Why do organochlorine differences between arctic regions vary among trophic levels?

Katrine Borga[1], Geir W Gabrielsen[1], Janneche U Skaare[2], Lars Kleivane, Ross J Norstrom[3], Aaron T Fisk[4]

[1]Norwegian Polar Institute
[2]Norwegian Veterinary Institute/School of Veterinary Science
[3]Carleton University
[4]University of Georgia

Introduction

Statistical analysis of organochlorine contaminants (OCs) in ringed seals (*Phoca hispida*) and polar bears (*Ursus maritimus*) has shown that, for most OCs, the European Arctic is more contaminated than the Canadian and US Arctic[1,2]. Recently, comparison of OC means and ranges in several seabird species, arctic cod (*Boregadus saida*) and zooplankton found no difference between these regions[1,2].

As OCs follow the flux of energy through the food web, one would expect that the spatial OC trends in high trophic level predators reflect geographic OC differences in lower trophic levels of the food web.

We hypothesize that differences in spatial trends of OCs between lower and higher trophic levels[1,2], are due to lack of rigorous statistical data analyses. To more fully examine spatial OC variation in the North American and European Arctic, and the differences between regional OC differences in marine mammals and some seabird species, and lower trophic level animals, we combined selected OC datasets from food web studies in northern Baffin Bay (Northwater Polynya NOW) and central Barents Sea (CBS) and performed simultaneous statistical analyses [see references etc in 3].

Materials and Methods

Details on sample collection and OC analyses for the NOW (May and June of 1998) and the CBS (June 1995, May 1999) studies have been summarized previously[see references in 3]. The present study includes only species collected from both sites: copepods (*Calanus hyperboreus* and *C. glacialis*), amphipods *Themisto libellula*), arctic cod, dovekie *Alle alle*, black guillemot *Cepphus grylle*, thick-billed murre *Uria lomvia*, black-legged kittiwake *Rissa tridactyla*, glaucous gull *Larus hyperboreus*, and ringed seal.

Whole body was analysed for OCs in zooplankton, whole body samples were analyzed for the CBS arctic cod, an approximately 3 cm cross section of the body posterior to head were analyzed for the NOW arctic cod, n appromixately 3 n and liver and blubber was analysed for seabirds and seals, respectively. All samples were analysed on high resolution gas chromatograph equipped with Ni-electron capture detector, except NOW ringed seals for which the gas chromatograph was equipped with a mass spectrometer detector. The samples were analysed for a suite of OCs, including HCB and various HCHs, Chlordanes, DDTs and PCBs, and only compounds analysed in the same species from both areas were included in the regional comparison.

OC accumulation was compared between NOW and CBS using univariate (analysis of covariance, ANCOVA, Type III SS, SAS V8 for Windows) and multivariate statistics (principal component analysis, PCA, CANOCO 4.5 for Windows).

Results and Discussion

The oceanographic and ecological characteristics of the two ecosystems examined in this study were similar[3], which is important when comparing OCs between systems: both NOW and CBS are high latitude ecosystems with high seasonal productivity and similar assemblages of species. Trophic positions, investigated by comparing differences in $d^{15}N$ values within species between the two areas, were relatively similar with the exception of amphipods, kittiwake and ringed seals[3]. In addition, trophic magnification factors (TMFs= enrichment of OC per trophic level[4]) among cold-blooded animals, and for OCs with similar TMFs between among cold- and warm-blooded animals, were similar between the NOW and the CBS marine food web[4,5].

Significant differences in OC concentrations were found between the NOW and CBS at most trophic levels, although the magnitude of difference, and the OCs contributing to a difference, were not the same for all animal groups. Based on ANCOVA and PCA results, spatial differences in OC concentrations in lower (zooplankton and fish) and upper (seabirds and marine mammals) trophic levels between the NOW and the CBS did not agree (**Fig. 1**)[see 3 for details]. In general, HCB and SHCHs levels differed consistently between the CBS and NOW for the various animal groups, with higher HCB and lower SHCH concentrations in the CBS than in the NOW (**Fig. 1**). Higher HCH levels in the NOW than in the CBS agree with other circumpolar studies, and is probably due to the closer proximity of the Canadian Arctic to sources of HCH in Asia[1,2]. Higher HCB levels in the CBS than in the NOW may be due to the closer proximity of CBS to industry and agriculture as compared to the NOW.

