Environment and Climate Change Canada | Environnement et Changement climatique Canada

SEA-RUN ARCTIC CHAR, MERCURY AND CLIMATE CHANGE

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Cambridge Bay, Nunavut
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New: Heidi Swanson

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WHY ARE WE MEASURING MERCURY IN SEA-RUN CHAR?

- In 2004, the **Northern Contaminants Program (NCP)** identified a need for more information on mercury and persistent organic chemicals in sea-run char because these fish are important in Inuit diets and some commercial fisheries

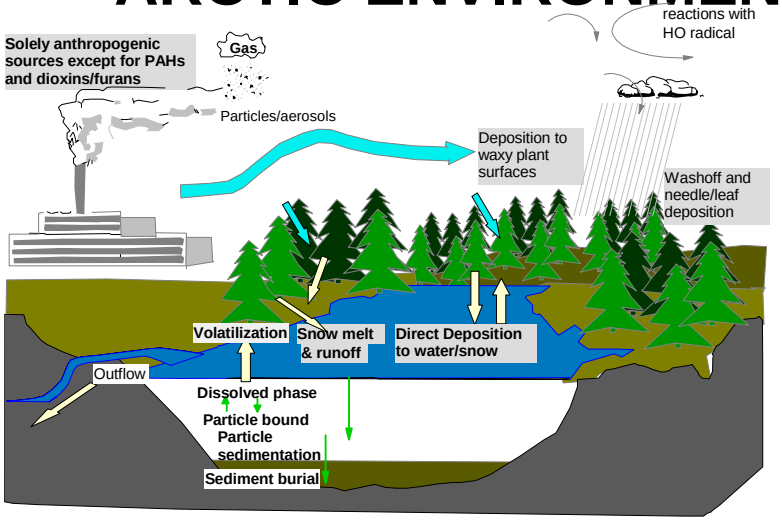
- Thus, we began our annual monitoring of sea run char at Cambridge Bay to see how concentrations are changing with time with a current focus on mercury.

WHAT IS THE NORTHERN CONTAMINANT PROGRAM AND WHAT IS IT CONCERNED ABOUT?

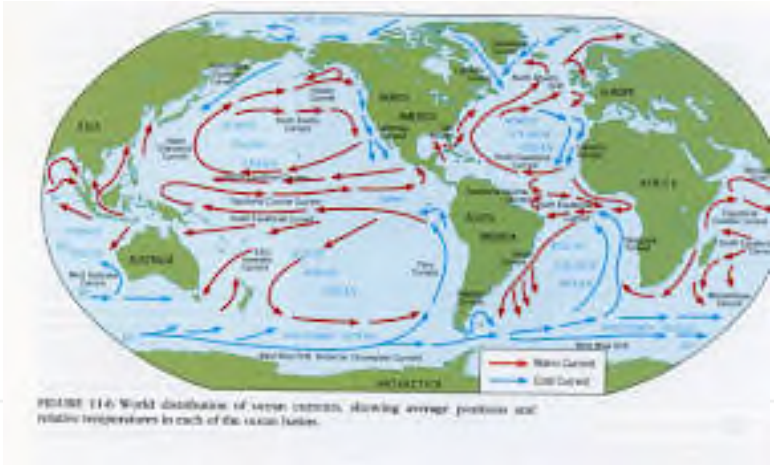
Småradóttir et al. 2014. Future Opportunities for Bioeconomy in the West Nordic Countries

- In the 1960s and 1970s, certain man-made chemicals were becoming harmful to the environment in various regions in the US and southern Canada
- In the late 1980s, researchers learned that some of these harmful contaminants were reaching subarctic and arctic environments from the south.
- In the early 1990s, the **Northern Contaminant Program (NCP)** was established to measure these chemicals in northern Canada.
- NCP works with with other subarctic and arctic countries under the **Arctic Monitoring Assessment Program (AMAP)** to reduce chemical contamination by providing **evidence** which can be used to restrict in chemical use.

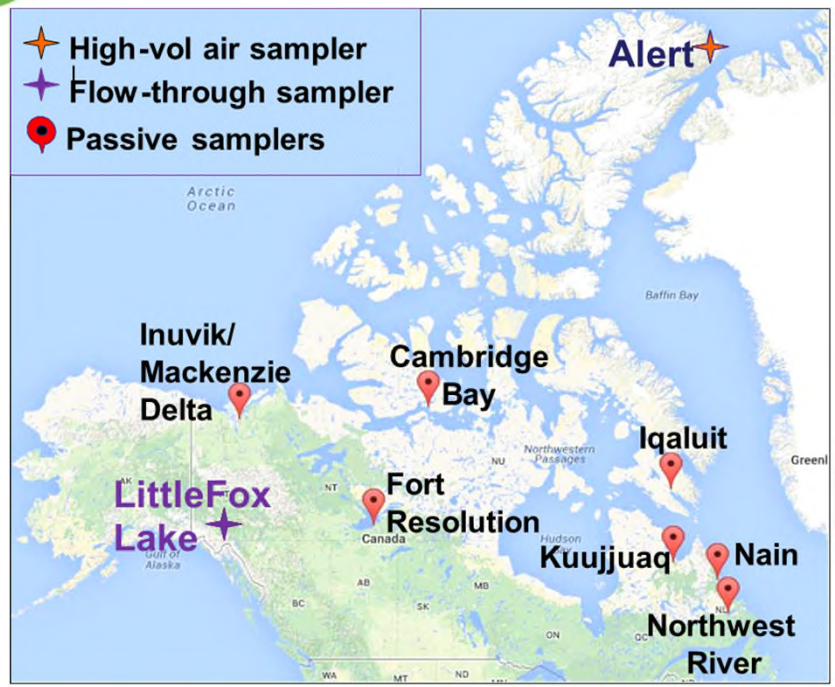
HOW DOES MERCURY AND OTHER CONTAMINANTS GET INTO ARCTIC ENVIRONMENTS?



