Spatial and temporal trends in persistent organic contaminants in lake trout and burbot from Great Slave Lake, Northwest Territories

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25 ans years – Programme de lutte contre les contaminants dans le Nord – Northern Contaminants Program

Introduction

Great Slave Lake (Fig. 1), the largest lake in the Northwest Territories, consists of two major regions - the East Arm, located on the Canadian Shield, and the West Basin, located on Paleozoic deposits, and profoundly influenced by the Slave River inflow. Early research emphasized the importance of Slave River inflow in affecting spatial gradients in limnological features, including standing stocks (Rawson 1951, 1953, 1956). More recent studies have focused on persistent organic contaminants (POCs) entering the lake from long-range atmospheric transport with the Slave River acting as an additional contaminant source. Here we report on our early lake studies and subsequent investigations of the spatial and temporal trends in POCs in lake trout (*Salvelinus namaycush*) and burbot (*Lota lota*) harvested from the West Basin and East Arm over 1993-2016 as part of the Northern Contaminants Program (NCP).

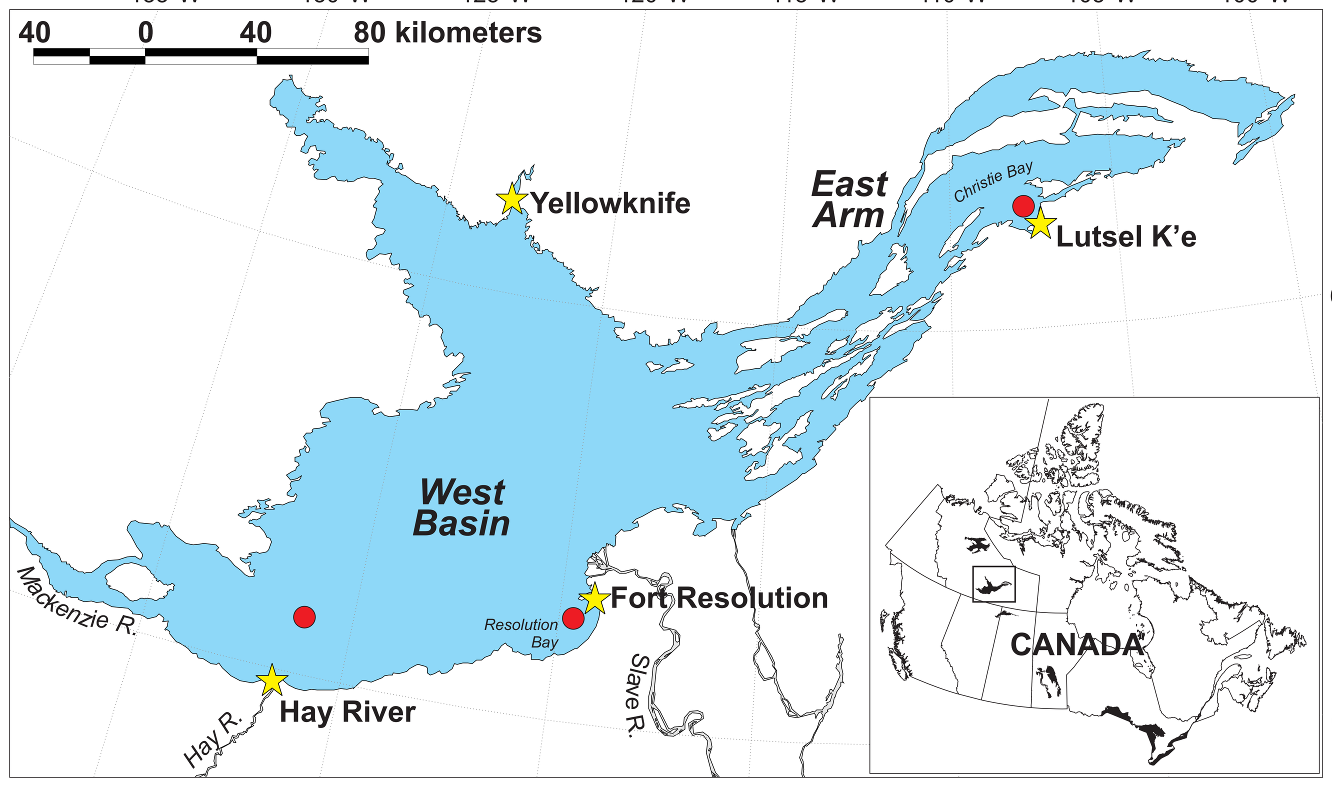

Figure 1. Map showing the communities and regions of Great Slave Lake. Approximate fish collection locations are indicated with red circles.

