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Composition of chlorinated hydrocarbon contaminants among major adipose tissue depots of polar bears (*Ursus maritimus*) from the Canadian high Arctic

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Abstract

Monitoring of environmental contaminants in Canadian Arctic polar bears (*Ursus maritimus*) typically has used superficial adipose tissue samples collected as part of controlled native subsistence hunts. However, little attention has been paid to the compositional difference in contaminants that may exist among the major adipose depots that are routinely collected. To address this knowledge gap, we investigated the profiles and concentrations of chlorinated hydrocarbon contaminants (CHCs), including major polychlorinated biphenyl (PCB) congeners and organochlorine (OC) pesticides and metabolites, in six major adipose depots (i.e. superficial, inter-muscular and intra-abdominal regions) obtained from adult male polar bears in the vicinity of Resolute Bay, Canadian high Arctic. Concentrations and congener patterns of PCBs (20 congeners) and OCs (14 compounds; chlordanes and dichlorodiphenyltrichloroethanes and metabolites, chlorinated benzenes, hexachlorocyclohexane isomers, octachlorostyrene and dieldrin) were found to be relatively uniform throughout the adipose tissue of male polar bears. The only exception was the inter-muscular adipose depot from the cervical region, which was characterized, compared to other major depots routinely sampled, by lower proportions of higher-chlorinated and recalcitrant congeners such as CB170/190, 180, 194 and 206, and higher contribution of the lower-chlorinated PCBs, CB47, 74 and 99. No difference in the OC makeup and concentrations was found among the adipose depots investigated. In view of this, we conclude that the determination of CHCs in adipose tissue of polar bears from any major depots, with the potential exception of the fat under the neck muscles, would give a representative picture of the overall CHC composition and concentrations in polar bear fat for purpose of trend monitoring.

Keywords: Chlorinated hydrocarbons; Contaminants; Adipose depots; Polar bears; *Ursus maritimus*; Canadian Arctic

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1. Introduction

Over the last two decades, there has been a considerable effort for the monitoring of spatial and temporal trends of environmental contaminants in tissues of circumpolar arctic wildlife. The polar bear (*Ursus maritimus*), a widely distributed apex predator in the marine ecosystem, is a key sentinel species that has received particular attention since the first report of polychlorinated biphenyl (PCB) and dichlorodiphenyltrichloroethane (DDT) contamination in populations from the Canadian Arctic nearly 35 years ago (Bowes and Jonkel, 1975). In the years following, comprehensive surveys undertaken throughout most of the distribution range of the polar bear have ascertained it is among the most highly contaminated by chlorinated hydrocarbons relative to other arctic mammals (de Wit et al., 2004; Braune et al., 2005). The highest concentrations of legacy chlorinated hydrocarbon contaminants (CHCs), comprising PCBs and organochlorine (OC) pesticides and metabolites, have been reported in polar bears from the eastern Greenlandic, Svalbard (Norwegian Arctic) and western Russian subpopulations (Norstrom et al., 1998; Andersen et al., 2001; Lie et al., 2003; Dietz et al., 2004; Verreault et al., 2005). Parallel assessments carried out using polar bear tissues for persistent and bioaccumulative chemicals of new and emerging environmental concern, e.g., polybrominated diphenyl ether (PBDE) flame retardants (Muir et al., 2006) and polyfluoroalkyl compounds such as perfluorooctane sulfonate (PFOS) (Smithwick et al., 2005), have provided additional information on geographical distribution and trends of organohalogen contaminants. Current understanding of contaminant-induced biological effects in polar bears points to evidence that chronic exposure to CHCs may compromise several components of their, e.g. endocrine, immune and reproductive systems, and perhaps also on population recruitment (de Wit et al., 2004; Fisk et al., 2005; Kirkegaard et al., 2005; Sonne et al., 2006).

Polar bear sampling campaigns that are designed as part of controlled native subsistence hunts commonly collect superficial adipose tissue samples. At present, there is no international agreement with reference to standardization of techniques for selection and processing of sampling depots in polar bear contaminant monitoring research. Fat biopsy, blood and milk samples also have been collected from live-captured polar bears tranquilized for research purposes. Little or no intra-individual variation in CHC residue composition and concentrations has been found between selected substrates, e.g., adipose tissue, plasma and milk (Bernhoft et al., 1997). However, scarce attention has been paid to contaminant variation that may exist among the readily accessible, major adipose depots that are routinely sampled. Up to 80% of the adipose tissue of adult polar bears is superficial, i.e. located between the skin/fur and the musculature (Pond et al., 1992; Pond and Mattacks, 1989). Although fat sample collections from polar bears have generally been taken from the rump area (e.g., a subcutaneous depot at the base of the tail), concerns regarding potential depot-specific variability in CHC profiles and concentrations in adipose tissue have essentially been overlooked in large-scale monitoring programs in Canada and in other circumpolar territories.

We presently investigated the composition and concentrations of legacy CHCs, including major PCB congeners and OC pesticides and metabolites (hereafter referred to as OCs only), in six major adipose depots collected from adult male polar bears in the vicinity of Resolute Bay, Canadian high Arctic. The prime objective of the present work was to document whether the collection of adipose tissue from a given storage site in polar bears has impact on CHC measurements and overall data variation. Another objective was to evaluate whether there is a need for global standardization of adipose tissue sampling and processing methods for purpose of trend monitoring in polar bears of legacy or emerging contaminants with similar, lipid-associated bioaccumulative properties as, e.g., the legacy CHCs.

2. Materials and methods

2.1. Sample collection

Samples of adipose tissue were obtained from adult male polar bears ($n=9$), aged 7 to 13 years, within 3 days postmortem. The bears were harvested as part of controlled native subsistence hunts in 1993 in the vicinity of Resolute Bay (Nunavut, Canada). All animals were sampled at the end of April, which corresponds in polar bears to the period near the end of hyperphagia (Ramsay et al., 1992). Adipose tissue samples were collected from six metabolically-active depots (Table 1). Details on adipose sample collection, processing and storage can be found in Letcher et al. (1996, 1998) and Norstrom et al. (1998). The samples were stored at −40 °C, and in 1994 they were chemically analyzed for CHCs. Concentrations of CHCs in liver samples of these same polar bears have been reported in Letcher et al. (1996). Methylsulfone PCB metabolite concentrations also were determined in a subset of six animals from this group where only subcutaneous fat samples were collected from the base of the tail (Letcher