empty
PUV-1-14	0.238	7	m	48.5	46	1225	sticklebacks
PUV-1-15	0.418	11	f	broken tail	51	1250	sticklebacks, unidentified digested fish
PUV-1-16	0.38	10	f	broken tail	48.5	1375	empty
PUV-1-17	0.668	13	f	52.5	48.5	1400	sticklebacks
PUV-1-18	0.36	8	m	broken tail	47.5	1050	unidentified digested fish
PUV-1-19	0.287	7	m	47.5	45.5	1050	empty
PUV-1-20	0.369	10	f	51.5	47.5	1250	empty
PUV-2-1	0.578	18	f	59	56	1600	sticklebacks
PUV-2-2	0.602	17	f	63	60	2100	unidentified digested fish
PUV-2-3	0.276	12	f	53	50.5	1250	one big unidentified fish and sticklebacks
PUV-2-4	0.489	14	f	broken tail	63	2450	empty
PUV-2-5	0.463	14	m	51	50	1200	sticklebacks
PUV-2-6	0.616	19	f	64	61	2200	sticklebacks
PUV-2-7	0.489	14	f	54	51	1550	unidentified digested fish
PUV-2-8	0.91	16	f	63	60	1800	sticklebacks
PUV-2-9	0.554	14	m	51	50	1250	sticklebacks
PUV-2-10	0.61	12	m	59	56	2300	empty
PUV-2-11	0.559	14	f	58	56	1550	sticklebacks
PUV-2-12	0.467	11	m	66	64	2650	empty
PUV-2-13	1.172	21	f	82	79	6000	a big whitefish
PUV-2-14	1.729	22	f	78	77	3000	empty
PUV-2-15	1.878	24	m	92	87	7000	empty
PUV-2-16	0.387	15	f	58	54	1750	sticklebacks
PUV-2-17	0.462	17	m	71	67	3000	fish bone
PUV-2-18	0.744	14	m	74	71	2500	a big whitefish
PUV-2-19	0.663	15	f	71	66.5	4050	a big whitefish
PUV-2-20	0.586	15	f	70	68	4000	two big whitefish
GL-1	0.601	10	f	50.5	broken	1075	caddie fly larvae
GL-2	0.801	11	f	52.5	49.5	1500	caddis fly larvae, a large ciscoes
GL-3	0.919	16	m	56.5	52.5	1400	two small suckers
GL-4	1.796	13	f	57.5	54.5	1625	caddie fly larvae
GL-5	0.834	12	f	53	50	1300	small unidentified fish
GL-6	0.26	9	m	42	40	670	caddie fly larvae, sticklebacks
GL-7	0.551	10	f	49.5	47	1050	caddie fly larvae
GL-8	0.927	15	m	60.5	57.5	2150	a huge brook trout, a smelt
GL-9	0.686	13	m	55.5	52.5	1400	branches
GL-10	0.58	10	m	50.5	47.5	1075	caddie fly larvae
GL-11	0.721	12	m	54.5	51.5	1425	sticklebacks
GL-12	0.926	12	m	54.5	51	1650	sticklebacks
GL-13	1.206	14	f	61.5	58	2250	caddie fly larvae, sticklebacks
GL-14	0.479	11	m	53	50.5	1600	sticklebacks
GL-15	0.38	10	m	48	46.5	975	caddie fly larvae, sticklebacks
GL-16	0.72	13	f	56.5	53	1500	sticklebacks
GL-17	0.645	11	m	52.5	49	1600	caddie fly larvae, sticklebacks
GL-18	0.506	9	m	43	40.5	750	sticklebacks
GL-19	0.523	10	m	48.5	46.5	1025	sticklebacks

GL-20	1.02	15	m	55.5	53.5	1550	small unidentified fish
TLK-1	0.75	14	m	48.5	46	1050	unidentified digested fish
TLK-2	0.35	8	f	48	45	1000	sticklebacks
TLK-3	0.605	13	m	54	51	1550	empty
TLK-4	0.71	11	m	48.5	46.5	1050	unidentified digested fish
TLK-5	0.771	14	m	56	53	1650	big ciscoes
TLK-6	0.374	10	m	45	43	870	ciscoes
TLK-7	0.862	16	m	72	68	3675	ciscoes
TLK-8	0.661	11	f	55.5	51.5	1550	sticklebacks, ciscoes
TLK-9	0.719	15	f	51	48.5	1225	empty
TLK-10	0.488	10	m	50	47	950	big ciscoes
TLK-11	1.2	10	m	47	44	825	big ciscoes
TLK-12	1.538	12	f	56.5	52.5	1745	ciscoes
TLK-13	0.791	13	m	54.5	51.5	1450	ciscoes
TLK-14	0.626	9	f	54	51	1575	ciscoes
TLK-15	1.022		m	54	52	1450	ciscoes
TLK-16	1.296	11	m	62	59	2500	ciscoes
TLK-17	1.105	11	m	55.5	52.5	1600	unidentified digested fish
TLK-18	0.405	9	m	48.5	45.5	975	ciscoes
PH-1	2.091	16	m	74.5	70	3475	empty
PH-2	1.29	25	f	77.5	74	4175	empty
PH-3	0.742	16	f	broken tail	56.5	1600	no gut
PH-4	0.805	10	m	broken tail	41	500	empty
PH-5	0.784	17	f	broken tail	64	2275	empty
PH-6	2.154	30	m	broken tail	69.5	2800	no gut
PH-7	0.59	17	f	56	53.5	1600	empty
PH-8	0.473	12	f	57.5	55	1650	empty
PH-9	0.68	14	f	57	54.5	1575	unidentified digested fish
PH-10	0.81	18	f	76	73.5	1850	unidentified fish bones
PH-11	1.38	24	m	broken tail	65.5	2650	empty
PH-12	0.784	18	m	76.5	74	2325	empty
PH-13	0.975	17	m	broken tail	58	1850	empty
PH-14	0.464	8	m	45.5	42	875	empty
PH-15	0.731	14	f	75.5	72.5	3050	unidentified digested fish
PH-16	0.56	18	f	54.5	51.5	1450	empty
PH-17	1.65	20	f	75.5	73	3875	unidentified digested fish
PH-18	0.864	12	m	56	53.5	1550	empty

Table 2. Omega-3 fatty acids and selenium in selected Nunavik lake trout.

Fish	Lake	EPA mg/g	DPA mg/g	DHA mg/g	EPA+DPA+DHA mg/g	Se ug/g ww
PH-1	Kangiqsualujjuaq - Pyramid Hill	1,72	2,31	6,79	10,82	0,61
PH-2	Kangiqsualujjuaq - Pyramid Hill	4,59	3,82	9,61	18,02	0,512
PH-3	Kangiqsualujjuaq - Pyramid Hill	0,37	0,18	1,27	1,82	0,406
PH-5	Kangiqsualujjuaq - Pyramid Hill	2,52	1,64	3,31	7,47	0,628
PH-6	Kangiqsualujjuaq - Pyramid Hill	0,31	0,23	1,84	2,38	0,44

PH-7	Kangiqsualujjuaq - Pyramid Hill	4,29	2,5	5,51	12,3	0,201
GL-7	Kuujjuaq - Gabriel Lake - Site 1	2,62	2,08	3,95	8,65	0,161
GL-8	Kuujjuaq - Gabriel Lake - Site 1	4,43	4,21	9,97	18,61	0,152
GL-9	Kuujjuaq - Gabriel Lake - Site 1	3,77	4,08	8,95	16,8	0,186
GL-10	Kuujjuaq - Gabriel Lake - Site 1	3,39	2,24	6,82	12,45	0,179
GL-11	Kuujjuaq - Gabriel Lake - Site 1	2,33	2,69	3,91	8,93	0,202
GL-12	Kuujjuaq - Gabriel Lake - Site 1	5,92	5,9	10,97	22,79	0,463
SAL-1-2	Salluit - site 1	5,73	3,65	8,56	17,94	0,552
SAL-1-4	Salluit - site 1	5,83	4,4	11,02	21,25	0,468
SAL-1-6	Salluit - site 1	5,03	4,17	9,93	19,13	0,525
SAL-1-7	Salluit - site 1	6,89	4,97	10,86	22,72	0,501
SAL-1-8	Salluit - site 1	3,6	2,42	6,8	12,82	0,483
SAL-1-9	Salluit - site 1	5,7	4,45	9,31	19,46	0,293
PUV1-1	PUV river - site 1	7,08	5,99	6,25	19,32	
PUV1-3	PUV river - site 1	5,4	4,56	3,8	13,76	0,333
PUV1-7	PUV river - site 1	1,76	1,58	5,03	8,37	0,32
PUV1-9	PUV river - site 1	4,64	3,36	6,87	14,87	0,296
PUV1-10	PUV river - site 1	3,17	3,82	3,6	10,59	0,274
PUV1-12	PUV river - site 1	6,37	6,31	21,99	34,67	0,326
INK-1-1	Inukjuak - site 1					0,407
INK-1-2	Inukjuak - site 1					0,44
INK-1-3	Inukjuak - site 1					0,415
INK-1-4	Inukjuak - site 1					0,389
INK-1-5	Inukjuak - site 1					0,374
TLK - 1	Kuujjuaq - Three lake - Site 2					0,185
TLK - 2	Kuujjuaq - Three lake - Site 2					0,15
TLK - 3	Kuujjuaq - Three lake - Site 2					0,15
TLK - 4	Kuujjuaq - Three lake - Site 2					0,176
TLK - 5	Kuujjuaq - Three lake - Site 2					0,153
INK-2-1	Inukjuak - site 2					0,577
INK-2-2	Inukjuak - site 2					0,394
INK-2-3	Inukjuak - site 2					0,564
INK-2-4	Inukjuak - site 2					0,58
INK-2-5	Inukjuak - site 2					0,575
PUV-2-1	PUV - site 2					0,524
PUV-2-2	PUV - site 2					0,491
PUV-2-3	PUV - site 2					0,398
PUV-2-4	PUV - site 2					0,509
PUV-2-5	PUV - site 2					0,491

Discussion and Conclusions:

In this section, we discuss our research findings as they related to the principal objectives of this project. We conclude with recommendations for future research and collaboration.

Relationships between fish growth parameters (fish length, weight and age) and mercury accumulation in lake trout

Positive correlations between fish growth parameters and mercury accumulation were found in lake trout from most of the waterbodies studied. Significant spatial variations exist in growth rate and/or mercury accumulation in lake trout from one waterbody to another. Tissue mercury content is a measure of the mercury body burden; it is directly related to the rate of mercury accumulation but is independent of growth. The mercury concentration in fish tissue is a result of the balance between the rate of two opposing processes: the net accumulation rate of mercury and the rate of increase of tissue mass. Mercury concentration will increase with fish age and size when growth is slow relative to the rate of mercury accumulation. In a fully-grown fish, changes in mercury body burden in the soft tissues depend on the corresponding rates of absorption and excretion. If growth is rapid, compared to mercury accumulation, the dilution effect resulting from the formation of new tissues will lead to a slow down or even decrease in body mercury concentration with age and size even though mercury content has increased over time. This is particularly the case if the metal concentration in the ambient aquatic ecosystem is very low. Dilution effect on tissue mercury concentration due to growth has been observed in a number of other fish species, including northern pike (Lockhart *et. al.* 1972), a fish that has very similar ecological niche as lake trout. In contrast, net accumulation of mercury in tissues may occur when excretion of mercury is very slow and limited compare with absorption. Over 90% of mercury in fish muscles is in the methyl form, which account for the long biological half-life of total mercury in fish (WHO 1990) since methylmercury has an extremely long biological half-life. The significant positive correlations between mercury concentration and fish growth parameters for lake trout could be a result of the fact that the net mercury accumulation rate outweighed the dilution effect of growth due to slower growth rate and / or the presence of higher mercury concentration in these aquatic ecosystems and hence absorption, outweighed excretion of mercury.

A myriad of other factors can influence mercury accumulation in lake trout apart from the fish growth rate in a watershed: (1) physicochemical characteristics of the water and sediments which affect the methylation process and subsequently the bioavailability of mercury to benthic and higher organisms; (2) the natural background levels of mercury in the bottom sediments which depends on the geological makeup of the bedrock; (3) the ecological niche of the lake trout especially its diet and its food-chain position; (4) fish behavior including whether the fish is migratory or sedentary and (5) the extent of influence of estuary/marine environment on the lake trout habitat. In the present study, Puvirnituq site 1 (Puvirnituq River) is very close to marine ecosystems, lake trout from this habitat might have anadromous characteristics. Mercury concentration of lake trout from Puvirnituq site 1 is consistently and significantly lower than all but one (Salluit site1) of the waterbodies studied. Anadromous lake trout have been studied in Nunavut and contained significantly lower mercury levels than their resident counterparts (Gantner *et. al*. 2011). Additionally, omega-3 fatty acids levels in Puvirnituq site lake trout are exceptionally high which is also a characteristic of the influence of marine ecosystems. Further research is needed in learning more about the mercury and nutritional compositions of these lake trout with anadromous characteristics and if there are ways local fisherfolk can identify them.

Bioaccumulation factors (BCFs) of methylmercury in aquatic lives are commonly in the region of tens and hundreds of thousands (US EPA 1980). However, the high BCFs of methylmercury alone do not explain the differences in mercury accumulation in lake trout from different locations nor do mercury concentration according to growth. Since food is an important source of many contaminants including mercury, the diet of an organism is an important determinant of bioaccumulation of contaminants (Phillips and Rainbow 1993). This trophic effect is particularly relevant for mercury because it is the only heavy metal that exhibits a biomagnification effect in aquatic food chains. It is the methylated forms of mercury that are responsible for the biomagnification phenomenon. Lake trout situated at a higher trophic level of food chains often has a diverse diet depending on what foods are available in surrounding ecosystems. The differences in diet of lake trout from different locations may have an important bearing in explaining the differences in mercury accumulation observed. Food availability also determines fish growth rate which in turns influence the two opposing processes that also determine tissue mercury concentrations: the rate of increase in tissue mass relative to the rate of increase in tissue mercury content (mercury body burden).

Another important factor that affects mercury bioaccumulation is the lifespan of an organism. As a generalization rather than a rule, organisms at the higher trophic levels usually live longer than those at the lower end of a food chain. This allows a longer period for bioaccumulation of mercury. The age range of the lake trout examined in this study was between 6 and 30 years old. It is not uncommon that lake trout grows well over 50 years of age (May 2014).

Assess the role of lake trout in contributing to total dietary mercury intake in Nunavimmuit

One of the principal investigators in this project, complemented the aims of this research project with the contribution of data from another study - primarily funded by Canadian Institute of Health Research (CIHR) that investigated consumption patterns of fish and other seafood's by pregnant Inuit women in Nunavik (see Appendix 3 presentation). Consumption of lake trout by pregnant women was assessed and the findings are highly relevant to the present study especially from the standpoint of assessing the importance of lake trout as a traditional food source and hence its contribution to the dietary mercury intake in this most vulnerable population group – the developing foetus. The followings are the relevant findings relating to lake trout consumption:

a. Reported consumption of most fish species in Nunavik is relatively low, except for arctic char. Women in this sample (n=130) provided information on fish consumption from fall to winter and results may not be reflective of spring and summer.
b. About 20% of women reported consuming lake trout more than once per month (14% one to three times/month, 6% once a wk or more), compared to 80% consuming lake trout never or less than once a month. Even so, lake trout is reported to be the 3rd most consumed fish/seafood item after arctic char and mollusks (during fall and winter). While the sample sizes are small by village, some women from Inukjuaq, Kuujjuaq, Kangiqsualujjuaq, reported consuming lake trout once a week or more (Table III).
c. The frequency of lake trout consumption (1/month versus <1/month) was not associated with significantly greater mean blood mercury levels. Because the sample size was 130 and only 20% of women reported consuming lake trout more than once per month, these results cannot be generalized to the small number of women (n=8) who were consuming lake trout more frequently (e.g. 1/week or more).

Table III: Frequency of lake trout consumption by Nunavik communities.

Community corrected, preferred variable	T0_laketrout never or	1-3/month	1/week	2+/week	Total
[1]Akulivik	10	0	0	0	10
[2]Aupaluk	3	0	0	0	3
[3]Inukjuaq	13	4	1	1	19
[4]Kangiqsualujjuaq	8	3	0	1	12
[5]Tasiujaq	7	0	0	1	8
[6]Kangiqsujuaq	9	0	0	1	10
[7]Kangirsuk	1	1	0	0	2
[8]Umijuaq	2	0	0	1	3
[9]Kuujjuaq	13	7	0	1	21
[10]Kuujjuarapik	10	2	0	0	12
[11]Puvirnituq	14	1	0	0	15
[12]Quaqtaq	3	0	0	0	3
[13]Salluit	11	0	1	0	12
Total	104	18	2	6	130

By documenting the lake trout consumption patterns of pregnant women, we were able to determine that while the fish is relatively commonly consumed, only a handful of women consume the fish at levels that would considered unsafe according to Health Canada Guidelines for mercury consumption. As such, the NRBHSS concluded that counseling about lake trout consumption should occur on a case-by-case basis rather than through untargeted public health messaging, which could adversely scare the population with regards to fish consumption. In the next two sections, we will specifically discuss the relevance of our research to fish consumption guidelines.

Relevance to dietary guideline on fish

By establishing the fish growth rate – mercury accumulation relationship for lake trout from different waterbodies, one of the objectives of this project is to examine the possibility of proposing a single safety guideline based on fish length. The Health Canada's mercury guideline for commercial fish (0.5 ug/g w.w.) is often used as the reference point to define the notions of high vs. low mercury levels in fish (Health Canada 2007). While the guideline is useful for researchers, it has limited practical applicability for those harvesting from land and sea.

