ABSORPTION OF PBDEs and PCBs BY GREY SEALS (*Halichoerus grypus*)

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Introduction

Polychlorinated biphenyls (PCBs) and polybrominated diphenyl ethers (PBDEs) bioaccumulate in marine foodchains, and have been identified as possible causes of long-term health problems in seals[1-5]. Polybrominated diphenyl ethers (PBDEs) have been found in marine top predators[5] and have also been implicated as endocrine disrupting chemicals[6]. We have found a significant relationship between PBDE levels in the blubber of grey seal (*Halichoerus grypus*) weaned pups and juveniles and thyroid hormone levels in the blood[7]. In order to determine how particular PCB and PBDE congeners may affect seals, we need to know more about their accumulation and bioavailability from the diet.

It was expected that net absorption of organohalogen chemicals by seals would follow a similar pattern to that seen in other animals in which other workers have previously seen rather high net absorption (>80%) at log K_{OW} values below approximately 5 and dramatically dropping absorption at higher log K_{OW} values[8-10].

A study was performed with captive animals to investigate the absorption of PBDEs and PCBs from the diet in juvenile grey seals.

Methods and Materials

Sampling

Three juvenile grey seals were taken from the wild and kept in a Home Office licensed captive study facility. The seals were used for various physiological studies for a period of approximately 3 months, kept on a stable diet of approximately 1kg of North Sea herring per day, before becoming available for the study reported here.

The seals were then kept for one month on a stable diet of herring and mineral supplements, followed by one month on the same diet plus one spiked cod liver oil capsule, containing 10 µg commercial decabromodiphenyl ether (99% pure), per day. After one month the capsules fed were changed to 'control' cod liver oil capsules (without decabromodiphenyl ether added). Decabromodiphenyl ether results will be reported elsewhere.

The amount of fish fed to the seals was weighed each day, and once a week during the study the seals were kept in dry, individual enclosures for 24 hours so that all of the faeces produced in that period by each seal could be collected. The faeces produced during each weekly dry period was weighed and assumed to represent the typical 24 hour faeces production under normal conditions. The entire faeces sample was stored in a glass jar and frozen until analysis. Fish was all obtained

from the same source in the North Sea, kept frozen since being purchased, and thawed on a daily basis, as required. On the weekly sampling days 3 whole fish were taken from the thawed batch, wrapped in tin foil and re-frozen for analysis. Seals were weighed and physiological parameters measured at weekly intervals and were released to the wild at the end of the study. On one occasion, near the middle of the study, the total body fat of the seals was estimated using a deuterated water isotope dilution method[11].

Chemical analysis

Fish and faeces samples were analysed for a range of PBDEs and PCBs using methods based on those previously published[12]. Before extraction faeces and fish samples were homogenised with anhydrous sodium sulphate. Briefly, the method entailed solvent extraction with dichloromethane, using an accelerated solvent extraction (ASE, Dionex) unit, followed by gravimetric extractable lipid determination, acidified silica gel chromatography clean-up, gel permeation chromatography and GC-MS analysis. PCBs were analysed in EI mode on a Finnigan TRACE GC-MS, PBDEs (except BDE209) were analysed in NCI mode on a Fisons MD800 GC-MS (using ammonia as the reagent gas). ^{13}C labelled PCB recovery standards were used throughout.

Results and discussion

Median concentrations of PCBs and PBDEs in fish and faeces are shown in Figure 1.

Input and output fluxes of each chemical (in ng/day) were calculated by multiplying the chemical concentration in fish or faeces by the total intake or output, respectively. All chemicals reported were found in the fish.

The net absorbed fraction (ABS) of each chemical analysed was defined as:

$$ABS = 1 - \left(\frac{FLUX_{OUT}}{FLUX_{IN}} \right)$$

The percentages of PBDE and PCB intake absorbed by the seals are summarised in Table 1. It can be seen that all of the chemicals analysed showed very high median absorption (>90%) in contrast to absorption seen in studies on other animals, which generally show high absorption at log K_{OW} < 5 and dramatically declining absorption above that value.

