



## Baseline

## Persistent organic pollutants and polycyclic aromatic hydrocarbons in penguins of the genus *Pygoscelis* in Admiralty Bay – An Antarctic specially managed area



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## ABSTRACT

Persistent organic pollutants were assessed in fat samples of the Gentoo (*Pygoscelis papua*), Chinstrap (*Pygoscelis antarcticus*) and Adélie (*Pygoscelis adeliae*) penguins collected during the austral summers of 2005/06 and 2006/07 in Admiralty Bay, King George Island, Antarctica. The predominant organic pollutants were PCB (114 to 1115), polycyclic aromatic hydrocarbons (PAHs) (60.1 to 238.7), HCB (<0.3 to 132.2) and BDE-47 (<1.0 to 10.7) in ng g<sup>-1</sup> wet weight. The mean concentrations of the majority of organic pollutants were similar among the three species of penguins. Chicks of all three species showed similar profiles of PCB congeners, with predominance of lower chlorinated compounds. The distribution of PAHs was similar in all birds, with a predominance of naphthalene and alkyl-naphthalene, which are the main constituents of arctic diesel fuel. These data contribute to the monitoring of the continued exposure to organic pollutants in the Antarctic biota.

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The Antarctic environment cannot be considered pristine due to the human impact in the region (UNEP, 2002), resulting in the input of anthropogenic compounds, such as polycyclic aromatic hydrocarbons (PAHs) (Bicego et al., 2009; Curtosi et al., 2009; Dauner et al., 2015) and persistent organic pollutants (POPs), which include organochlorine pesticides (OCPs), polychlorinated biphenyls (PCBs) and polybrominated diphenyl ethers (PBDEs) (Corsolini et al., 2011; Cipro et al., 2013; Colabuono et al., 2015; Zhang et al., 2015). The South Shetland Islands are especially vulnerable due to their proximity to South America as well as the increasing local tourism and research activities (Tin et al., 2009). King George Island, which is located in this region (62°02'S 58°21'W), has had particularly considerable human activity since the 19th century. Permanent research stations operated by eight Antarctic Treaty nations (Argentina, Brazil, Chile, China, Korea, Poland, Russia and Uruguay), a summer research station (Peru) and a refuge (United States of America) are located on the island, which also receives a large influx of tourists (Gröndahl et al., 2009; Kennicutt, 2009).

Admiralty Bay, which is located in the central portion of King George Island, is an area of outstanding environmental, historical, scientific and aesthetic value (<http://www.admiraltybayasma.aq/>). This area was designated an Antarctic Specially Managed Area (ASMA no. 1) during the

Antarctic Treaty System Consultative Meeting in 1996 (ATCM XXVIII, 2005; ATCM XXXVI, 2014) to minimize the cumulative environmental impact of human occupation. Admiralty Bay is characterized by rich seabird and mammal breeding grounds, diverse marine ecosystems and terrestrial plant habitats. Three species of penguins [the Gentoo (*Pygoscelis papua*), Chinstrap (*Pygoscelis antarcticus*) and Adélie (*Pygoscelis adeliae*)] breed in Admiralty Bay. Together, these species constitute up to 95% of the biomass of the breeding community in this area (Sander et al., 2005).

Seabirds tend to have a long lifespan and occupy higher trophic positions, which make them more prone to incorporate POPs over the years and accumulate these compounds in their tissues (Furness and Camphuysen, 1997). Thus, seabirds are considered useful indicators of pollution in the marine environment, including polar regions (Letcher et al., 2010; Mallory et al., 2010; Cipro et al., 2013; Colabuono et al., 2014; Guzzo et al., 2014).

Penguins can be used to assess contaminant trends in the Southern Ocean, since they are widely distributed in Antarctica (Corsolini, 2009). Lukowski et al. (1987) were the first researchers to detect POPs in Antarctic penguins from Admiralty Bay and found PCBs in the tissues of these three species of the genus *Pygoscelis*. Lara et al. (1990) contributed additional data on organochlorine pesticides, such as DDT and HCB. Subsequent studies also indicated the accumulation of organic pollutants in Antarctic penguins, especially organochlorine compounds

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(e.g., Inomata et al., 1996; Taniguchi et al., 2009) and other contaminants, such as PBDEs (Corsolini et al., 2007; Cipro et al., 2010, 2013). Recent data also indicate the presence of POPs in the blood of penguins and unhatched eggs at Admiralty Bay (Corsolini et al., 2007, 2011).

Few studies on organic pollutants in the fat tissue of seabirds have been conducted in Antarctica. The lack of such studies may be due to the difficulty in obtaining a significant number of well-preserved carcasses, which are exposed to the continuous action of natural predators. Despite this limitation, the few samples available are important to the evaluation of pollution in the Antarctic biota.

The aim of the present study was to evaluate the occurrence of HCB, PCBs, PBDEs and PAHs in the adipose tissue of *P. adeliae*, *P. papua* and *P. antarcticus* collected during the austral summers of 2005/06 and 2006/07 in Admiralty Bay, King George Island, Antarctic Peninsula. These data can make an important contribution to the monitoring of POPs in the Antarctic biota.

Sampling of penguins found dead was conducted in two different areas in Admiralty Bay (King George Island) during the austral summers of 2005/06 and 2006/07 (Fig. 1). Subcutaneous fat samples from the

carcasses of *P. adeliae* ( $n = 4$ ) and *P. papua* ( $n = 2$ ) were collected near to Llano Point ( $62^{\circ}10'S$ ,  $58^{\circ}26'W$ ). Fat samples from *Pygoscelis antarcticus* ( $n = 3$ ) were collected at Chabrier Rock ( $62^{\circ}11'S$ ,  $58^{\circ}17'W$ ). All samples were wrapped in aluminum foil and kept frozen at  $-20^{\circ}C$ .