A reference point based on fish length instead of mercury concentration is more practical to implement and can easily be used by the Nunavimmuit to gauge if certain sizes of lake trout are safe to eat. In the present study, fork length, age and fresh weight that are corresponding to the 0.5 ug/g guideline were estimated from the best-fit-lines of the correlation plots between these two growth parameters and mercury concentrations in lake trout from different waterbodies (Appendix 1, slide 6). The fork lengths corresponding to the 0.5 ug/g guideline vary between 34 and 56 cm which is relatively narrow considering lake trout often grow to substantial sizes. It is seemingly possible to recommend a fork length below which the 0.5 ug/g guideline is not likely to be exceeded. However, one major problem is that because all the lake trout collected for this project were caught with 4-inch mesh gill nets, the smallest lake trout caught has a 36cm fork length and the majority (over 70%) were well over 50cm. This rendered an accurate estimation of the lower end of the fork length range that corresponded to the 0.5ug/g guideline not possible. This is further exacerbated by the fact that the majority of our samples in this study have mercury concentrations above the 0.5ug/g guideline. Although 4-inch mesh gill nets are most commonly used throughout Nunavik for subsistent harvest, line-fishing is a common practice. A great number of lake trout of a wide size-range, including the smaller younger fish are caught by line and consumed. A study that focuses on the mercury accumulation in smaller younger lake trout from these waterbodies is needed for us to better assess if fish length can indeed be useful as a guideline. This study found significant spatial variations in the mercury concentrations in lake trout from one waterbody to another (Appendix 1, slide 3). Lake trout from certain waterbodies consistently have high mercury concentration, e.g. Inukjuak sites 1 and 2, Kuujjuaq sites 1 and 2, and Kangiqsualujjuaq; whereas fish from certain other waterbodies consistently have low mercury concentrations, e.g. Puvirnituq site 1, Salluit site 1 and 2. It seems that where the fish were caught may be a more useful indicator of the likelihood that fish will surpass the 0.5 ug/g guideline.

Estimates of Safety Consumption Frequencies

Health hazard assessment (HHA) is routinely used by the Bureau of Chemical Safety of Health Canada to assess possible risk of chemical substances in foods sold commercially. Health hazard assessment (HHA) is a multi-step process based on careful consideration of two basic parameters: toxicity of the chemical substances (Provisional Tolerable Daily Intake or pTDI) and potential human exposure to these chemicals (Probable Daily Intake or PDI). To carry out a "comprehensive" health hazard assessment of a contaminant such as mercury for a population, the pTDI of the contaminant is compared with the PDI determined for the population. Subsequently, recommendations can be made and steps can be taken to manage the risk if needed. In essence, this approach of HHA involves recommendations and decision-making based on comparing the total amount of that particular contaminant that an individual is exposed to from <u>all sources</u> (PDI) with the amount that an individual can be exposed to over a lifetime without a health effect (pTDI). In reality, it is very difficult, if at all possible, to determine accurately the PDI of a contaminant for a population since there exists a complex myriad of sources of the contaminant to constitute the total exposure. Many of these sources are difficult to identify and quantify. This is further complicated by the changing pattern of exposure over time due to changes in habit, requirement and availability of foods. However, it is possible to carry out a "simplified" HAA for one source alone (lake trout in this case) using the PDI approach if that source is significantly more important due to its high contaminant concentration and/or its importance as a food source in comparison with other sources. For the PDI of lake trout:

$$\text{PDI (ug/kg BW/day)} = \frac{\text{Fish portion (g/time)} * \text{frequency (times/day)} * \text{Hg in fish (ug/g w.w.)}}{\text{Body weight (kg)}}$$

The calculated PDI values are then compared with the pTDI established for that contaminant. The pTDI is the quantity of a contaminant that can be ingested every day during a lifetime with reasonable assurance that no health hazard would result. pTDI is measured in micrograms of the contaminant in question per kilogram body weight per day. The 1989 and 1990 Annual Meetings of the FAO/WHO Joint Expert Committee on Food Additive (JECFA) proposed pTDI values for total mercury and methylmercury to be 0.71 and 0.47 μg/kg body weight/day respectively. Since it is well established that over 90 % of mercury in fish muscles is in the methyl form, the pTDI value for methylmercury was used in the comparing with the PDI values for fish. It is important to note that the formulation of environmental guidelines and pTDI values of mercury assume the subject of exposure is an average size adult of normal health. The HHA is based on a body weight of 60 kg – an average body weight of an adult (adopted by Health Canada). Hence, the interpretation of an HHA must take into consideration of the higher degree of susceptibility of vulnerable groups in a population such as infants, pregnant women, and women of childbearing age. Indeed, the pTDI value of 0.47 ug/kg body weight/day established by the JECFA in 1989/1990 was applicable for the "general population" only; in the 61st meeting in June 2003, JECFA recommended that it may be necessary to lower the pTDI value to 0.23 ug/kg body weight/day to safeguard the health of the more vulnerable groups in a population (JECFA 2003). According to this, the consumption limit for these more vulnerable groups in the population should be half that for the general population.

In the present study, PDI values for four communities (Inukjuak, Kuujjuaq, Kangiqsualujjuaq and Puvirnituq) were calculated using the mean mercury concentrations of lake trout from waterbodies frequented by these communities for their subsistent harvest (Table I). The results suggest that in almost no situation should lake trout be recommended to be consumed more than once per week by pregnant women in Nunavik, except perhaps in cases where there is no other country food to eat. However, the PDI formula does not take into consideration the beneficial nutrients found in lake trout nor does it consider food security in the region. Based on these findings and the consultation with NNHC, it was suggested that public health messages should be targeted to at-risk women during prenatal consultations using the screening of blood for mercury levels or questionnaire about beluga meat (the most important dietary source of mercury in Nunavik) and lake trout consumption, instead of releasing general public health messages about mercury in lake trout at the regional level. Messages could also be adapted on a case-by-case basis to address specific circumstances of the communities, taking into consideration the median levels of mercury found in lake trout from that location.

Table I: What is the number of times a 60 kg women can eat a fish portion of 150g in these villages?

	1 time/day	3 times/week	1 time/week	3 times/month
Inukjuak - 0.85 ug/g	2,13	0,91	0,30	0,21
Kuujjuaq - 0.73 ug/g	1,83	0,78	0,26	0,18
Kangiqsualujjuaq - 0.53 ug/g	1,33	0,57	0,19	0,13
Puvirnituq - 0.43 ug/g	1,08	0,46	0,15	0,10

"Recommended Maximum Weekly Intake" (RMWI) is another routinely used approach in health hazard assessments (HHA) by Health Canada in assessing potential risk of chemical substances in foods sold commercially. In the Northern Contaminant Program (DIAND 1994, Health Canada 1993), the RMWI approach has been recommended by Health Canada for use in assessing potential hazard of contaminants in country foods harvested for subsistence purposes.

$$\text{RMWI (grams per week)} = \frac{\text{pTDI} * \text{Body weight (kg)} * 7 \text{ (days)}}{\text{concentration of the contaminant in the food (ug/g w.w.)}}$$

RMWI values for the general population (pTDI =0.47ugHg/kg body weight/day) and the more vulnerable groups (pTDI = 0.23ugHg/kg body weight/day) for five communities (Inukjuak, Kuujjuaq, Kangiqsualujjuaq, Puvirnituq and Salluit) were calculated using the mean mercury concentrations of lake trout from waterbodies frequented by these communities for their subsistent harvest (Table II). Both the RMWI approach and the PDI approach are equally used by Health Canada in risk assessments, but the RMWI is somewhat a less stringent index than the PDI. Based on the Health Canada suggested 150 grams meal portion and 60kg average adult body weight, he RMWI results suggested that vulnerable groups (pTDI = 0.23ugHg/kg body weight/day) in the population of Puvirnituq can eat up to one portion of lake trout per week, whereas for Salluit, up to one and a half portions of lake trout can be consumed per week. The general populations of Inukjuak, Kuujjuaq and Kangiqsuallujjuaq (pTDI = 0.47 ugHg/kg body weight/day) can consume up to one and a half portions of lake trout per week. The general populations of Puvirnituq and Salluit can consume up to 2.5 and 3 portions of lake trout per week.

Table II. Recommended maximum weekly intake (RMWI) of lake trout for the general populations (pTDI = 0.47ugHg/kg body weight/day) and vulnerable groups (pTDI = 0.23ugHg/kg body weight/day) for a 60kg individual.

Community	RMWI, grams per week (general population)	RMWI, grams per week (vulnerable groups)
Inukjuak	232	114
Kuujjuaq	278	136
Kangiqsualujjuaq	221	109
Puvirnituq	380	186
Salluit	470	230

A major limitation of both the RMWI approach and the PDI approach is that consumption of mercury from sources other than the one specified is ignored. Hence, the indices calculated in this study assume lake trout is the only source of mercury that the individual is exposed to. Such an assumption is seemingly difficult to rationalize in that an individual is often exposed to a number of mercury sources. However, if the species in question constitutes a principal component in the diet of an individual or a community, the assumption may become more acceptable. Also, geometric means of mercury concentrations were used in calculating both RMWI and PDI values and the effect of fish growth on mercury accumulation was not taken into account. Hence, the indices might have somehow overstated the potential health risk due to mercury if one's diet only includes small and young lake trout. Conversely, large and old lake trout might accumulate sufficiently large quantities of mercury in their meat that renders the RMWI value calculation an overestimation and the PDI value an underestimation.

Despite their limitations, both RMWI and PDI do translate the technical language used in contaminant measurement such as μg/g, ppb and ppm into a more meaningful term that can be used directly for risk assessment purposes. They are also useful as indices in comparing the degrees of health risk between species and between locations of the same species. Since the Nunavik Regional Board of Health and Social Services (NRBHSS) is the sole authority in Nunavik to deliver public health advice regarding food safety, no recommendation regarding public health will be made in this study. However, the findings of this study will be submitted to NRBHSS to facilitate the formulation of the final public health messages regarding lake trout.

Determine the concentrations of beneficial nutrients in lake trout

As with other country foods, the nutritional, economical and cultural aspects of subsistence harvest are important considerations. The JECFA (2003) also commented that ". *…fish make up an important nutritional contribution to the diet, especially in certain regional and ethnic diets, and recommended that when considering setting limits for methylmercury concentration in fish or fish consumption, nutritional benefits should be weighed against the possibility of adverse effects."* Winter ice fishing for lake trout is a traditional activity for the Inuit. Such subsistence harvest of foods from their land constitutes an important part of the identity of the Inuit. Consumption of lake trout also important economically as this species makes up a significant portion of fish harvestable especially during the winter month. All these needed to be taken into consideration when considering the risks entailed by consuming lake trout.

While this study does not investigate the economic or cultural importance of lake trout, we did conduct additional analyses on two important nutrients known to be found in elevated quantities in fish: selenium and omega-3 fatty acids. Our results show that lake trout is rich in both nutrients and that specimens from certain regions had exceptionally high levels of omega-3 fatty acids.

Future directions

This CHARS-funded project will lead to other projects to further clarify the importance of lake trout as a food source to Nunavimmuit. Detailed surveys based on interviews and questionnaires are being planned to assess general fish consumption profiles in all Nunavik communities that take into account seasonal and demographic variations. For the next step, it is planned that Qualtrics, the online survey software routinely used by our colleagues from Trent University (Jacobs *et. al.* 2014) will be used in conducting a comprehensive Nunavik fish consumption survey. Questionnaires of the survey will be translated into Inuktittut and a format adaptable to the Nunavik situation. The survey will be conducted by Inuktittut-speaking technicians from the Nunavik Research Centre via telephone interviews of individuals across the demographic spectrum from each Nunavik communities. Further funding is being seeked to finance this study. Apart from helping the NRBHSS to formulate health messages to the public, the survey will help to further refine a questionnaire that has already been developed for Nunavik health professionals that allow them to identify pregnant women likely to have elevated mercury concentrations based on their diet. Given that systematic blood mercury screening of pregnant women may be recommended, there is an opportunity to determine the sensitivity and specificity of the general fish consumption questionnaire in regards to predicting blood mercury levels. Subsequently, tools and interventions can be developed to improve the counseling of pregnant women about mercury in diet during their first trimester, and then the impact of the intervention can be evaluated.

Another important outcome of this CHARS-funded project is that the mercury in Nunavik lake trout data will be entered into the national fish mercury dataset for Canada (Depew *et. al*. 2013). In the map (figure 1) depicting the distribution of freshwater locations across Canada where fish have been sampled for mercury analysis, it is evident that very little work had been done in the Nunavik region (highlighted in yellow).

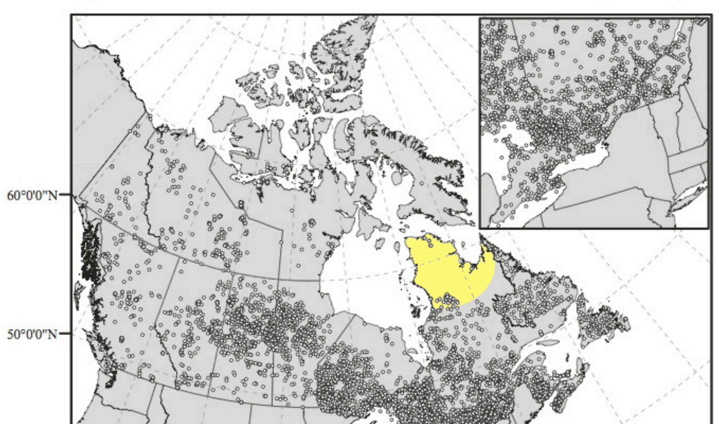

Fig. 1. Distribution of freshwater locations across Canada where fish have been sampled for Hg analysis between 1967 and 2010 (n = 5202). Note that reservoirs and designated downstream water bodies, locations impacted by Hg point-source pollution, and estuarine or marine locations are not included here. Inset panel shows central and southern Ontario and southwestern Quebec in greater detail.

The present study also provided baseline data of mercury levels in lake trout in different locations in Nunavik so that long-term monitoring effort can be put in place to ascertain the temporal trends of mercury in the aquatic environment in Nunavik. The active involvement of Nunavik communities in field work has been strongly emphasized, which promoted capacity building through training of Inuit from these communities in carrying out field sampling and recording of biological data.

Recent evidence showed that northbound flux of mercury is on a slow but significant increase, although the magnitude of atmospheric influx of mercury from the south to the Arctic is still awaiting accurate quantitation. The Northern Contaminants Program (INAC 1997) has identified a lack of temporal records of changes in mercury levels in aquatic ecosystems in the north. The absence of any point source of mercury contamination renders the monitoring of the fisheries in Nunavik an ideal opportunity to investigate the long-term changes of mercury levels in isolated arctic waterbodies subjected to continuous influx of mercury deposition through long-range atmospheric transport. Lake trout represents an excellent biomonitor to be used to gauge this long-term temporal change. Since lake trout situates at the higher level of aquatic food chains, its mercury concentration is readily measurable with accuracy. Also, this species is widely distributed and readily obtainable from all water bodies throughout Nunavik. Since the increase in mercury flux to the north through atmospheric transport is a slow and subtle process, it is recommended that a comprehensive monitoring exercise should be carried out every few years over one to two decades by revisiting the waterbodies that lake trout had been sampled and analyzed.

Appendices:

Appendix 1, M. Kwan's presentation at NNHC, "Mercury & Lake Trout in Nunavik."

Appendix 2, M. Lemire's presentation at NNHC, "Lake trout project in Kuujjuaraapik, Inukjuak, Puvirnituq, Salluit, Kuujjuaq and Kangiqsualujjuaq, Nunavik."

Appendix 3, C. Prikle's presentation at NNHC, "Reported Fish Consumption in Pregnant Inuit Women from Nunavik."

Appendix 4, "Mercury levels in lake trout from different lakes and communities in Nunavik" (a non-technical summary of the project for Nunavik communities in Inuktittut and English versions)

Appendix 5, "Preliminary Results Summary for the Mercury Lake Trout Projects" by Lemire *et. al*. (a summary of the discussion and consultation with Nunavik Regional Board of Health and Social Services took place on 24th March 2015 in Kuujjuaq).

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Performance indicators CHARS is obligated to report on its performance on an annual basis, using the performance indicators listed below, as well as other measures. Please assist us by filling out the following table.		
Themes	Indicators	Details
Outreach and capacity building	List the Northern leads and collaborators	Nunavik Research Centre, Makivik Corporation; Nunavik Regional Board of Health and Social Services (NRBHSS) & the Nunavik Nutrition and Health Committee (NNHC) Nunavik Hunting, Fishing and Trapping Association; Nunavik Hunter Support Program
	Number of Northern participants in the funded project (Workshop, school visits, meetings, consultations, part of your project team, hires, other).	Early community consultation with the five communities: **10** Nunavimmuit from Kuujjuaq, Puvirnituq, Salluit, Inukjuak and Kangiqsuallujjuaq as local coordinators and fishermen who collected samples: **9** Participants of Nunavik Nutrition and Health Committee (NNHC) meeting on 11th February 2015 in Quebec City where the progress of this project was presented: **15** Participants of Nunavik Nutrition and Health Committee (NNHC) meeting on 24th March 2015 in Kuujjuaq where findings of this project were presented: **10**
	Number of youth participants (under the age of 25) in the funded project (Workshop, school visits, meetings, consultations,	na

	part of your project team, hires, other).	
Decision making and policy	How did the project include participation and input of end users?	Please see "Activities in 2014 – 2015" section of the Annual Project Report and communication to communities in non-technical summary Appendix 4.
	How will these research results be used by decision-makers?	Please see "Activities in 2014 – 2015" and "Abstract" sections of the Annual Project Report.
	Will these results contribute to the development and implementation of regional, national, and international policies and regulation? If yes, how?	Please see "Activities in 2014 – 2015" and "Abstract" and "Discussion and Conclusions" sections of the Annual Project Report.
Knowledge mobilization Please provide references (if available).	Number of peer-reviewed articles/book chapters (projected) from the funded project.	At least two peer-reviewed articles are planned: one focused on the spatial trend of lake trout growth – mercury accumulation in Nunavik waterbodies; the other focused on health hazard assessment, public health implications and recommendations of lake trout consumption in Nunavik.
	Number of conference presentations (projected) from the funded project	Three presentations each given by one of the three principal investigators at the NNHC meeting in Kuujjuaq on 24th March 2015 (Please see "Activities in 2014 – 2015" section, Appendices 1, 2 and 3). A further meeting and presentations is planned in June/July 2015 in Kuujjuaq that will combined the findings of this CHARS-funded project with the dietary survey that will take place in May to assess the importance of lake trout in Nunavimmuit diet (Please see "Discussion and Conclusions" section for more on this survey planned). An abstract is being prepared for submission to a national or international conference (e.g. Arctic Change) in the near future.
	Number of other reports (projected) from the funded.	Data from this study has been included in a report to the NRBHSS on the risks and benefits of mercury exposure that is to be disseminated to health professionals in the region.

