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; mercury and persistent organic pollutant (POPs) concentrations were low at all locations. Consequently, our sampling program has been reduced from 6 sites investigated annually over 2004-2009 to a single site, Cambridge Bay, where a commercial char fishery has operated for several decades and the new Canadian High Arctic Research Station (CHARS) is located. Our current focus is on the assessment of temporal trends in mercury concentrations in sea-run char and the influence of climate and other drivers in affecting these trends. We recently completed a synthesis of our mercury data collected over 2004-2013 [1], and are working on a POPs synthesis.

Methods

- 20 sea-run char were provided from the Cambridge Bay domestic fishery. Ten fish were selected for stable isotope, mercury and metals analyses; the remaining tissue was archived for possible later analyses including legacy organic contaminants and PDBE and PFC analyses.
- 15 char and 15 lake trout were collected from Grenier Lake (winter 2014-15) by the Ekaluktutiak Hunters and Trappers Organization and provided to us for mercury and other biological analyses. Sea-run char sampled from the domestic fishery are believed to reside primarily in this lake on their return inland.
- Fisheries and Oceans Canada is conducting stock assessment studies at the mouths of the several river/lake ecosystems where the commercial fisheries focus their efforts. Subsamples of sea-run char were provided from the Halovik, Jayco, and Lauchlan rivers for mercury analyses and enhanced trend assessments.
- We contributed to the Canadian Arctic Contaminant Assessment Report and to the Arctic Monitoring Assessment Program (AMAP) assessment of POPs trends in sea-run for Cambridge Bay, Pond Inlet and Nain.

Results and Discussion

Temporal trends of mercury in Cambridge Bay sea-run char

- There was a weak trend ($p=0.07$; $R^2=0.09$) of mercury decrease over 1977-2014 (Fig. 1).
- This trend was stronger when condition factor (38.523-0.020*Yr-0.0296*CF; $R^2=0.27$, $F=19.44$) was included in the model.
- A decrease in mercury with increased condition factor may be related to growth dilution and was observed at other locations [1].
- Increasing condition factor may be driven by warmer temperatures, enhanced feeding and growth.
- Mercury analyses of fish from the Halovik (2011, 2014), Jayco (2010, 2014) and Lauchlan (2012) rivers are ongoing; the limited historic record and recent analyses suggest that mercury concentrations tended to be higher in Jayco R. char than in Halovik R. and Lauchlan R. char.

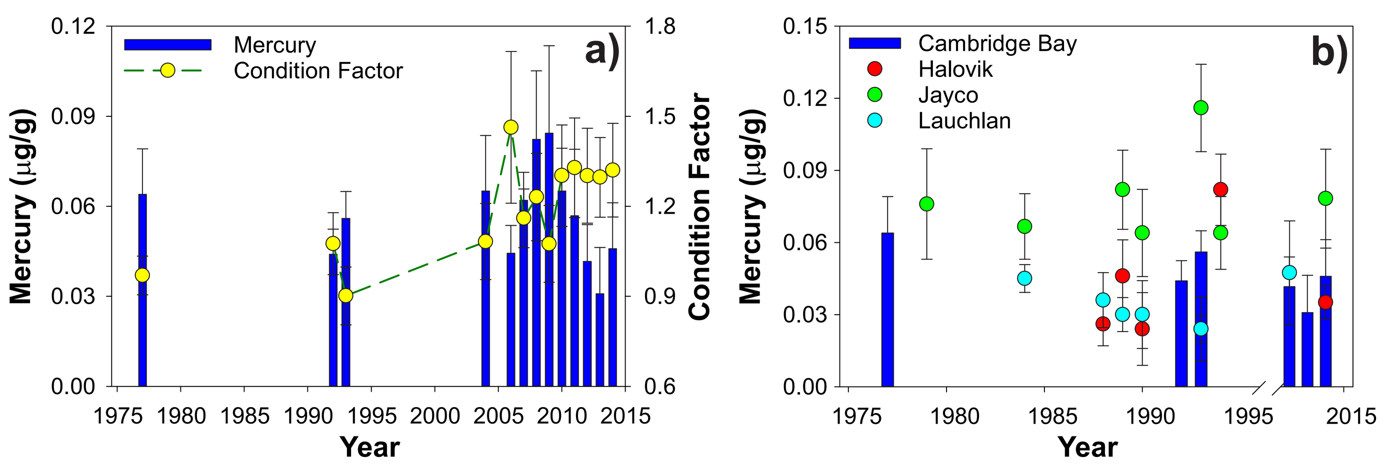

Figure 1. a)Temporal variations in mercury concentrations and condition factor in Cambridge Bay sea-run char harvested over 1975-2014, and b) temporal variations in mercury concentrations in sea-run char collected from Cambridge Bay and three river sites over 1977-2014.