- Primary source is long range atmospheric transport
  - Human various industrial activities and uses and releases as emissions.
  - Natural: forest fires, volcanoes
- Major ocean currents
- River inflow, e.g., Mackenzie



Air Monitoring Contaminants across the Arctic



Using passive sampling techniques

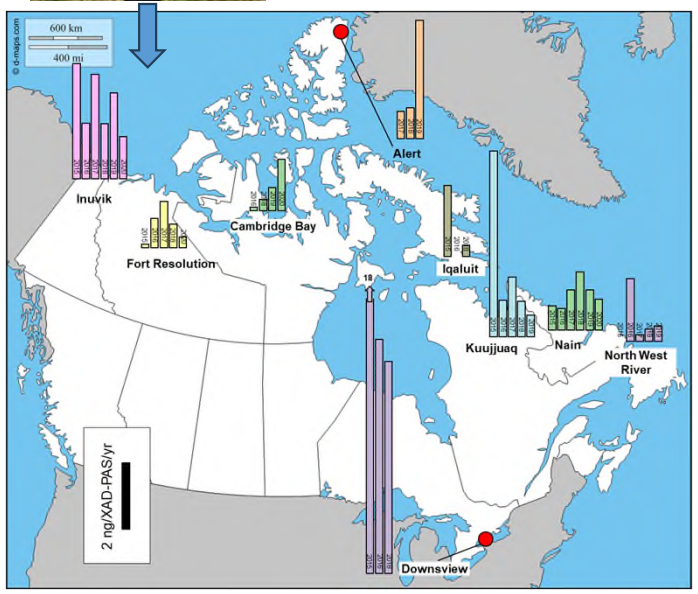
POPs (2014)

Mercury (2019)

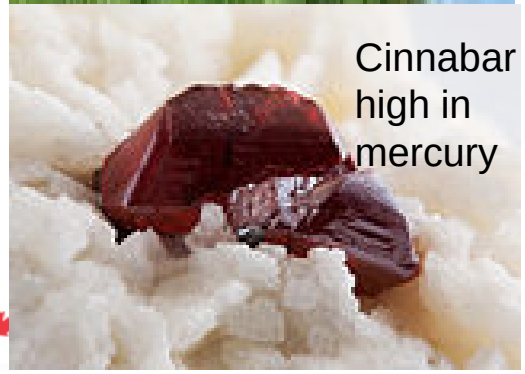
Chemicals for Teflon coating, stain prevention sprays hamburger wrappers, popcorn bags and firefighting foam

(Per- and polyfluoroalkylated compounds)

NCP: Hayley Hung, Sandy Steffen



What is mercury and where does it come from? Some basic facts



Cinnabar high in mercury

- Mercury is one of more than 100 chemicals (atoms or elements) created at the beginning of time when uiverses created
  - More familiar elements are oxygen, iron, and copper
  - Mercury is also known as quicksilver
  - Mercury concentrations are high in rocks such as cinnabar
- Mercury is found everywhere
- Mercury cannot be seen in the natural environment
- Very specialized analyses and instruments are required to measure mercury in the environment

Canada

MERCURY USES

- Ancient peoples used as mirrors, in pigments (cinnabar), and medicines. Pools of mercury. Gold extraction.
- Modern uses in dental fillings, medicines, pigments, batteries, thermometers, light bulbs, and in the production of chlorine which has various uses, e.g. bleaching wood pulp.
- Mercury uses being phased out.
- Major current sources are coal-fired power plants, vegetation burning, and artisanal gold mining.

MERCURY CAN BE TOXIC

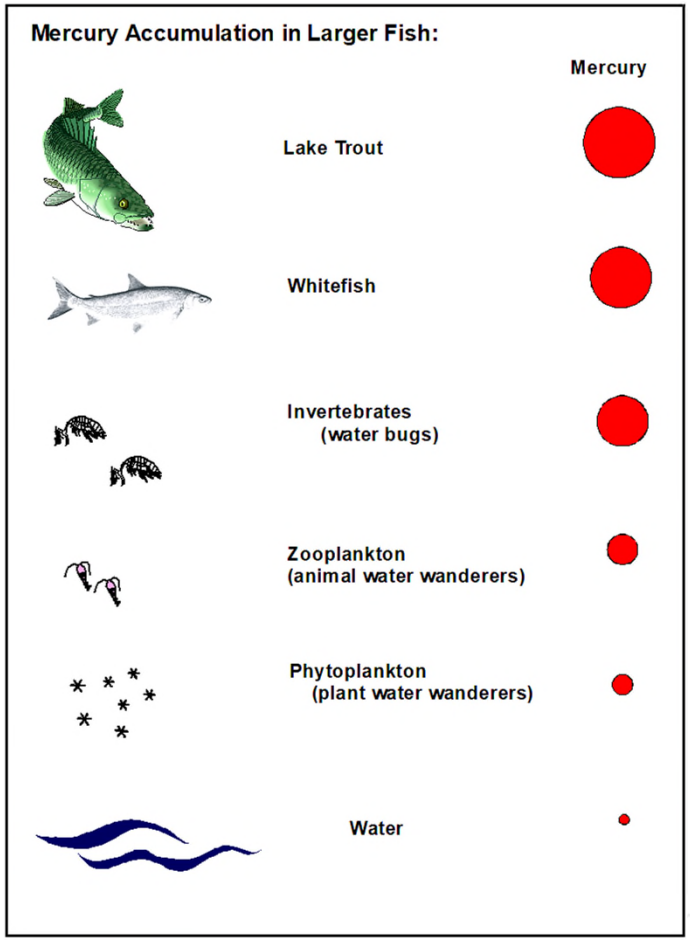
In high concentrations, mercury can produce harmful effects on nervous, digestive and immune systems, lungs and kidneys

- **Mercury vapors**
  - Ancient artisan workers used liquid mercury to extract gold from ore. Mercury burned off and toxic fumes released
  - Felt production in the 18th and 19th centuries used mercury: Mad Hatter disease
- **Mercury ingestion**
  - Chinese emperor poisoned by mercury ingestion
  - 1971 Iraq poison grain disaster
    - Grain treated with mercury to kill fungi
    - 459 deaths; more cases of brain damage
  - Fish consumption in certain environments

WHERE CAN MERCURY CONCENTRATIONS BE HIGH IN FISH?

