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Persistent organohalogen contaminant burdens in Antarctic krill (*Euphausia superba*) from the eastern Antarctic sector: A baseline study

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ABSTRACT

A baseline for persistent organohalogen compound (POC) accumulation in the Antarctic keystone species, Antarctic krill (*Euphausia superba*) has been established for a 50° longitudinal range of the eastern Antarctic sector. Samples of adult krill, caught from 12 sites distributed between 30° and 80°E (60–70°S), were analysed for >100 organohalogen compounds including chlorinated pesticides, polychlorinated biphenyls (PCBs), polybrominated organic compounds and polychlorinated dibenzo-*p*-dioxins/furans (PCDD/Fs).

Organochlorine pesticides dominated measured krill contaminant burdens with hexachlorobenzene (HCB) as the single most abundant compound quantified. Krill HCB concentrations were comparable to those detected at this trophic level in both the Arctic and temperate northwest Atlantic, lending support for the hypothesis that HCB will approach global equilibrium at a faster rate than other POCs. *Para*, *para*′-dichlorodiphenylethene (*p*,*p*′-DDE) was detected at notable concentrations. Measurements of DDT and its degradation products provide an important baseline for monitoring the temporal and geographical influence of renewed, DDT usage for malaria-control in affected southern hemisphere countries.

In contrast to the Arctic, PCBs did not feature prominently in contaminant burdens of Antarctic krill. The major commercial polybrominated diphenyl ether (PBDE) congeners -99 and -47 were quantified at low background levels with clear concentration spikes observed at around 70°E , in the vicinity of modern, active research stations. The likelihood that local anthropogenic activities are supplementing low PBDE levels, delivered otherwise primarily via long range environmental transport, is discussed. The suspected naturally occurring brominated organic compound, 2,4,6-tribromoanisole (TBA), was a ubiquitous contaminant in all samples whereas the only PCDD/Fs quantifiable were trace levels of octachlorodibenzo-*p*-dioxin (OCDD) and 1,2,3,4,7,8/1,2,3,4,7,9-hexachlorodibenzofuran (HxCDF).

With the aims of; i) Generating a robust and broadly applicable POC auditing platform for the scarcely studied eastern Antarctic sector; ii) Determining the compounds accumulating in Antarctic krill for further toxicity evaluation studies and iii) Establishing a baseline for Antarctic predator exposure to POCs, this study represents one of the most comprehensive reports of POC contamination of the Antarctic food web to date.

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1. Introduction

Persistent organohalogen contaminants (POCs) are ubiquitous, toxic chemicals released around the world and transported to polar regions primarily via air masses according to global distillation and fractionation processes (Wania and Mackay, 1993). As volatility decreases markedly with falling temperature, colder, higher latitude environments act as major sinks for these compounds (Aguilar et al., 2002).

Historically, industries utilising process stable organic chemicals have been concentrated in the northern hemisphere with the Arctic environment sustaining substantial contamination. A high dependency upon lipid derived energy in high latitude environments ensures efficient transfer of these often highly lipophilic chemicals along polar food chains. Geographical location and lipid-rich diets have contributed to the heightened risk status of Arctic Inuit populations and other high trophic level consumers. These populations and their associated ecosystems have as a result been the focus of extensive scientific research and comprehensive intergovernmental monitoring programs over the past decades (AMAP, 2002).

By comparison, Antarctic POC research has been neglected. Persistent organochlorine compounds were first detected in Antarctic biota and snow in the late 1960s contributing further evidence towards the long range environmental transport potential of these compounds (Sladen et al., 1966; George and Frear, 1966; Riseborough et al., 1968). Since this time there has been a consistent, albeit limited (average ~2 publications/year), contribution of Antarctic POC auditing data to the scientific literature. Restricting the ongoing value of many of these reports are inconsistencies in sampling and analytical methods, target analytes and reporting information preventing satisfactory comparison between studies and regions. Further, to date studies have primarily been limited to the Antarctic Peninsula and the Ross Sea (~60°W and ~170°W respectively) with only ~10 studies ever reported from the Australian Antarctic Territory (AAT), the largest of all the Antarctic territories (~44–160°E).