Spatial patterns of mercury in sea-run char

- Mercury concentrations were low in sea-run char at all sites examined averaging 0.05±0.02 µg/g (Fig. 2).
- Mercury tended to be higher in fish at more northerly latitudes (fish were larger, older, and slower growing) and in western Canada, where the Mackenzie River influence was strong and factors such as terrestrial inputs of mercury and relatively high productivity may have enhanced mercury methylation rates (Fig. 3).

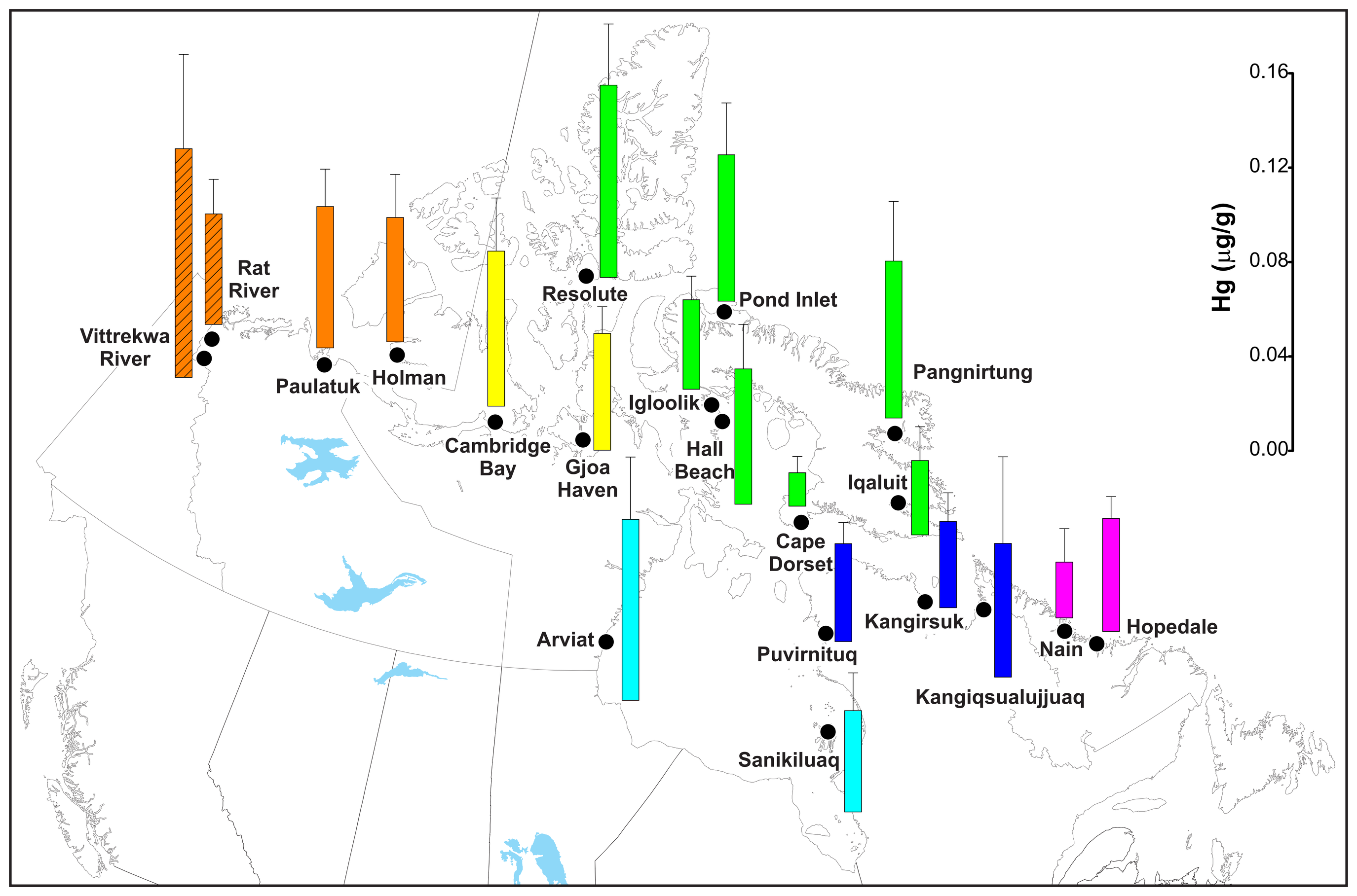

Figure 2. Map showing mean (±1 standard deviation) mercury concentrations of sea-run char collected from all study sites over 2004-2014.