- **Where mercury is used to extract chloride from salt (sodium chloride) to make chlorine and the mercury waste discharged into waterways in high concentrations.**
  - Minamata in Japan in 1956 where a factory produced various chemicals using chlorine
  - Grassy Narrows, Ontario in the 1960s where mercury released into Wabigoon-English river system by pulp and paper mills
  - Sarnia, Ontario in the late 1960s where there were numerous chemical manufacturing various compounds using chlorine
- The common factor was that these people ate a lot of predatory fish (e.g., pike, walleye, lake trout) on a regular basis and mercury built up in their bodies

WHY DO SOME FISH HAVE HIGH MERCURY CONCENTRATIONS- BIOMAGNIFICATION



- Mercury in taken up from the water by small plants.
  - This mercury builds up over the short time the plant cell lives before dividing into two - every few days
- Small animals (zooplankton, aquatic insects) eat these plants and consume this mercury.
  - Mercury builds up over the weeks to months that the animal lives
- Fish that eat these small aquatic insects have more mercury in their food than the food insects eat.
  - This mercury builds up in the fish over its lifetime of two to several years of its life.
- Very large fish-eating will have the greatest amount of mercury in their food. Some fish can live more than 20 years
- A mercury concentration guideline of 0.5 parts per million (µg/g) established for commercial sale of fish.

Second reason- Mercury transformations

Cinnabar containing metal (inorganic) mercury.

Humans process in various ways to make useful products such as filling material

Inorganic

Inorganic mercury

Organic mercury

Soils, sediments and water also contain inorganic mercury

Organic mercury

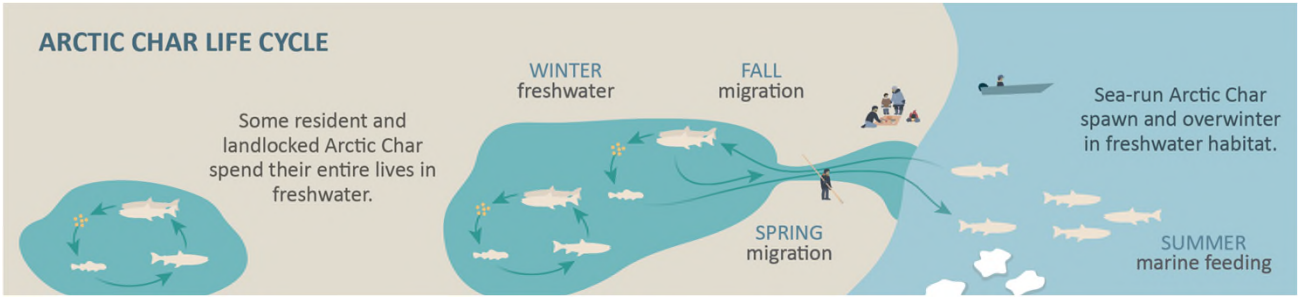
Organic mercury more easily taken up and biomagnified in food web and fish than inorganic.

In warm, organic-rich aquatic/marine environments, certain bacteria convert inorganic mercury to organic mercury (methyl mercury)

Climate change and warming may increase these transformation rates

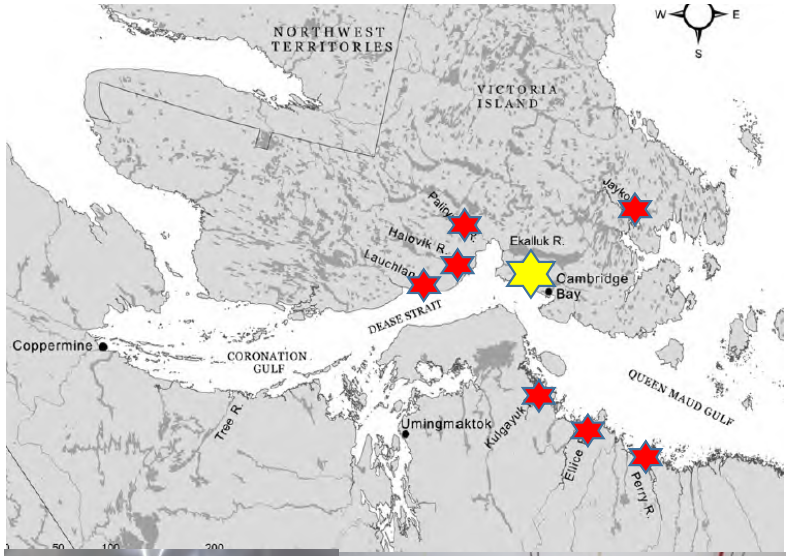
Arctic char and Inuit communities

- Important in Inuit diets for thousands of years
- High in protein, a good source of essential fatty acids (especially omega-3 fatty acids), calcium and vitamin D



