Temporal trends and spatial variations in persistent organic pollutants and metals in sea-run Arctic char from Cambridge Bay, Nunavut

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Introduction

Sea-run char are important in the diets of many northern communities. Since 2004, we have been investigating spatial and temporal variations in contaminant concentrations in char across northern Canada. Initially we focused on investigating spatial variability in persistent organic pollutant (POPs) and mercury, concentrations in char at 20 locations, including Cambridge Bay and Nain, both of which support commercial fisheries. In recent years, our program has focused on mercury trends in sea-run char at Cambridge Bay, the location of the new Canadian High Arctic Research Station (CHARS). Our study is investigating the influence of climate and other drivers in affecting mercury trends. We also have begun investigating char and lake trout in Grenier Lake where our sea-run char are believed to live most of the time.

Methods

- Since 2004, 20 sea-run char were provided by participating communities from their domestic fishery. Ten fish were selected for stable isotope, POPs, mercury and metals analyses; the remaining tissue was archived for possible later analyses including legacy organic contaminants, PDBEs and PFCAs. Since 2010, analyses have focused on mercury and metals in char at Ekaluktutiak (Cambridge Bay).
- Since 2014, 15 char and 15 lake trout from Grenier Lake have been provided annually to us by the Ekaluktutiak Hunters and Trappers Organization for mercury and various biological analyses. These collections are allowing us to investigate how mercury concentrations and trends differ between char feeding in the ocean and the freshwater and with respect to warming and other trends.
- We are working with other researchers at Grenier Lake investigating ecosystem dynamics, including lipids in food webs.
- Fisheries and Oceans Canada is conducting stock assessment studies at the mouths of the several river/lake ecosystems and have provided us with samples of sea-run char. These samples are allowing us to compare sea-run char populations and make better use of the commercial fish records of mercury in char.

Results and Discussion

Temporal trends of mercury in Cambridge Bay sea-run char

- Mercury concentrations have been consistently low in sea-run char harvested in the domestic fishery at Cambridge Bay (Fig 1).
- Variations in mercury concentration in char over 2004-2016 were best explained by a positive relationship with fork length and a negative relationship with year and condition factor.
- The decrease in mercury with increased condition factor may be related to growth dilution as has been observed elsewhere [1].
- Mercury concentrations tended to be higher in Jayco than in Halovik and Lauchlan River char. Some of these fish may have been resident and not sea-run.
- Ongoing analyses are investigating temperature and air circulation indexes as factors affecting mercury trends in char.