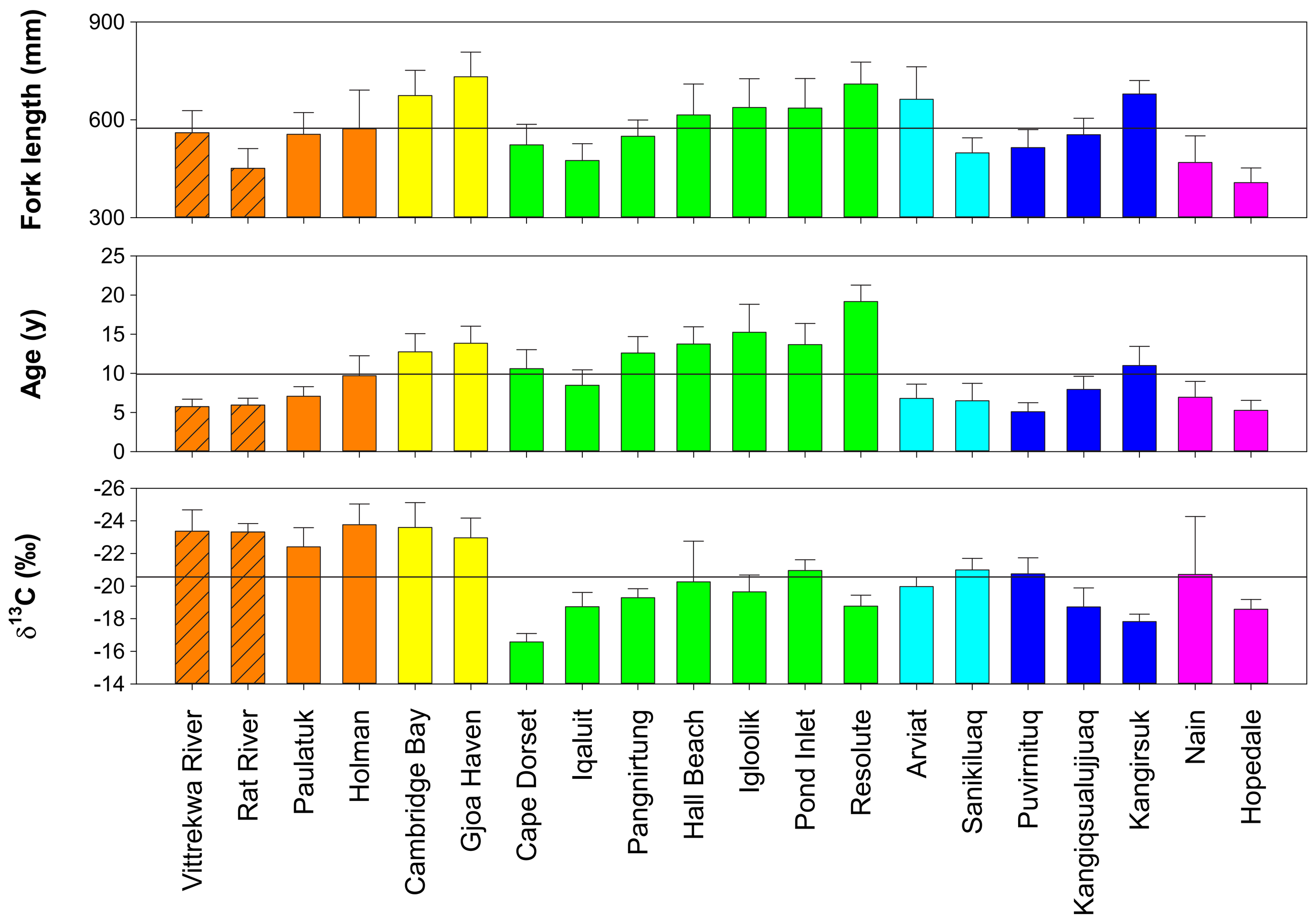

Figure 3. Mean (±1 standard deviation) length, age and carbon isotope of sea-run char investigated over 2004-2014. Reference lines indicate average of all locations.

Grenier Lake char and 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) and lake trout (501±19 mm).
- Mercury concentrations were lower in sea-run char (0.05±0.02 µg/g) than in char that had not migrated (0.07±0.04 µg/g).
- Mercury concentrations were substantially higher in lake trout (0.40±0.10 µg/g) with a few lake trout having mercury concentrations exceeding 0.5 µg/g.

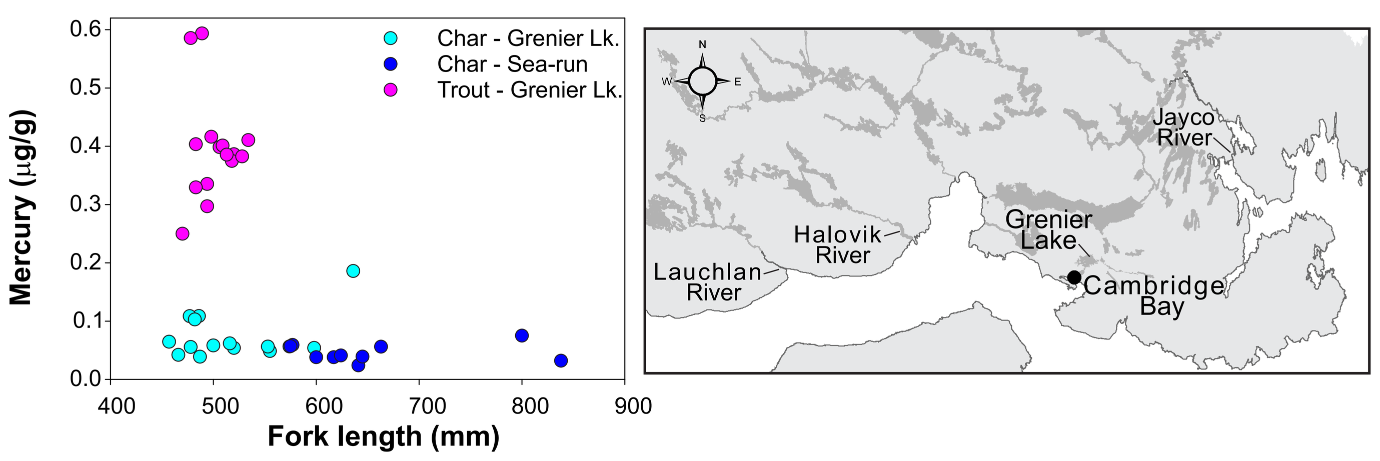

Figure 4. Mercury concentrations and fork length of char and lake trout collected from Cambridge Bay waters and Grenier Lake 2014. Also shown is a map of the Cambridge Bay area.

Temporal trends of POPs in sea-run char

- The strongest data bases for POPs trends assessments are for Cambridge Bay (1987-2012; n=5-7 years 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 declines in Σ-chlordane and Σ-DDT since 1987 [3].
- Pond Inlet char exhibited a weak trend ($p=0.054$) of decline in α-HCH.
- Nain char exhibited a significant 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.

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 early measurements made in the late 1980s and 1990s.
- Trends of mercury increase have been reported in parts of northern Canada and related to warming temperatures [5]. However, warmer temperatures may also enhance fish growth rates resulting in increased condition factor and reduced mercury concentrations [1,6].
- Our continuing studies at Cambridge Bay will allow us to better investigate climate and mercury trends in char.

Acknowledgements

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