

# Summary of Human Health Risks and Methylmercury

## Overview of Baseline and Predicted Exposure Scenarios for Lake Melville and Hg in Hair Summary

St. John's Nfld., June 28

# Guiding Principals of an HHRA

- At its most basic level, HHRA compares (1) a measure or estimate of human exposure to a chemical to (2) a benchmark of “acceptable” exposure.
- The primary Canadian regulatory authority for methods of HHRA for environmental exposure to chemicals is Health Canada.
- The risk of adverse health effects due to exposure to a chemical depends on the magnitude, duration and timing of the exposure dose.

# Guiding Principals of a HHRA

- HHRA is not a science – it is a framework, based on first principles and related guidance, for the presentation and evaluation of scientific evidence.
- “The dose is the poison” ... in exposure scenario’s many things are considered beyond simply the a contaminant concentration.
- A HHRA for MeHg is actually one of the more ‘simple’ exercises, because there is only 1 receptor, 1 contaminant and 1 exposure media
- In the case of MeHg, we are more concerned about more ‘sensitive’ receptors to MeHg such as children and pregnant women or of age.



# Guiding Principals of an HHRA

- A chemical exposure experienced over a relatively long duration is referred to as “chronic” exposure. In a HHRA for MeHg, exposure is considered ‘chronic’ demanding exposure >3 months.
- For most people, it takes months of ‘chronic’ exposure to MeHg that are higher than ‘baseline’ before concentrations equilibrate in the body. However, MeHg can be detected in hair within days/weeks after consumption.
- Exposure to the fetus in pregnant women demands a more conservative approach to exposure, reflected in the TDI.

# Health Benefits of Fish Consumption

- All HC guidance documents now begin with a statement regarding the health benefits of fish consumption.
- While all fish contain MeHg, fish is also an excellent source of high quality protein and is one of the best food sources of omega-3 fatty acids and vitamin D; as well as essential elements selenium, iodine, magnesium, iron and copper. Regular fish consumption can benefit cardiovascular health and child development.
- HC's Food Guide for Healthy Eating recommends eating at least two 75 g servings of fish per week (i.e., 150 g of fish/week).

# Health Benefits of Fish Consumption

- This guidance targets the general population and does not target First Nations or Indigenous peoples
- Health benefits of fish consumption accrue far beyond simply the nutritional benefits ... connection to the land, traditional knowledge, physical activity related to the pursuit of country foods, family and community connections and others ...
- Ineffective risk communication can result in decreased fish consumption. Adverse health effects associated with reduced fish consumption can outweigh the potential health benefits associated with avoiding MeHg in fish (Mozaffarian and Rimm 2006, Teisl et al. 2011)
- Generally, a fish meal is a 'healthier' meal than nearly any other, especially if you are an indigenous person.



# How Much Fish is 'Safe' to Eat?

- Tolerable Daily Intake – HC defines a TDI as the total intake by ingestion “to which it is believed that a person can be exposed daily over a lifetime **without** deleterious effect”. HC also states that exceedance of a TDI “for a small proportion of the lifespan does not necessarily imply that exposure constitutes an undue health risk”.
- HC’s pTDI for daily MeHg exposure for the general population, over their lifetime, is 0.47  $\mu\text{g}$  methylmercury/kg body weight/day ( $\mu\text{g}/\text{kg}/\text{d}$ ). For women of child-bearing age and children less than 12 years of age its more conservative at 0.2  $\mu\text{g}/\text{kg}/\text{d}$ .

# How Much Fish is 'Safe' to Eat?

- HCs TDIs for MeHg is based on: 1) the [MeHg] in the fish; 2) the average meal size; and 3) body weight of the consumer. That pTDI only applies to the person consuming the fish.

$$SW = \frac{(pTDI \times BW \times \theta \times \delta)}{(C \times S)}$$

Where:

$SW =$  Number of servings of fish that can be consumed per week without exceeding the pTDI

$pTDI =$  Health Canada's pTDI for methylmercury (mg/kg/d)

$BW =$  Body weight (kg)

