Spatial and temporal trends of flame retardants in ringed seals (*Phoca hispida*) from the Canadian Arctic

Magali Houde[1], X. Wang[2], S. Ferguson[3], P. Gagnon[1], S. Tanabe[4], T. Kunito[5], M. Kwan[6] and D.C.G. Muir[2]

[1] Centre Saint-Laurent, Environment Canada, [2] Environment Canada, Canada Centre for Inland Waters, [3] Fisheries and Oceans Canada, Arctic Aquatic Research Division, [4] Ehime University, Center for Marine Environmental Studies, [5] Shinshu University, Department of Environmental Sciences, [6] Nunavik Research Centre

ABSTRACT

Concentrations of polybrominated diphenyl ethers (PBDEs) and alternative flame retardants were analyzed in ringed seal blubber (*Phoca hispida*) collected during aboriginal hunts between 1998 and 2012.

Results indicated that the highest ΣPBDE concentrations (sum of 13 congeners) were found in seals in Nain (Labrador) as well as Inukjuaq and Arviat (Hudson Bay). The lowest mean concentrations were found in seals from Lancaster Sound. BDE-47 and -99 were the predominant congeners quantified. The most frequently detected non-PBDE flame retardants were 1,2-bis(2,4,6-tribromophenoxy)-ethane (BTBPE; 12% of samples analyzed for this chemical) and hexabromocyclododecane (HBCD; 33%). ΣPBDEs have significantly increased from 1998 to 2012 in the regions of southern Beaufort Sea and East Baffin with peaks recorded in 2011 and 2008, respectively. Concentrations of BTBPE and HBCD were found to have significantly increased at several sites during the past decade.

The increases of flame retardants in ringed seals suggest their continuous inputs in the Canadian Arctic environment.

INTRODUCTION

The ringed seal (*Phoca hispida*) is :

- the most abundant Arctic pinniped with a circumpolar distribution
- a relatively sedentary seal species of a great cultural, economic, and nutritional importance to native Arctic communities
- a key biomonitoring organism for the evaluation of spatial and temporal trends of persistent environmental pollutants in the Arctic
- a high trophic level marine mammal inhabiting northern industrialized regions as well as remote locations such as the Canadian Arctic archipelago, Alaska north slope, Greenland and Svalbard

➢ A large suite of organic contaminants, including flame retardants, have been reported in their tissues

OBJECTIVES

- Evaluate the spatial distribution of PBDEs as well as a suite of alternative flame retardants in blubber of ringed seals harvested from subsistence hunting across the Canadian Arctic
- Determine the temporal trends of these chemicals
- This information will help understand the long-range transport of flame retardants to higher latitudes as well as evaluate repercussions of the PBDE regulations on Canadian Arctic wildlife.

MATERIALS AND METHODS

Ringed seals were harvested between 1998 and 2012 by subsistence hunters

Recorded information:
- date and location of collection
- gender
- girth
- length
- blubber thickness

Samples collected:
- blubber
- liver
- muscle
- teeth

Figure 1. Sampling locations for ringed seals across the Canadian Arctic. Sites with identical color were included in the same region for temporal analyses, red: Beaufort Sea, green: Lancaster Sound, blue: East Baffin, and orange: Hudson Bay. Sites in black were only used for spatial analyses because of limited sampling years.

Table 1. Specific locations, years of sampling, sampling size and gender of ringed seals for which samples were analyzed for PBDEs. Ranges of age, total length, blubber thickness and stable isotopes of carbon ($\delta^{13}C$) and nitrogen ($\delta^{15}N$) of animals are indicated.

Region	Specific region	Years of sampling	N	Age (year)	Length (cm)	Blubber thickness (cm)	$\delta^{13}C$ (‰)	$\delta^{15}N$ (‰)
Hudson Bay	Arviat, NU	1998-2012	93	<1-35	72-160	1.5-9	-24.3, -18.1	13.2-18.2
	Inukjuaq, QC	2002 and 2007	18	<1-19	74-140	1.3-5.1	-20.9, -19.0	13.2-14.6
Lancaster	Arctic Bay, NU	2004 and 2009	18	<1-38	58-159	2.5-6.8	-19.8, -18.2	15.0-17.2
	Grise Fiord, NU	2003 and 2008	17	<1-27	86-1472	2-6.3	-21.2, -17.8	14.1-16.9
	Resolute Bay, NU	2000-2013	76	<1-42	52-160	1.3-7.6	-23.4, -17.7	14.1-18.2
Beaufort	Sachs Harbour, NT	2001-2013	68	<1-30	83-140	2.5-4.3	-21.8, -16.4	15.0-19.0
East Baffin	Kangiqsualujjuaq, QC	2007	3	na	66-69	2.5-3.2	-17.9, -17,1	16.0-19.1
	Nain, NL	2005	8	4-12	97-125	0.6-3.8	-18.9, -16.9	13.5-16.1
	Pangnirtung, NU	1999-2013	41	<1-19	79-141	2.5-5.1	21.5, 16.6	13.5-19.1
	Qikiqtarjuaq, NU	2005	7	3-12	99-150	2.5-5.1	-19.1, -18.3	14.8-16.7
	Ungava*	2002	12	3-12	84-140	2.5-5.1	na	na
Kitikmeot	Gjoa Haven, NU	2004-2009	18	<1-24	41-165	2-5	-23.8, -21.2	15.7-19.3

na: not available for all seals. *Ungava includes Quartaq, Kangiqsujuaq, and Kangiqsualujjuaq, QC.

