Allometric relationships to liver tissue concentrations of cyclic volatile methyl siloxanes in Atlantic cod

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Introduction

Cyclic volatile methyl siloxanes (cVMS) congeners octamethylcyclotetrasiloxane (D4), decamethylcyclopentasiloxane (D5), and dodecamethylcyclohexasiloxane (D6) are key ingredients in personal care product formulations. Although these chemicals are inherently volatile, they are emitted to the aquatic environment through wastewater emissions, where they accumulate in aquatic compartments (i.e., sediment, biota)[1-4] due to their high hydrophobicity/lipophilicity.

Currently there is much debate regarding the persistence and bioaccumulation potential of cVMS. Trophic dilution of cVMS has been observed in industry reports as well as the peer-reviewed literature[5, 6]. However, these findings contradict other studies that have reported bioaccumulation potential[2, 4] and trophic magnification of cVMS[1]. This suggests that other factors such as site specific differences and/or allometric relationships (e.g., fish length/weight, age) may play a significant role in the variation observed in accumulated concentrations of cVMS between studies and needs to be investigated.

The objectives of this study was to 1) investigate the spatial distribution of D4, D5 and D6 within Atlantic cod collected near the town of Tromsø in Northern Norway, 2) compare concentrations of investigated cVMS to known persistent organic pollutants (PCB 153, 180) and 3) assess allometric relationships (fish length/weight) between on D4, D5 and D6 accumulation in Atlantic cod.

Materials and methods

Atlantic cod and sediment were collected in November 2010 and April 2011 near the community of Tromsø, Norway. Sampling was conducted at two locations during both sampling campaigns: Tromsøysund, the harbour adjacent to the town of Tromsø (69º 38.539' N / 18º 58.250' E) and Nipøya, a small island located approximately 30 km northeast of Tromsø (69º 49.432' N / 19º 22.276' E). All personnel involved in sample handling did not use personal care products to avoid contamination of samples. Total fish length and weight were recorded and used to determine conditional status of fish.

Dissection and extraction of fish liver for cVMS was carried out within a clean room facility (U.S. Federal Standard 209e) to reduce risk of contamination of cVMS present within indoor air. Prior to extraction, total liver weight was recorded. Cod otoliths were removed for age determination. Full details regarding determination of age, conditional status, and extraction/analysis procedures for PCB and cVMS have been previously published[7]

Results and discussion

Liver was chossen as the targeted tissue in ths study as it is the largest organ within cod fish containing the highest lipid content; thus favoring uptake of cVMS and PCBs due to their hydrophobicity. All cVMS congeners investigated (e.g., D4, D5 and D6) were detected in all cod liver tissues with exception to 2 cod collected from Nipøya sampling location in which concentrations were below method detection limits. No statistical differences were observed in cVMS concentrations between 2010 and 2011 sampling campaigns at both Tromsøysund and Nipøya sampling locations, indicating temporal variations in emission and exposure are minor. No correlations were observed between cVMS concentration and conditional status of the fish indicating that detected concentrations are a reflection of recent emissions/exposure. Concentration data from both 2010 and 2011 sampling campaigns were pooled together to provide greater statistical power to assess spatial

distributions which showed statistically different concentrations between the two sampling locations (Table 1.) Higher concentrations of cVMS detected in cod from Tromsøysund are due to this sampling location being impacted by wastewater emissions, which are known emission sources of cVMS to the aquatic environment

	Concentration (ng/g lw)		
	D4	**D5**	**D6**
Tromsøysund			
Average	58.8	1240	77.2
Std.dev.	24.7	692	28.8
Median	47.5	1025	75.2
Range	15.7 - 111	338 - 2530	28.8 - 139
Nipøya			
Average	10.3	269	38.2
Std.dev.	3.3	414	47.5
Median	10.8	109	20.5
Range	5.6 - 15.0	30.0 - 1260	4.6 - 146

Table 1. Average, standard deviation, median and range of lipid normalized concentrations (ng/g lw) of cVMS in Atlantic cod liver from Tromsøysund and Nipøya[7]

D5 was found to be the dominant compound detected of the cVMS congeners investigated at both sampling locations. This has also been observed in previous studies investigating aquatic environments[1, 2, 4] and can be attributed to its higher production/use. Concentrations of D5 were also found to be greater than concentrations of known persistent polychlorinated byphenyl congeners (i.e., PCB 153 and 180) within cod livers from both locations, indicating its efficient uptake/accumulation from the surrounding aquatic environment (Figure 1).

