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Contaminants in Canadian Arctic Bowhead whales

Contaminants chez les baleines boréales du Canada

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ABSTRACT

Organochlorine (PCBs and OC pesticides) and mercury concentrations have been measured in bowhead whale tissue from across the Canadian Arctic over a period of 1994 to 2003. Their tissue levels were then compared to those in beluga from similar locations and years. While organochlorine and mercury levels in the beluga tissues have now reached levels that would probably cause effects in many other species (AMAP, 2003) those in the bowhead tissues are significantly lower and almost certainly pose minimal risk to these animals and to the Inuit who consume these tissues as part of their traditional diets.

RÉSUMÉ

Les concentrations d'organochlorés (BPC et pesticides organochlorés) et de mercure ont été mesurées dans les tissus de baleines boréales d'un peu partout dans l'Arctique canadien de 1994 à 2003. Les concentrations trouvées dans les tissus ont ensuite été comparées à celles trouvées dans les tissus de bélugas provenant des mêmes endroits au cours de la même période. Alors que les niveaux d'organochlorés et de mercure dans les tissus de bélugas sont maintenant d'une importance telle qu'ils entraîneraient probablement des effets chez plusieurs autres espèces (PSEA, 2003), ceux trouvés dans les tissus de baleines boréales sont beaucoup plus faibles et ne posent presque certainement qu'un risque minime à ces animaux ainsi qu'aux Inuits qui consomment leur chair dans le cadre de leur régime traditionnel.

INTRODUCTION

The Arctic has been at the receiving end of numerous environmental contaminants, with atmospheric, aquatic and biological transport delivering pollutants into its remote food webs. Concerns about the quality of Inuit traditional foods drove multi-agency research, with DFO, INAC and HC working to study the levels, trends and effects of PCBs, organochlorine pesticides, flame retardants, and mercury.

Mercury (Hg) has long been known as a neurotoxin, and is emerging as a critical contaminant issue in the Arctic. In the western Arctic the issue is clear; marine mammals have exhibited increasing Hg concentrations during the past two decades. Hg levels have been measured in liver of beluga whales from the Beaufort Sea area since 1982, peaking at 29.0 μg/g (wet wt., age corrected; 41.5 μg/g without age correction) in 1996, and remaining as high as 13.5 μg/g in 2002 (Lockhart *et al.* 2005). Hg liver concentration in ringed seals from Holman, Sachs Harbour and Tuktoyaktuk have reached as high as 200 μg/g (Stern, unpublished results). Arctic marine mammals, therefore, bioaccumulate mercury to levels that would probably cause effects in many species (AMAP 2003). Recently, Outridge *et al.* (2008) reported that mercury inputs and losses from the Arctic Ocean were near equilibrium and that marine biota (bacteria to marine mammals) only represent a small fraction (~1%) of the existing total Hg and methyl-Hg inventories in each of these water masses. Observed variation in mercury concentrations in the marine biota are most likely, therefore, associated with processes controlling the bioavailability of Hg such as increasing methylation rates, increasing primary productivity changing food web structures and/or animal feeding habitat or behavior. These findings also suggest that deep and sustained cuts to global anthropogenic Hg emissions (like that of green house gases) will be required to return biotic Hg levels to their natural state. Studies by Gaden *et al.* (2009) and Loseto *et al.* (2006; 2008a,b; 2009) on western Arctic ringed seal and beluga, respectively, suggest that mercury exposure for these animals may be related to climate warming, in particular, changing sea ice duration, extent and concentration.

Temporal concentrations of organic contaminants (e.g., PCB, organochlorine pesticides) in blubber from Hendrickson Island beluga in the western Arctic (1989 to 2007) and from Pangnirtung beluga in Nunavut (1982-2007) have been reported by Stern *et al*. (2008). Like mercury, OC concentrations in these animals have now reached levels that would probably cause effects in many other species (AMAP 2003).

Marine mammals, with the exception of the bowhead whale and walrus, generally feed at the highest level in marine food webs and as such these species are exposed, through their diets, to higher levels of contaminants. The $\delta^{15}N$ values of the bowhead whale is consistent with known feeding behaviour as this species feeds mainly on plankton (Lowry 1993), and subsequently occupies a lower-trophic level position, than do belugas, narwhal and ringed seal whose diets consist mainly of pelagic fishes (e.g., Arctic cod, capelin and herring) (Hoekstra 2003). Walrus too feed at a lower tropic level, their diets consisting of primarily benthic species such as mussel.

