

DIOXINS AND FURANS IN CANADIAN ARCTIC SEABIRDS

Birgit M. Braune and Mary Simon

Canadian Wildlife Service, Environment Canada, National Wildlife Research Centre, Ottawa,
Ontario, Canada K1A 0H3

Introduction

Polychlorinated dibenzo-*p*-dioxins (PCDDs) and dibenzofurans (PCDFs) enter the environment as by-products of industrial processes^{1,2}. Such activities located in or near the Arctic are suspected as local sources of PCDDs and PCDFs to the Arctic environment² but long-range transport is still considered to be the main dispersion mechanism of persistent organochlorines to remote marine regions^{1,3}.

Eggs and tissues of seabirds have been used to monitor contamination of the Canadian Arctic marine environment since 1975^{4,5,6}. At the time of egg formation, organochlorine compounds are transferred along with lipid to the eggs thus reflecting the contaminant burden in the female at the time of laying⁷. Three seabird species have been chosen to monitor contaminants in the Canadian Arctic: thick-billed murres (*Uria lomvia*), black-legged kittiwakes (*Rissa tridactyla*) and northern fulmars (*Fulmaris glacialis*). These three species represent different trophic levels, feeding strategies and overwintering habits, all of which may affect contaminant exposure. Residue data are available for organochlorines, mercury and selenium in seabird eggs and tissues collected from Prince Leopold Island in Lancaster Sound, Nunavut, Canada⁶. However, until recently, PCDDs, PCDFs and non-*ortho* PCBs have not been measured in Canadian Arctic seabirds.

Methods and Materials

Eggs and liver samples of thick-billed murres, black-legged kittiwakes, and northern fulmars collected from the Prince Leopold Island Migratory Bird Sanctuary (74°02'N, 90°05'W) in Lancaster Sound, Nunavut, Canada at intervals between 1975-1998 were archived in the Canadian Wildlife Service's Specimen Bank. Liver samples from adults of all three species collected in 1975 and 1993 were analyzed as single pools, and archived egg homogenates of thick-billed murres and northern fulmars collected in 1975, 1987, 1993 and 1998 were analyzed in pools of five eggs each for polychlorinated dibenzo-*p*-dioxins (PCDDs), dibenzofurans (PCDFs) and non-*ortho* substituted polychlorinated biphenyls (NOPCBs) using HRGC/HRMS Selected Ion Monitoring (SIM) according to CWS Method No. MET-CHEM-PCDD-01C⁸. The non-*ortho* PCB congeners analyzed were PCB-37, PCB-77, PCB-81, PCB-126 and PCB-169. Residue levels were corrected for internal standard recoveries. Toxic equivalents (TEQs) were calculated by multiplying congener concentrations by a congener-specific avian toxic equivalency factor (TEF) as recommended by the World Health Organization⁹.

Results and Discussion

Detectable concentrations of PCDDs, PCDFs and non-*ortho* PCBs were found in all the Arctic

seabird samples analyzed. The predominant PCDD/F congener found in the livers of all three species was 2,3,4,7,8-PnCDF, both in 1975 and 1993. Of the non-*ortho* PCBs measured, PCB-126 occurred in the highest concentrations and contributed the majority of the non-*ortho* PCB-TEQ in livers of all three species in both 1975 and 1993. The NOPCB fraction of the TEQ decreased and the PCDF fraction increased from 1975 to 1993 in kittiwake and murre livers. In fulmars, the PCDFs constituted the dominant fraction in both 1975 and 1993 livers. Details of these results can be found in Braune and Simon¹⁰. The highest concentrations of dioxins and furans as well as the highest TEQ values were found in the northern fulmar livers in both 1975 and 1993 (Table 1).