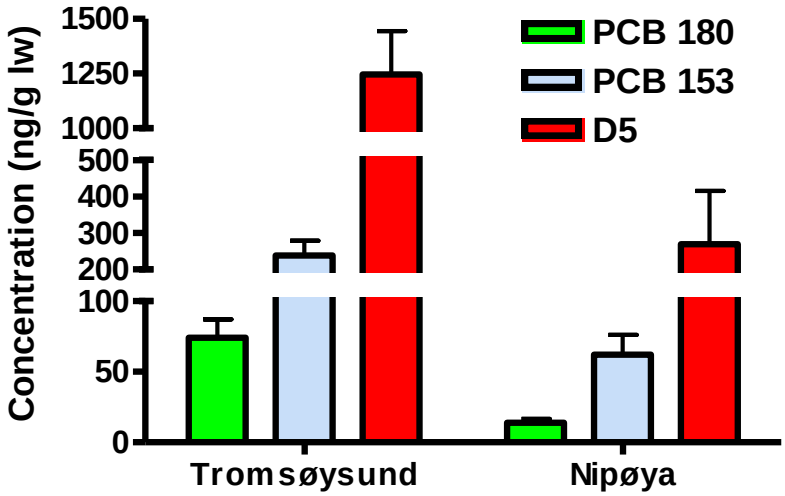

Figure 1. Lipid normalized concentrations (ng/g lw) of D5, PCB 153 and PCB 180 in Atlantic cod liver at Tromsøysund and Nipøya sampling locations[7].

Concentrations of D4 and D6 were found to be significantly correlated with fish length and weight in fish collected from Tromsøysund (Figure 2.). This indicates that Atlantic cod capacity to eliminate D4 and D6 increases with fish size.

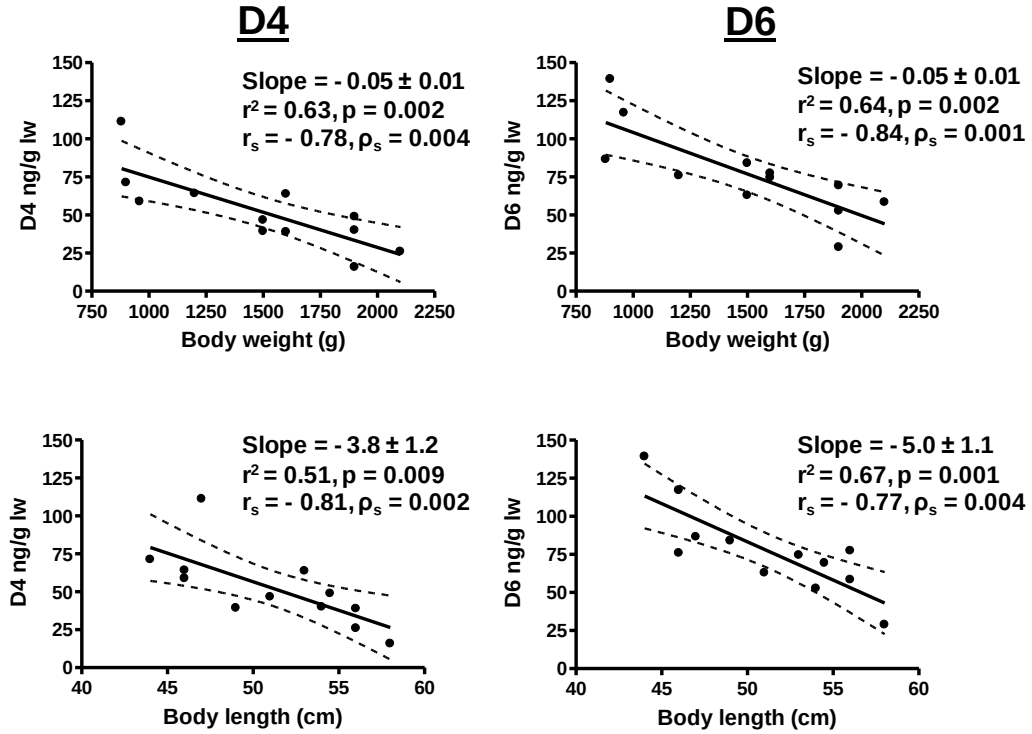

Figure 2. Linear regressions and Spearman correlations of D4 andD6 liver concentrion (ng/g lipid weight (lw)) to fish length and weight in Tromsøysund (*Dashed line surrounding linear regression represent the 95% confidence interval of the linear regression; r^2 represents correlation coefficient for linear regression; p represents the probability for the observed linear regression to be caused by random sampling; r_s represents the correlation coefficient from the Spearman correlation test; ρ_s represents the probability for the Spearman correlation to be caused by random sampling*)[7]

However, no significant correlations were observed between D5 and fish length or weight. This may be attributed to the large variation observed in detected concentrations of D5 in Tromsøysund (Table 1.). What is also surprising is that negative correlations were only observed with D5 and age (data not shown), a physiological parameter closely associated with fish length. However, the strength of these correlations is limited due to the small age range for fish collected within this study (3-6 years) and needs to undergo further investigation in future studies.

Correlations between fish length/weight and PCB 153 and 180 concentrations were also investigated. However, no significant correlations were observed with exception to PCB 180 and fish weight. Correlation strength between PCB 180 and fish weight (r_s = -0.60) was also weaker compared to those observed for D4 (r_s = -0.78) and D6 (r_s = -0.84) and may be attributed to differences in lipid/tissue partioning behaviour between cVMS and PCBs[5].

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