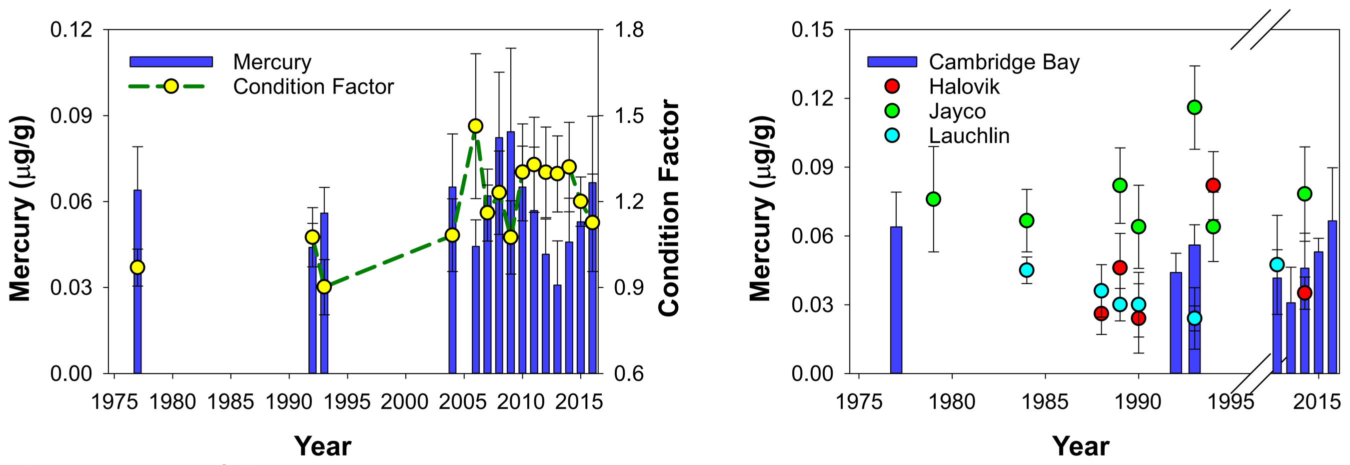

Figure 1. a)Temporal variations in mercury concentrations and condition factor in Cambridge Bay sea-run char over 1977-2016, and b) temporal variations in mercury concentrations in sea-run char from Cambridge Bay and three river sites over 1977-1994 and 2011-2016. See fig. 4 for locations.

Sea-run char and mercury concentrations in northern Canada

- Mercury concentrations in char were low (0.05±0.02 µg/g), tending to be higher at more northerly latitudes and in western Canada (Fig. 2).
- Fish were old (12.9±2.8 yr) especially in the northern and central Arctic where fishing pressures may have been less intense (Fig 3).
- Carbon isotope ratios were lowest in the western Arctic suggesting a Mackenzie River terrestrial influence; this infuence enhanced mercury inputs and potentially methylation rates (Fig. 3).