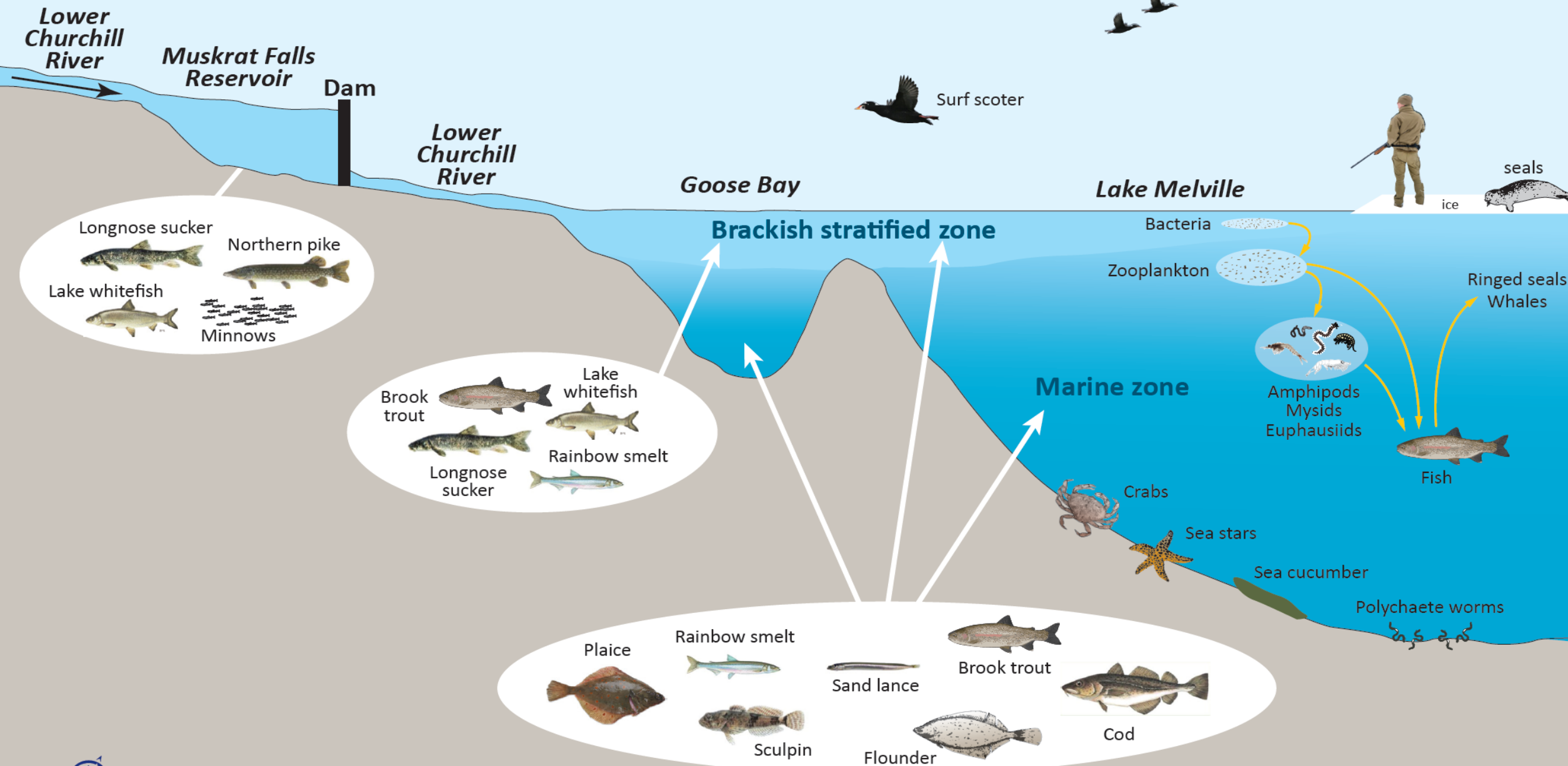
$\theta =$  Unit conversion constant = 1000 g/kg

$\delta =$  Unit conversion constant = 7 days/week

$C =$  Concentration of methylmercury in fish (mg/kg wet weight)

$S =$  Average serving size of fish (g wet weight)





# Consumption Limits – Example

- Assumed male body weight of 70 kg; female 60 kg
- Assumed meal size of 75 gm for toddler; 163 gm for adult
- Assuming baseline [MeHg]'s for key species:
  - Brook trout 0.06 ppm
  - Rainbow smelt 0.04 ppm
  - Seal 0.12 ppm
- Assumed 30% increase in [MeHg] peak post-flood

# Consumption Limits – Example

Maximum number of servings of fish per week that can be consumed without exceeding Health Canada's provisional tolerable daily intake for MeHg