The analytical procedure followed that described by MacLeod et al. (1985) with minor modifications described by Colabuono et al. (2014). Briefly, 0.25 g of fat sample and 10 g of anhydrous sodium sulfate were extracted in a Soxhlet apparatus for 8 h using 80 mL of a mixture of *n*-hexane and dichloromethane (DCM) (1:1, v/v). Prior to extraction, the surrogates naphthalene- $d_8$ , acenaphthene- $d_{10}$ , -phenanthrene- $d_{10}$ , chrysene- $d_{12}$  and -perylene- $d_{12}$  (for PAHs), PCB 103 and PCB 198 (for PCBs, OCPs and PBDEs) were added to all samples, blanks and reference material. The concentrated extracts were cleaned using column chromatography with 8 g of silica and 16 g of alumina (both 5% water deactivated) and eluted with 80 mL of a mixture of *n*-hexane and DCM (1:1, v/v). The internal standards tetrachloro-*m*-xylene (TCMX), fluorene- $d_{10}$  and benzo[b]fluoranthene- $d_{12}$  were added prior to the gas chromatographic analysis.

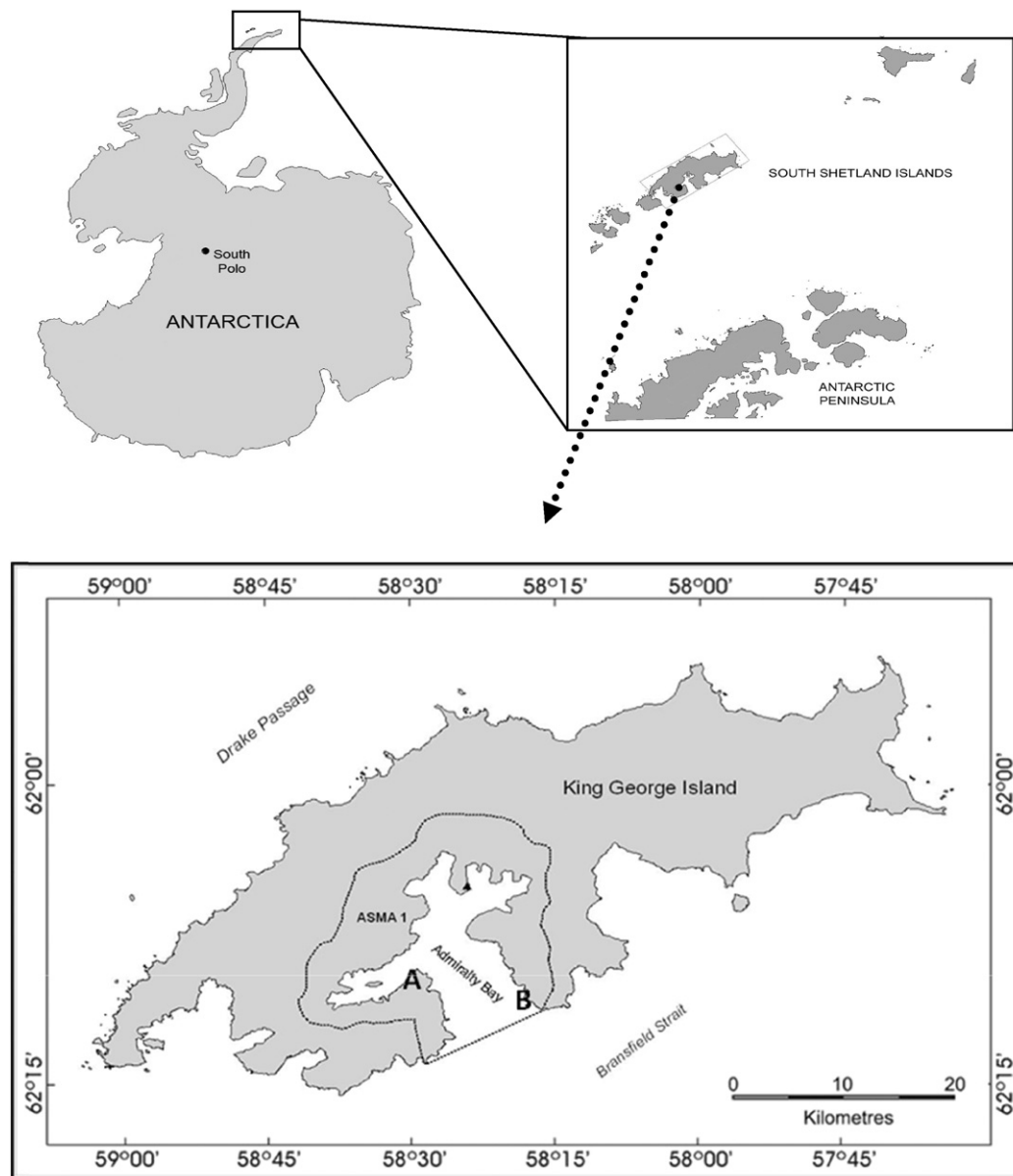


Fig. 1. Sampling site on King George Island – Admiralty bay Antarctic Specially Managed Area (ASMA 1) A – Llano Point – Gentoo and Adelie penguin colonies B – Chabrier Rocker – Chinstrap penguin colonies.

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