	Number of quoted data.	na

Mercury & Lake Trout in Nunavik

2006/07 and 2015 studies

Rationale: Mercury bioaccumulation increases as the fish grows older and larger.

Objectives:

(1) To provide data for a closer assessment of the importance of lake trout in contribution to the total dietary mercury intake in Nunavimmuit.

(2) To examine the relationships between fish age, length and weight and mercury accumulation. The findings might be useful for the local Health Authority to explore the possibility to work out recommendations in terms of fish size smaller than which mercury is not a health risk.

Total number of water systems sampled: 16

Total number of fish collected: 349 (200 from 2006/07 study, 149 from 2015 study)

(*M. K. H. Kwan 2015*)

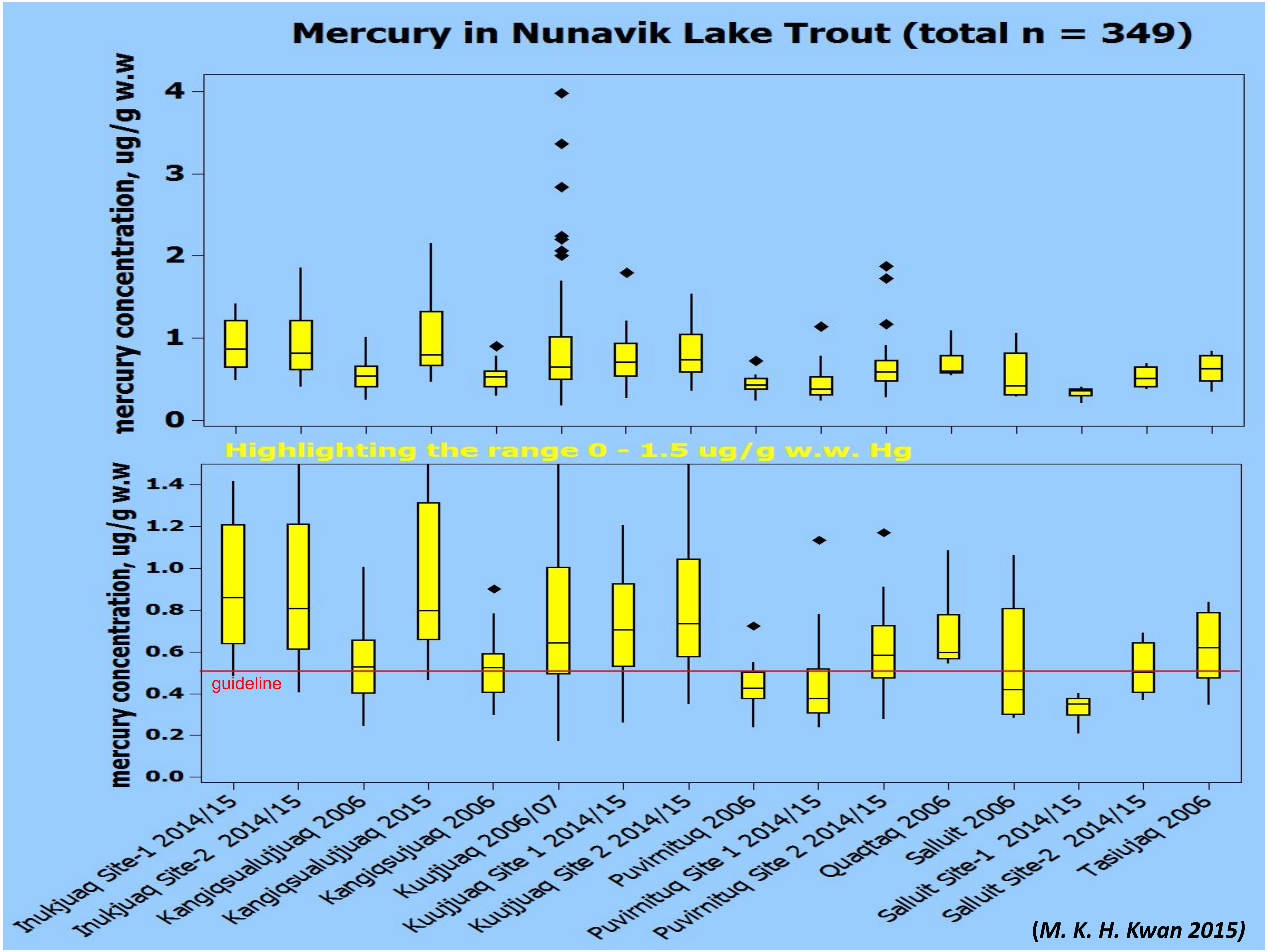
Percentage of Nunavik Lake Trout exceeding Health Canada's Mercury Guideline (> 0.5 ug/g w. w.) for Fish Consumption

	% > safety guideline	% > 2 x safety guideline	% > 4 x safety guideline
2006/2007 [1] n = 200	71 (n = 143)	15 (n = 30)	3.4 (n = 7)
2014/ 2015 [2] n = 149	73.2 (n = 109)	22.1 (n = 33)	1.3 (n = 2)

[1] Kuujjuaq (Gabriel & Stewart Lakes), Tasiujaq, Kangiqsujuaq, Salluit, Puvirnituq, Kangiqsualuujjuaq.

[2] Kuujjuaq (Gabriel Lake, Three Lake), Inukjuaq, Salluit, Puvirnituq, Kangiqsualuujjuaq.

(*M. K. H. Kwan 2015*)


Mercury in Nunavik Lake Trout (total n = 349)
mercury concentration, ug/g w.w
Highlighting the range 0 - 1.5 ug/g w.w. Hg
guideline
Inukjuaq Site-1 2014/15
Inukjuaq Site-2 2014/15
Kangiqsualujjuaq 2006
Kangiqsualujjuaq 2015
Kangiqsujuaq 2006
Kuujjuaq 2006/07
Kuujjuaq Site 1 2014/15
Kuujjuaq Site 2 2014/15
Puvirnituq 2006
Puvirnituq Site 1 2014/15
Puvirnituq Site 2 2014/15
Quaqtaq 2006
Salluit 2006
Salluit Site-1 2014/15
Salluit Site-2 2014/15
Tasiujaq 2006
(M. K. H. Kwan 2015)

Summary of data on Mercury in Nunavik Lake Trout, ug/g w.w. (total n = 349)

Community / Location	Number of samples	Geometric mean (Range)	Median (1st , 3rd quartiles)
Inukjuaq Site 1 (2014/15)	20	0.85 (0.48 – 1.42)	0.86 (0.64, 1.21)
Inukjuaq Site 2 (2014/15)	18	0.84 (0.41 – 1.85)	0.81 (0.61, 1.21)
Kangiqsualujjuaq (2006)	19	0.53 (0.24 – 1.01)	0.53 (0.40, 0.65)
Kangiqsualujjuaq (2015)	18	0.89 (0.46 – 2.15)	0.79 (0.66, 1.31)
Kangiqsujuaq (2006)	21	0.51 (0.30 – 0.90)	0.52 (0.40, 0.59)
Kuujjuaq (2006/07)	122	0.72 (0.17 – 3.97)	0.64 (0.49, 1.00)
Kuujjuaq Site 1 (2014/15)	20	0.69 (0.26 – 1.80)	0.70 (0.53, 0.92)
Kuujjuaq Site 2 (2014/15)	18	0.73 (0.35 – 1.54)	0.73 (0.58, 0.92)
Puvirnituq (2006)	19	0.43 (0.24 – 0.72)	0.42 (0.37, 0.50)
Puvirnituq Site 1 (2014/15)	20	0.41 (0.24 – 1.14)	0.38 (0.31, 0.52)
Puvirnituq Site 2 (2014/15)	20	0.63 (0.28 – 1.88)	0.58 (0.47, 0.72)
Quaqtaq (2006)	7	0.67 (0.54 – 1.09)	0.60 (0.57, 0.78)
Salluit (2006	8	0.49 (0.28 – 1.06)	0.42 (0.30, 0.81)
Salluit Site 1 (2014/15)	9	0.32 (0.21 – 0.40)	0.35 (0.30, 0.38)
Salluit Site 2 (2014/15)	5	0.51 (0.37 – 0.69)	0.50 (0.40, 0.64)
Tasiujaq (2006)	16	0.59 (0.35 – 0.84)	0.62 (0.47, 0.78)

(M. K. H. Kwan 2015)

Spearman Rank Correlation Coefficients (r) between Mercury and Growth

(ns, not significant ($p > 0.05$); *, $0.02 < p \leq 0.05$; **, $0.01 < p \leq 0.02$; ***, $p \leq 0.01$)

Community / Location	Hg vs. age	Hg vs. length	Hg vs. weight
Inukjuaq Site 1 (2014/15)	0.923 ***	0.815 ***	0.765 ***
Inukjuaq Site 2 (2014/15)	0.595 ***	0.689 ***	0.416 ns
Kangiqsualujjuaq (2006)	-0.046 ns	-0.281 ns	-0.249 ns
Kangiqsualujjuaq (2015)	0.572 **	0.550 *	0.648 ***
Kangiqsujuaq (2006)	0.462 *	0.535 **	0.488 *
Kuujjuaq (2006/07)	0.600 ***	0.650 ***	0.475 ***
Kuujjuaq Site 1 (2014/15)	0.849 ***	0.859 ***	0.765 ***
Kuujjuaq Site 2 (2014/15)	0.465 ns	0.630 ***	0.543 *
Puvirnituq (2006)	0.574 **	0.465 ns	0.432 ns
Puvirnituq Site 1 (2014/15)	0.885 ***	0.839 ***	0.753 ***
Puvirnituq Site 2 (2014/15)	0.595 ***	0.657 ***	0.585 **
Quaqtaq (2006)	0.873 *	0.793 *	0.793 *
Salluit (2006	0.994 ***	0.970 ***	0.976 ***
Salluit Site 1 (2014/15)	0.351 ns	0.460 ns	0.444 ns
Salluit Site 2 (2014/15)	0.821 ns	0.500 ns	-0.051 ns
Tasiujaq (2006)	0.763 ***	0.734 ***	0.341 ns

(M. K. H. Kwan 2015)

Growth parameter estimates corresponding to the 0.5 ug/g Hg guideline

Community / Location	Age	Fork length, cm	Fresh weight, g
Inukjuaq Site 1 (2014/15)	7.0	43.1	656
Inukjuaq Site 2 (2014/15)	7.7	34.4	X
Kangiqsualujjuaq (2015)	9.3	X	723
Kangiqsujuaq (2006)	X	51.8	X
Kuujjuaq (2006/07)	9.1	49.5	622
Kuujjuaq Site 1 (2014/15)	9.4	46.8	723
Kuujjuaq Site 2 (2014/15)	X	45.0	X
Puvirnituq (2006)	14.3	X	X
Puvirnituq Site 1 (2014/15)	11.4	52.2	2401
Puvirnituq Site 2 (2014/15)	13.8	55.9	1460
Salluit (2006	12.7	39.0	703
Tasiujaq (2006)	8.8	47.0	X

"X" denotes either no significant correlation ($p > 0.05$) or the correlation is only marginally significant ($0.02 < p < 0.05$) as determined by the two-tailed Spearman's Rank Correlation

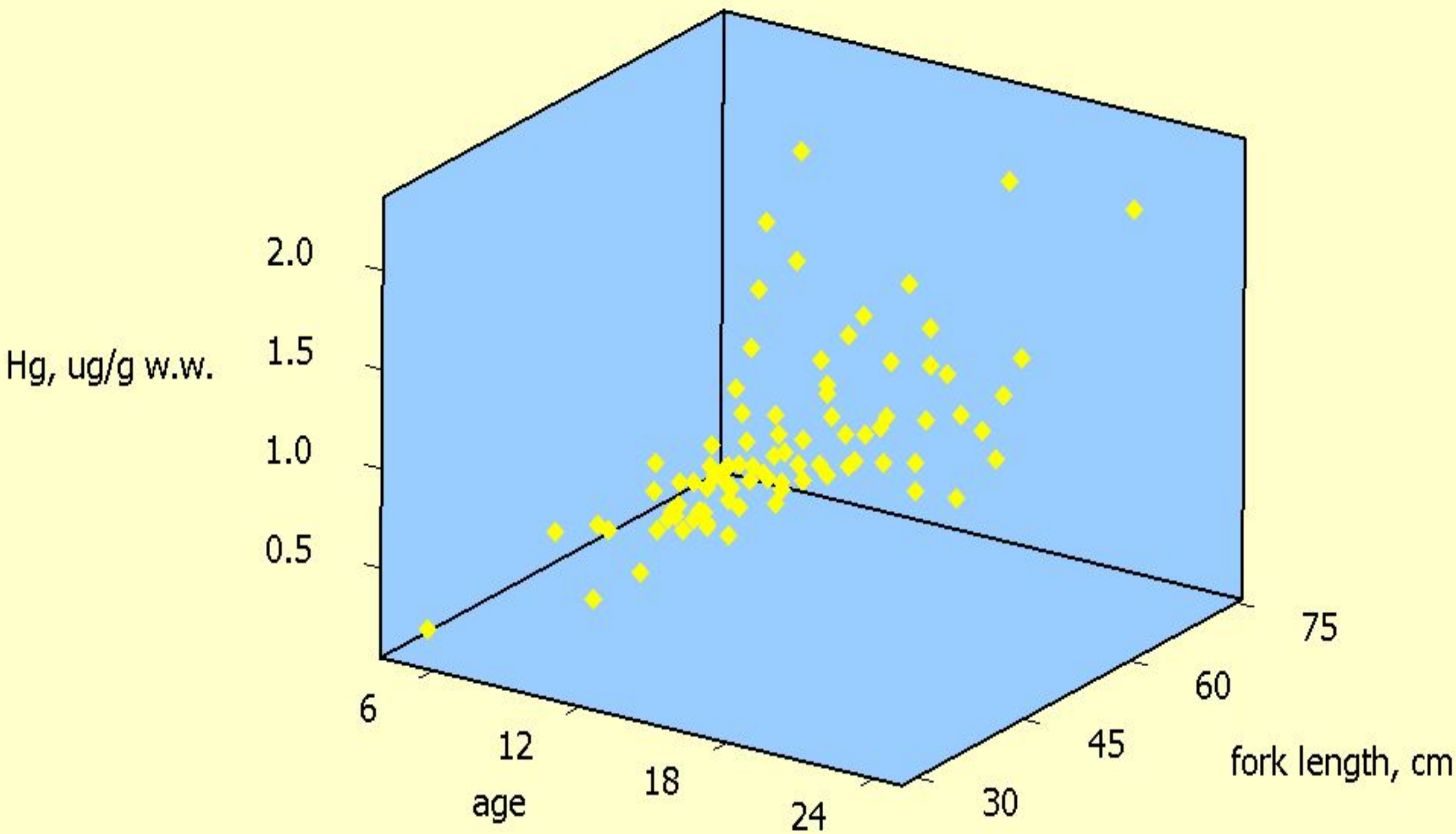
(M. K. H. Kwan 2015)

Analysis of Covariance (ANCOVA) of $\log_{10}$ – transformed Mercury Data

	No covariate (i.e. ANOVA)	Age as covariate	Fork length as covariate	Fresh weight as covariate
F - ratio	7.88	10.23	6.86	7.80
p - value	0.001	0.001	0.001	0.001

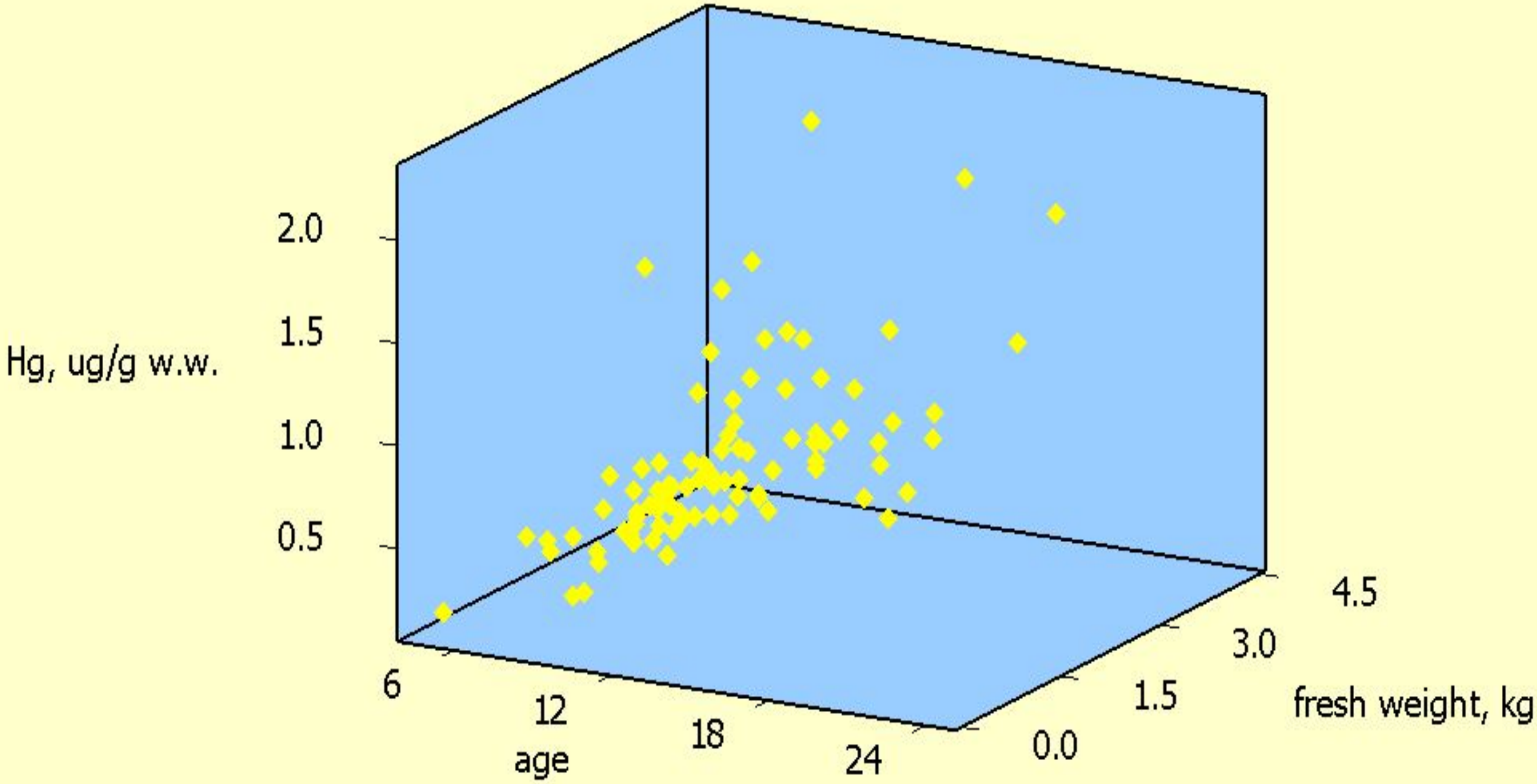
(M. K. H. Kwan 2015)