Species	Location	Average peak methylmercury concentration mg MeHg/kg ww	Toddler	Child	Female Teen	Women of Child Bearing Age	Male Teen	Other Adult	
			age	7 mo. - 4 y	5 - 11 y	12 - 19 y	> 20 y	12 - 19 y	> 20 y
			75	125	150	163	150	163	
<b>Seal</b>	<b>Muskrat Falls - Baseline</b>	<b>0.130</b>	<b>2</b>	<b>3</b>	<b>4</b>	<b>5</b>	<b>10</b>	<b>11</b>	
	<u><b>MFR - Post-Impoundment</b></u>	<b>0.143</b>	<b>2</b>	<b>3</b>	<b>4</b>	<b>4</b>	<b>9</b>	<b>10</b>	
<b>Rainbow Smelt</b>	<b>Muskrat Falls - Baseline</b>	<b>0.040</b>	<b>8</b>	<b>9</b>	<b>14</b>	<b>15</b>	<b>33</b>	<b>36</b>	
	<u><b>MFR - Post-Impoundment</b></u>	<b>0.052</b>	<b>6</b>	<b>7</b>	<b>11</b>	<b>12</b>	<b>25</b>	<b>27</b>	
<b>Brook Trout</b>	<b>Muskrat Falls - Baseline</b>	<b>0.030</b>	<b>10</b>	<b>12</b>	<b>19</b>	<b>20</b>	<b>44</b>	<b>48</b>	
	<u><b>MFR - Post-Impoundment</b></u>	<b>0.039</b>	<b>8</b>	<b>9</b>	<b>14</b>	<b>16</b>	<b>34</b>	<b>37</b>	
<b>Commercial canned albacore tuna</b>	<b>Health Canada (2007)</b>	<b>0.36</b>	<b>1</b>	<b>1</b>	<b>2</b>	<b>2</b>	<b>4</b>	<b>4</b>	
<b>Commercial canned light tuna</b>	<b>Health Canada (2007)</b>	<b>0.06</b>	<b>5</b>	<b>6</b>	<b>9</b>	<b>10</b>	<b>22</b>	<b>24</b>	
<b>Commercial halibut</b>	<b>Health Canada (2007)</b>	<b>0.31</b>	<b>1</b>	<b>1</b>	<b>2</b>	<b>2</b>	<b>4</b>	<b>5</b>	
<b>Commercial cod</b>	<b>Health Canada (2007)</b>	<b>0.06</b>	<b>5</b>	<b>6</b>	<b>9</b>	<b>10</b>	<b>22</b>	<b>24</b>	

# Summary of Meal Size – Mass Perspective

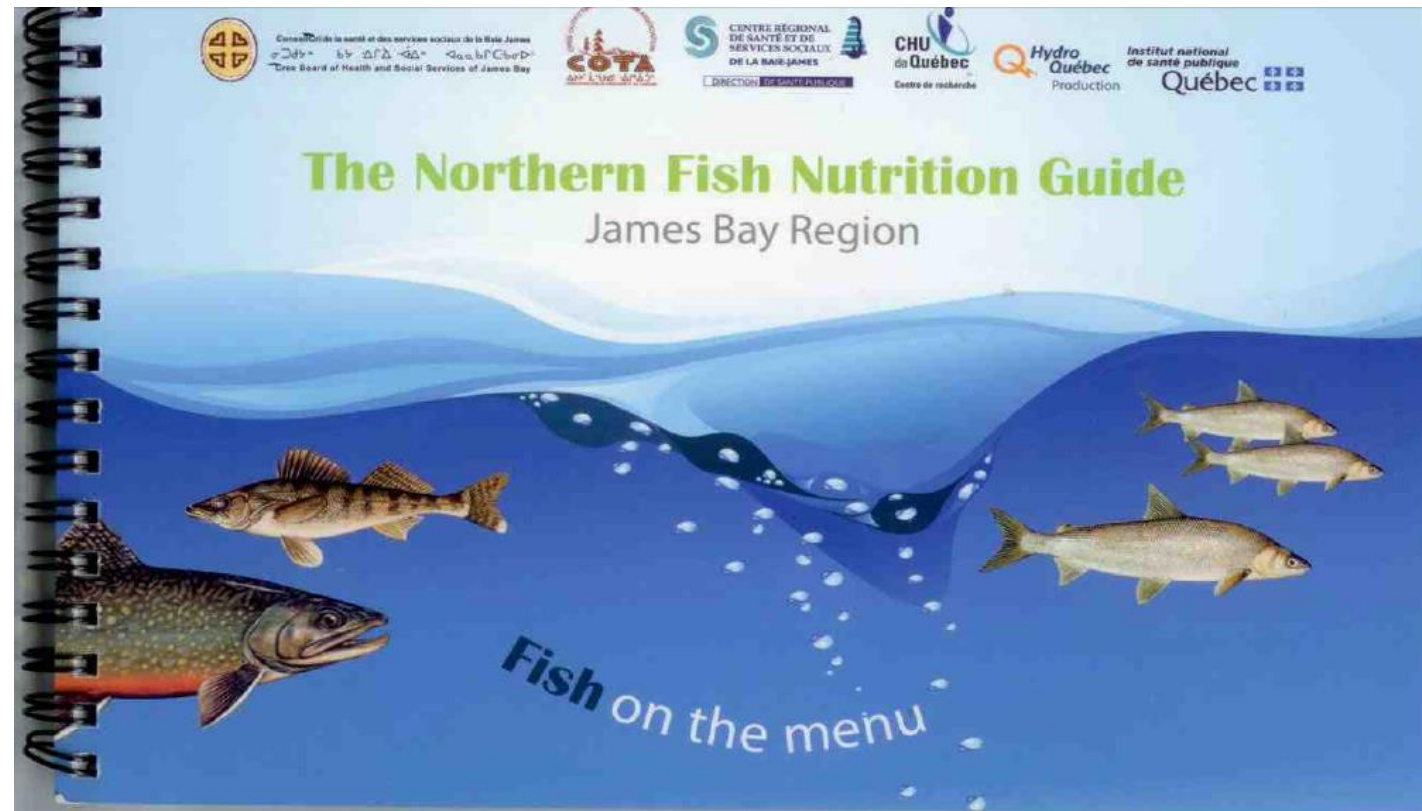
- In terms of the amount (gm) of fish that can be eaten per week for key species and remain below HC guidelines, this equals:

	<u>Baseline</u>	<u>Post-Inundation</u>
»		
– Brook trout	7.8 kg/wk	7.1 kg/wk
– Rainbow smelt	5.8 kg/wk	4.5 kg/wk
– Seal	1.8 kg/wk	1.6 kg/wk



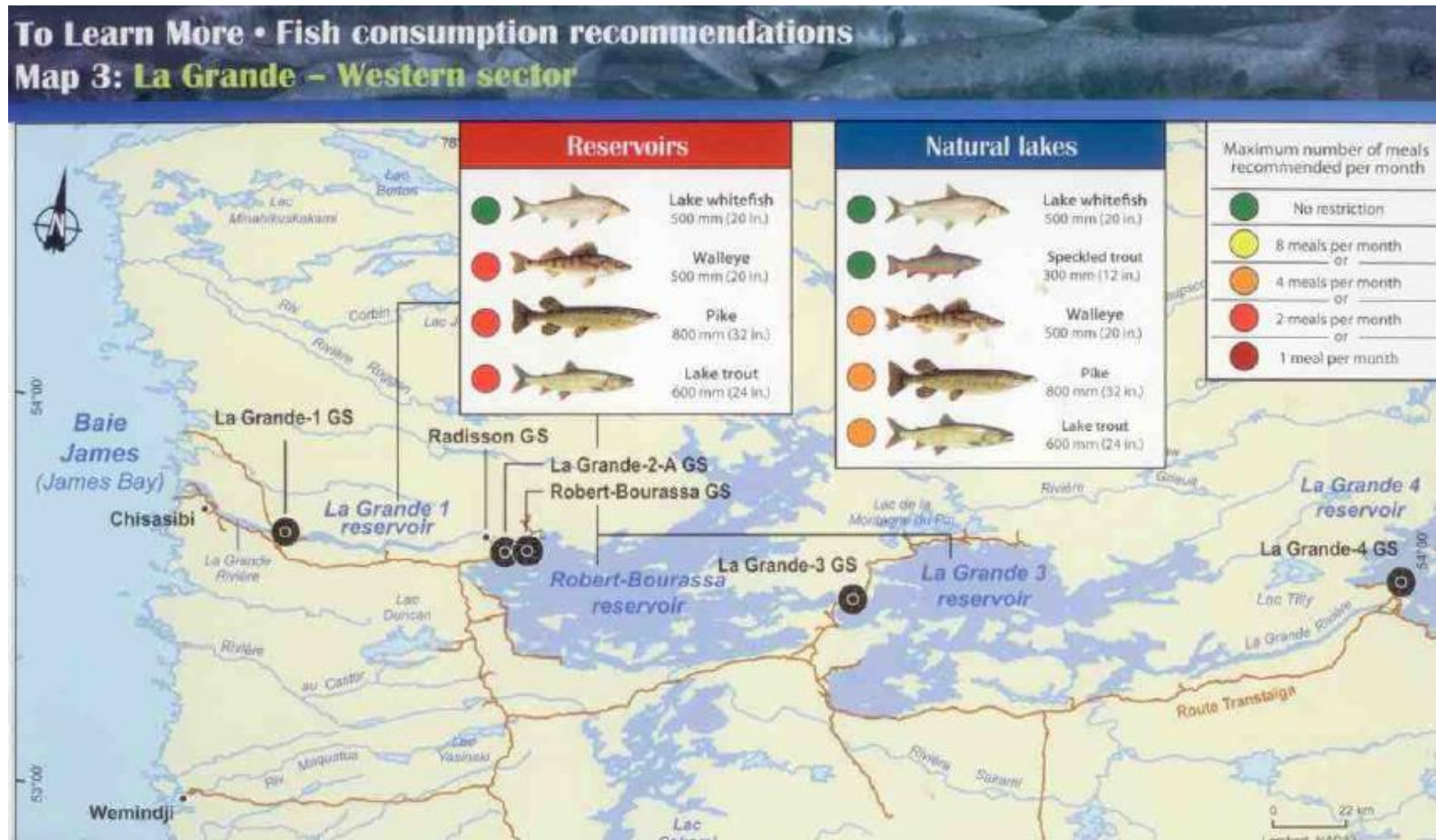
# Overview of Fish Consumption Communication Information