Grey seals are entirely pisciverous and have a high body-fat content compared to most land animals. The digestive process of the seal is extremely efficient in that each kilogram of fish intake produced a median of only 16 g faeces in this study. A combination of the high capacity for storage of lipophilic chemicals and the huge reduction in fugacity capacity (i.e. the reduction in organic – lipophilic – matter) of the gut contents during the digestion process are the most likely causes for the efficient absorption of PCBs and PBDEs compared to other species which have been studied.

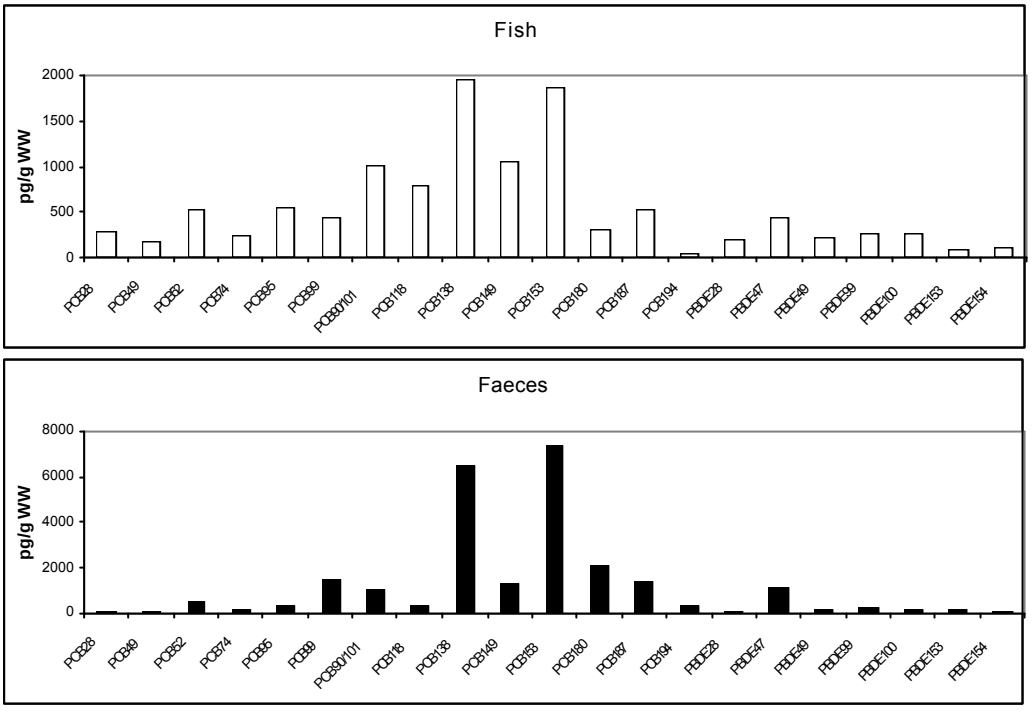

Figure 1 – Median concentrations of PCBs and PBDEs in fish (n=9) and faeces (n=27)

Table 1 – Absorption of PCBs and PBDEs by grey seal juveniles

PCB	Median Absorption (Min - Max) %
28	100 (97-100)
49	98 (95-100)
52	96 (93-100)
74	98 (94-100)
95	99 (96-100)
99	89 (78-99)
90/101	97 (93-100)
118	99 (96-100)
138	90 (81-100)
149	97 (93-100)
153	89 (76-99)
180	89 (56-99)
187	94 (86-100)
194	92 (47-99)

PBDE	Median Absorption (Min - Max) %
28	100 (98-100)
47	94 (73-100)
49	99 (90-100)
99	98 (90-100)
100	99 (92-100)
153	99 (91-100)
154	99 (95-100)

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