3D – Scatterplot of mercury concentration vs. age vs. fork length of lake trout from Gabriel Lake near Kuujjuaq (2015 and 2007, n = 92)



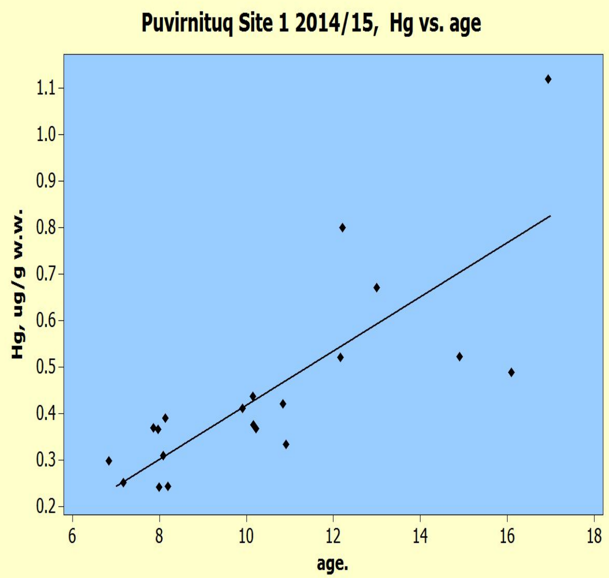
(M. K. H. Kwan 2015)

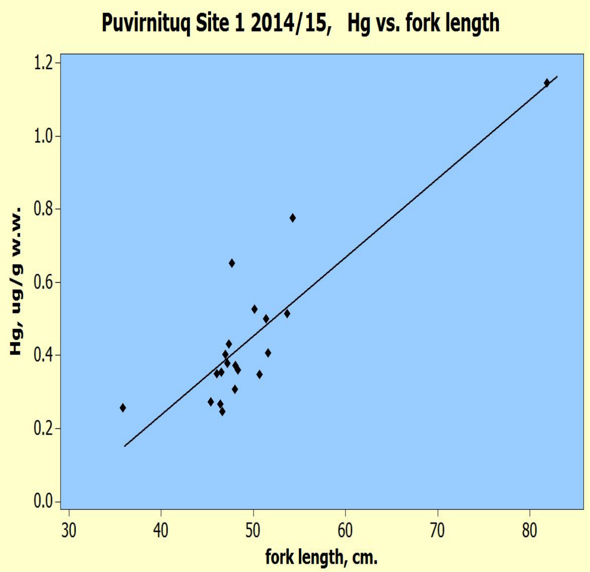
3D – Scatterplot of mercury concentration vs. age vs. fresh weight of lake trout from Gabriel Lake near Kuujjuaq (2015 and 2007, n = 92)

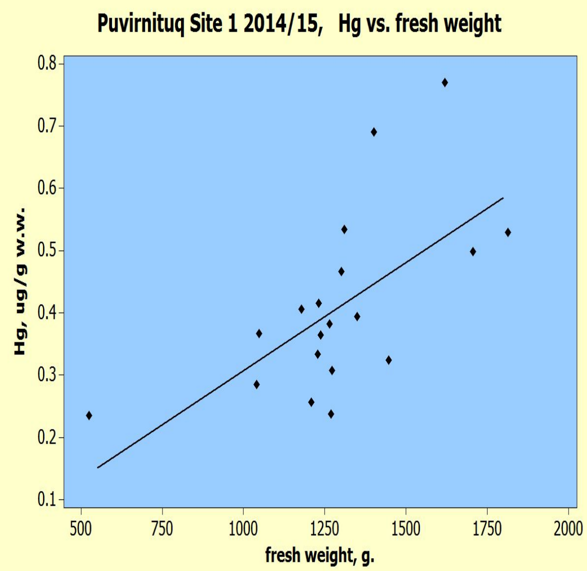


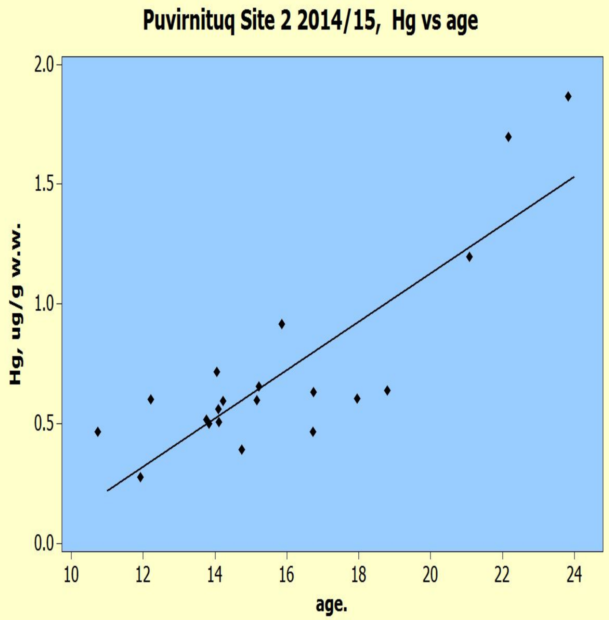
(M. K. H. Kwan 2015)

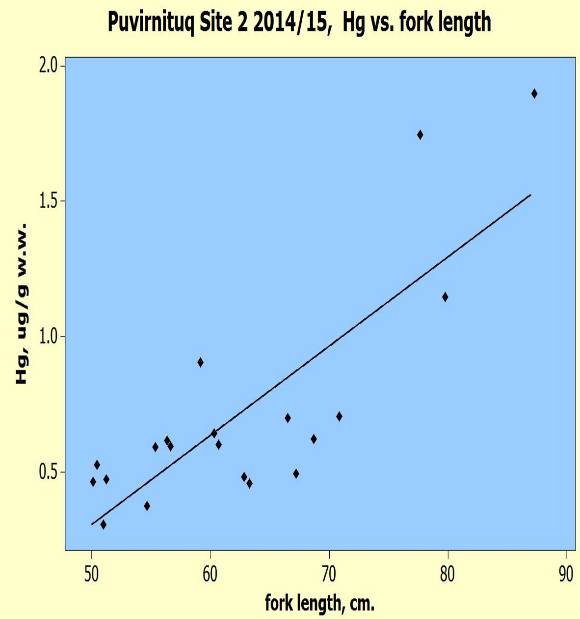
Correlations between Mercury Concentration and Growth Parameters
(with best-fit-lines)

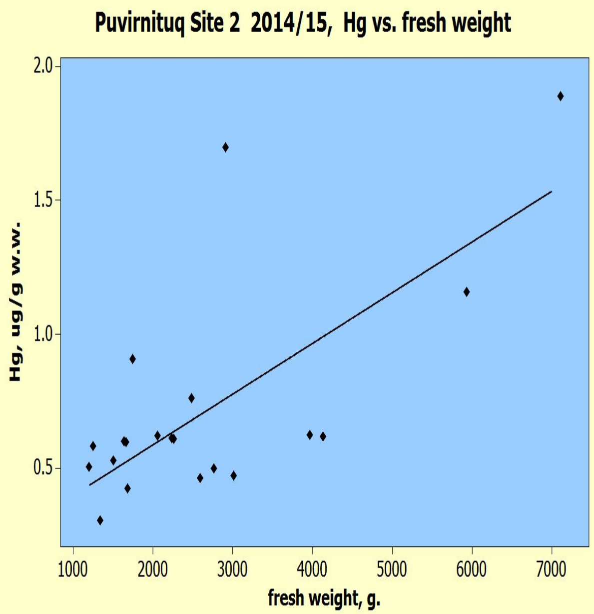






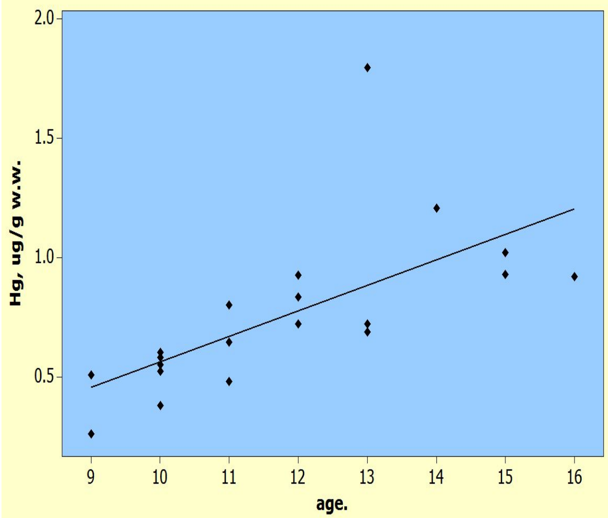




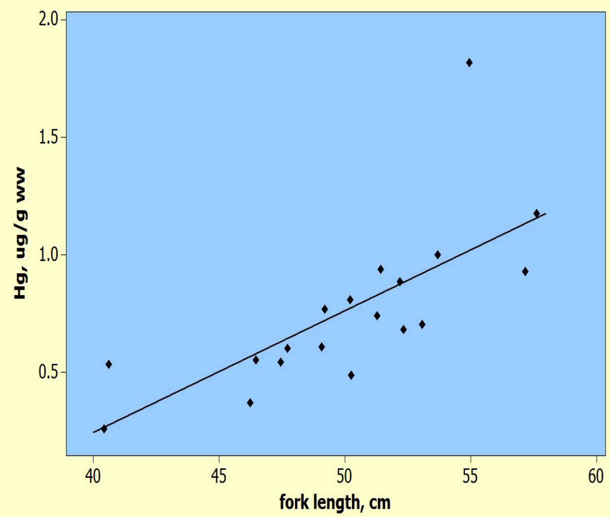


Correlations between Mercury Concentration and Growth Parameters
(with best-fit-lines)

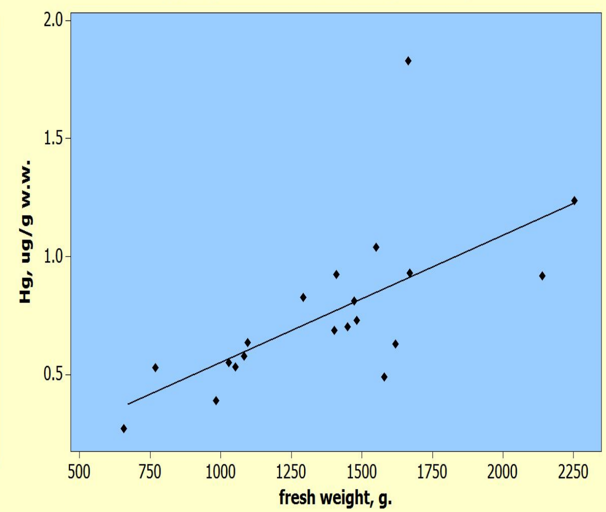
Kuujjuaq Site 1 2014/15, Hg vs. age



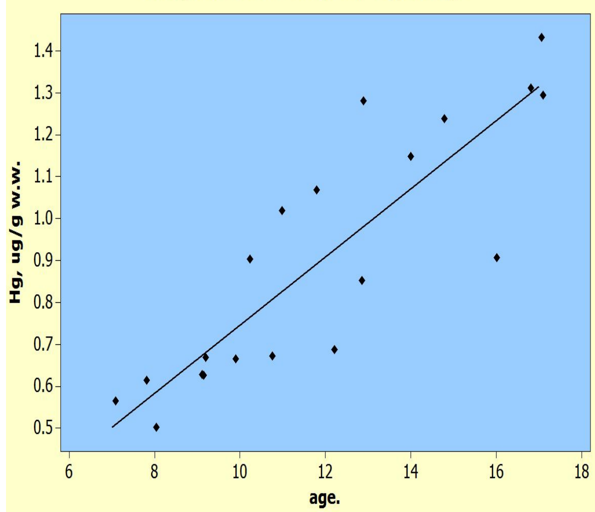
Kuujjuaq Site 1 2014/15, Hg vs. fork length



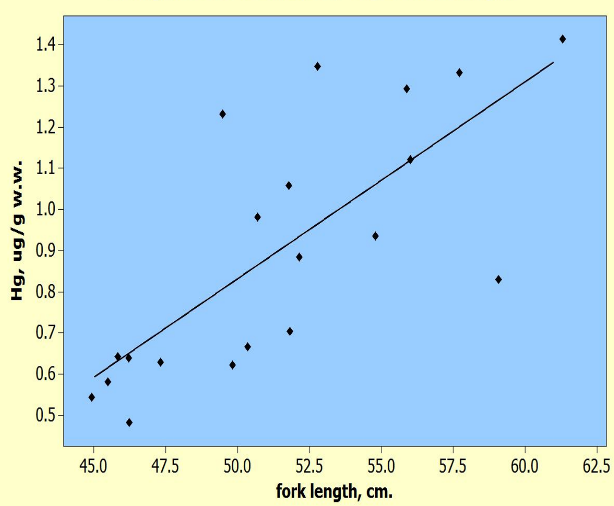
Kuujjuaq Site 1 2014/15, Hg vs. weight



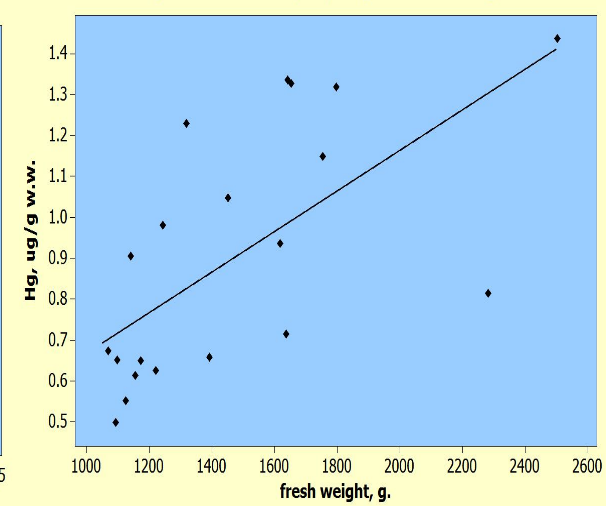
Inukjuak Site 1 2014/15, Hg vs. age



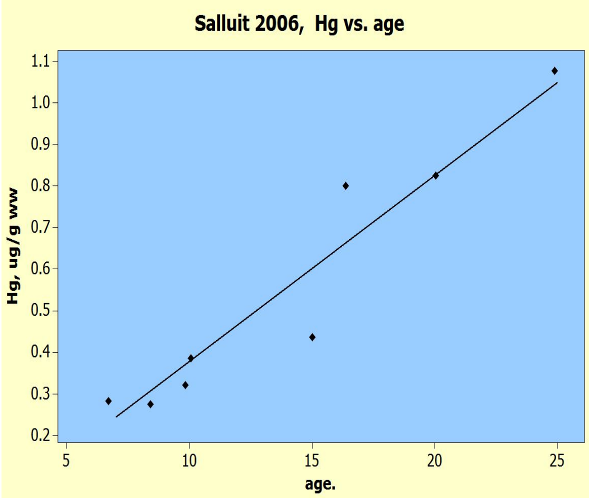
Inukjuak Site 1 2014/15, Hg vs. fork length

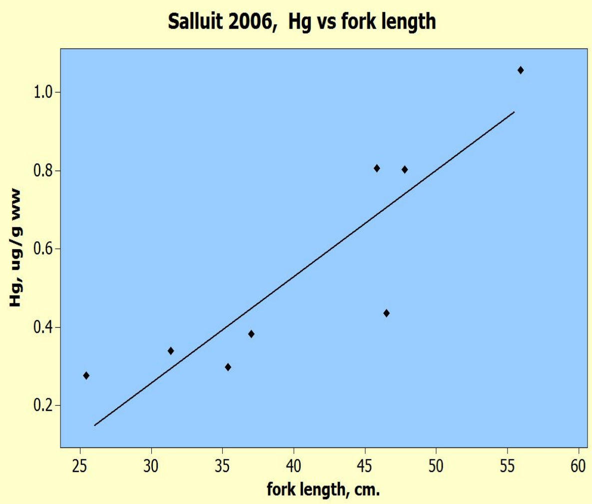


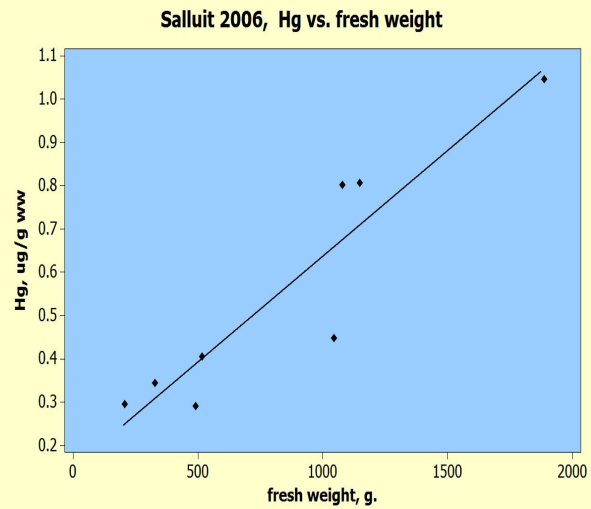
Inukjuak Site 1 2014/15, Hg vs. fresh weight

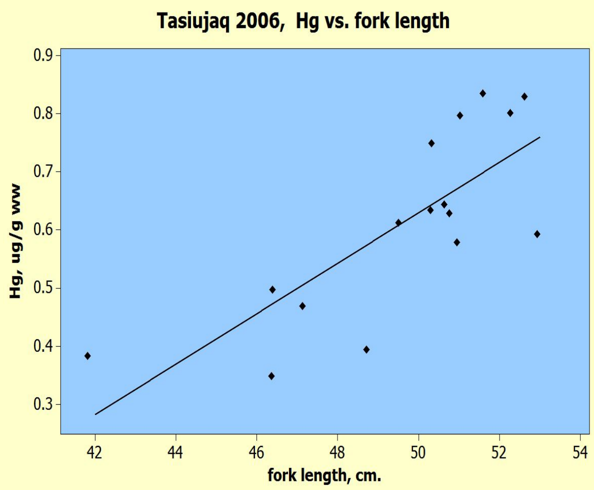


Correlations between Mercury Concentration and Growth Parameters
(with best-fit-lines)

