Environmental Research 151 (2016) 50–57

Contents lists available at ScienceDirect

Environmental Research

journal homepage: www.elsevier.com/locate/envres

Circumpolar contaminant concentrations in polar bears (*Ursus maritimus*) and potential population-level effects

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ARTICLE INFO

Article history:
Received 19 May 2016
Received in revised form
8 July 2016
Accepted 15 July 2016

Keywords:
Polar bear
Ursus maritimus
Population effects
Pollution
Bioaccumulation
Arctic
PCB
DDT
Dieldrin
PBDE

ABSTRACT

Polar bears (*Ursus maritimus*) currently receive much attention in the context of global climate change. However, there are other stressors that might threaten the viability of polar bear populations as well, such as exposure to anthropogenic pollutants. Lipophilic organic compounds bio-accumulate and biomagnify in the food chain, leading to high concentrations at the level of top-predators. In Arctic wildlife, including the polar bear, various adverse health effects have been related to internal concentrations of commercially used anthropogenic chemicals like PCB and DDT. The extent to which these individual health effects are associated to population-level effects is, however, unknown. In this study we assembled data on adipose tissue concentrations of ∑PCB, ∑DDT, dieldrin and ∑PBDE in individual polar bears from peer-reviewed scientific literature. Data were available for 14 out of the 19 subpopulations. We found that internal concentrations of these contaminants exceed threshold values for adverse individual health effects in several subpopulations. In an exploratory regression analysis we identified a clear negative correlation between polar bear population density and sub-population specific contaminant concentrations in adipose tissue. The results suggest that adverse health effects of contaminants in individual polar bears may scale up to population-level consequences. Our study highlights the need to consider contaminant exposure along with other threats in polar bear population viability analyses.

1. Introduction

Arctic ecosystems are threatened by multiple anthropogenic stressors, such as global warming, increased human activity and pollution (Huntington, 2009; Letcher et al., 2010; Bennett et al., 2015). Combined, these factors may constitute a threat to Arctic wildlife species, in particular endemic top predators with low population numbers, such as the polar bear (*Ursus maritimus*) (Jenssen, 2006; Stirling and Derocher 2012; Jenssen et al., 2015). Although climate change has received by far the most attention with respect to viability of polar bear populations, it is likely that also other stressors, such as environmental pollutants, may threaten the polar bear (Sonne, 2010; Jenssen et al., 2015; Dietz et al., 2015). The lipophilicity of many persistent organic pollutants (POPs) causes them to accumulate in tissue of animals (MacKay and Fraser, 2000; Borgå et al. 2004). Due to trophic transfer the chemicals are transported along the food chain and the highest internal concentrations are generally reached in the highest trophic levels of a certain system (Skaare et al., 2000; Borgå et al. 2004; Sørmo et al., 2006). In the Arctic food chain high concentrations of POPs have been found in the apex predator, the polar bear (Lie et al. 2003; Verreault et al., 2005; McKinney et al., 2011). The dependency on a diet high in fat, their position in the food chain and the extreme seasonal dynamics, which force them to rely on their lipid stores for a large part of the year (Stirling and Derocher, 1993; Borgå et al. 2004), make polar bears particularly vulnerable to deleterious effects of anthropogenic pollution.

Many studies have focused on the potential adverse health effects of contaminants in wildlife, fish and humans, including Arctic species (Bustnes et al., 2003; Van Oostdam et al., 2005; Jørgensen et al., 2006; Miljeteig et al., 2012). In polar bears, organochlorine contaminants have been associated with a variety of effects, including endocrine disruption of thyroid hormones, sex hormones and stress hormones, as well as effects on vitamin levels, liver, kidney and thyroid gland morphology, decreased bone

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http://dx.doi.org/10.1016/j.envres.2016.07.021
0013-9351/