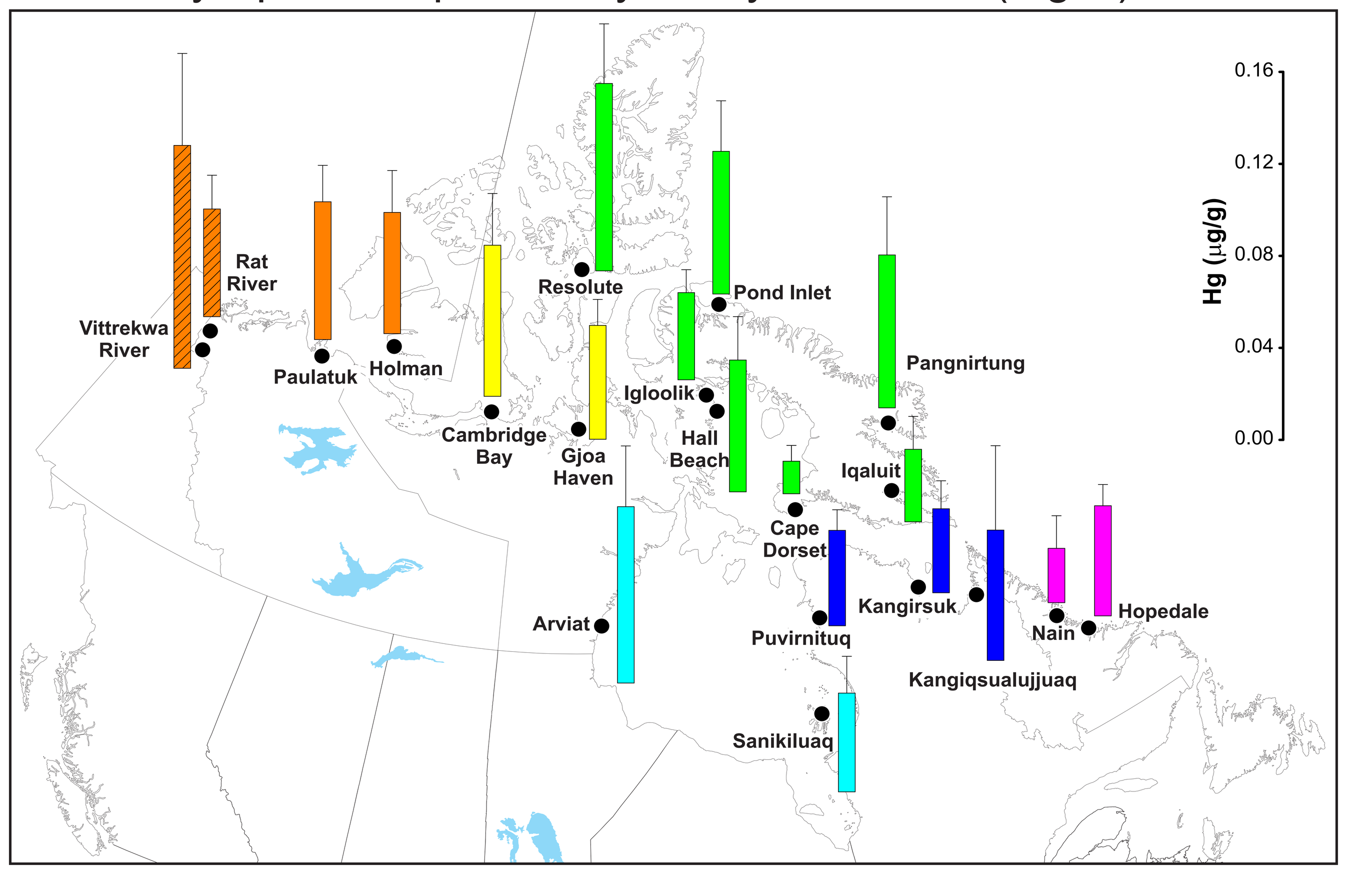

Figure 2. Map showing mean (±1 standard deviation) mercury concentrations of sea-run char collected from all study sites over 2004-2016.