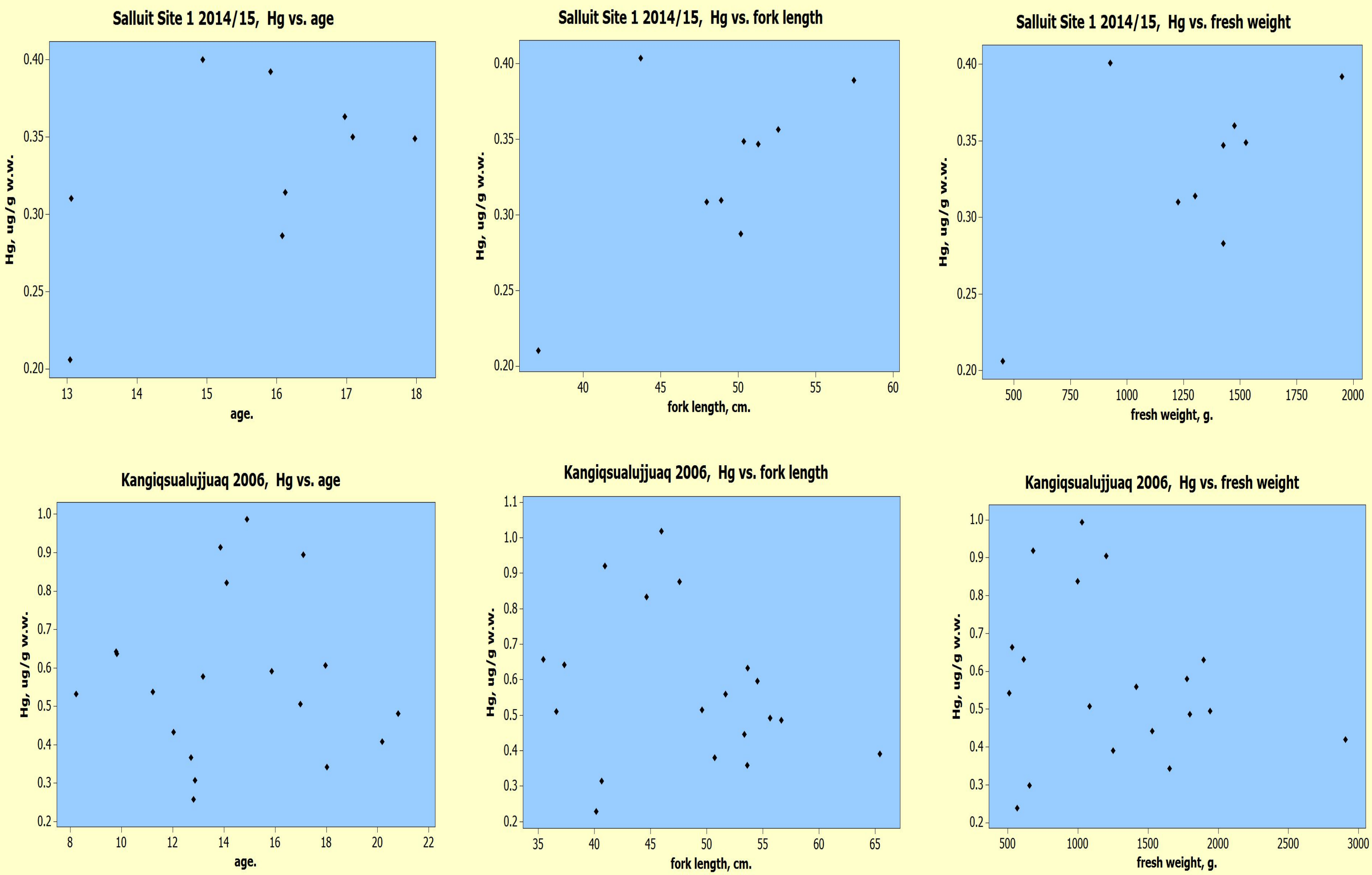








Lack of a Significant Correlation between Mercury Concentration and Growth Parameters for Lake Trout from some Water Systems



Effects of Cooking on Mercury Concentration in Lake Trout

	Percentage decrease of Hg concentration **on a wet weight basis** Mean +/- std. dev. (Range), %
Boiled (n = 17)	**16.22 +/- 6.07 (7 - 24.5)**
Baked (n = 15)	**8.35 +/- 7.66 (0 – 18.2)**

Boiling: A 200g piece of fish was vigorously boiled in one liter of tap water for 12 minutes.
Baking: A 200g piece of fish was baked in a loosely covered aluminum dish at 350°F for 30 minutes.

Percentage water contents for uncooked, boiled and baked lake trout are 77.2%, 72.3% and 72% respectively. To convert Hg concentration on a dry weight basis to facilitate comparison:

	Percentage decrease of Hg concentration **on a dry weight basis** Mean +/- std. dev. (Range), %
Boiled (n = 17)	**31.23 +/- 4.88 (23.4 - 37.8)**
Baked (n = 15)	**25.37 +/- 6.25 (13.5 - 35.7)**

(*M. K. H. Kwan 2015*)

Lake trout project in Kuujjuaraapik, Inukjuak, Puvirnituq, Salluit, Kuujjuaq, and Kangiqsualujjuaq, Nunavik

♪

CHARS project

Nov. 2014 – March 2015

M. Kwan, M. Lemire, C. Pirkle, C.Furgal, S. Ricard, M. Brisson, JF Proulx, S Déry

Preliminary data presentation
Kuujjuaq
March 24, 2015

Proposed agenda

9:00 Welcome
9:15 Updates about the progression of the project, the 0.5 and 1 µg/g guidelines for Hg in fish and method for calculating Hg intakes
9:30 Presentation by Michael about preliminary data on mercury level in lake trout from 9 different lakes and results from cooking experiments
10:30 Presentation by Mélanie about preliminary data omega-3 in lake trout
10:45 Presentation by Catherine about data from pregnant women in the Arctic Char Distribution Project

12: 00 Lunch (bring your own or at Kuujjuaq Inn)

13:30 Presentation by Chris of the web survey
14:00 Summary of preliminary findings
14:30 Selection of the next steps: timeline, creation of the follow-up committee, date for the next meeting

Project objectives

- → Produce exhaustive and recent data about mercury levels in lake trout from 9 different lakes fished by communities in Nunavik
- → Produce new data about omega-3 and selenium levels in lake trout from Nunavik
- → Evaluate pregnant women fish consumption, Hg exposure and nutrient status in Nunavik based on the Artic Char Distribution project
- → Document the knowledge of community members about fishing traditions and fish consumption

Canadian guidelines for Hg in fish

→ 0.5 ug/g of total Hg in general commercial fish

→ 1.0 ug/g of total Hg for commercial predatory fish

Are there any standards (maximum limits) for the amount of mercury permitted in retail fish?

- A standard (maximum limit) of 0.5 parts per million (ppm) total mercury in retail fish, with three exceptions, has been in place in Canada for many years. Health Canada has recently made a small change to this standard and implemented a two-tiered standard for total mercury in retail fish. Now there is a standard of 0.5 ppm total mercury in all retail fish (including all canned tuna) **except** fresh/frozen tuna, shark, swordfish, escolar, marlin, and orange roughy. A 1.0 ppm standard for total mercury has been established for fresh/frozen tuna, shark, swordfish, escolar, marlin, and orange roughy; these fish are also subject to consumption advice. Both standards are enforced by the Canadian Food Inspection Agency (CFIA).

Why are there two different standards for mercury in fish?

- Health Canada and CFIA's scientists continue to find that the total mercury levels in the majority of commercial fish species, including canned tuna, are below the 0.5 ppm standard for total mercury in commercial fish, which was first established in 1970. However, certain varieties of piscivorous (fish-eating) fish tend to contain more than 0.5 ppm total mercury. Although these types of fish are higher in mercury they are normally consumed less frequently than other types of fish and therefore are not considered to be a significant source of mercury to the average diet. Rather than prevent the sale of these piscivorous fish, fresh/frozen tuna (**not including canned tuna**), shark, swordfish, escolar, marlin, and orange roughy are permitted to be sold as long as they contain less than 1.0 ppm total mercury. These fish are also subject to consumption advice.

- http://www.hc-sc.gc.ca/fn-an/securit/chem-chim/environ/mercur/merc_fish_qa-poisson_qr-eng.php
- http://www.ec.gc.ca/doc/mercure-mercury/1241/index_e.htm

Health Canada guidelines
provisional tolerable daily intake (pTDI)

→ Childbearing age women and children:

0.2 ug/kg body weight/day (8 ug/L or 40 nmol/L in blood)

* pTDI derived based on a 10 ug/g in maternal hair (≈ 40 ug/L in blood) as the approximate threshold for neurodevelopmental outcomes (Grandjean et al. 1997) + 5-fold uncertainity factor

→ Other adults:

0.47 ug/kg body weight/day (20 ug/L or 100 nmol/L in blood)

* Hg MADO: 12 ug/L or 60 nmol/L in blood

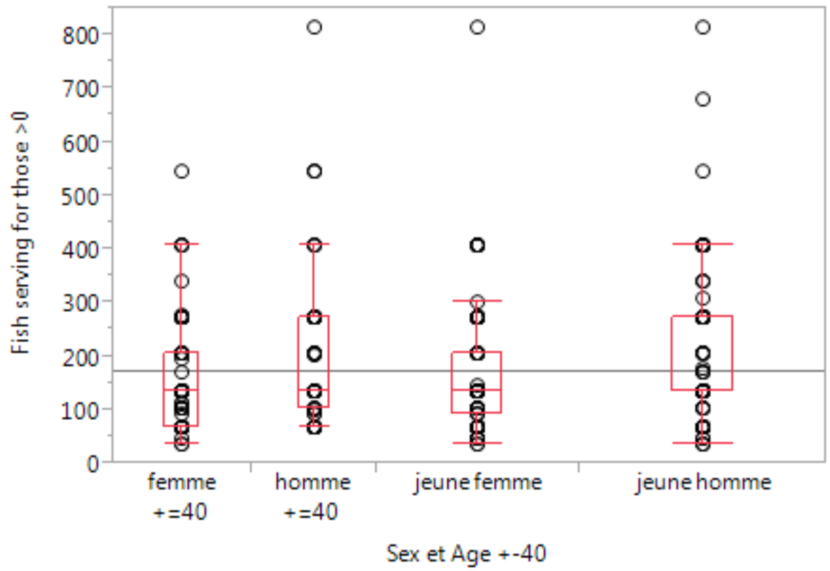
Health Canada guidelines provisional tolerable daily intake (pTDI)

$$pTDI\ (ug/kg\ BW/day) = \frac{\text{Fish portion (g/time)} * \text{frequence (time/day)} * \text{Hg level in fish (ug/g)}}{\text{Body weight (kg)}}$$

Portion	g/time
Fist portion	100
Inuit portion	136
HC portion	150
Big portion	300
Frequence	time
1 time/day	1,00
3 times/week	0,43
1 time/week	0,14
3 times/month	0,10
Hg level	ug/g
low 0.2 ug/g	0,2
high 0.5 ug/g	0,5
very high 1.0 ug/g	1,0
extreme Hg 2.0 ug/g	2,0
Women BW	kg
low BW	48
median BW 1st trim	60
mediam BW Qanuippitaa	64
high BW	89

Scenarios	pTDI	Time > pTDI		Scenarios	pTDI	Time > pTDI
Inuit portion, LOW Hg, med BW				**Big portion, LOW Hg, med BW**		
1/day	0,45	2,3		1/day	1,00	5,0
3/week	**0,19**	**1,0**		3/week	0,43	2,1
1/week	**0,06**	**0,3**		**1/week**	**0,14**	**0,7**
3/month	**0,04**	**0,2**		**3/month**	**0,10**	**0,5**
Inuit portion, high Hg, med BW				**Big portion, high Hg, med BW**		
1/day	1,13	5,7		1/day	2,50	12,5
3/week	0,49	2,4		3/week	1,07	5,4
1/week	**0,16**	**0,8**		1/week	0,36	1,8
3/month	**0,11**	**0,5**		3/month	0,24	1,2
Inuit portion, very high Hg, med BW				**Big portion, very high Hg, med BW**		
1/day	2,27	11,3		1/day	5,00	25,0
3/week	0,97	4,9		3/week	2,14	10,7
1/week	0,32	1,6		1/week	0,71	3,6
3/month	**0,22**	**1,1**		3/month	0,48	2,4

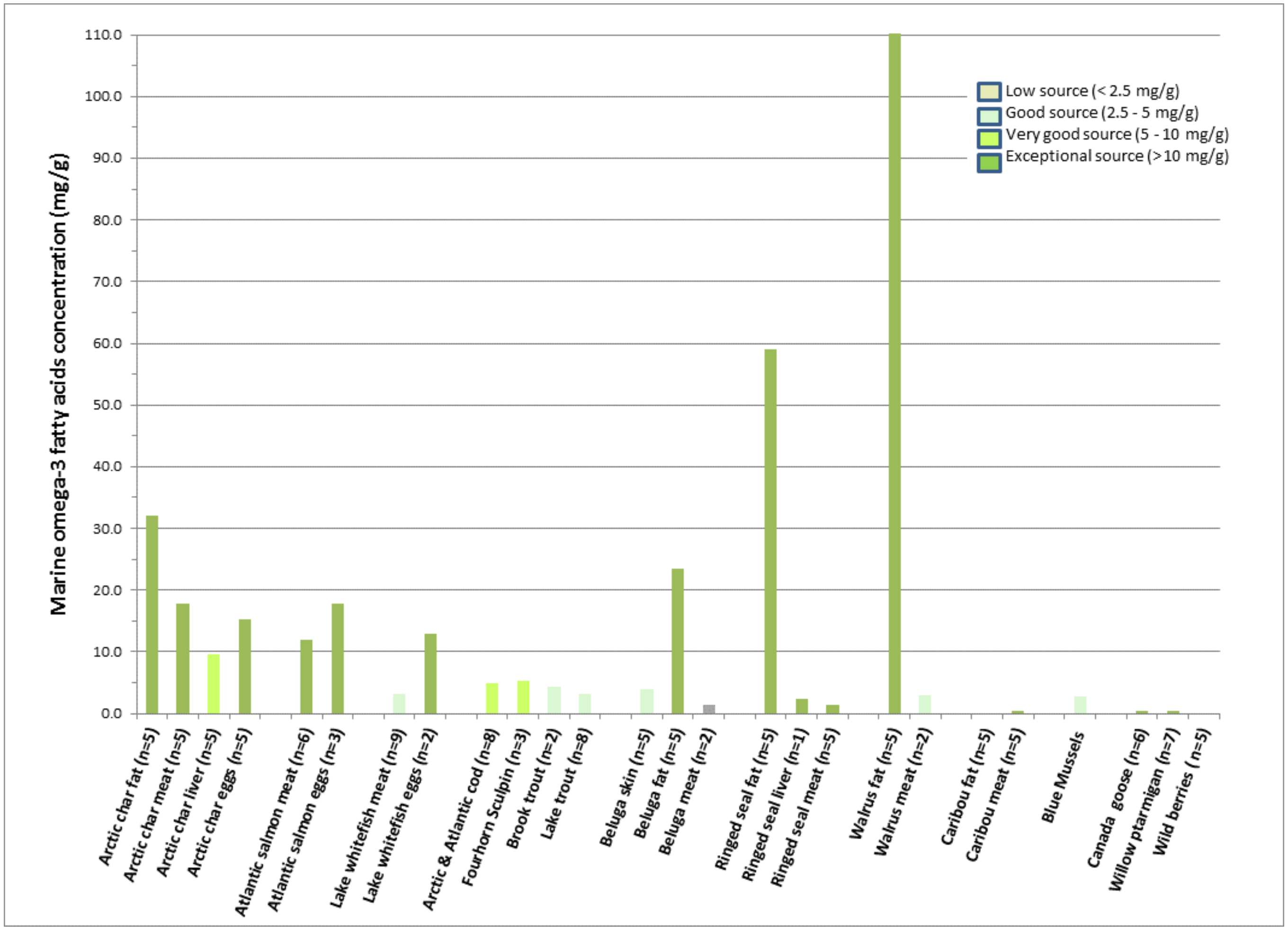
Oneway Analysis of Fish serving for those >0 By Sex et Age +-40