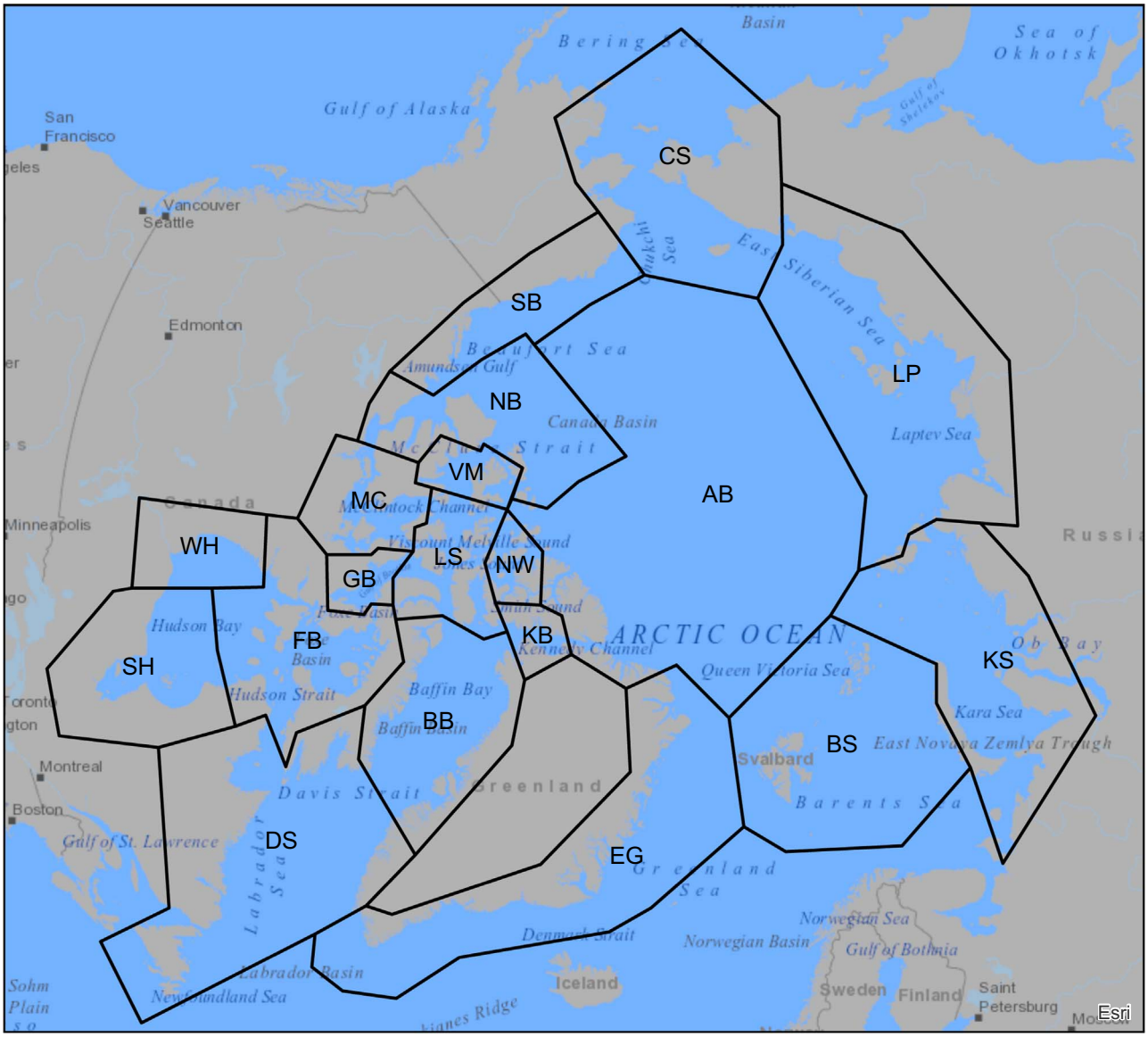

Fig. 1. Geographic location of the 19 currently recognized polar bear subpopulations (see Paetkau et al. (1999) and Peacock et al. (2015) for detailed information on data underlying this subdivision). WH: Western Hudson Bay, SH: Southern Hudson Bay, DS: Davis Strait, BB: Baffin Bay, FB: Foxe Basin, KB: Kane Basin, NW: Norwegian Bay, LS: Lancaster Sound, GB: Gulf of Boothia, MC: M'Clintock Channel, VM: Viscount Melville Sound, NB: Northern Beaufort Sea, SB: Southern Beaufort Sea, CS: Chukchi Sea, LP: Laptev Sea, KS: Kara Sea, BS: Barents Sea, EG: East Greenland (PBSG, 2015).

mineral density and impairment of both the reproductive and immune system (Haave et al., 2003; Oskam et al., 2003; Braathen et al., 2004; Oskam et al., 2004; Sonne, 2010; Gustavson et al., 2015). Recently, Dietz et al. (2015) indicated that although a temporal decrease in the levels of POPs, including PCBs, has been observed in polar bears during the past two decades, concentrations are still above toxic thresholds (i.e. risk quotient (RQ) > 1) in all 11 subpopulations examined for reproductive traits, immunotoxic and carcinogenic effects (for subpopulations see Fig. 1). PCBs were the main contributor (Dietz et al., 2015). However, these studies have all focused on individual health effects only. There have been no efforts to examine if pollutants affect polar bears at the population level (Jenssen et al., 2015; Letcher et al., 2010).

To assess the threat of contaminant exposure on the population level, effects need to be assessed on population-relevant endpoints such as survival, reproductive success or population density. Population effects of environmental pollution are of increasing scientific interest (Forbes et al., 2016), however for Arctic species only a few published studies exist. In glaucous gull (*Larus hyperboreus*), a 10-fold increase in oxychlordane levels in the blood was found to reduce adult survival probability up to 29% (Bustnes et al., 2003). Later studies on organochlorine levels in the same species found evidence for sex-dependent threshold values for mortality in adult birds and an association between organochlorine level of the mother and hatching sex ratio (Erikstad et al., 2011, 2013).

The aim of the present study was threefold: 1) to assemble data on internal contaminant concentrations in polar bears across the entire Arctic, 2) to compare these contaminant concentrations with toxicity thresholds for adverse individual health effects, and 3) to investigate potential associations between subpopulation-specific contaminant concentrations and population-level characteristics, based on the data that is currently available. In addition to subpopulation-specific contaminant concentrations, the role of other anthropogenic stressors, such as relevant global warming proxies (ice coverage), human population density and harvest rate were examined.