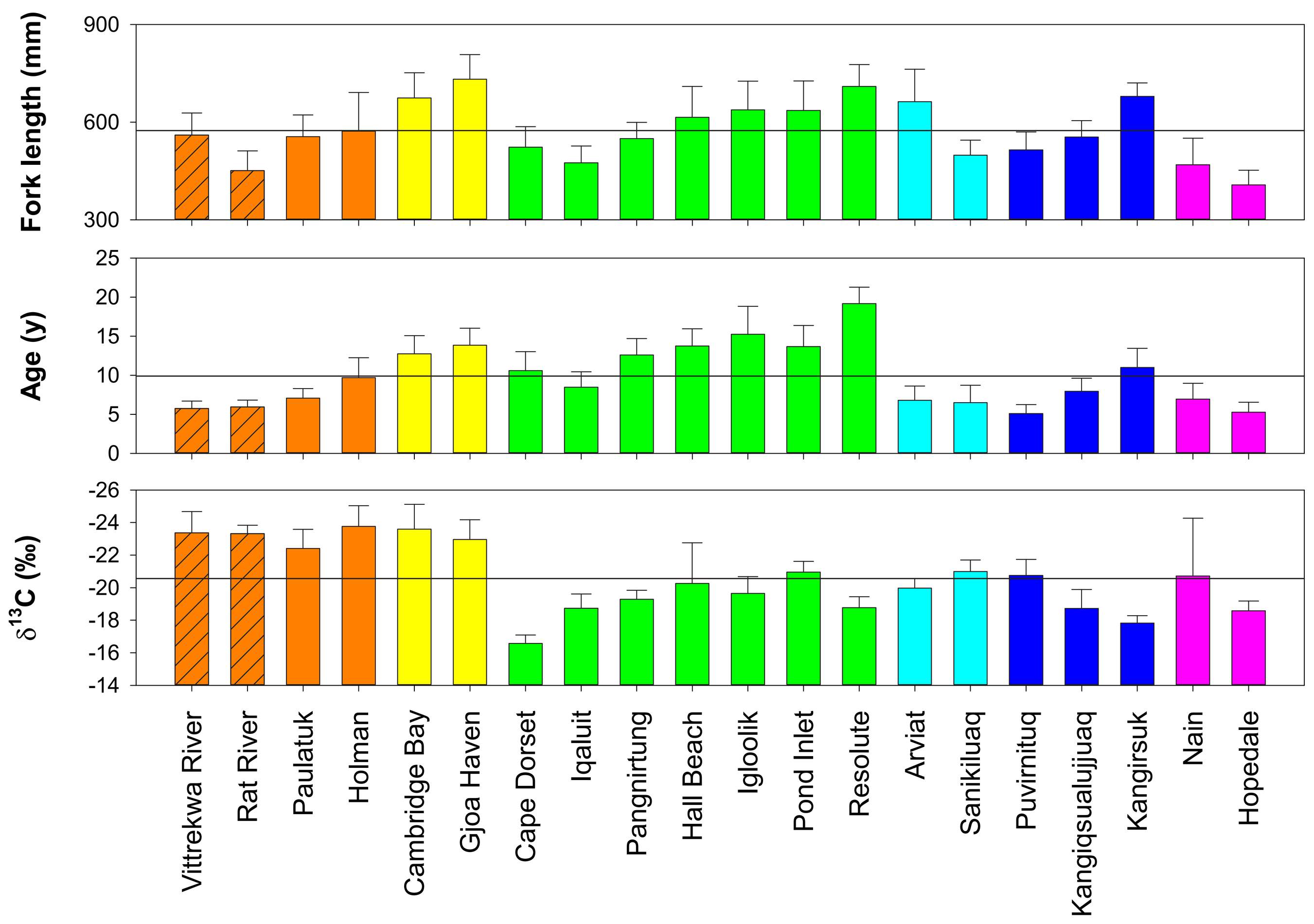

Figure 3. Mean (±1 standard deviation) length, age and carbon isotope ratios of sea-run char investigated over 2004-2016. Reference lines indicate average of all locations.

Cambridge Bay and Grenier Lake char and Greneier Lake trout

- Sea-run char from the domestic fishery (Fig. 4) were larger (fork length 658±90 mm) than char that had not gone out to sea (519±53 mm). Lake trout were small (501±19 mm) and old (26.8±8.5 yr).
- Mercury concentrations were lower in sea-run (0.05±0.02 µg/g) than in char living in the lake (0.07±0.04 µg/g). Grenier L. char had food in their stomachs, i.e., aquatic invertebrates and small fish.
- Mercury concentrations were substantially higher in lake trout (0.40±0.10 µg/g); some old fish had mercury concentrations exceeding 0.5 µg/g, the commercial sale guideline.