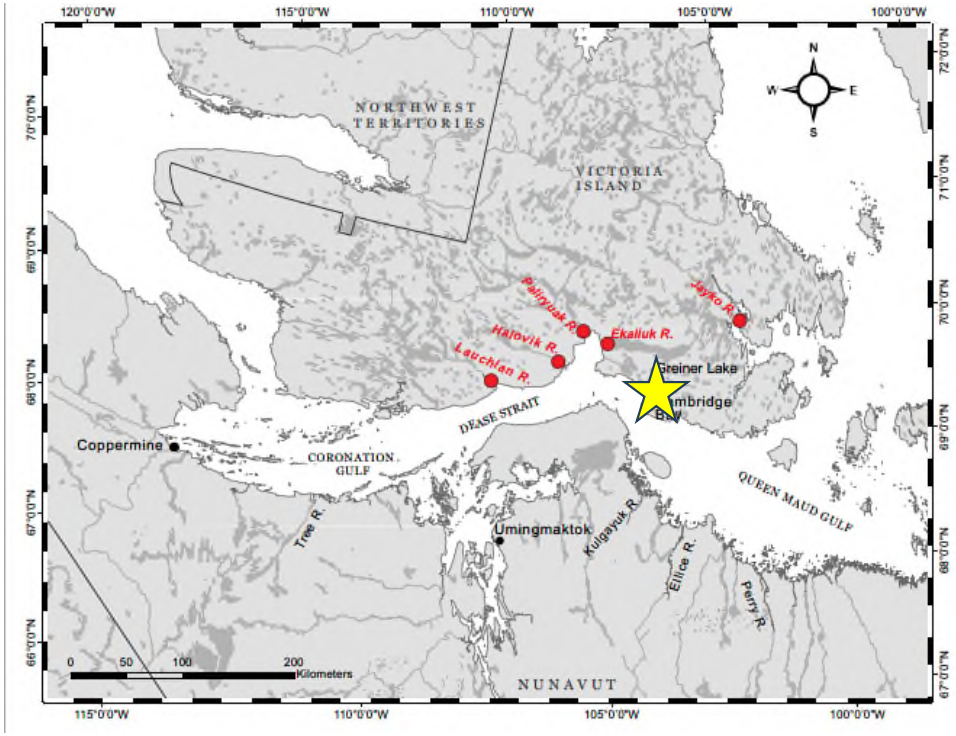
- Arctic char lives in lakes and rivers along the coastal arctic and subarctic. Three ecological types:
  - **Landlocked char** live in waters with no sea connection. Keyhole Lake.
  - **Resident char** live and feed in waters with marine connections but do not migrate to sea.
  - **Sea-run char** migrate to the sea every two years (?) to feed intensively on marine life. May not feed inland in the second year when they reproduce.

Arctic char and Cambridge Bay: History of our Study

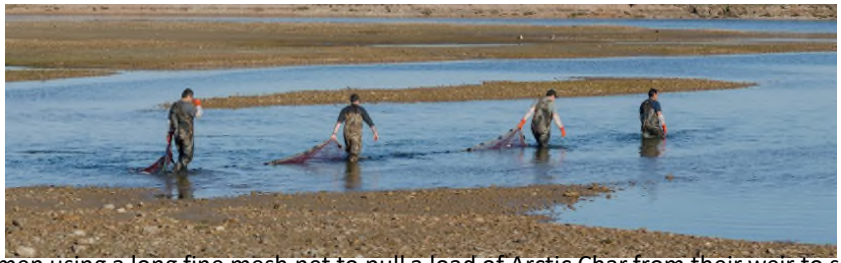


- Commercial sea-run fishery at several locations (red stars).
  - Over 1987-1994 small numbers of fish analyzed for mercury.
  - Concentrations were low averaging 7 times below commercial sale guidelines.
- Over 2004-2012, NCP, we investigated mercury and other chemicals (e.g., PCBs) in sea-run char at 20 communities including Cambridge Bay
- Concentrations were low with no issues with PCBs, DDT, etc., including Cambridge Bay, a former DEW Line site.
- Since 2012, only mercury and metals are being measured in the sea run char at Cambridge Bay annually.

Sea run char sampling

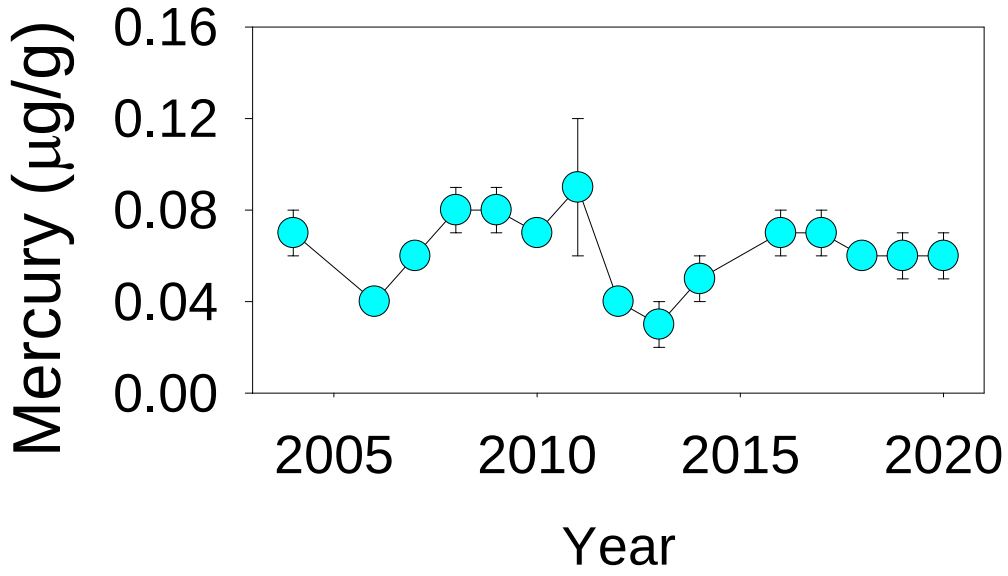


- Each year Bev arranges for 20 sea run char to be caught for us from the domestic fishery. Yellow star
- Fish are shipped to Saskatoon and measured, and sex and age determined. Also measured for mercury and over 40 other metals
- Les Harris from DFO has been providing us from fillet from the commercially harvested rivers which we analyze for mercury as circumstances allow.



