PBDEs in American Eels from the Delaware River Estuary, USA

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Introduction.

The Delaware River, like other rivers that bisect urbanized and industrialized lands, receives substantial loadings of contaminants through numerous point and non-point inputs such as urban and agricultural run-off, industrial discharges, and atmospheric deposition. The river also has significant 'in-place" repositories of contamination within its sediments. Although many research studies and monitoring efforts have characterized the magnitude and extent of contaminants such as heavy metals, PCBs and organochlorine pesticides, less information regarding other contaminant classes such as polybrominated diphenyl ethers (PBDEs) exists. The objective of this research was to assess the levels of PBDEs in American eels (*Anguilla rostrata*) collected from the Delaware River Estuary. American eels are thought to have limited home ranges (e.g., Parker 1995) and consequently have been shown to be reliable bio-indicators of polychlorinated biphenyl (PCB) pollution within water bodies such as the Delaware and Hudson Rivers (Ashley et al 2003). Because PBDEs have similar structures and lipophilic natures compared to PCB congeners, it was hypothesized that eels may also be reliable indicators of localized PBDE contamination within the Delaware River and its tributaries.

Materials and Methods.

In 1998, American eels were captured (using eel pots or electroshocking) from various locations within the Delaware River Estuary (Figure 1) and subsequently analyzed for mercury, PCBs and other organochlorine pesticides (NJDEP 2000; Ashley et al 2003). The unused homogenized filets (skin-off) from these eels were subsequently archived in individual sealed jars at -20°C. In late 2005, seventeen of these homogenates were thawed, re-extracted, and subsequently re-analyzed for PCBs and analyzed for the first time for PBDEs as part of this study. These quantifications of PCB levels compared very well to the values obtained years prior with differences observed for each sample on par with the differences we often observe for replicate PCB analysis (relative percent differences from 2 to 30%). From these comparative data, it is reasonable to suggest that the process of long-term archiving at low temperatures did not have an affect on the samples' PCB levels. Because PCB and PBDE congeners have similar structures and similar physicochemical properties, PBDE loss through long term archiving is hypothesized to be minimal as well. Length and weight measurements of all collected eels were made upon collection while lipid content was determined gravimetrically prior to PCB and PBDE analysis in 2005. Identification of sex was not consistently performed and is not reported. Subsamples (several grams wet weight) of homogenized eel tissue were extracted and quantified for PCBs and PBDEs using previously published methods (Ashley et al 2003b; Swackhamer 1987; Stapleton et al 2004).

Figure 1. Collection sites of American eels within the Delaware River Estuary.

Results and Discussion.

Both PCB and PBDE congener patterns remained relatively invariant over the spatial scales studied. That is, congener profiles of Maurice and Cohansy Rivers' eels compared very closely to those eels captured in the northern reaches of the Delaware River at DE Water Gap, and sites between these two end members. The most abundant brominated diphenyl ether (BDE) congeners detected in American eels, in order of largest contributor to smallest, were 47 < 100 < 154 < 119 and 49. Coeluting BDE congeners 28+33, 66, 75, 99, 153, 154, and 155 were often detected but at very low concentrations.

The fully brominated conformation of the diphenyl ether (BDE 209) was not detected in any of the eel samples. Stapleton et al (2004a) found transformation of BDE 209 to lesser brominated products in the common carp. Moreover, through additional dietary exposure studies, BDE 99 was rapidly debrominated to BDE 47, which accumulated in carp tissue (Stapleton et al 2004b). The high relative abundance of BDE 47 and low to non-detectable levels of BDE 99 and 209 suggests that American eels have, like carp, the potential for metabolic debromination. Preliminary data (Ashley unpublished data) on PBDE levels and patterns in Delaware River Estuary sediment confirms that 209 is the dominate congener in this matrix. Eels are therefore likely exposed to BDE 209 but do not accumulate it because of its low bioavailability (Stapleton et al 2004a; Kierkegaard et al 1999) and due to debromination/biotransformation processes.

American eels from the heavily urbanized and industrialized Passaic River have recently been analyzed as part of a New Jersey Department of Environmental Protection's (NJDEP) survey (Ashley unpublished data) with t-PBDEs comparable to the ranges observed in this study (Table 1). More data has been garnered on European eels. Concentrations on a lipid normalized basis were comparable to this study (Table 2). For example, a study in Holland conducted from 1983-1989 revealed t-PBDE concentrations ranging from <50 to 1,700 ng/g lipid (de Boer 1990). The highest reported literature values comes from a report by Goemans and Belpaire (2004) who found up to 32,000 ng/g lipid in eels collected from Belgium. The numbers of eels analyzed in this study were comparable to other American and European studies but the need to more fully evaluate these contaminant levels is warranted to more fully and statistically evaluate the factors determining their levels. Moreover, it is prudent to recognize that reported biotic concentrations of total PBDEs will vary simply due to the definition of 'total' PBDEs in each study. However, in these studies, the predominant congeners found were consistently similar to those found in this study reflecting the widespread usage of the technical formulations used as flame retardants. However, with several states within the U.S. now following western European bans on the penta and octa formulations and the fact that fishes may selectively debrominate some congeners, differences in world-wide congeneric patterns may begin to be discerned.

Table 1. Comparison of ranges of t-PBDE concentrations in American and European eels.

Location	t-PBDEs Concentrations	Units	n	Reference
The Netherlands	<50 to 1,700	ng/g lipid	34	de Boer, 1990
Belgium	2 to 14	ng/g wet	4	Covaci et al., 2005
Germany	3.6 to 21.4	ng/g lipid	5	Lepom et al., 2002
Belgium	~50 to 32,000	ng/g lipid	18	Geomans and Belpaire, 2004
Passaic River	1,604 to 6,439	ng/g lipid	11	Ashley, Unpublished Data
Delaware River	10 to 5,652	ng/g lipid	17	This Study

Acknowledgement. The authors wish to thank the Delaware Estuary Program, Philadelphia University, and the Patrick Center for Environmental Research Endowment Fund for providing funding for this research.

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