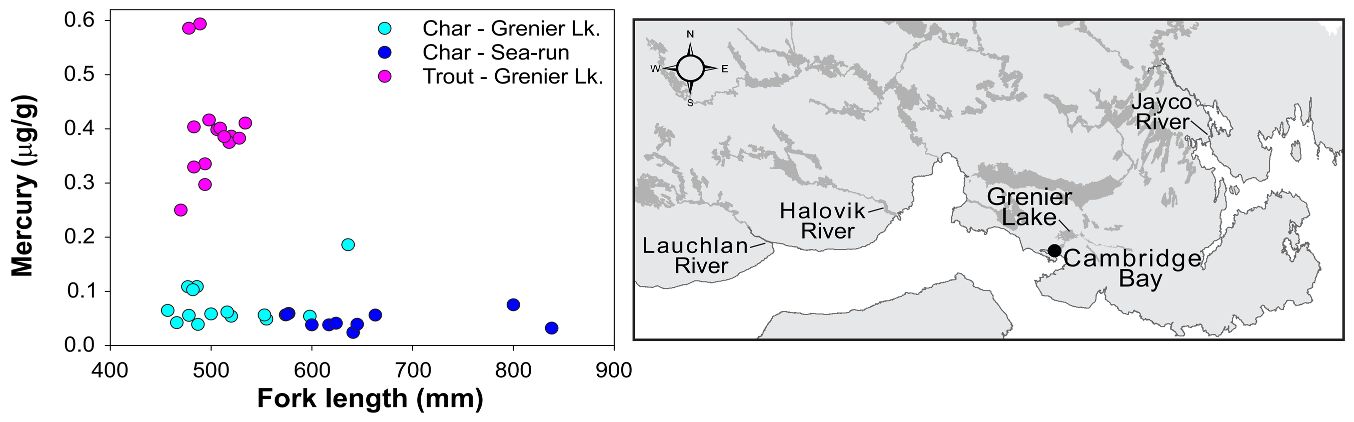

Figure 4. Mercury concentrations and fork length of char and lake trout collected from Cambridge Bay waters and Grenier Lake. Also shown is a map of the Cambridge Bay area and river sites where char are fished.

Temporal trends of POPs in sea-run char

- The strongest data for POPs trend assessments are for Cambridge Bay (1987-2012; n=5-7years depending on the compound), Pond Inlet (2005-2012; n=6-7 years) and Nain (1997-2010; n=4-5 years). Temporal trends were examined using PIA [2].
- Cambridge Bay char (Table 1) exhibited significant ($p<0.05$) declines in Σ-chlordane and Σ-DDT [3].
- Pond Inlet char exhibited a weak trend ($p=0.054$) of decline in α-HCH.
- Nain char exhibited a significant ($p<0.05$) decrease in α-HCH and γ-HCH.
- Decreases in α- and γ-HCH and Σ-chlordane appear to be related to declining atmospheric concentrations [4].
- No time trends were detected in BDE47 and BDE99 but the period of record is short. Overall, POCs concentrations were low.

Table 1. Time trends in lipid-adjusted persistent organic pollutant concentrations in sea-run char from Cambridge Bay, Nain and Pond Inlet. Data shown are the slope (% annual change per year) and R^2, the proportion of variance explained by the regression. Statistically significant (<0.05) slopes are in bold.

Parameter	Cambridge Bay		Pond Inlet		Nain	
	%/yr	R^2	%/yr	R^2	%/yr	R^2
% Lipid	+0.12	0.00	+1.9	0.06	+3.2	0.37
α-HCH	+0.9	0.00	-15	0.55	**-10**	**0.86**
β-HCH	+2.8	0.02	+4.4	0.11	-0.6	0.01
γ-HCH	-3.2	0.01	+7.7	0.12	**-9.5**	**0.86**
HCB	+2.4	0.16	0.6	0.01	0.6	0.05
Σ-PCB10	-7.5	0.21	-2.8	0.18	-5	0.18
CB153	-7.2	0.16	+1.6	0.04	-0.03	0.00
Σ-Chl	**-8.5**	**0.77**	3.9	0.10	+4.6	0.37
Σ-DDT	**-10**	**0.85**	-2.2	0.05	-1.2	0.03
p,p'-DDE	+16	0.43	+6.5	0.24	+2.6	0.06
Dieldrin	+1.2	0.02	0.3	0.00	-1.0	0.08
BDE 47	+7.7	0.16	-18	0.35	+11	0.07
BDE 99	-12	0.17	-31	0.28	+12	0.11

Conclusions

- Mercury and POPs concentrations are low in sea-run char fillet across northern Canada.
- The limited data suggest that POPs concentrations have declined since the early measurements made in the late 1980s and 1990s, including at former DEW-line sites.
- Trends of mercury increase have been reported in parts of northern Canada and related to warming temperatures [5]. However, warmer temperatures may enhance fish growth rates resulting in increased condition factor and reduced mercury concentrations [1,6].
- Our continuing studies at Cambridge Bay are allowing us to better investigate climate and mercury trends in char in marine and freshwater environments complementing studies at Resolute.

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