➢ Tooth aging was determined following the methods of Stewart *et al.* (1979)

➢ PBDEs and other BFRs were extracted using procedures previously described with minor modifications (Johansen *et al.*, 2004; Muir *et al.*, 2006).

➢ Only females and juvenile males (<5 year-old or <100 cm length) were used for temporal trend analyses considering the known bioaccumulation of organic contaminants with age in male seals.

RESULTS

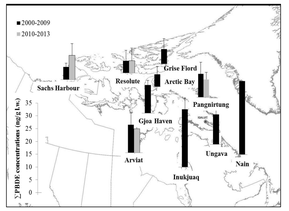

Figure 2. Mean ΣPBDE concentrations (ng/g l.w.) for all ringed seal blubber samples collected before (2000-2009) and after (2010-2013) listing of Penta- and OctaBDEs under the Stockhom Convention

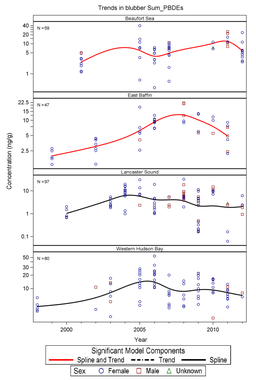

Figure 3. Temporal trends of ΣPBDEs in blubber female and juvenile ringed seals collected in Beaufort Sea (Sachs Harbour), Lancaster Sound (Resolute Bay), Western Hudson Bay (Arviat) and, East Baffin (Pangnirtung).

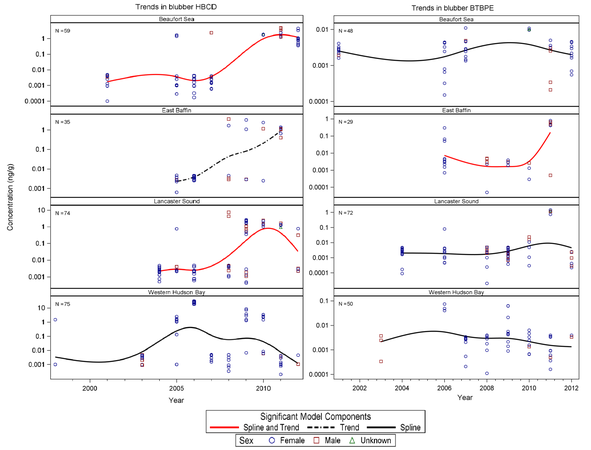

Figure 4. Statistically significant temporal trends of non-PBDE flame retardants. HBCD and BTBPE in blubber of female and juvenile male ringed seals collected in Beaufort Sea (Sachs Harbour), Lancaster Sound (Resolute Bay), Western Hudson Bay (Arviat) and, East Baffin (Pangnirtung).

RESULTS AND DISCUSSION

Results indicate:

- The highest blubber concentrations of ΣPBDEs were found in Inukjuaq in 2002 and 2007 (25.8 ng/g l.w. and 19.6 ng/g l.w. respectively), Arviat in 2006 (20 ng/g l.w.) and Nain in 2005 (28.8 ng/g l.w.), the three southernmost sites of this study.
- The lowest mean concentrations were found in seals from Resolute Bay, Grise Fiord and Arctic Bay (<6 ng/g l.w.).
- ΣPBDE concentrations increased overtime in seal blubber from Sachs Harbour (p=0.006, +12%/year) and East Baffin (p<0.0001, +12%/year.
- PBDE concentrations between the two Hudson Bay sites were significantly different for both years of simultaneous sampling (2002 and 2007) with highest levels found in seals from the east Hudson Bay (2002: 25.8±10.3 ng/g l.w., 2007: 19.6±17.6 ng/g l.w.) compared to the western site (11.2±21.1 ng/g l.w., 6.8±3.6 ng/g l.w.).
- The most frequently detected non-PBDE flame retardants in Canadian ringed seals were BTBPE and HBCD.
- Rapid HBCD concentration increased in seals from Beaufort Sea (p=0.003, +113% of estimated yearly increase), Lancaster Sound (p<0.0001, +101%), and East Baffin (p<0.0001, +167%).

➢ **Results of this long-term study indicate the on-going bioaccumulation of regulated PBDEs and alternative flame retardants in pinnipeds throughout the Canadian Arctic suggesting the continuous input of these chemicals in the Arctic environment.**

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