The other OCs (SChlordanes, SDDTs and SPCBs) were greater in CBS seabirds and ringed seals compared with the NOW (**Fig. 1**), consistent with circumpolar trends observed in ringed seals[6] and polar bears[7]. In contrast, levels of SChlordanes, SDDTs and SPCBs were generally similar in zooplankton and arctic cod between the CBS and NOW (**Fig. 1**). The inconsistent spatial differences of chlordanes, DDT and PCB between lower and higher trophic levels in the Arctic may reflect a combination of their history of use in North America and Europe. Chlordanes, DDT and PCB have been banned or have had restrictive use in North America and Europe since the 1970s[1,8], which has resulted in a decline of these chemicals in Arctic biota between the 1970s and 1990s[1,2]. OC levels may be approaching equilibrium between the Canadian and European Arctic, and temporal trends of several OCs in polar bear and other animals have shown a slower decline in the

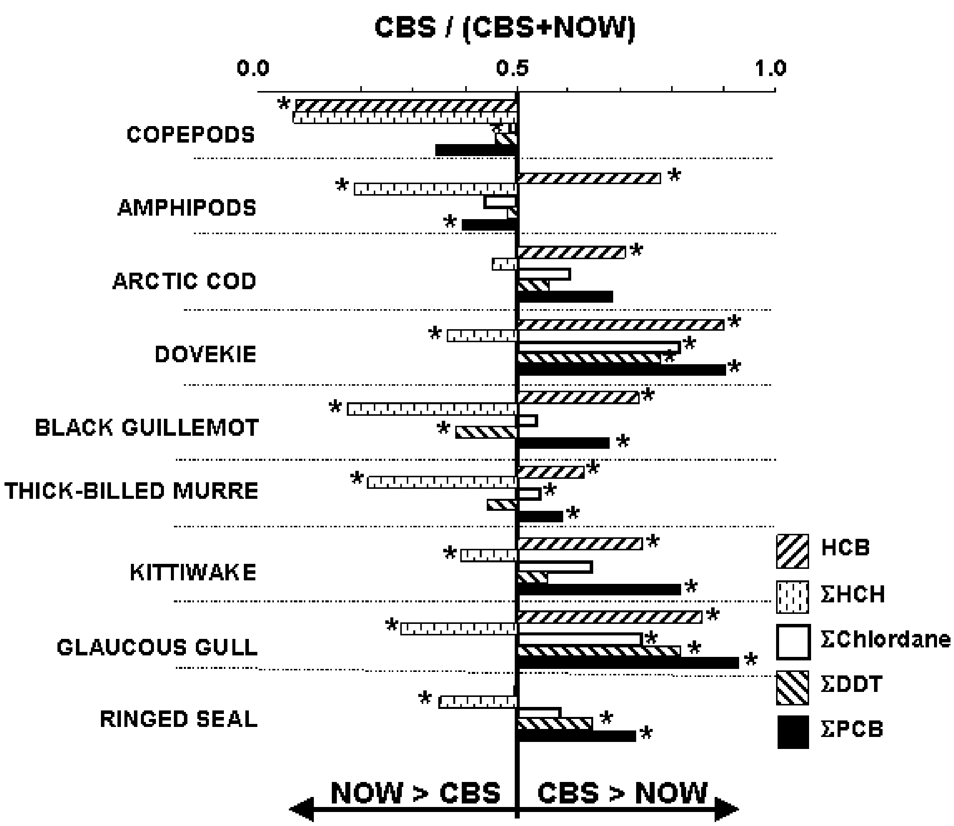

Figure 1. Summary of regional comparison of organochlorine concentrations in various animals representing different trophic positions in the Arctic marine food web of the central Barents Sea (CBS) in the European Arctic and the Northwater Polynya (NOW) in northern Baffin Bay in the Canadian Arctic. The bars indicate the direction or greater

concentrations, with asterix indicating that the statistical comparison was significant (ANCOVA: OC ng g^{-1} wet weight = AREA + LIPID).

Canadian as compared to the European Arctic[1], which supports this hypothesis. A change in OC levels in the abiotic environment would be observed first in lower trophic level organisms since they are short lived (< 4 years for zooplankton and < 10 years for arctic cod) compared to seabirds and marine mammals that can live for decades. As well, maternal transfer of OCs to offspring in zooplankton and fish is likely insignificant compared to mammals and birds. Since the half-life of recalcitrant OCs in seabirds and marine mammals is on the order of years, if not longer, OC concentrations in marine mammals and seabirds may reflect a much longer time period (decades) than in zooplankton and arctic cod. Thus, higher levels of PCBs in seabirds and marine mammals from the CBS are likely due in part to higher OC levels in the past in this region.

Another important factor that could influence observed high OC levels in CBS seabirds is winter migration. Migration to the northern Norwegian coast for black guillemot, and sampling of non-breeding dovekie and thick-billed murre individuals from eastern Kara Sea colonies, may explain elevated OC levels in these species as both the Norwegian coastline and the Kara Sea are more contaminated than the CBS and the NOW[1,8]. CBS kittiwake and glaucous gulls probably migrate south and southwest dispersing over the whole north Atlantic region, and they are also recaptured along the coast of north and mid-Europe, which would explain elevated OC levels in gulls.

We suggest that any conclusions drawn from contaminant data, or any studies proposed for the Arctic that address spatial or temporal trends consider the differences across a number of trophic levels. Questions or studies that address current inputs of contaminants to the Arctic are likely to be less biased if they consider lower trophic levels, as they more rapidly reflect environmental changes in OC exposure.

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