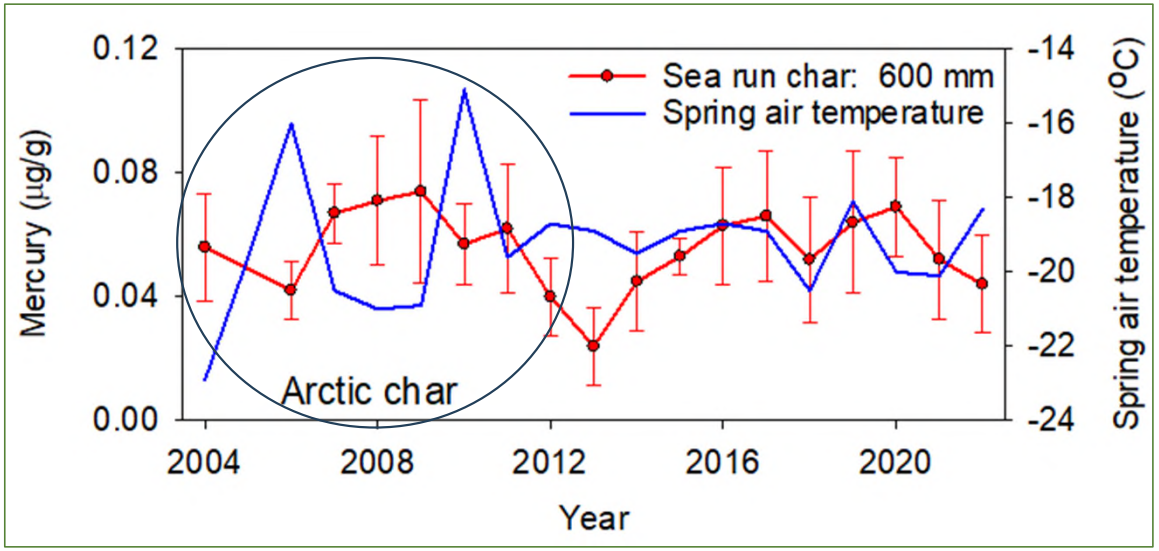
Fishermen using a long fine mesh net to pull a load of Arctic Char from their weir to shore in Halokvik River near Cambridge Bay, Nunavut. (Aug. 2017). Photo credit: Matthew Gilbert

Sea-run char and Cambridge Bay: NCP highlights



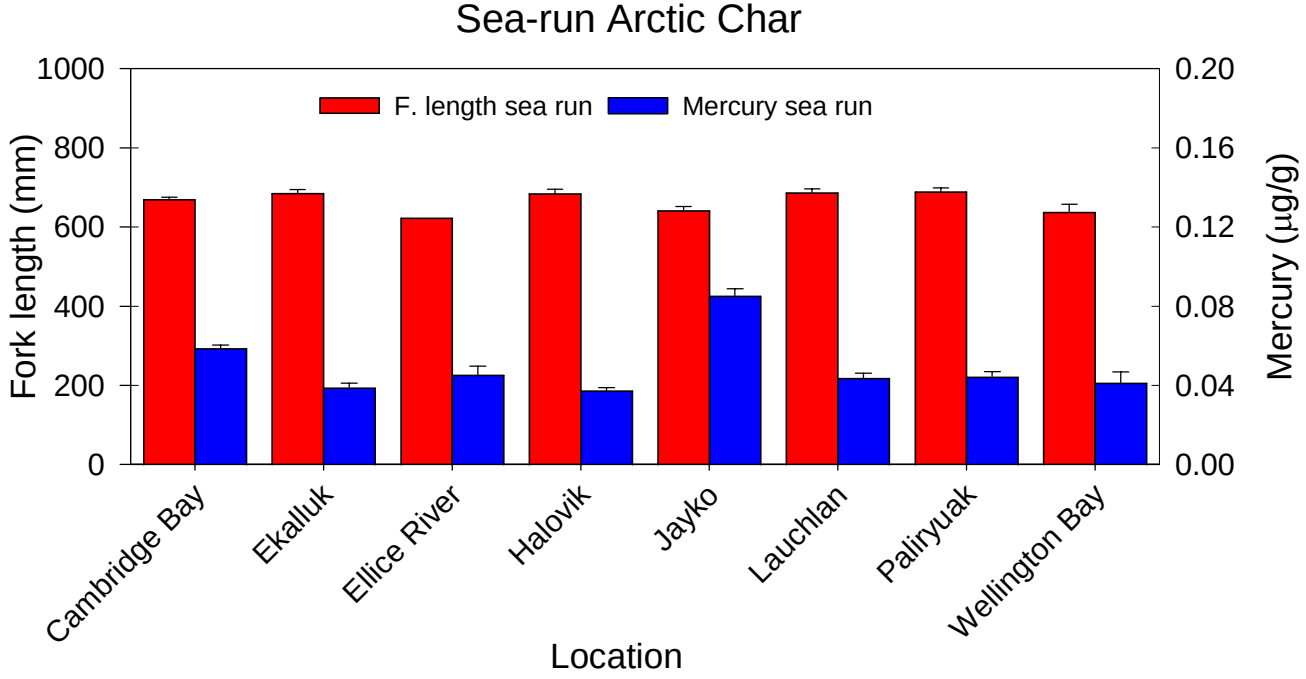
- Mercury concentrations remain low in the community fishery with an average 0.05 µg/g or 10 times lower than commercial sale guideline.
- Some of the small differences between years are related to fish length, age, how fat the fish were and where they were feeding.
- We are not seeing any trends of mercury increase