This paucity in our basic knowledge regarding transport to, distribution of, levels and trends of both legacy and emerging POCs in the Antarctic comes despite knowledge that global trade, legislation and progress of developing southern hemisphere nations is significantly altering emission patterns of these chemicals (Connell et al., 1999). In turn, this knowledge gap has further prevented true progress in the field of south polar POC research in the form of species-specific toxicology, parameterised environmental transfer models and associated environmental risk assessments.

Antarctic krill (*Euphausia superba*) is a keystone species in the Antarctic with the majority of Antarctic predators feeding either exclusively or opportunistically on the krill swarms that form during the austral summer. Antarctic krill are also experiencing ever increasing commercial popularity, particularly in nutriceutical and aquacultural industries (Kawaguchi and Nicol, 2007). In 2004, Atkinson et al. reported a long-term monitoring dataset which indicated that Antarctic krill biomass may have declined by as much as 80% over the past 40 years (Atkinson et al., 2004).

With the aims of generating a robust and broadly applicable POC auditing platform for the scarcely studied eastern Antarctic sector, determining the compounds accumulating in Antarctic krill for further toxicity evaluation studies and establishing a baseline for Antarctic predator exposure to POCs, the current study analysed Antarctic krill from across a 50° latitudinal gradient of the eastern Antarctic sector. This paper details the findings and thus represents one of the most comprehensive reports of persistent organohalogen contamination of the Antarctic food web published to date.

2. Materials and methods

2.1. Sample collection and transportation

Mixed-sex adult krill samples were collected onboard the Australian Antarctic Division RSV Aurora Australis, during the 2005/2006 Broke West krill survey. Samples were collected during January and February 2006 and originated from 12 sampling stations between 30 and 80°E (Fig. 1, Table 1). Krill were collected either by target or regular trawls using a RMT-1+8 net (Baker et al., 1973) in combination with hard codends to preserve the condition of the catch.

Krill for chemical analyses were randomly sorted, placed in aluminium foil envelopes, labelled and stored at −85 °C. Upon return to Australia, samples were transported on dry ice to the Norwegian National Institute for Air Research (NILU) where chemical analyses were performed.

2.2. Chemical analyses

Krill samples were analysed for chlorobenzenes (hexa- and penta-chlorobenzene); chlorinated pesticides; hexachlorocyclohexanes (α-, β-, γ-HCH); the dichlorodiphenyltrichloroethane (DDT) group (*o,p′*-DDE, *p,p′*-DDE, *o,p′*-DDD, *p,p′*-DDD, *o,p′*-DDT, *p,p′*-DDT); toxaphene (Tox-26 or B8-1413, Tox-32 or B7-515, Tox-40+Tox-41 or B8-1414+B8-1945, Tox-42a or B8-806, Tox-44 or B8-2229, Tox-50 or B9-1679, Tox-62 or B9-1025); polychlorinated cyclodienes (endosulfan-I, endosulfan-II, endosulfan-sulphate, heptachlor-*exo*-epoxide, heptachlor-*endo*-epoxide, *trans*-chlordane, *cis*-chlordane, oxychlordane,

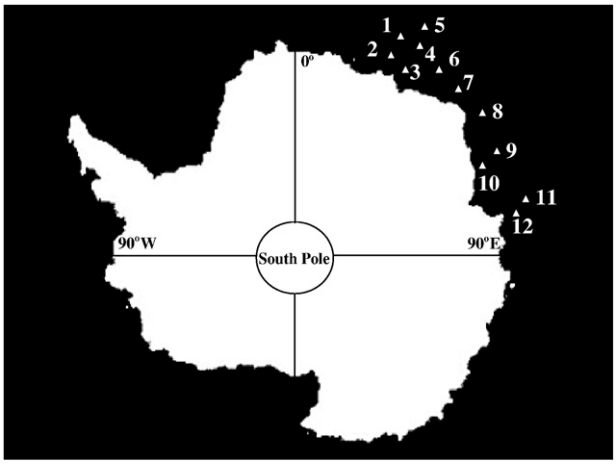

Fig. 1 – Map showing the geographical origin and sampling site numbers of analysed krill samples.