Weight	Population_weight
Missing Rows	33
Excluded Rows	22

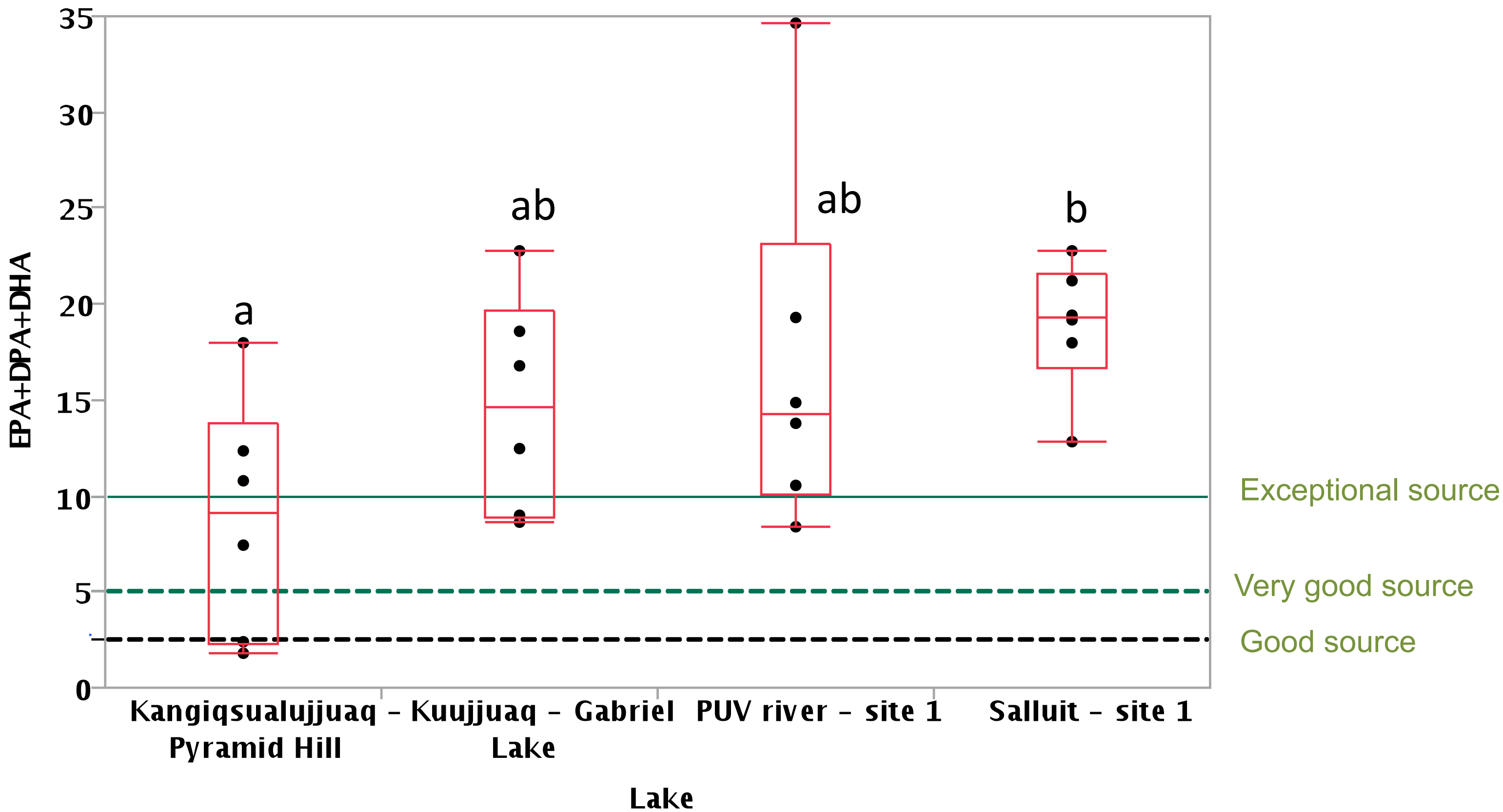
Quantiles

Level	Minimum	10%	25%	Median	75%	90%	Maximum
femme +=40	34	68	68	136	204	272	544
homme +=40	68	68	102	136	272	272	816
jeune femme	34	68	90,576	136	204	272	816
jeune homme	34	68	136	136	272	340	816



Marine omega-3 fatty acids concentration (mg/g)
110.0
100.0
90.0
80.0
70.0
60.0
50.0
40.0
30.0
20.0
10.0
0.0
Low source (< 2.5 mg/g)
Good source (2.5 - 5 mg/g)
Very good source (5 - 10 mg/g)
Exceptional source (>10 mg/g)
Arctic char fat (n=5)
Arctic char meat (n=5)
Arctic char liver (n=5)
Arctic char eggs (n=5)
Atlantic salmon meat (n=6)
Atlantic salmon eggs (n=3)
Lake whitefish meat (n=9)
Lake whitefish eggs (n=2)
Arctic & Atlantic cod (n=8)
Fourhorn Sculpin (n=3)
Brook trout (n=2)
Lake trout (n=8)
Beluga skin (n=5)
Beluga fat (n=5)
Beluga meat (n=2)
Ringed seal fat (n=5)
Ringed seal liver (n=1)
Ringed seal meat (n=5)
Walrus fat (n=5)
Walrus meat (n=2)
Caribou fat (n=5)
Caribou meat (n=5)
Blue Mussels
Canada goose (n=6)
Willow ptarmigan (n=7)
Wild berries (n=5)

Marine omega-3 level in lake trout



Level	- Level	Score Mean Difference	Std Err Dif	Z	p-Value
Salluit - site 1	Kangiqsualujjuaq - Pyramid Hill	5,166667	2,081666	2,481986	0,0131*
Kuujjuaq - Gabriel Lake	Kangiqsualujjuaq - Pyramid Hill	3,166667	2,081666	1,521217	0,1282
PUV river - site 1	Kangiqsualujjuaq - Pyramid Hill	3,166667	2,081666	1,521217	0,1282
Salluit - site 1	Kuujjuaq - Gabriel Lake	2,833333	2,081666	1,361089	0,1735
Salluit - site 1	PUV river - site 1	2,166667	2,081666	1,040833	0,2980
PUV river - site 1	Kuujjuaq - Gabriel Lake	0,166667	2,081666	0,080064	0,9362

Reported Fish Consumption in Pregnant Inuit Women from Nunavik

PRESENTED AS PART OF THE LAKE TROUT RESEARCH PROJECT

Presentation overview

- Overview of AC/DP
  - Reminder of study design
  - Description of participants
- Fish consumption patterns
  - Food frequency questionnaire
  - Frequency of fish/seafood consumption
  - Predictors of fish/seafood consumption

Description of the Arctic Char Distribution Program

- Evaluation research study funded principally by the Canadian Institutes of Health Research

- Mixed-methods study (quantitative and qualitative)
  - Longitudinal epidemiological study
  - Pregnant women 18 and older
  - Recruitment from fall 2013 to early spring 2014
  - All villages with pregnant women (none in Ivujivik)
  - Ungava coast included as a control (no Char program)

Sample Characteristics at Baseline

	AC/DP	National Household Survey- 2011
AGE, *mean (min, max)*	25 (18*-43)	NA
PARITY, *mean (min, max)*	2.1 (0-7)	NA
Marital Status		
Cohabiting, N(%)	101, 79%	48%
Single, N(%)	27, 21%	52%
Education		
Completed high school, N(%)	43, 33%	41%
Did not complete high school, N(%)	87, 67%	59%
In labour force		
Working	52, 40%	56%
Not working	78, 60%	44%

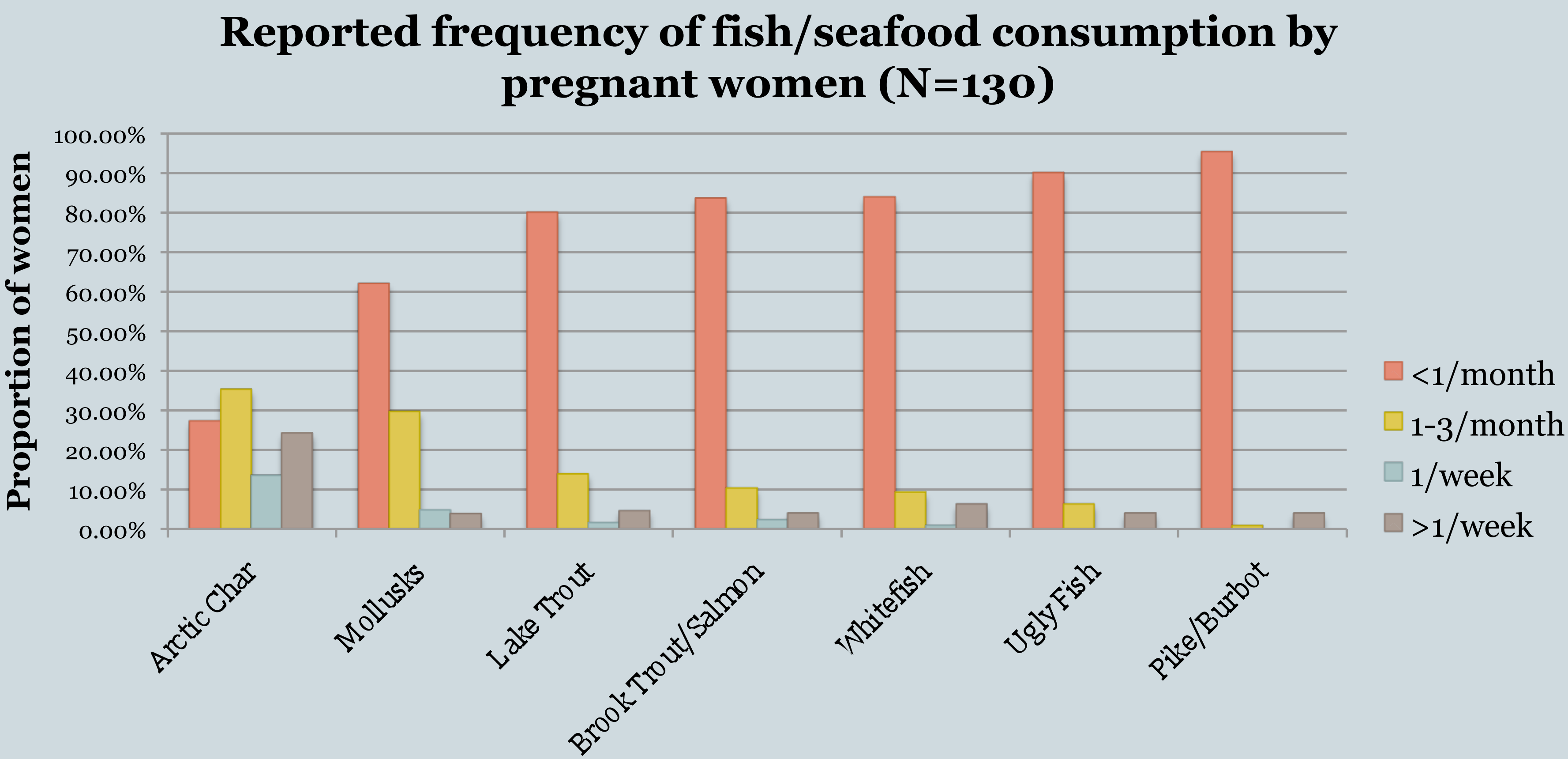
*Study inclusion criteria- had to be 18 years of age or older

Statistics Canada. 2013. Nunavik, Inuit region, Quebec (Code 640002) (table). National Household Survey (NHS) Aboriginal Population Profile. 2011 National Household Survey. Statistics Canada Catalogue no. 99-011-X2011007. Ottawa. Released November 13, 2013. http://www12.statcan.gc.ca/nhs-enm/2011/dp-pd/aprof/index.cfm?Lang=E (accessed March 20, 2015).

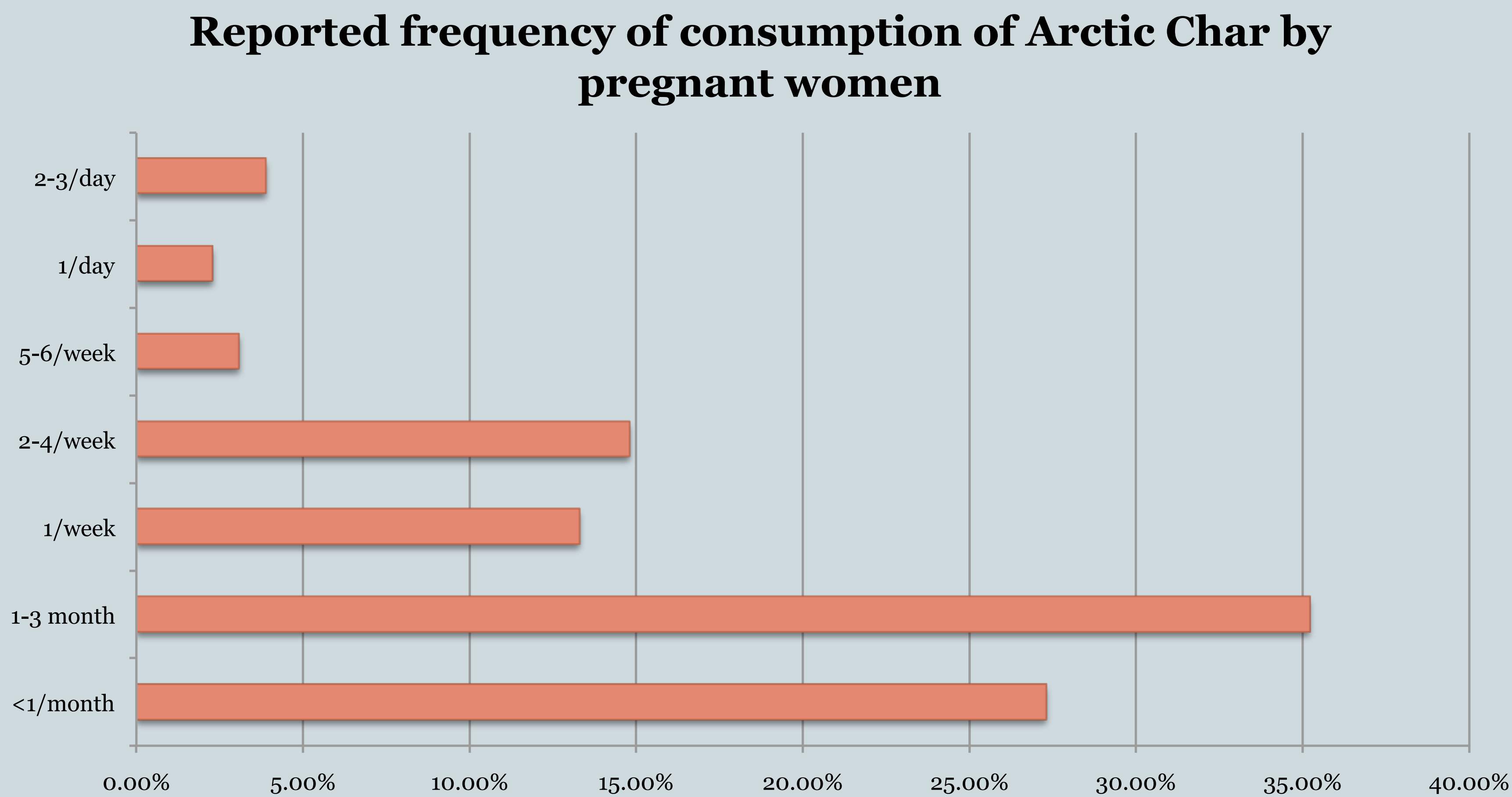
Food Frequency Questionnaire

- Quantitative description of what people eat
- Enquired about food consumption in the last 3 months
- 7 questions on country food seafood & fish consumption:
  - Arctic char, brook trout/salmon, lake trout, lake whitefish, ugly fish, pike/burbot, molluscs (mussels, clams, scallops)
- Possible responses:
  - Never or less than 1/month, 1-3 times/mo, 1/week, 2-4/wk, 5-6/wk, 1/day, 2-3/d, 4-5/d, and 6+/d

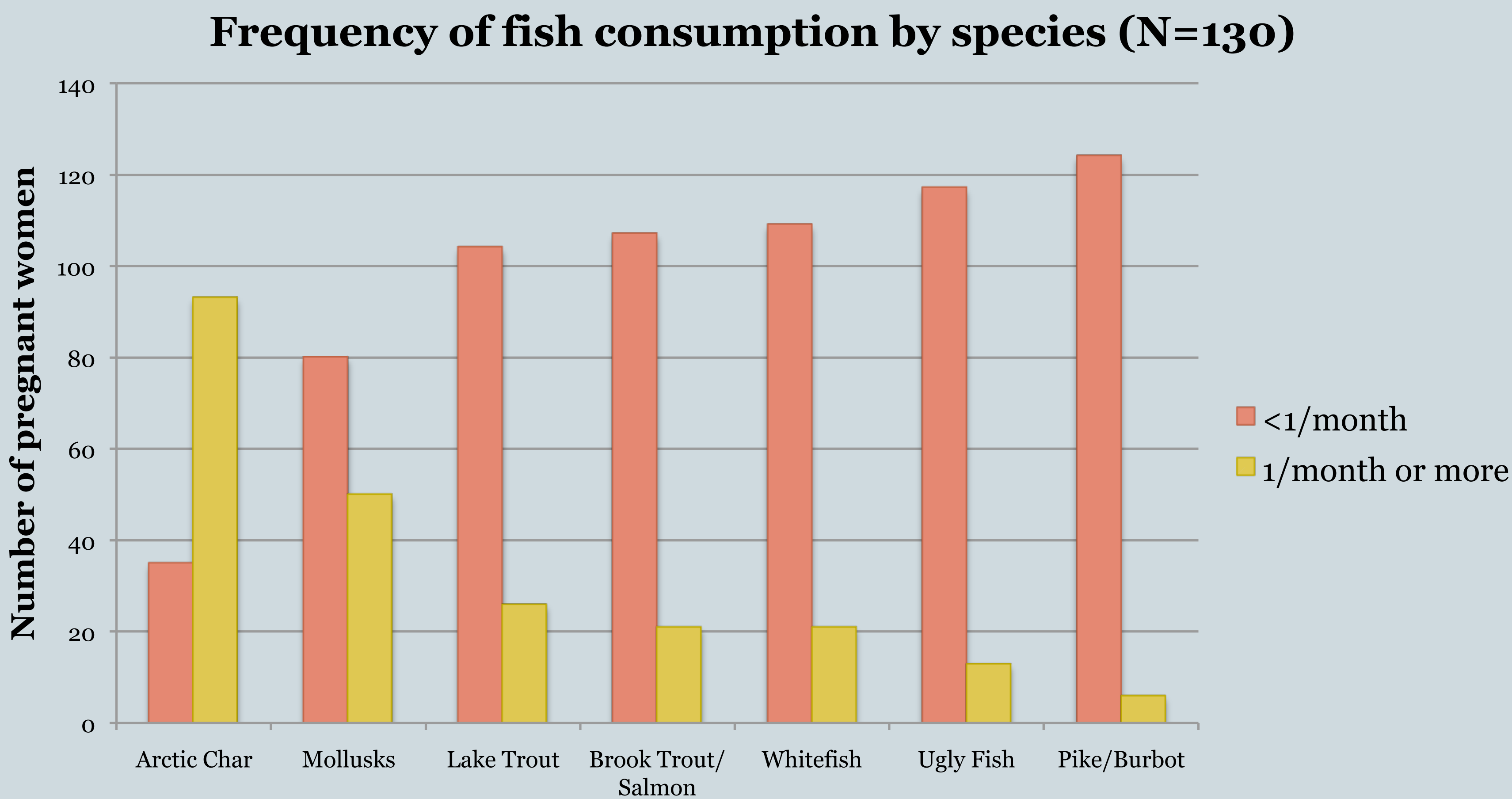
Most women report relatively low fish consumption except for Arctic Char