- Each province has a different approach
- [www.epa.gov/fish-tech](http://www.epa.gov/fish-tech); [www.ec.gc.ca/mercure-mercury/](http://www.ec.gc.ca/mercure-mercury/)



# Consumption Advisory Options

**Quebec Public Health Institute** – worked with QH to develop guidelines: assumed that [Hg] of <0.30 ppm was ‘safe’ with no restrictions; 0.30 – 0.49 = 8 meals/month, etc.

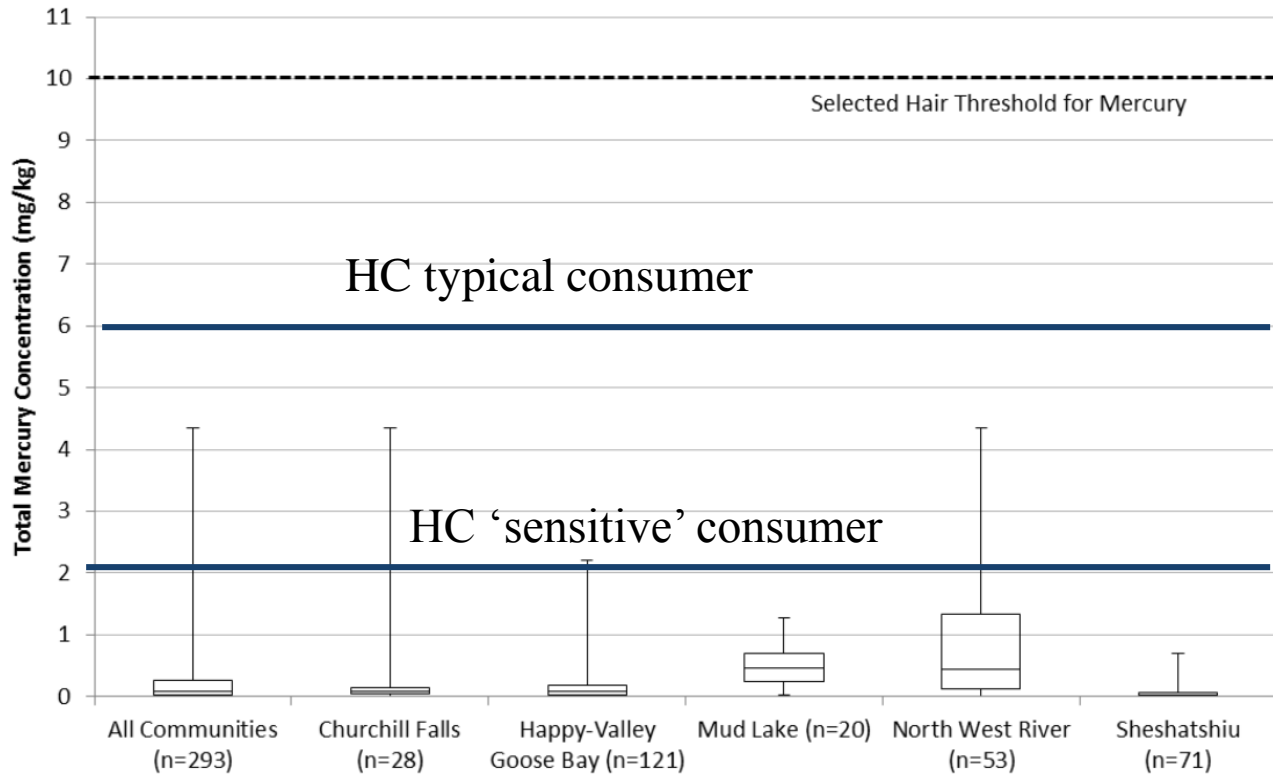


# MeHg in Hair – Overview of Data

- Measuring mercury in hair is a common biomonitoring tool. It integrates exposure of MeHg from fish over time (months / years)
- Health Canada has ‘guideline’ concentrations for Hg in hair for the general population (6 ppm) and ‘sensitive’ individuals (2 ppm).
- Similar to guidelines for dietary exposure to MeHg in fish, exceeding a guideline concentration does not mean that there is an imminent health risk. This is because of inherent conservatism built into guidelines and is why they are not called ‘threshold’ concentrations.



# MeHg in Hair – Current Exposure



- The most commonly eaten fish are salmon, brook trout, smelt, lake trout and rock cod. Most participants eat fish once a week or less, with only a few eating fish more than once a week.

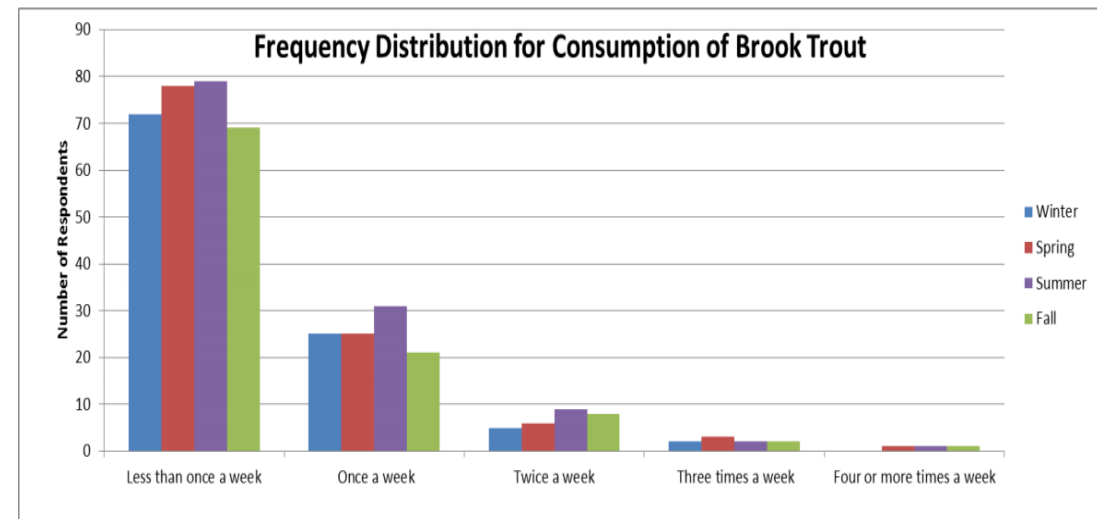