METHODS

SAMPLE COLLECTIONS

All tissue samples were collected as part of organized harvest-based monitoring programs in each of the different regions.

Mercury

Tissue sub-samples were taken from the interior of the frozen sample tissue, eliminating outside contamination. We used approximately 0.2 g tissue for the analyses. After heating and digesting in sulfuric and nitric acids, mercury levels were determined using Cold Vapour Atomic Absorption (CVAAS; 22); the limit of detection was 0.005 μg/g wet weight. Replicates, blanks, and standard reference material (SRM; LUTS-1, TORT-2, CRM 2976) were all used as measures of quality control. Methyl mercury analysis was analyses by Gas Chromatography Atomic Fluorescence Spectroscopy (GCAFS) with ECD detector following methods from Uthe *et. al.* (1972) and Cai *et al.* (1997).

Organic contaminants

Analysis of organochlorine contaminants levels in marine blubber samples were previously described by Stern *et al.* (2005). Briefly it involves extraction of the contaminants using hexane in a ball mill and analysis using high-resolution gas chromatography (GC) with ^{63}Ni electron capture detection (ECD) on an automated Varian 3400 GC (Varian Instruments, Palo Alto, CA).

RESULTS AND DISCUSSION

Tables 1 and 2 list the total and methyl mercury concentration, respectively, in selected tissues of bowhead whales collected over a period from 1991 to 2002. For comparison purposes, Table 3 lists the total mercury concentration beluga tissues. If we compare the mercury levels in similar tissues from both species captured at Coral Harbour we note that the levels range from 27 to 97 times higher in the beluga muscle and liver, respectively. No effects are expected in bowhead whales at these levels (AMAP 2003). Similarly, and not unexpectedly, the PCB and organochlorine pesticide concentrations are also significantly lower in the blubber from bowhead relative to that of either beluga or walrus (Tables 4 and 5). If we adjust for differences in lipid content (Figure 1) then we note that the highest OC concentrations among bowhead sampled are found in the western Arctic, with the exception of PCBs levels found in the 1998 Hall Beach animal. We must keep in mind, however, that we are only looking at samples with an “n” equal to one or two (per year and location). As with the mercury, OC/PCB concentrations at the levels outlined in Table 4, almost certainly pose minimal risk to these animals (AMAP 2003).

Table 1. Total mercury concentrations in bowhead tissues.

			Total Mercury (ug/g, wet wt.)			
Sample ID	Location	Year	Muscle	Liver	Kidney	Muktuk
BM-97-IG-01	Igloolik	1997	ns	ns	ns	<0.010
BM-IG-94-01	Igloolik	1994	<0.010	0.013	0.019*	<0.010
?	Igloolik	1991	0.027	0.017	0.063	ns
AR-BM-PG-2003-001	Pangnirtung	2003	0.016	ns	ns	0.011
NSA-BM-98-01	Pangnirtung	1998	0.033	ns	ns	ns
BM-99-HB-04	Hall Beach	1999	0.014	ns	ns	ns
BM-99-HB-05	Hall Beach	1999	<0.010	ns	ns	<0.010
BM-CH-2000-001	Coral Harbour	2000	0.026	0.058	0.071	0.010
RMD-BM-96-02	Repulse Bay	1996	0.034	0.025	0.044*	0.014
AR-BM-KU-2002-001	Kugaaruk	2002	ns	ns	ns	<0.010
RMD-BM-96-01	W. Arctic	1996	0.024	0.063	0.044	0.010

ns = no sample; *tissue looked like liver not kidney.

Table 2 Total methyl mercury concentrations in bowhead tissues.

			MeHg (ug/g, wet wt.)			
Sample ID	Location	Year	Muscle	Liver	Kidney	Muktuk
BM-CH-2000-001	Coral Harbour	2000	0.018	0.033	nd	nd
RMD-BM-96-02	Repulse Bay	1996	0.048	0.015	-	nd
RMD-BM-96-01	W. Arctic	1996	0.021	nd	nd	-

nd = non-detect.

Table 3 Mean (SD) total mercury concentrations in beluga tissues from selected locations and years (Lockhart *et al.* 2005).