Sea-run char and Cambridge Bay and spring air temperature



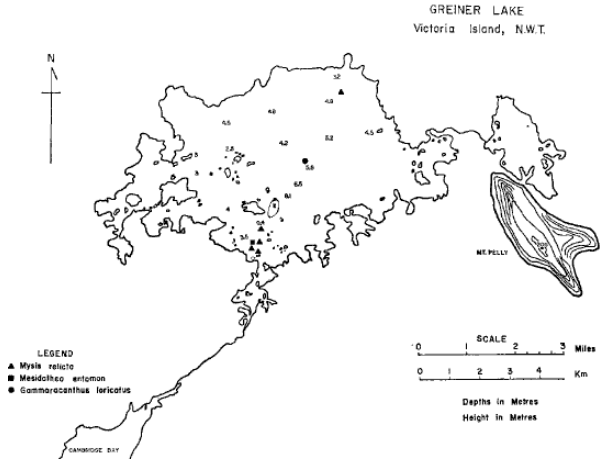
- We looked at mercury concentrations in 600-mm long char to see if we could see any trends
- Initially, it seemed that mercury concentrations were higher in fish in cold than warm springs over 2004-2010
- We thought this was related to slower char growth, thinner fish and more concentrated mercury in the cold springs where the spring diatom bloom was delayed than warm springs
- Average spring air temperatures and mercury concentrations not changing much in recent years.
- Big gaps in summer air temperature readings

Mercury concentrations in commercially harvested locations



- Similar size fish (red) caught at all sites
- Mercury concentrations in at these commercial fishery sites very low.
- About twice as high at Jayko than other sites. These may be resident char living in the river who do not go out to sea.
- Jayko char may be particularly vulnerable to climate warming.

Greiner and other lake studies

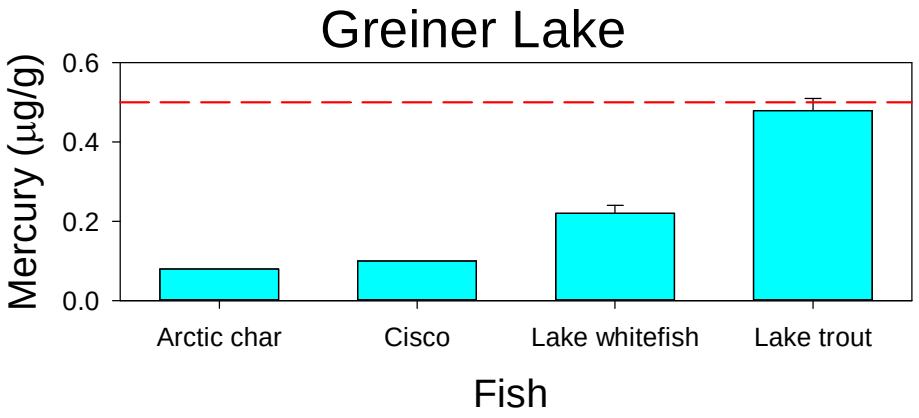


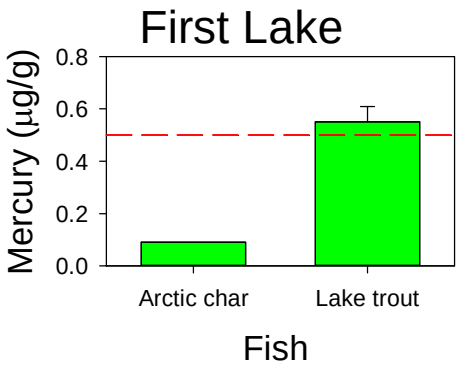
- In 2014 and 2015, using ECCC funds, we obtained char and lake trout from Greiner Lake for mercury analyses
- This early study allowed us to develop a partnership with Milla Rautio and the HTO to do more in-depth studies in Greiner Lake with the funding Milla obtained.
- Milla's focus is on the entire food web, including fish and on fatty acids. Also oxygen and temperature.
  - **Letters of support provided by the HTO have been essential in our obtaining our funding over the years**

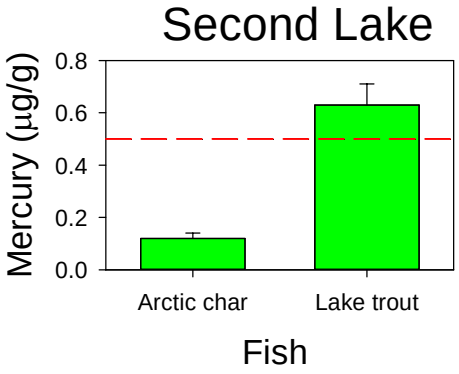
Lake studies with Milla Rautio

- Milla initially focused on Greiner Lake
- Fish collection with community fishermen
- Food web samples: fairy shrimp, copepods, mysids, stickleback
- Fatty acid and stable isotope analyses
- Mercury: fish (Evans)
- Later looked at fish in First and Second Lakes and CBL-5 at community request.
- Winter studies – dissolved oxygen

What have we found out about mercury in lake fish?