Figure 67: Box and whisker plot illustrating distribution of total mercury concentrations for all communities combined (n=293) and for each community. Lower and upper whiskers illustrate minimum and maximum, respectively, lower and upper limits of box illustrate first quartile (i.e., 25<sup>th</sup> percentile) and third quartile (i.e., 75<sup>th</sup> percentile), respectively, and middle line in box represents median (i.e., 50<sup>th</sup> percentile). The selected hair threshold for mercury is 10 mg/kg.

Figure 18: Frequency Distribution for Consumption of Brook Trout



# MeHg in Hair – Current Exposure

**Table 5: Summary Statistics of Total Mercury Concentrations in Hair for All Study Participants**

Community	Summary Statistics of Total Mercury Concentrations in Hair (mg/kg)					
	Arithmetic Mean	Geometric Mean	Median	Standard Deviation	Minimum	Maximum
All Participants (n=293)	0.3117	0.0931	0.089	0.5993	0.004	4.34
<b>Females</b>						
1-4 years (n=7)	0.0673	0.0484	0.0743	0.0495	0.012	0.134
5-11 years (n=27)	0.0506	0.0274	0.0274	0.0698	0.0061	0.288
12-19 years (n=24)	0.0536	0.0251	0.0195	0.0686	0.004	0.257
20+ years (n=139)	0.2802	0.1155	0.106	0.4767	0.0041	4.12
<b>Males</b>						
1-4 years (n=6)	0.0674	0.0391	0.04715	0.0638	0.0098	0.146
5-11 years (n=11)	0.0374	0.0226	0.017	0.0477	0.0095	0.158
12-19 years (n=14)	0.0763	0.0409	0.0695	0.0729	0.0041	0.244
20+ years (n=65)	0.7288	0.2781	0.329	0.9346	0.008	4.34