		Total Mercury (ug/g, wet wt.)			
Location	Year	Muscle	Liver	Kidney	Muktuk
Igloolik	1995	-	9.11 (8.14)	7.60 (3.16)	-
Pangnirtung	1997	-	8.21 (3.14)	4.27 (1.76)	-
Pangnirtung	1984	0.98 (0.23)	9.83 (2.52)	3.12 (1.31)	-
Western Arctic	1996	1.15 (0.45)	13.9 (3.56)	9.43 (2.73)	1.95 (0.73)
Coral Harbour	1993	0.70 (0.11)	5.63 (1.50)	3.34 (0.99)	0.53 (0.14)

Table 4. Mean (SD) of major HOC groups in bowhead blubber samples (ng g^{-1}, wet wt).

Sample ID	Location	Year	% Lipid	ΣCBz	ΣHCH	ΣCHL	ΣDDT	ΣPCB	ΣCHB
BM-IG-94-01	Igloolik	1994	91.0	4.56	7.28	8.27	5.48	11.87	308.79
AR-BM-PG-2003-001	Pangnirtung	2003	86.1	1.07	5.78	2.50	1.96	6.31	90.03
NSA-BM-98-01	Pangnirtung	1998	87.6	1.18	5.37	3.85	3.34	8.15	125.14
BM-99-HB-02	Hall Beach	1999	90.2	2.20	5.41	4.56	3.79	13.68	170.23
BM-99-HB-05	Hall Beach	1999	88.7	1.17	6.32	2.86	1.88	6.17	92.89
BM-98-HB-001	Hall Beach	1998	34.8	1.38	1.81	2.03	1.96	8.28	24.32
BM-CH-2000-001	Coral Harbour	2000	92.3	4.34	5.26	3.35	1.66	10.12	103.86
AR-BM-GJ-2002-001	Goja Haven	2002	86.0	3.74	6.48	7.06	6.28	10.50	226.09
AR-BM-SH-2003-001	Sachs Harbour	2003	87.8	5.38	4.69	15.58	13.56	20.75	509.87

Table 5. Mean (SD) of major HOC groups in beluga and walrus blubber from selected Canadian Arctic location (ng g^{-1}, wet wt).

Location	Species	Year	n	%lipid	ΣCBz	ΣHCH	ΣCHL	ΣDDT	ΣPCB	ΣCHB
Hendrickson Isl.	Beluga	2005	10	92.4	623.50	269.28	2568.83	4545.83	3733.03	5680.10
				(3.44)	(196.27)	(68.14)	(1715.55)	(3593.31)	(2154.25)	(3776.00)
Pangnirtung	Beluga	2005	10	93.3	152.41	81.85	1120.74	2198.23	1813.63	3870.19
				(1.8)	(92.36)	(24.51)	(638.47)	(1432.58)	(905.57)	(1617.23)
Repulse Bay	Beluga	1997	3	81.0	573.55	264.23	2599.53	3347.08	4327.48	12335.81
				(3.6)	(325.39)	(79.74)	(1245.84)	(1420.50)	(1986.05)	(5895.35)
Igloolik	Walrus	1993	5	79.3	2.07	86.00	184.60	16.6	101.60	497.00
				(13.4)	(0.41)	(28.70)	(76.00)	(8.45)	(42.90)	(264.4)
Igloolik	Walrus	1996	7	78.4	1.81	107.3	237.7	17.50	141.50	606.90
				(5.0)	(0.65)	(33.7)	(90.60)	(11.30	(67.30)	(67.30)

ΣDDT = Sum of *p,p*'-DDT, *p,p'*-DDE, *p p*'-DDD, *o,p*'-DDT, *o,p*'-DDE and *o,p*'-DDD; ΣHCH = α- β- and γ-HCH isomers; ΣCHL = all chlordane related compounds, including heptachlor; ΣCBz = Sum of 1245TCB, 1234TCB, P5CBz, HCBz; ΣPCB = Sum of CB1, 3, 4/10, 7, 6, 8/5, 19, 18, 17, 24/27, 16/32, 26, 25, 31, 28, 33, 22, 45, 46, 52, 49, 47, 48, 44, 42, 41/71, 64, 40, 74, 70/76, 66, 95, 56/60, 91, 84/89, 101, 99, 83, 97, 87, 85, 136, 110, 82, 151, 144/135, 149, 118, 134, 114,131, 146, 153, 132, 105, 141, 130/176, 179, 137, 138, 158, 178/129, 175, 187, 183, 128, 185, 174, 177, 171, 156, 201/ 157, 172/197, 180, 193, 191, 200, 170, 190, 198, 199, 196/203, 189, 208, 195, 207, 194, 205, 206, 209