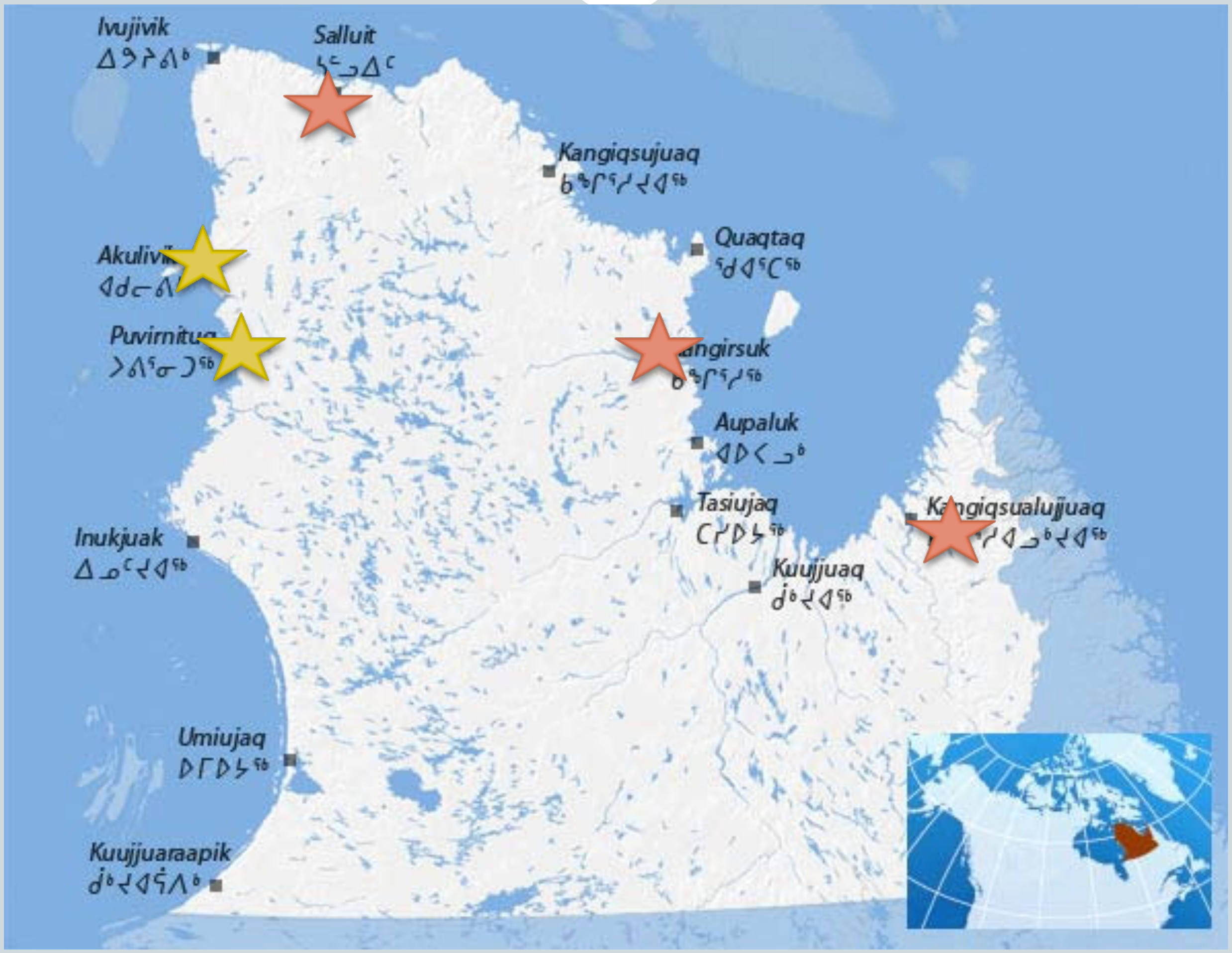
More than a third of women consume Arctic char more >1/week



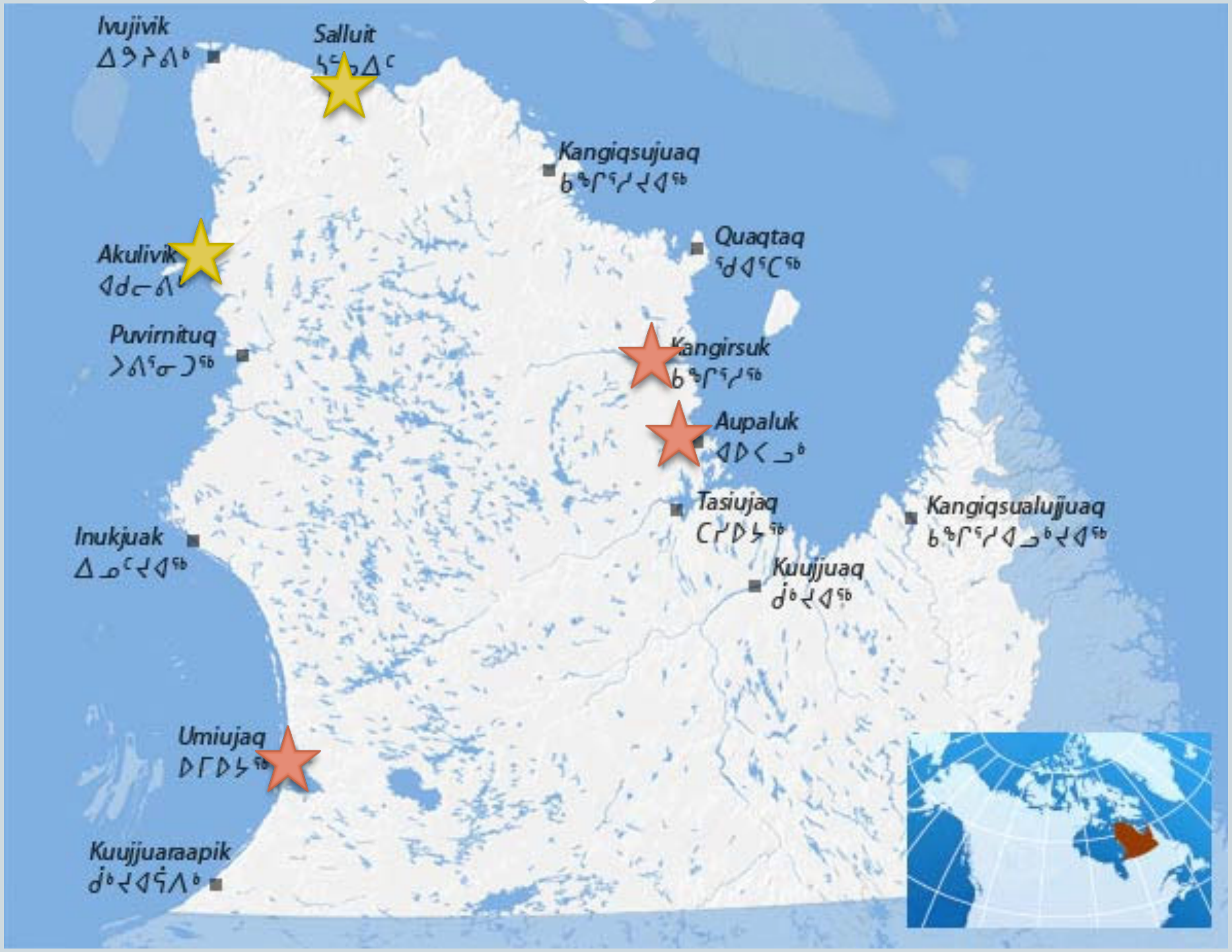
Only Arctic Char, Molluscs, and Lake Trout are reportedly consumed ≥1/month by >20% of women



Communities where 90% of pregnant women report consuming Arctic Char ≥1/month



Communities where 50% of pregnant women report consuming molluscs ≥1/month



Locations where 30% of pregnant women report consuming lake trout more than ≥1/month

Not working is associated with less fish consumption

Consumption of seafood/fish at least once per month			
	Arctic Char (N,%)	Molluscs (N,%)	Lake Trout (N,%)
Age			
≤25	61; 72.6%	34; 40.5%	14; 16.7%
>25	32; 72.7%	16; 34.8%	12; 26.1%
Marital status			
Partnered	73; 73.7%	40; 40.0%	20; 19.8%
Single	20; 74.1%	9; 33.3%	6; 22.2%
Education			
≥high school	29; 69.1%	18; 41.0%	11; 25.6%
<high school	64; 74.4%	31; 36.1%	15; 17.2%
In labour force			
Working	**43; 84.3%**	**16; 30.8%**	**16; 30.8%**
Not working	**50; 64.9%****	**33; 42.0%**	**10; 12.8%****

** P-value <0.05

Frequency of fish/seafood consumption by community characteristics

Consumption of seafood/fish at least once per month			
	Arctic Char (N,%)	Molluscs (N,%)	Lake Trout (N,%)
Region1			
Hudson	53; 75.7%	32; 45.1%	11; 15.5%
Ungava	40; 69.0%	18; 30.5%	15; 25.4%
Region2			
Hudson Strait	19, 76.0%	13, 52.0%	2, 8%
Hudson Bay	42, 72.4%	21, 36.2%	10, 17.0%
Ungava Bay	32, 71.1%	15, 32.6%	14, 30.4%*
Population Size			
≤800	39, 78.0%	19, 38.0%	8, 15.7%
>800	54, 69.2%	30, 38.0%	18, 22.8%

*P=0.06

Summary of consumption results

- Overall, fish consumption is relatively low in this sample of pregnant women, except for Arctic Char

- Few individual or community variables explain consumption patterns

- Strong association between working and consuming fish once or more per month
  - Char: OR 2.77 (95%CI 1.10-6.95)*
  - Lake trout: 2.73 (95%CI 1.09-6.88)*

* Using logistic regression models and adjusting for participant age.

Prediction of Nutrients & Contaminants according to reported fish/seafood consumption*

	DHA (units?)	Log Selenium (umol/l)	Log Mercury (nmol/l)
Arctic Char			
<1/mo	-ref-	-ref-	-ref-
1-3/mo	0.57 (0.05; 1.10)	-0.07(-0.26; 0.12)	0.20(-0.20; 0.60)
1/wk	0.83 (0.12; 1.54)	-0.03 (-0.28; 0.22)	0.40(-0.14; 0.94)
2+/wk	**1.30 (0.72; 1.88)**	**0.22 (0.01; 0.43)**	0.41 (-0.02; 0.85)
Molloscs			
<1/mo	-ref-	-ref-	-ref-
≥1/mo	**0.42 (-0.03; 0.87)**	0.10 (-0.06; 0.26)	0.18 (-0.15; 0.50)
Lake Trout			
<1/mo	-ref-	-ref-	-ref-
≥1/mo	0.26 (-0.30; 0.82)	0.13 (-0.06; 0.33)	0.20 (-0.20; 0.60)

*Linear regression models were used and included the covariates working/not working & region

Conclusions

- Reported consumption of fish/seafood is relatively low; few fish are consumed more than 1/month
- About 20% of women report consuming lake trout more than once per month
- Reported lake trout consumption (>1/month) not significantly associated with greater mean mercury levels
  - Number of women consuming more than 1/month too few to investigate whether they have greater mean Hg levels
- Lake trout consumption not associated with improved nutrient profiles (DHA or selenium)

Appendix 4

ᑭᑭᐊᑦᓴᔭᖃᕐᓂᖏᑦᑕ ᐳᕐᑐᓂᖏᑦ ᐃᓱᐅᕋᓕᑦᑖᒦᑦᑐᑦ ᐊᑦᔨᒋᖏᑐᓂᑦ ᑕᓯᕐᓃᓯᒪᔪᓂᑦ ᓄᓇᓕᖕᓂᓄ ᓄᓇᕕᒻᒥ

ᖃᐅᔨᓴᕐᑏᑦ:

ᒉᑯ ᕼᒍᐊᕼ, ᑕᓚᕐᓇᑐᓕᕆᔨ, ᓄᓇᕕᐅᑉ ᖃᐅᔨᒐᔪᐊᕐᕕᖓᓂᑦ, ᒪᑭᕝᕕᑯᓂ, ᑰᔾᔪᐊᒥ;
ᒥᐊᓚᓂ ᓚᒥᐅ, ᐃᓕᓴᔨᓪᒪᕆᐅᑦ ᐃᑲᔪᕐᑎᖓ, ᓚᕚᓪ ᐃᓕᓐᓂᐊᕕᓪᒪᕆᖓᓂ, ᑯᐯᒃ ᓯᑎᒥᑦ;
ᑲᑕᓇᓐ ᐆᑯᓐ, ᐃᓕᓴᔨᓪᒪᕆᐅᑦ ᐃᑲᔪᕐᑎᖓ, ᐃᓄᓕᒫᑦ ᖃᓄᐃᖕᒋᓯᐊᕐᓂᓕᕆᓂᖏᑦᑕ ᖃᐅᔨᓴᕐᑕᐅᓂᖏᓐᓄᑦ, ᐃᓕᓐᓂᐊᕕᓪᒪᕆᖓᓂ Hawai'I, Manoa

ᐱᓇᓱᐊᖃᑕᐅᔪᑦ: ᓯᐅᓐᕕᐊ ᓇᑳᑦ, ᓄᓇᕕᒻᒥ ᐃᓗᓯᓕᕆᔩᑦ ᑲᑎᒪᔨᖏᑦ, ᓄᓇᕕᒻᒥ ᐊᖑᔭᓪᓚᕼ ᑲᑐᑦᔨᖃᑎᒌᖕᓂᖓ, ᒪᒃᑭᑎᓂᒃ ᓴᐳᒻᒥᔩᑦ, ᐃᓚᒦᓂᒃ ᐊᖏᕐᕋᖃᕐᑎᓯᔩᑦ (ᐃᓄᑦᔪᐊᒥ., ᐳᕕᕐᓂᑐᒥᒧ, ᑰᔾᔪᐊᖅᐱᓪᒥᒧ).

ᑭᑭᐊᑦᓴᔭᕼ ᓱᑯᓇᕐᑐᓴᐅᑐᕼ ᓱᑯᐃᑐᐃᓐᓇᓇᐊᖃᕐᓯᓂ ᖃᓄᐃᖕᒋᔪᐊᕐᑐᒥᒃ, ᐱᓗᐊᕐᑐᒥᒃ ᐱᐊᕋᑦᓴᓂᒃ ᐱᐊᕋᕐᓂᓗ ᐱᔭᐅᕕᖕᖓᖃᑦᑐᐊᕋᒥᒃ ᐱᐊᕋᑦᓴᖃᕐᑐᓄᑦ. ᓄᓇᕕᒻᒥ ᕿᑲᓗᒐᕕᓂᐅᑦ ᓂᕿᖕᖓ, ᐊᓪᓚ ᒥᑭᓂᕐᓴᐅᒐᓗᐊᕐᑎᓗᒍ ᑕᓇᐅᒥᐅᑕᐅᑦ ᐅᒪᔪᖏᑦᑕ ᐃᕐᕋᕕᖏᓐᓂ, ᑭᑭᐊᑦᓴᔭᕐᑕᖃᕐᔨᑎᒃ ᓂᕿᑦᓴᓇᔭᐅᓪᒪᓇᔫᑦ ᐃᓄᓐᓄᑦ.

ᐅᑭᐅᓇᓐᓂᓴᑦ ᐃᓱᐅᕋᓕᑦᑖᑦ ᑭᑭᐊᑦᓴᔭᕐᑖᓯᒪᓂᕐᓴᐅᒍᓐᓇᔩᑦ. ᑌᒪ ᓄᓇᓕᓐᓂ ᐃᓱᐅᕋᓕᑦᑖᓂᒃ ᓂᕿᑐᐃᓐᓇᖃᕐᑲᕙᓗᔩᓄᑦ (ᐊᕐᕌᒍᓕᒫᒥ ᐅᑭᐅᒥᓐᓘᓃᑦ), ᑭᑭᐊᑦᓴᔭᕐᑖᐱᐅᓪᒪᓇᔾᔪᑐᐃᓐᓇᓇᐊᓃᑦ ᐃᓄᓐᓄᑦ. ᑭᓯᐊᓂᓕ, ᐃᓱᐅᕋᓕᑦᑖᑦ ᑭᑭᐊᑦᓴᔭᖃᕐᓂᖏᑦ ᐊᔨᑦᔨᔨᒪᑐᐃᓐᓇᓇᐊᖃᔾᔪᑦᔨᑎᒃ ᒪᓕᑦᔨᒥᑦ ᓇᑭᑦ ᐱᔭᐅᔾᔪᓂᖏᑦ, ᐊᓪᓚ ᐃᓱᐅᕋᓕᑦᑖᑦ ᐱᕆᕐᐸᓕᐊᒍᔨᒥᔾᔪᖏᑦ. **ᐅᖃᕐᑕᐅᒍᓐᓇᒥᔭᕼ ᐃᒫᒃ, ᐃᓅᓯᓐᓂᓴᑦ ᐃᖃᓗᐃᑦ ᐊᓪᓚᓘᓐᓃᑦ ᐃᖃᓗᐃᑦ ᐃᓚᖏᓐᓂᑦ ᑕᓯᕐᓂᑦ ᐱᓯᒪᔭᑦ ᑭᑭᐊᑦᓴᔭᕐᑕᖃᓗᐊᕈᓇᐅᔾᔪᖏᒋᑦᑐᑦ ᐊᓪᓚ ᓂᓇᓗᒥᑦ ᐊᑦᑕᓇᖕᖏᑑᓂᕐᓴᐅᔨᑎᒃ ᑭᓯᐊᓂ ᓯᓚ ᑕᒪᓐᓇ ᓯᕐᖁᐃᑕᐅᒥᐊᓕᒃ.**

> ᑕᒪᓐᓇ ᖃᐅᔨᓴᕐᓂᖅ ᕿᒥᕐᕈᐃᐅᓂᐊᕐᑐᖅ ᑭᑭᐊᑦᓴᕙᓐᓄ ᓄᑭᓇᕐᑐᓴᔭᖏᓐᓂᓄ ᐳᕐᑐᓂᖏᓐᓂᒃ ᐃᓱᐅᕋᓕᑦᑖᒦᑦᑐᓂᒃ ᐊᑦᔨᒋᖏᑐᓂᑦ ᑕᓯᕐᓂᑦ ᐱᓯᒪᔪᓂᒃ ᐊᓪᓚ ᓄᓇᓕᖕᓂᑦ ᓄᓇᕕᒻᒥ. ᖃᐅᔨᓴᐅᓯᒪᔪᐃᑦ ᒪᓕᒃᓗᒋᑦ, ᑕᒪᑦᓯᒍᕐᓚ ᓄᓇᕕᒻᒥ ᐃᓗᓯᓕᕆᔩᑦ ᑲᑎᒪᔨᖏᑦ ᐱᕙᓪᓕᐊᑎᑦᓯᑐᐃᓐᓇᓇᐊᖃᕐᓂᐊᑐᑦ ᐊᑦᑕᓇᕐᑌᓕᒪᓂᕐᒍᑦ ᑐᑭᒍᐊᑦᑎᓯᒍᑎᑦᓴᓂᒃ ᐊᑐᕐᑕᐅᒍᓐᓇᓂᐊᕐᑐᓂᒃ ᓇᓪᓚᖏᑦ ᐃᓱᐅᕋᓕᑦᑖᑦ, ᒪᓕᒃᓗᒥᑦ ᐊᖏᓂᖏᑦ ᐊᓪᓚᓘᓐᓃᑦ ᓇᓪᓕᐊᓂᑦ ᑕᓯᕐᒦᓯᒪᓂᖏᑦ, ᐊᑦᑕᓇᖕᖏᑑᒥᐊᖏᑦ ᑭᓇᓕᒫᒃᑯᓄᑦ ᓂᕆᔭᐅᒍᑎᒃ.