Methods

- Basic limnological studies were conducted in the mid-1990s and included investigations of spatial variations in POC concentrations in lake sediments and sedimentation rates.
- Lake trout were collected in the West Basin (1993) and East Arm (1993, 1995) and burbot from the West Basin (1993, 1995, 1996) and East Arm (1993).
- The annual NCP monitoring program began in 1999. POCs monitoring became biannual in 2013.
- Twenty fish were collected each year; length, weight, sex, age and carbon and nitrogen isotope ratios were determined on all fish (fillet).
- Ten homogenized skin-on muscle (lake trout) and liver (burbot) samples were analyzed for a suite of organochlorines and brominated flame retardants and PFCAs using procedures outlined in Muir et al. (2014).
- Time trends in POC concentrations were investigated following Rigét et al. (2010) with fork-length adjusted (lake trout) or lipid-adjusted (burbot) data.

Results and Discussion

Spatial patterns in sediment POCs

- Most POCs, including PCBs, occurred in higher concentrations in West Basin than East Arm sediments (Fig. 2; Evans and Muir 2016). Concentrations were low.
- Higher concentrations in West Basin sediments may be related to Slave River influences including greater suspended sediments inputs which provided more surfaces for binding POCs; sedimentation rates were high in the West Basin.

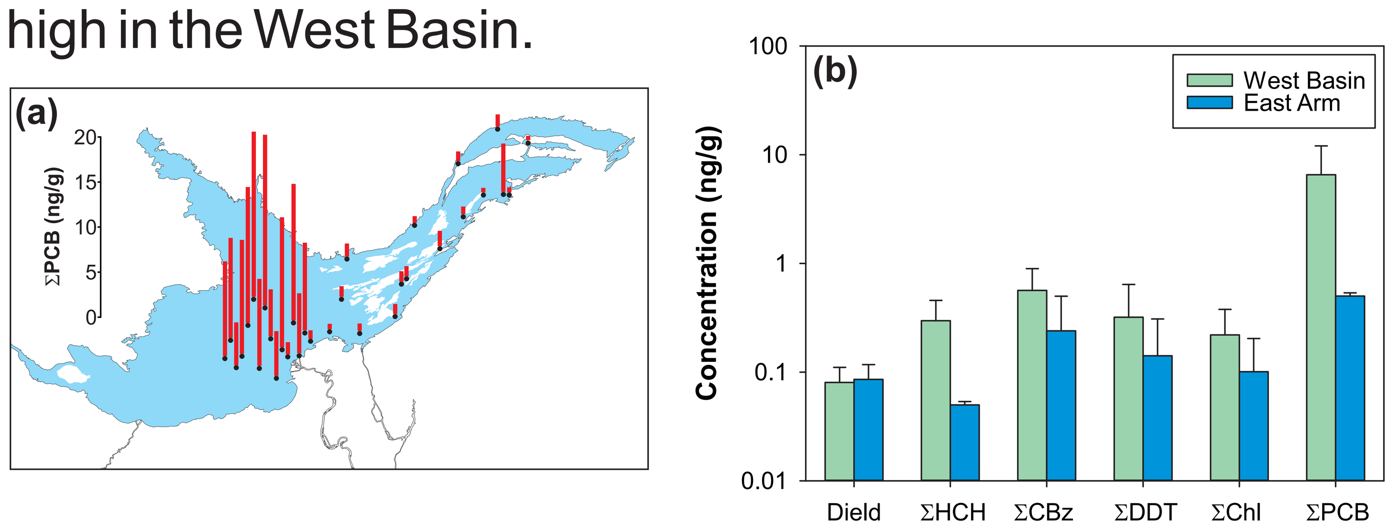

Figure 2. (a) Map showing ΣPCB concentrations (ng/g) in surface sediments (1994-96 collections). (b) Average (±1 SD) POC concentrations (ng/g) sediments as in (a) but grouped into West Basin and East Arm categories.

Spatial differences in fish POC concentrations

- POC concentrations were substantially higher in burbot liver than lake trout fillet (Fig. 3). This is because burbot liver is fattier than lake trout fillet and POCs concentrate in fats.
- POC concentrations were lowest for dieldrin and ΣDDT and highest for ΣPCB and ΣToxaphene.
- POC concentrations were generally lower in West Basin than East Arm fish. This may be related to the higher productivity and muddier waters of the West Basin which provide more particles for the contaminants to absorb onto rather than being taken up by fish from the water.