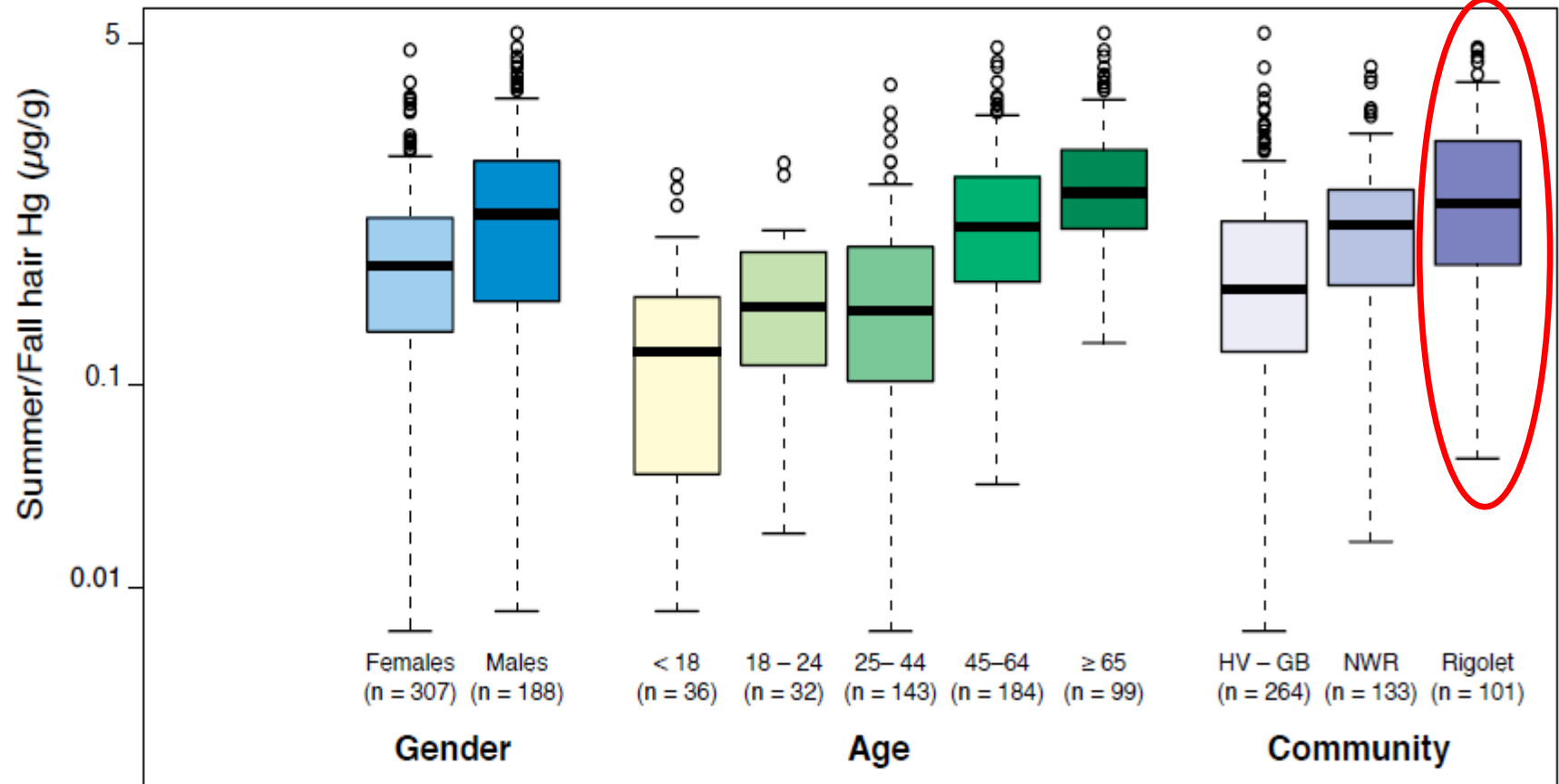
From Golder 2015 n=293

# MeHg in Hair – Exposure Summary

- Females and males under 20 y of age have very low hair Hg concentrations, averaging less than 0.07 mg/kg, which is >10x lower than the most conservative guideline (2 mg/kg).
- Mean adult female hair [MeHg] is 0.28 mg/kg; also very low
- Mean adult male hair [MeHg] is 0.73; also very low and almost 10x lower than the guideline of 6 mg/kg.
- These data suggests that fish / marine mammal consumption is exceedingly low for almost all individuals.