Table 1. Concentrations and TEQs for total PCDDs (Σ PCDD), total PCDFs (Σ PCDF) and total non-*ortho* PCBs (Σ NOPCB) in Arctic seabird livers from Prince Leopold Island

Species year	% Lipid	Concentration (ng/kg lipid weight)			Σ TEQ	
		Σ PCDD	Σ PCDF	Σ NOPCB	ng/kg lipid wt	ng/kg wet wt
Kittiwake						
1975	9.0	663	653	20631	2386	214
1993	4.3	195	651	7436	1117	47
Fulmar						
1975	2.6	8518	27416	5380	27000	688
1993	4.4	2456	7218	24067	8192	357
Murre						
1975	8.6	26	54	32121	1923	166
1993	3.3	169	431	5066	719	24

The LOEL for induction of CYP1A in the common tern has been estimated as approximately 25 ng/g TEQ liver lipid¹¹ and the TEQ based on PCDD/Fs in livers of piscivorous birds from a heavily polluted lake area in China has been estimated to be 552 pg/g wet weight¹². The TEQs for livers of Canadian arctic fulmars (Table 1) are certainly within the range of the Chinese samples, and the liver TEQs exceeded the LOEL TEQ for induction of CYP1A in common terns in the 1975 samples. Although the TEQs calculated for Canadian Arctic seabirds may not be critical compared with avian toxicological thresholds in the literature, they are, nevertheless, at levels which warrant continued monitoring.

In eggs, concentrations of total PCDDs and total PCDFs appear to have decreased in northern fulmars between 1975 and 1998, whereas in thick-billed murre, the pattern is less clear due mainly to a slight increase in concentrations in 1993 (Figure 1). Concentrations of total non-*ortho* PCBs decreased in both the fulmars and the murre between 1975 and 1998 (Figure 2). Comparing these trends with other biota, no significant change in concentrations of PCDDs or PCDFs in ringed seals from the Canadian Arctic was observed during the period from 1981 to 1996¹³ whereas, in the Great Lakes, concentrations of TCDD, PnCDD and HxCDD in herring gull eggs showed a decline in most colonies between 1981 and 1984 followed by no obvious temporal trends between 1984 and 1991¹⁴. Stable-nitrogen isotope analyses ($\delta^{15}\text{N}$) have shown that the temporal trends observed for contaminant concentrations in eggs of Canadian Arctic seabirds were

not the result of shifts in trophic level⁶. The different demographic and life history strategies of these birds provide a likely explanation for differing exposures through time.

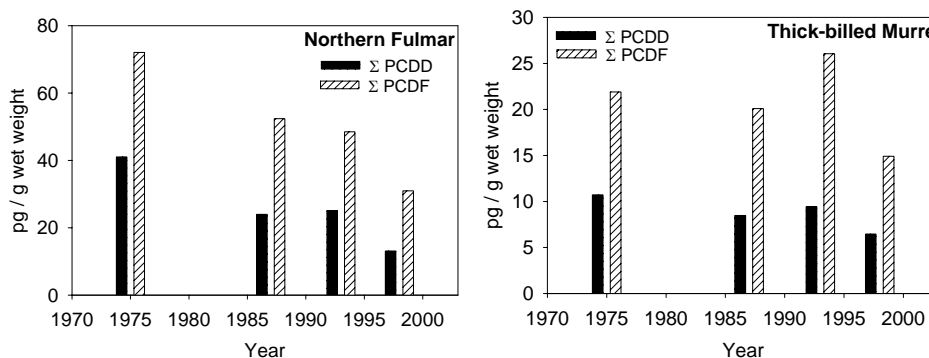


Figure 1. Mean concentrations (pg/g wet weight) of total PCDDs (Σ PCDD) and total PCDFs (Σ PCDF) in eggs of northern fulmars and thick-billed murres collected from Prince Leopold Island.

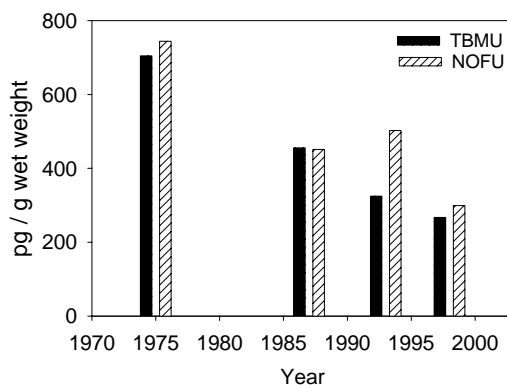


Figure 2. Mean concentrations (pg/g wet weight) of total non-ortho PCBs (sum of PCB-77, PCB-81, PCB-126, PCB-169) in eggs of thick-billed murres (TBMU) and northern fulmars (NOFU) collected from Prince Leopold Island.

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