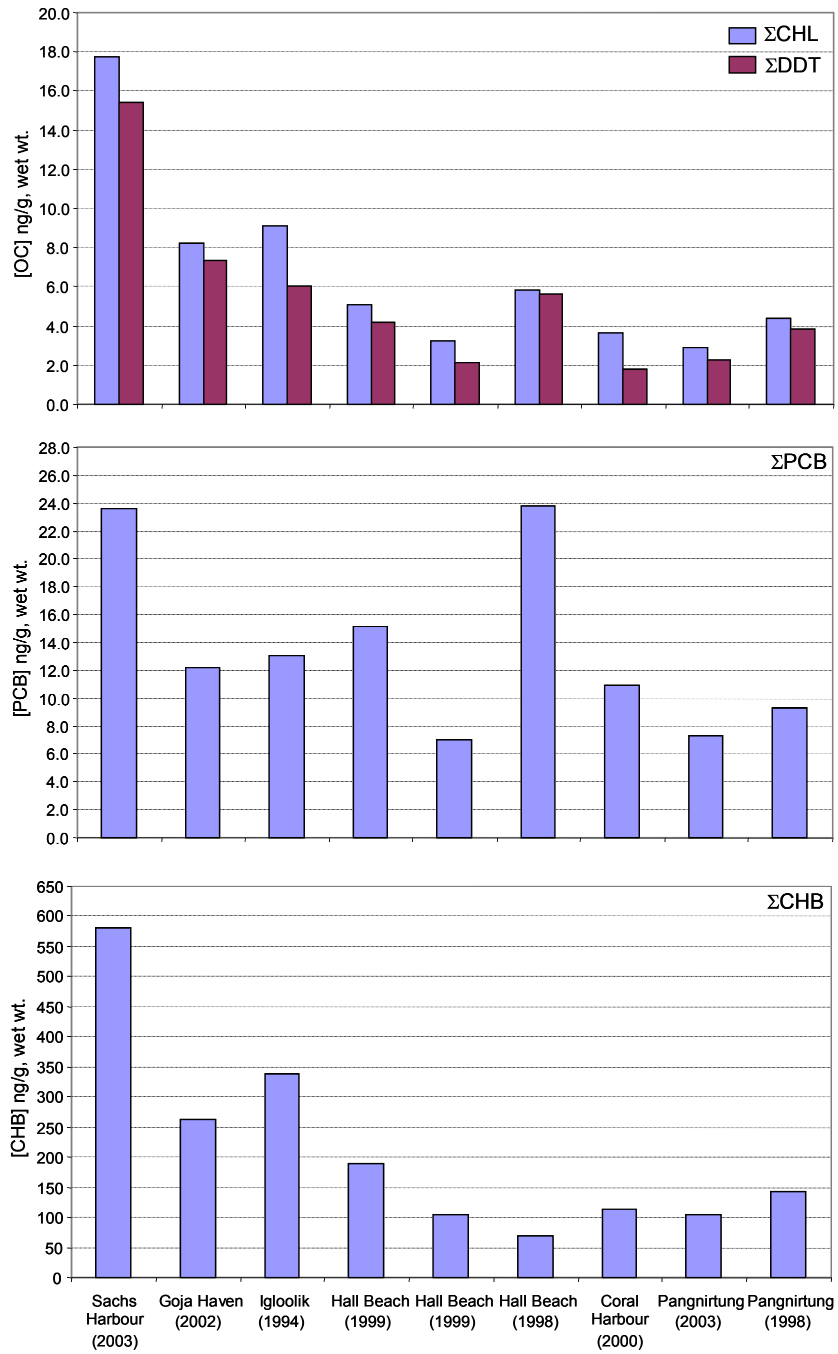

Figure 1. Lipid normalized chlordane (∑CHL) and ∑DDT (top), ∑PCBs (middle) and ∑CHB (bottom) in bowhead blubber samples. See also Table 5.

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