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Polychlorinated biphenyls (PCBs) and Polybrominated diphenylethers (PBDEs) in current and historical samples of avian eggs and fish from nesting sites in Buzzards Bay, MA, USA

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Introduction

Well-documented effects of contaminants such as PCBs and chlorinated pesticides have resulted in US regulations limiting their distribution in the environment. More recently, polybrominated diphenyl ethers (PBDEs) have been added to the list of contaminants of 'emerging concern'. PBDEs are part of a larger class of contaminants called brominated flame retardants that are used to reduce the intensity and spread of fire in household and commercial products such as televisions, computers and electronic equipment. PBDEs are similar to PCBs in chemical and physical properties, and similarly persistent in the environment. Like PCBs, PBDEs can bioaccumulate in humans and wildlife. However unlike PCBs, PBDE levels have been increasing in avian populations breeding in the U.S. Migratory avian species are exposed to a wide variety of contaminants through diet on their breeding grounds, but also through their over-wintering habitats. Avian eggs are useful for environmental monitoring because maternally-transferred contamination has the potential to cause serious effects in sensitive early life stages.

This project represents collaborative efforts by various partners. Massachusetts Division of Fisheries and Wildlife collected Common Tern eggs from Ram Island in Buzzards Bay, MA, in spring of 1994-96, 98-99 and 2005, and additional eggs were available through Canadian Wildlife Service archives (1972). In 2006, fish were collected from tern colonies by Massachusetts Division of Fisheries and Wildlife. Chemical analyses were developed and conducted by the U.S. EPA, Atlantic Ecology Division, Narragansett, RI.

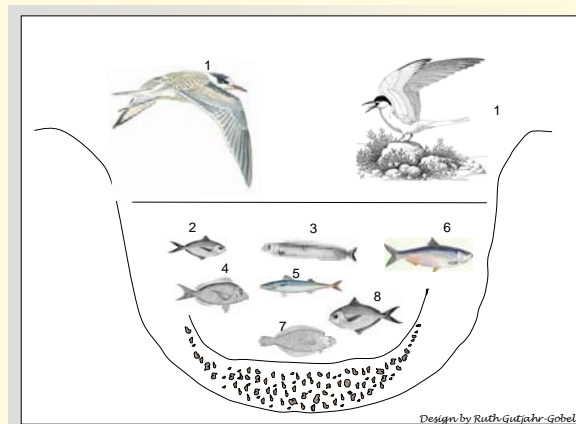
Here we present the concentrations of PCBs and PBDEs in eggs of migratory bird species with summer breeding habitats near or at a PCB Superfund site. Common Terns (*Sterna hirundo*) feed on small fish within 20 km of the breeding colonies. Roseate Terns feed mostly sand lance (*Ammodytes americanus*) to their chicks and Common Tern chicks enjoy a greater diversity of fish species. Fish species collected from tern colonies (butterfish, Atlantic herring, sand lance, mackerel, bluefish, scup and flounder) were analyzed for PCBs and PBDEs. The terns share major breeding colonies in Buzzards Bay, MA, and have similar but distinctive feeding preferences, which may affect their exposure to contaminants.

Chemical Analysis

Homogenized eggs were extracted using acetonitrile and pentane. PCBs were analyzed on a Gas Chromatograph (Agilent 6890) equipped with an electron capture detector. PBDEs were analyzed on a GC-MS in negative chemical ionization mode.

The mean concentration of PCBs is the sum of 18 PCB congeners and that of PBDEs is the sum of 7 congeners. Archived egg extracts stored at -4°C were analyzed for PBDEs in 2007. Fish were analyzed in 2008 for PCBs and PBDEs. PBDE Congener 209 was analyzed in fish and not in tern eggs.

Study System



Food web diagram: Schematic representation of routes for trophic transfer and bioaccumulation of sediment PCBs. Study species are Common and Roseate terns (1), piscivorous birds nesting in colonies offshore from the Superfund site, and feeding over a broad area on fish species; butterfish (2), sand lance (3), scup (4), mackerel (5), herring (6), flounder (7) and bluefish (8).

**Breeding site:
one source of contamination**



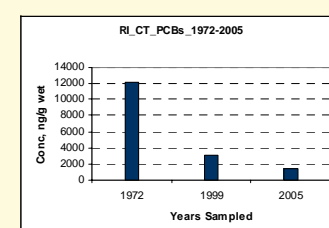
NBH Superfund site above and red box, right with nearby tern breeding colonies in Buzzard's Bay, MA, USA: (1) Ram Island (~10 km from NBH), (2) Bird Island, and (3) Penikese Island.