ᐅᓪᓗᓇᔭᐅᓂᐊᕐᑐᓄᑦ 2014-2015-ᒥ:

- ᓅᕕᕝᐱᕆᒥ: ᑐᑭᓯᓂᐊᕐᓂᖃᕐᓗᑎᒃ ᓇᓪᓚᑳᕆᓗᑎᓪᓗ ᑕᓯᕐᓂᒃ ᐱᔪᑦᓴᐅᔫᕐᕕᐅᔪᓂᒃ ᐊᑐᓂᑦ ᓄᓇᓕᓐᓄᑦ
- ᑏᓯᕝᐱᕆᒥ: ᐃᓄᑦᑎᑑᓕᕐᑎᑕᐅᓗᑎᒃ ᑐᓴᕐᑎᓯᒍᑎᖏᑦ, ᐅᖄᓚᕕᒥᓗᒥᑦ ᓄᓇᓖᑦ ᐊᖑᔭᓛᐱᖏᑦ ᐊᓪᓚ ᐃᖃᓗᓐᓂᒃ ᖃᐅᔨᓴᕋᑦᓴᑖᕈᓯᕐᒥᒃ
- ᑏᓯᕝᐱᕆᒥᑦ ᔭᓄᐊᕆᒧᑦ: ᑭᑭᐊᑦᓴᔭᕐᒥᒃ ᓱᑯᓇᕐᑐᓴᔭᕐᒥᓗ ᖃᐅᔨᓴᕐᑕᐅᔭᖃᕐᓗᓂ ᓄᓇᕕᐅᑉ ᖃᐅᔨᒐᔪᐊᕐᕕᖓᓂ, ᐅᓯᖃᑦᓯᐊᕈᑎᖏᓐᓗ ᕿᒥᕐᕈᔭᐅᓗᑎᒃ ᑯᐯᒃ ᓯᑎᒥ; ᐅᖃᖃᑎᒥᓗᒥᑦ ᓯᐳᓕᕐᑏᑦ ᐊᓯᖏᓐᓗ ᐊᐅᓚᑦᓯᔨᐅᓯᑦ ᓄᓇᓕᖕᓂ ᖃᐅᔨᓴᕐᕕᐅᓂᐊᕐᑐᓂ
- ᔭᓄᐊᕆᒥᑦ ᕖᕗᐊᕆᒧᑦ: ᑐᑭᓯᒪᐅᑏᑦ ᕿᒥᕐᕈᔭᐅᓗᑎᒃ ᐱᓇᓱᐊᖃᑎᒌᑦᑐᐃᓗ ᑲᑎᒪᓂᖃᕐᓗᑎᒃ ᑰᔾᔪᐊᒥ ᐃᓚᒥᓗᒥᑦ ᓄᓇᕕᒻᒥ ᐃᓗᓯᓕᕆᔩᑦ ᑲᑎᒪᔨᖏᑦ ᐅᖄᒍᑎᖃᕐᓗᓂ ᖃᐅᔨᓴᕐᑕᐅᓯᒪᔪᑦ ᖃᐅᔨᔭᐅᓯᒪᔪᓂᒃ ᐃᓕᓐᓂᖃᕐᓂᐊᑐᓂᒃ ᐊᑦᑕᓇᕐᑌᓕᒪᓂᕐᒍᑦ ᑐᑭᒍᐊᒍᑎᑦᓴᐅᓕᕐᑐᓄᑦ
- ᒫᑦᓯᒥ: ᖃᐅᔨᒪᔭᐅᔪᓂᒃ ᑐᑭᖃᕐᑎᓯᒍᑎᓂᒃ ᓄᐃᑕᐅᔪᖃᕐᓗᓂ ᐊᓪᓚ ᐱᓪᓗᑯᐊᐱᖕᖏᑐᑦᓴᔭᕐᓂᒃ ᑐᓴᕐᑎᓯᒍᑎᓕᐅᕐᓗᓂ ᓄᓇᓕᖕᓄᑦ
- ᐁᕆᓕᒥ: ᐴᓇᐊᕐᓗᒥᑦ ᓄᓇᓖᑦ ᖃᐅᔨᓴᐅᓯᒪᓕᕐᑐᓂᒃ ᖃᐅᔨᑎᒥᐊᕐᑐᒥᑦ ᑐᓂᔭᐅᔪᖃᕐᓗᓂᓗ ᑐᑭᖃᕐᑎᓯᒍᓯᕐᓂᒃ

ᐊᒥᓱᓪᒪᕇᑦ ᐊᓯᖏᑦ ᓂᕿᑐᐃᓐᓇᓴᕋᑦ ᑭᑭᐊᑦᓴᔭᕐᑕᖃᓗᐊᖏᑦᑐᑦ ᐊᒥᓱᓚᓐᓂᓗ ᓄᑭᓴᐅᑎᖃᕐᓯᐊᓯᑎᒃ, ᐅᑦᑐᑎᒥᓗᒍ ᐅᓯᖃᕐᓯᐊᕈᓯᖏᑦ: ᕿᓚᓗᒐᑦ ᐊᓪᓚ ᒥᓯᕋᕼ ᐳᐃᔨᕕᓂᕐᒥᑦ, ᐃᖃᓗᑦᐱᑦ, ᑲᕙᓯᓃᑦ, ᑲᓇᔪᐃᑦ, ᓯᐯᑦ, ᑕᓇᐅᑦ ᓂᕿᑦᓴᔭᖏᑦ, ᑐᑦᑐᐃᑦ, ᓂᕐᓂᑦ, ᐊᕿᒡᒋᑦ, ᐸᐅᕐᕋᑦ, ᐊᓯᖏᓐᓗ.

ᑐᑭᓯᒥᐊᓪᓚᕆᓪᒪᒍᕕᑦ, ᐅᖄᓚᕕᒃᑭᕐᓇᐳᑎᑦ ᒪᐃᑯ ᕼᒍᐊᕼᒧᑦ ᐱᑕ ᒣᒍᓪᓘᑦ ᐅᕗᖕ 819-964-2951-ᒧᑦ.

Mercury levels in lake trout from different lakes and communities in Nunavik

Investigators:
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Partners: Sylvie Ricard, Nunavik Regional Board of Health and Social Services (NRBHSS), Nunavik Hunting Fishing and Trapping Associations (NHFTAs), Hunter Support Programs (HSPs), Family Houses (Inukjuak, Puvirnituq, Kuujjuaraapik)

Mercury is a contaminant that may damage health, especially the health of the foetus and children when consumed in elevated amount during pregnancy. In Nunavik, beluga whale meat, and to lesser extent marine mammal organs, are the most important food sources of mercury for Inuit.

Older lake trout may often accumulate very high amount of mercury. Then, in villages where lake trout is an important country food (year-round or during winter), it may also be an important source of mercury for Inuit. However, the mercury in lake trout may change with the characteristics where it's from, and with the lake trout's growth rate. **In other words, younger fish and/or fish from some lakes may be low in mercury and be safe to eat, but this remains to be confirmed.**

> This study will examine mercury and nutrient levels in lake trout from different lakes and communities in Nunavik. According to the findings, this may allow the NRBHSS to develop safety guidelines for lake trout that can be used to gage which lake trout fish, of certain sizes and/or from certain lakes, are safe for everyone to eat.

Timeline for 2014-2015:

- November: Consultation and selection of the lakes of interest in each community
- December: Translation of the summary, contact with local HFTAs and fish sampling
- December - January: Mercury and selenium samples analyses at NRC, omega-3 fatty acids analyses in Quebec City; Contact with mayors and any other relevant stakeholder in each communities involved
- January - February: Data analysis and team meeting in Kuujjuaq with the NRBHSS to discuss the study findings and the relevance of safety guidelines
- March: Production of knowledge translation tools and non-technical summaries for the communities
- April: Visit of the communities to share results and present tools

Many others country foods are low in mercury and rich in several nutrients, such as good fats: beluga and seal misirak, Arctic char, brook trout, lake whitefish, sculpin, fish eggs, seafoods, caribou, geese, ptarmigan, berries, etc.

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Preliminary Results Summary for the Lake Trout Mercury Project
Authors: Melanie Lemire, Michael Kwan, Catherine Pirkle, Chris Furgal

Background: Food safety may be a concern for lake trout because it is a predatory fish at the top the food chain and may have a high concentration of mercury (Hg). Little is known about Hg concentrations in lake trout from different areas in Nunavik, nor the contribution of this country food to body burdens of Hg in people, particularly childbearing-age women. The Health Canada guidelines for Hg in fish, the provisional tolerable daily intake (pTDI) guidelines, and the formula for probable daily intake (PDI), can inform public health recommendations regarding the consumption of certain foods (Box).

For fish:
0.5ug/g of total Hg in commercial fish

For childbearing age women and children:
pTDI: 0.2ug Hg/kg body weight/day (8ug/l in blood)
For adults excluding childbearing age women:
pTDI: 0.47ug Hg/kg body weight/day (20ug/l in blood)

$$\text{PDI(ug/kg BW/day)} = \frac{\text{(Fish portion (g/time) * frequency (times/day) * Hg in fish (ug/g))}}{\text{body weight (kg)}}$$

Preliminary Research Findings
Hg and omega-3 in lake trout

a. Over 70% of lake trout samples surpassed the Health Canada guideline of 0.5ug/g of Hg in fish.
b. Characteristics of the fish such as age, length and weight are not reliable enough to identify fish with high Hg concentrations. Although there is evidence that smaller fish do have lower average Hg concentrations, the types of net used to catch most lake trout do not permit catching fish that are small enough to consistently be below the 0.5ug/g Health Canada guideline.
c. Certain watersheds had consistently high and low Hg fish. Knowledge of where the fish were caught may be the most useful indicator of the likelihood that fish will surpass the Health Canada guideline (see table 1).
d. Omega-3 concentrations were high in lake trout and varied dramatically from site to site, again suggesting that the location the fish were caught may be the most important variable for public health purposes.
e. Lake trout from certain locations closer to marine ecosystems had lower mean Hg concentrations and high mean omega-3 concentration suggestive of a non-landlocked life history.

Lake trout consumption patterns of pregnant women in the Arctic Char Distribution Project

a. Reported consumption of most fish is relatively low, except for Arctic Char. Women in this sample (n=130) provided information on fish consumption from fall to winter and results may not be reflective of spring and summer.
b. About 20% of women reported consuming lake trout more than once per month (14% one to three times/mo, 6% once a wk or more), compared to 80% consuming lake trout never or less than once a month. Even so, lake trout is reported to be the 3rd most consumed fish/seafood item after Arctic char and mollusks (during fall and winter). While the

sample sizes are small by village, some women from Inukjuaq, Kuujjuaq, Kangiqsualujjuaq, reported consuming lake trout once a week or more (table 2).

c. The frequency of lake trout consumption (1/mo versus <1/mo) was not associated significantly greater mean blood Hg levels. Because the sample size was 130 and only 20% of women reported consuming lake trout more than once per month, these results cannot be generalized to the small number of women (n=8) who were consuming lake trout more frequently (e.g. 1/week or more).

Next steps:

In Spring, 2015 a detailed survey about the importance of lake trout as a country food will be conducted among those who fish/consume lake trout the most (snowball sampling method). Chris Furgal/his student will visit Nunavik to train Peter and Sandy at the NRC on interview methods and web data collection. Preliminary results from this survey will be presented June 2/3 at the next NNHC meeting. Subsequently, decisions will be made about public health messaging and interventions that health professionals in Nunavik can take to reduce Hg exposure from diet in pregnant women.

Conclusion

Using Health Canada's PDI formula and mean Hg levels in fish caught near different communities in Nunavik (table 3), results suggest that in almost no situation should it be recommended that lake trout be consumed more than once per week by pregnant women in Nunavik, except in cases where there is no other country food to eat. However, the PDI formula does not take into consideration the beneficial nutrients found in lake trout nor does it consider food security. Based on these findings, it was suggested that public health messages should be targeted to at-risk women during prenatal consultations using the screening of blood for Hg levels or questions about beluga meat and lake trout consumption, instead of releasing general messages about mercury in lake trout at the regional level. Messages could also be adapted to specific circumstances of the communities, taking into consideration the median levels of mercury found in lake fish from this area.

Future Research Suggestions:

1) Biological studies of lake trout to determine if certain species are anadromous, because these will have lower Hg levels and more omega-3. Information on how to identify these fish and/or waterbodies will be important.
2) Some individuals in Umiujaq have expressed interest in the lake trout research and there are anecdotal reports of elevated lake trout consumption in this village. Testing of Hg concentration in fish near this village may be warranted.
3) A questionnaire has been developed for Nunavik health professionals to help them identify women pregnant likely to have elevated Hg concentrations based on their diet. Given that systematic blood Hg screening of pregnant women may be recommended, there is an opportunity to determine the sensitivity and specificity of the diet questionnaire in regards to predicting blood Hg levels.
4) If tools and interventions are developed to improve the counseling of pregnant women about mercury in diet during their first trimester, then there is a need to evaluate the impact of the intervention.
    a. First, during their prenatal consultations, do health professionals incorporate suggestions about the counseling of pregnant women on Hg in food and its effects on the health of their children?

b. Second, how systematically and how well do health professionals apply these messages (e.g. do all women receive the same quality messages)?
c. Third, how well is the counseling received by pregnant women and does it lead to behavior changes?
d. Forth, how effective is the behavior change on reducing blood Hg level and how long does it take to reduce these levels? Overall, do our interventions protect the fetus from elevated Hg exposure?

Table 1:

Summary of data on Mercury in Nunavik Lake Trout, ug/g w.w. (total n = 349)

Community / Location	Number of samples	Geometric mean (Range)	Median (1st, 3rd quartiles)
Inukjuaq Site 1 (2014/15)	20	0.85 (0.48 – 1.42)	0.86 (0.64, 1.21)
Inukjuaq Site 2 (2014/15)	18	0.84 (0.41 – 1.85)	0.81 (0.61, 1.21)
Kangiqsualujjuaq (2006)	19	0.53 (0.24 – 1.01)	0.53 (0.40, 0.65)
Kangiqsualujjuaq (2015)	18	0.89 (0.46 – 2.15)	0.79 (0.66, 1.31)
Kangiqsujuaq (2006)	21	0.51 (0.30 – 0.90)	0.52 (0.40, 0.59)
Kuujjuaq (2006/07)	122	0.72 (0.17 – 3.97)	0.64 (0.49, 1.00)
Kuujjuaq Site 1 (2014/15)	20	0.69 (0.26 – 1.80)	0.70 (0.53, 0.92)
Kuujjuaq Site 2 (2014/15)	18	0.73 (0.35 – 1.54)	0.73 (0.58, 0.92)
Puvirnituq (2006)	19	0.43 (0.24 – 0.72)	0.42 (0.37, 0.50)
Puvirnituq Site 1 (2014/15)	20	0.41 (0.24 – 1.14)	0.38 (0.31, 0.52)
Puvirnituq Site 2 (2014/15)	20	0.63 (0.28 – 1.88)	0.58 (0.47, 0.72)
Quaqtaq (2006)	7	0.67 (0.54 – 1.09)	0.60 (0.57, 0.78)
Salluit (2006	8	0.49 (0.28 – 1.06)	0.42 (0.30, 0.81)
Salluit Site 1 (2014/15)	9	0.32 (0.21 – 0.40)	0.35 (0.30, 0.38)
Salluit Site 2 (2014/15)	5	0.51 (0.37 – 0.69)	0.50 (0.40, 0.64)
Tasiujaq (2006)	16	0.59 (0.35 – 0.84)	0.62 (0.47, 0.78)

(M. K. H. Kwan 2015)

Table 2: Frequency of lake trout consumption by community

Community corrected, preferred variable	T0_laketrout				
	never or	1-3/month	1/week	2+/week	Total
[1]Akulivik	10	0	0	0	10
[2]Aupaluk	3	0	0	0	3
[3]Inukjuaq	13	4	1	1	19
[4]Kangiqsualujjuaq	8	3	0	1	12
[5]Tasiujaq	7	0	0	1	8
[6]Kangiqsujuaq	9	0	0	1	10
[7]Kangirsuk	1	1	0	0	2
[8]Umijuaq	2	0	0	1	3
[9]Kuujjuaq	13	7	0	1	21
[10]Kuujjuarapik	10	2	0	0	12
[11]Puvirnituq	14	1	0	0	15
[12]Quaqtaq	3	0	0	0	3
[13]Salluit	11	0	1	0	12
Total	104	18	2	6	130

Table 3: What is the number of times a 60 kg women can eat a fish portion of 150g in this village?

	1 time/day	3 times/week	1 time/week	3 times/month
Inukjuak - 0.85 ug/g	2,13	0,91	0,30	**0,21**
Kuujjuaq - 0.73 ug/g	1,83	0,78	0,26	**0,18**
Kangiqsualujjuaq - 0.53 ug/g	1,33	0,57	**0,19**	**0,13**
Puvirnituq - 0.43 ug/g	1,08	0,46	**0,15**	**0,10**