# MeHg in Hair – Current Exposure

Figure 6.9. Measured hair mercury concentrations stratified by gender/age and community. HV-GB=Happy Valley-Goose Bay, NWR= North West River. Happy Valley-Goose Bay includes the nearby community of Mud Lake. Source: Calder et al. (in prep).



# MeHg in Hair – Summary

- Lake Melville region Inuit mean hair [Hg] (n=499) was 0.38 ppm (spring) and 0.51 ppm (fall). Top 5% = 2.4 ppm
- Similar results to Chan et al. (2011) study; <10% of Inuit adults exceeded 2 ppm reference dose for ‘sensitive’ receptors.
- NO children or women of child-bearing age exceeded 2 ppm.
- These concentrations are lower than other Inuit communities (1.5 ppm; Chan et al. 2011) and Nunavik (2.6; Dewailley et al. 2004)
- 67% of MeHg exposure from country foods; 23% store-bought



# MeHg in Hair Key Results

- Hair Hg in most communities similar, with Rigolet slightly higher than others. Men > women >> kids ...
- No children or women of child-bearing age exceeded the most conservative guideline of 2 ppm in hair.
- Presently, unlikely that there is any risk to humans given low concentrations and low consumption of country foods in diet.

## QUANTIFYING THE HEALTH IMPACTS OF DIETARY FISH CONSUMPTION ADVISORIES FOR METHYLMERCURY AMONG INUIT IN LABRADOR

CALDER, Ryan<sup>1</sup>; SUNDERLAND, Elsie<sup>1</sup>;  
(1) Harvard University, Cambridge, MA, USA

ry.calder@mail.harvard.edu

Traditional diets of northern indigenous populations are rich in birds, fish and marine mammals, leading to high exposures to methylmercury (MeHg) and polychlorinated biphenyls (PCBs). Dietary advisories restricting consumption of local traditional foods are the predominant tool used to reduce risks associated with bioaccumulative contaminants. However, traditional foods contribute disproportionately to overall intakes of vitamin D, omega-3 fatty acids and other essential nutrients, and the transition to diets based on store-bought foods has been linked to adverse health outcomes including increased rates of obesity, cardiovascular disease and diabetes. Therefore, dietary advisories must weigh the risks posed by increased exposures to bioaccumulative contaminants against the risks posed by the loss of key nutrients, which act alternately on cardiovascular, neurodevelopmental and oncogenic endpoints. We quantify for the Inuit of Labrador, Canada the significance of local and store-bought foods to the overall dietary calories, MeHg, PCBs and a suite of nutrients. While local foods account for only 10% of total calories, they are the main source of MeHg (70%), PCBs (>90%) and a disproportionate source of omega-3 fatty acids (36%) and vitamin D (39%). We construct scenarios to forecast the cardiovascular, neurodevelopmental, cancer and nutritional impacts of substituting store-bought foods for local foods in comparison to the risks posed by increasing levels of MeHg. We find that substituting store-bought foods for local foods to preserve baseline MeHg exposures can reduce but not completely eliminate neurological impacts on developing children. However, the relative risk of cardiovascular death is greater for store-bought food substitution scenarios (population mean < 1.5) than the baseline diet for MeHg increases in local foods up to roughly seven times the baseline measured values. Food substitution scenarios generally increase population-wide cancer risks (population mean relative risk < 1.1, hepatic and colorectal cancers) relative to baseline and are associated with a decline in sufficiency of key nutrients (e.g., iron, phosphorus) of < 10% required daily intake. This work demonstrates that dietary advisories alone cannot be used to mitigate risks associated with increased exposures to MeHg and, in many cases, may increase these risks.

*However, the relative risk of cardiovascular death is greater for store-bought food substitution scenarios than the baseline diet for MeHg increases in local foods even up to roughly seven times the baseline measured values. Food substitution scenarios generally increase population-wide cancer risks ... and are associated with a decline in sufficiency of key nutrients ...*

### Key Conclusion in 2017 Poster at Global Hg Conference

- <10% of calories from country foods
- Greater health risks accrued from eating anything else but country foods
- Risk – communication very important