Perfluorinated Sulfonate and Carboxylate Compounds in Seabird Eggs From the Canadian Arctic: Temporal Trends

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Abstract

Temporal trends of perfluorooctane sulfonate (PFOS) and perfluorinated carboxylates (PFCAs) were determined in eggs thick-billed murres and northern fulmars from Prince Leopold Island in the Canadian Arctic from 1975 to 2012. ΣPFCA concentrations increased from 1975 to 2008 in fulmar eggs, and to 2010 in murre eggs, followed by decreases. PFOS concentrations did not change significantly. PFUnA (C_{11}) and PFTrA (C_{13}) were the major PFCAs.

Introduction

- Poly- and per-fluorinated alkyl substances (PFASs) are ubiquitous in the Arctic environment.
- The major fluorinated compounds measured are the perfluorinated sulfonates (PFSAs) - e.g. perfluorooctane sulfonate (PFOS) - and the PFCAs which include perfluorooctanoate (PFOA).
- PFASs can biomagnify and have been found in arctic biota including seabirds and their eggs.
- In this study, we examined temporal trends of PFOS and PFCAs in eggs of two seabird species, the thick-billed murre (*Uria lomvia*) and northern fulmar (*Fulmarus glacialis*), from the Canadian Arctic.

Methods

- From 1975 to 2012, eggs of northern fulmars and thick-billed murres were collected from Prince Leopold Island (74°02'N, 90°05'W) in Lancaster Sound.
- Egg homogenates were analyzed as pooled (composite) samples consisting of three eggs.
- The PFAS extraction, cleanup and analysis have been described in Chu and Letcher (2008) and Gebbink et al. (2011).
- PFCAs and PFSAs were determined based on liquid chromatography-negative electrospray ionization-tandem mass spectrometry (LC-ESI(-)-MS/MS).
- Quantification used an internal standard approach; concentrations were inherently recovery-corrected.

Data Treatment

- Since PFASs such as PFCAs and PFSAs bind to proteins rather than partition into lipid, concentrations were not lipid-normalized.
- Statistical tests were performed using Statistica for Windows Version 7.0 with a significance level of $p < 0.05$.
- Temporal trends were analyzed by backward stepwise regression analysis, with year and $\delta^{15}N$ as regressors.

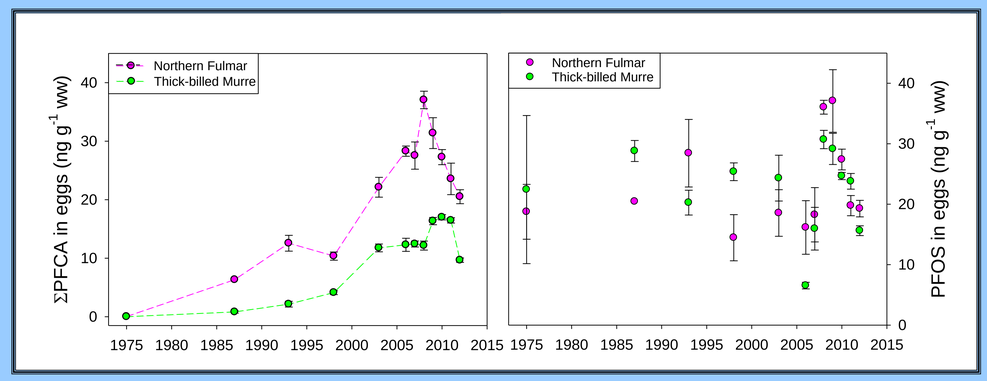

Figure 1. Mean annual concentrations (± standard error) of ΣPFCA and PFOS in eggs of northern fulmars and thick-billed murres from Prince Leopold Island, Nunavut, Canada, 1975-2012. ΣPFCA = sum of PFHxA (C_6), PFHpA (C_7), PFOA (C_8), PFNA (C_9), PFDA (C_{10}), PFUnA (C_{11}), PFDoA (C_{12}), PFTrA (C_{13}), PFTeA (C_{14}) and PFPA (C_{15}).

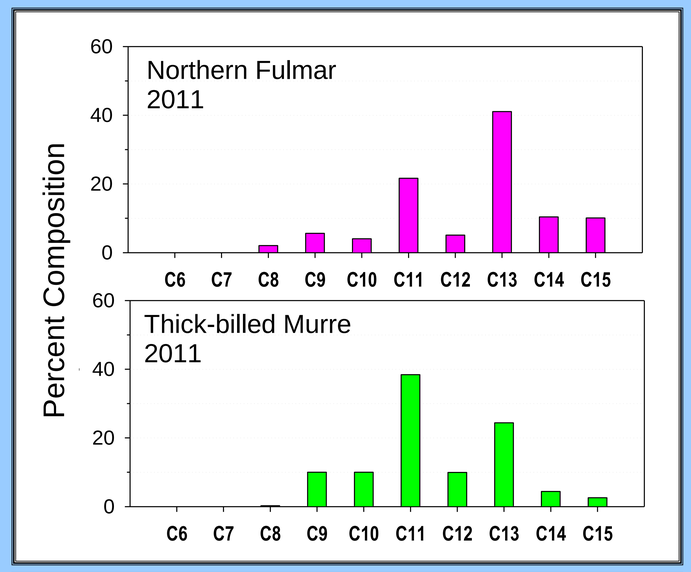

Figure 2. Mean contributions (%) PFHxA (C_6), PFHpA (C_7), PFOA (C_8), PFNA (C_9), PFDA (C_{10}), PFUnA (C_{11}), PFDoA (C_{12}), PFTrA (C_{13}), PFTeA (C_{14}) and PFPA (C_{15}) to ΣPFCA in eggs of northern fulmars and thick-billed murres from Prince Leopold Island, Nunavut, Canada, 2011.

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Results

- ΣPFCA levels increased significantly from 1975 to 2010 in northern fulmar eggs (n=47, r=0.89, p<0.0001) and from 1975 to 2008 in murre eggs (n=35, r=0.88, p<0.0001) followed by decreases (Figure 1, left graph).
- PFOS has not changed significantly although levels may be decreasing in recent years (Figure 1, right graph).
- Significant increases in concentrations of all longer-chained PFCAs (C_9–C_{15}) contributed to the increase in ΣPFCA in the murres and the fulmars.
- PFUnA (C_{11}) and PFTrA (C_{13}) were the predominant PFCAs measured in eggs of both species (Figure 2). These two PFCAs together constituted >60% of ΣPFCA in all years, with PFTrA dominating the fulmar PFCA profile and PFUnA dominating the murre PFCA profile.
- PFOA (C_8) has been detected in eggs of both species only since 2008 and comprises <3% of the PFCA profile.
- In 2011, the fulmar PFCA profile showed a stronger presence of the longer-chained PFCAs (C_{10}-C_{15}) which comprised >90% of ΣPFCA, whereas in the murres, the profile was dominated (>90%) by the C_9-C_{13} PFCAs (Figure 2).

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