**Wintering site(s):
other sources of contaminations?**

Banding recoveries have shown that both Roseate and Common terns from the three study sites migrate to spend the winter on the north and east coasts of South America. During this period, most birds of both species feed in coastal waters far from sources of industrial contamination, but many Common Terns winter in the outer parts of the Rio Plata estuary where they may be exposed to contaminants from industrial areas in Argentina and Uruguay.

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Ram Island Common Tern Eggs 1972-2005

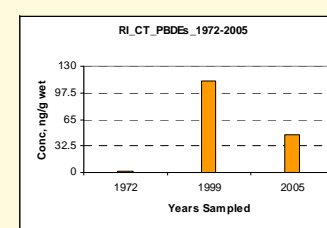


PCBs declined
Note: difference in scale

Long-term trends

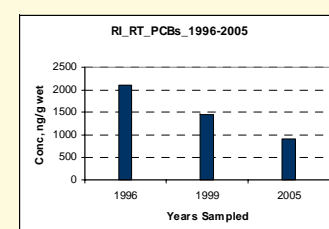


Recent trends

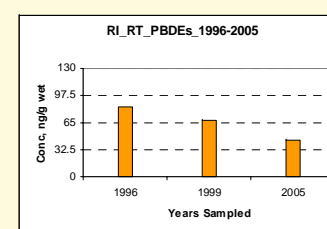


PBDEs peaked & declined

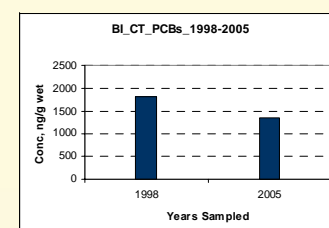
Ram Island Roseate Tern Eggs 1996-2005



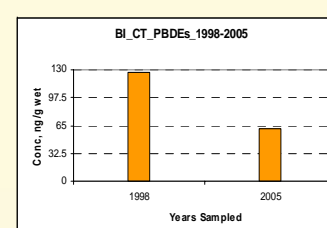
Both PCBs and PBDEs declined



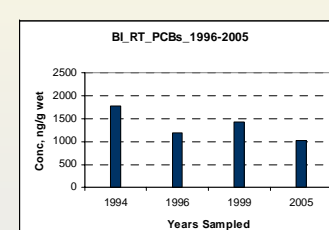
Bird Island Common Tern Eggs 1998-2005



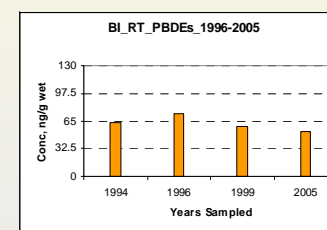
Both PCBs and PBDEs declined



Bird Island Roseate Tern Eggs 1994-2005










PCBs and PBDEs showed small declines



Results

Concentrations of PCBs and PBDEs (ng/g wet) in fish from tern colonies at NBH - 2006

Fish Species	Collection Site	Total PCBs ng/g wet	Total PBDEs ng/g wet	% Lipid
Butterfish (<i>Poronotus triacanthus</i>) 	Ram Island Penikese Island N=8	6.64	5.99	2.61
Sand lance (<i>Ammodytes americanus</i>) 	Penikese Island N=2	16.3	5.12	6.25
Scup (<i>Stenotomus chrysops</i>) 	N=1	74.3	2.58	1.03
Mackerel (<i>Scomber scombrus</i>) 	Bird Island N=1	76.5	6.49	1.74
Herring (<i>Clupea harengus</i>) 	Ram Island Penikese Island N=5	76.9	8.39	1.94
Flounder (<i>Paralichthys dentatus</i>) 	Ram Island N=1	156	38.6	1.45
Bluefish (<i>Pomatomus saltatrix</i>) 	Bird Island Ram Island Penikese Island N=4	193	6.35	2.72

The food and drug administration (FDA) limit for PCBs in food items for human consumption is 500 ng/g wet wt. (K.S. Sajwan *et al.*)

Conclusions

Long-term trends, 1972-2005

- Total PCBs in recently collected Common Tern eggs (2005) have declined to 12% of 1972 levels.
- In contrast to PCBs, total PBDEs have increased during this same period to 3079% of 1972 levels.

Recent trends, 1994-2005

- Total PCB and PBDE egg concentrations for recently collected samples of tern eggs were not significantly different:
 - between species
 - among nesting colonies

- Bluefish had the highest PCB contribution, followed by flounder. No correlation was observed between lipid percent and total contamination levels.
- PBDE congener 47 provided the largest contribution to the total PBDEs in tern eggs.
- PBDE concentrations were lower in fish species. Of the eight PBDEs measured, only 47 and 209 were present in fish. High levels of PBDE 209 in fish were unexpected. Additional study will be conducted to confirm this observation.
- PBDE 47 was the most dominant in tern eggs, whereas PBDE 209 was most dominant in fish species.
- Tern eggs will be reanalyzed for PBDE 209.