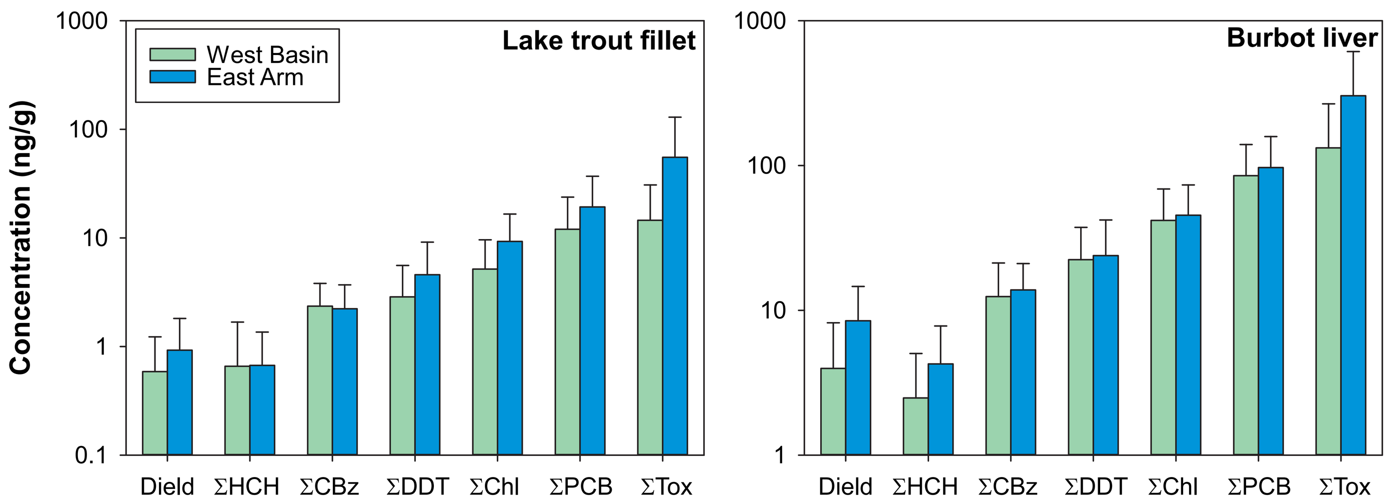

Figure 3. Average (±1 SD) POC concentrations (ng/g) in West Basin and East Arm fish.

Temporal trends in POC concentrations

- Most POCs exhibited statistically significant declines (shown as *) in concentration in both species (Fig. 4). Rates of decline were greater in West Basin fish.
- The faster rate of decline for West Basin than East Arm fish may be related to the shorter residence time of water (and POCs) and greater sedimentation rates in the former region.