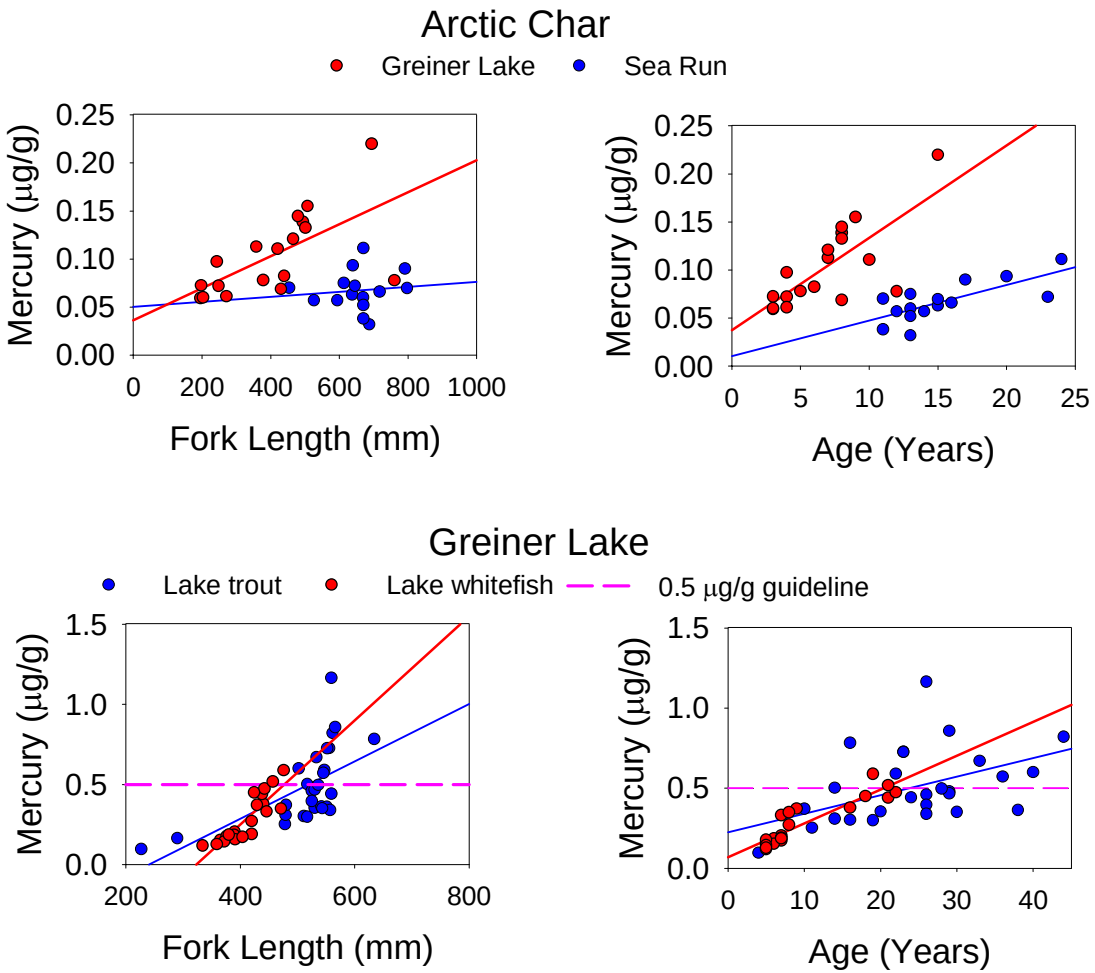






- Mercury concentrations are very low in char and cisco (herring)
- About 3-4 times higher in lake whitefish.
- Mercury concentrations are highest in lake trout
  - Average concentrations approach the 0.5 µg/g guideline
- Char and whitefish have the highest “good fat” concentrations (Milla)
- Similar results for First and Second Lakes for lake trout and char

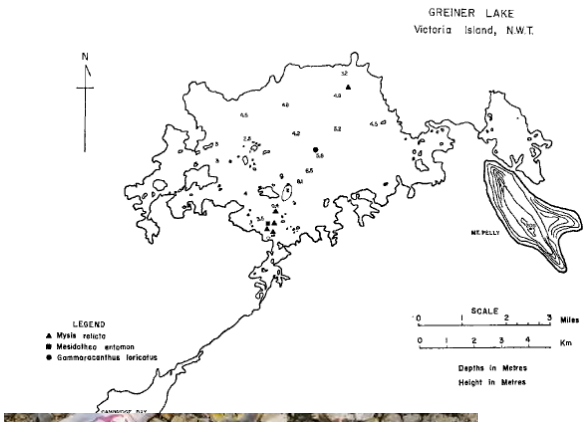
Species and Cambridge Bay (sea) versus Greiner Lake comparisons 2017



- Mercury concentrations increase with char length and age in Grenier Lake
- Substantially lower concentrations in sea run char and less of an increase with length and age
- Mercury concentrations may be higher in lake than sea water and more readily transformed into organic mercury

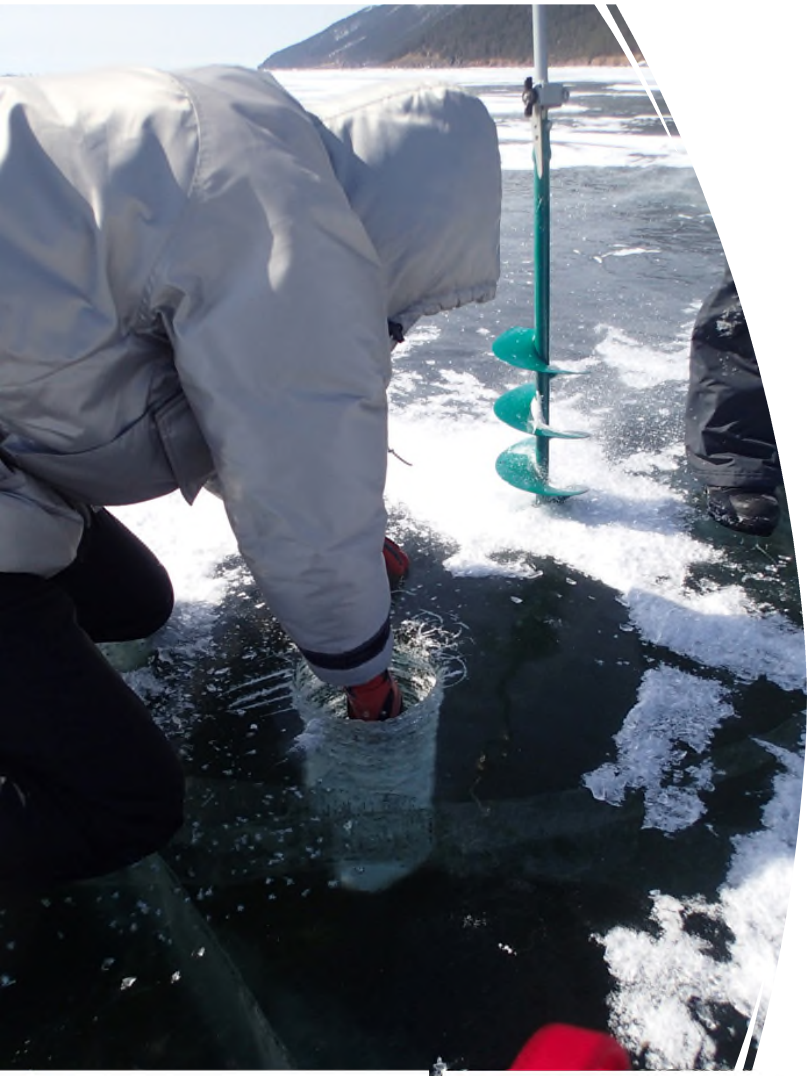
- For Greiner Lake, mercury concentrations increase strongly with lake whitefish and lake trout length and age
- Higher concentrations associated with fish greater than 500 mm long and 20-44 years old
- These two species not fished much
- There may be slow and fast growing fish in this lake