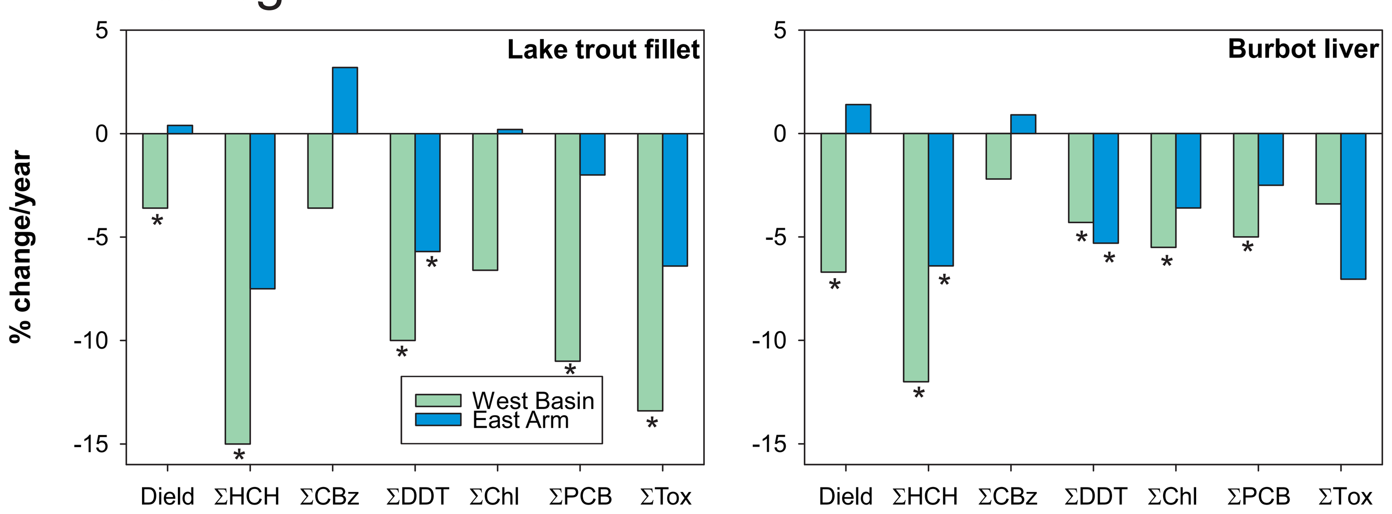

Figure 4. Rate of change in POC concentrations by species and compound. * indicates statistically significant at p<0.05.

- The slow rate of POCs decline in burbot may be related to these fish living close to and on the sediments where they are exposed to accumulated POCs. Lake trout live above the sediments.
- The slow rate of decline for many POCs, particularly PCBs and toxaphene, demonstrates their continued persistence in the Great Slave Lake ecosystem despite several decades of reduced use globally (Fig. 5). They will continue to be detected in the environment for decades to come.
- Newer organic contaminants such as PBDEs and PFCAs are being monitored for trends; they are more responsive to reduced use in the environment.

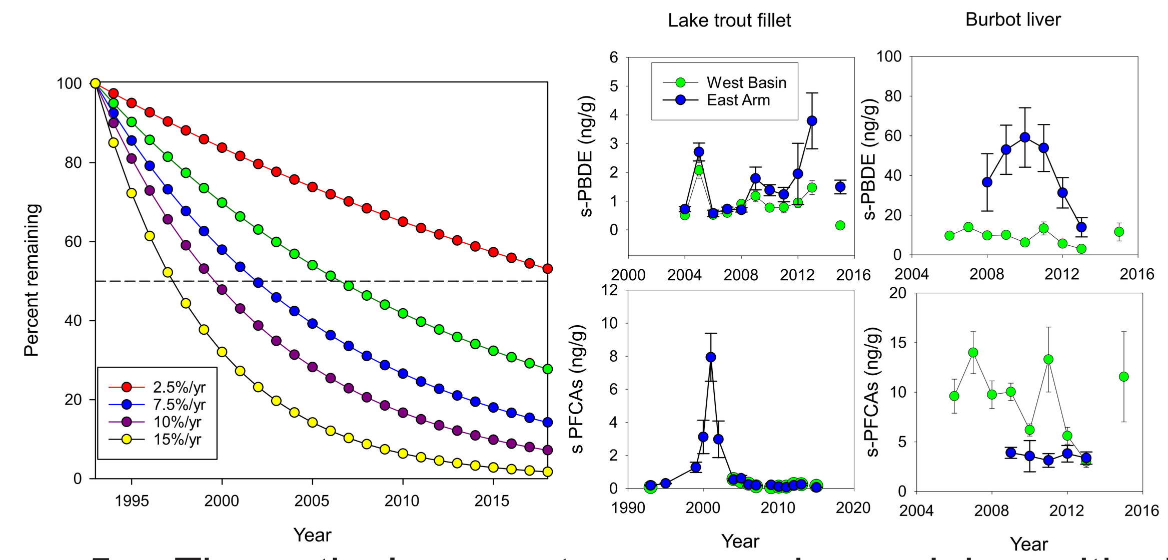

Figure 5. Theoretical percent compound remaining with different decline rates. Also shown are time trends in ΣPBDE and ΣPFCA concentrations for West Basin and East Arm fish.

Conclusions

- POC concentrations tended to be higher in fish in the East Arm than the West Basin, while the converse was observed for lake sediments.
- The Slave River inflow, contributing tremendous quantities of water and suspended sediments to the West Basin and enhancing lake productivity, provides various mechanisms by which POCs are lower in West Basin than East Arm fish. Fish yield is higher in the West Basin.
- While many POCs are exhibiting significant declines in concentration over 1993-2015, these compounds remain persistent in the environment. Continued inputs from long-range atmospheric sources and recycling from lake sediments and the watershed may be imporant influencing factors for their persistence.

Acknowledgements

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