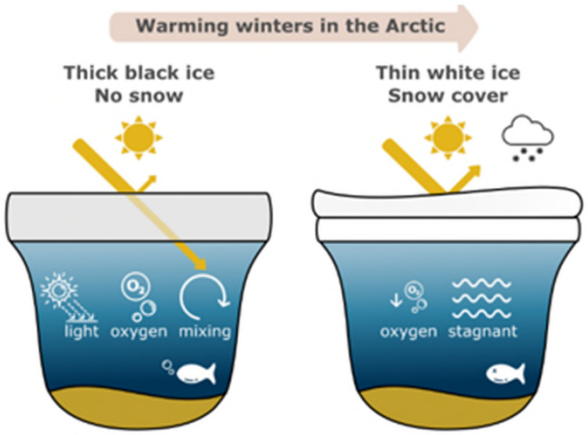
Where do we want to go next? Mercury in fish

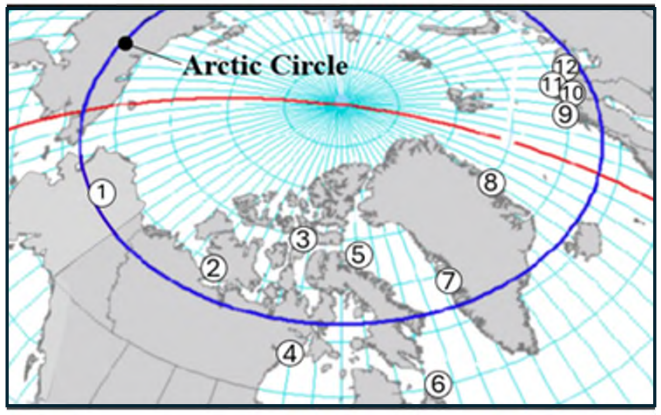


- For several years we have wanted to establish a **formal** program for the long-term monitoring of mercury in lake trout and summer caught char lake in Greiner Lake to determine how mercury concentrations change over time (climate warming, mercury emissions).
- Warming temperatures may benefit lake trout, char, llake whitefish, allowing them to grow faster and reduce their mercury concentration.
- However, mercury concentrations could also increase in all fish with permafrost melt and more vegetation growth.
- Working with Milla will tell us more about the lake environment
- NCP has approved summer caught char and lake trout monitoring from Grenier Lake for 2025-2026 and 2026-2027 and probably beyond.

We want to develop opportunities for community-based lake monitoring, possibly as part of high school classes, CHARS, and the technical college. Science Fairs?







FROST

Milla's new project

Arctic freshwater food systems: Influence of warming winters and increased snow cover (2025-2029)

Milla Rautio (lead, UQAC) & Kimmo Kahilainen (co-lead, UHelsinki)
+ 13 Canadian and international PIs
+ 5 Inuit and 2 Sami partner institutions. Bev and the HTO partners

NordForsk

Social Sciences and Humanities Research Council of Canada
Conseil de recherches en sciences humaines du Canada
Canada

Conclusions

- Mercury concentrations are very low in sea run char and only slightly higher in char that not go out to sea in the summer. They are well below commercial sale guidelines
- We are monitoring mercury trends in sea run char but are not seeing any, possibly because the ocean is so big and cold and slow to respond to climate change and changes in mercury input. Greiner Lake would be more responsive.
- Mercury concentrations are somewhat higher in lake whitefish than char in Greiner Lake. Very old lake whitefish (>20 years) have higher values
- Mercury concentrations are highest in lake trout and increase with fish age (up to 40 years).
- We believe lake whitefish and lake trout are not fished much and that is why they are old.

Conclusions

- Climate warming is more likely to affect char and other fish living in Greiner Lake than in the ocean and so we will begin monitoring trends in their char and lake trout in 2025.
- Milla Rautio has obtained new funding to investigate the influence of warming winters and snow cover on Grenier Lake and 7 other Canadian Arctic systems.
- Bev and the HTO will be an important part of studies at Greiner Lake with her/their own funding.
- Heidi Swanson from the University of Sir Wilfred Laurier is joining this project building on her work on the Coppermine River with community members, the Deh Cho, and her earlier work in the Cambrdige Bay area on lake trout and char.

ACKNOWLEDGEMENTS

- Funding and partnerships provided by Northern Contaminants Program, Environment and Climate Change Canada, Department of Fisheries and Oceans and Arctic Net and Polar Knowledge funding to Milla Rautio.
- Community partnerships with the Ekaluktutiak Hunters and Trappers have been invaluable and are strengthening as capacity and knowledge grows