

Spatial Distribution of PBDEs and HBCD in Fish, Marine Mammals and Birds: Results of the FIRE Project

Pim Leonards¹, Kine Bæk², Jenny Bytingsvik³, Hege Gaustad³, Bjørn Munro Jenssen³, Elisabeth Lie², Janneche Utne Skaare², Eugen G. Sørmo³, Dick Vethaak⁴

¹ Institute for Environmental Studies, Vrije Universiteit, De Boelelaan 1087, 1081 HV Amsterdam

² National Veterinary Institute, POB 8156 Dep., NO-0033 Oslo, Norway

Norwegian School of Veterinary Science, POB 8146 Dep., NO-0033 Oslo, Norway

³ Department of Biology, Norwegian University of Science and Technology, NO-7491 Trondheim, Norway

⁴ National Institute for Coastal and Marine Management/RIKZ, Kortenaerkade 1, 2518 AX Den Haag, The Netherlands

Introduction

The European project FIRE is a multi- and interdisciplinary project that focuses on the improvement of risk assessment of brominated flame retardants (BFRs) for human health and wildlife, and was recently completed. BFRs, such as the high production volume chemicals polybrominated diphenyl ethers (PBDEs), tetrabromobisphenol-A (TBBPA) and hexabromocyclododecane (HBCD) have been identified as potential endocrine disrupters. One of the main aims of the FIRE project was to identify and characterize the presence of the major BFRs (PBDEs, TBBPA and HBCD) in abiotic and biotic samples from the EU environment, and to determine the food chain transfer of BFRs from water, sediment to invertebrates to predators (fish) and fish-eating top-predators (tern, harbour seals, and polar bear). This paper gives an overview of the spatial distribution of PBDEs and HBCD in marine biota from the Arctic (Spitsbergen, Bear Island) to the Norwegian west coast (Froan), Skagerrak (Oslofjord), Dutch coast, to the Wadden Sea and Western Scheldt estuary in the Netherlands. The Arctic was selected, as it will act as reference site, since the pollutant levels in the Arctic should be much lower than in the North Sea and Skagerrak. The Western Scheldt estuary (NL) was selected as this location is situated industrial activities, including BFR factories and users of BFRs.

Several species (fish, tern, and seal) were selected in all areas to provide comparative information on geographical trends within the same species.

Materials and methods,

Samples from marine organisms were taken along a transect from Spitsbergen (Norway), Barents Sea (Bearend island, Norway), Norwegian Sea (Froan), Skagerrak (outer Oslofjord), to the Dutch Wadden Sea and the Western Scheldt estuary (NL). Polar cod, harbour seal, and arctic tern eggs were collected in Svalbard. Zooplankton, cod, sandgoby, arctic tern (eggs) and harbour seal were collected from Norwegian Sea (Froan). Zooplankton, sandeels, goby, cod, whiting, common terns (eggs) and harbour seal was collected from the Skagerrak (outer Oslofjord). For the Dutch waters, sampling of fish (e.g. sandeels goby) and common tern eggs from the Western Scheldt, and fish (e.g. whiting, goby) and harbour seals (Wadden Sea) was carried out. PBDEs and HBCD were determined in all samples using GC-MS and/or LC-MS. Levels of BFRs were normalized on lipid weight basis.

Results and discussion

In the Western Scheldt an increasing trend of PBDE and HBCD levels in common tern eggs upstream were found, probably due to the use and emission of these BFRs in the production of various products upstream the estuary, as has been reported earlier (de Boer et al., 2003), and BFR levels in Scheldt terns were substantially higher (6-21 times) than in common tern eggs from the Skagerrak Sea. This

higher environmental load of BFRs in Western Scheldt was also evident when comparing other Scheldt organisms to corresponding organisms from the Dutch Wadden Sea and Skagerrak. In goby higher concentrations of PBDEs and HBCD were found in the Western Scheldt (190 and 191 ng/g lipid respectively), where concentrations of PBDEs were about 5 to 10 times higher and HBCD about 15 times higher, than in goby from the Dutch Wadden Sea (average 33 and 12 ng/g lw, respectively) and Skagerak Sea (19 and 11 ng/g, respectively).

In Norwegian waters, levels of PBDEs and HBCDs generally decreased as function of increasing latitude in zooplankton, cod, terns and harbour seals, reflecting distance for release sources (Sørmo et al.; Jenssen et al. 2007). For zooplankton, cod, and seals levels generally decreased by one order of magnitude from the Skagerak Sea in the south to Spitsbergen in the high Arctic. For terns (Arctic and Common) much less differences were seen between populations, most likely being they are exposed during migration. However, the substantially elevated levels of PBDEs and HBCD in the Western Scheldt terns suggest their high exposure and bioaccumulation to these compounds at their breeding grounds. In all species, HBCD was predominantly found as α -HBCD.

In polar cod, levels of sum PBDE and HBCD were much higher at Bear Island than at Spitsbergen, but lower than in cod from the Skagerak Sea and Froan. At Froan and Bear Island the levels of PBDEs were about 33-50% and 10%, respectively, of those reported in cod from the Oslofjord. With respect to spatial trends in HBCD, the differences between Spitsbergen, Froan and Oslofjord were not as large as for the PBDEs.

The tern egg results showed that the levels of sum PBDE and HBCD was highest in the Western Scheldt, and the levels in the Oslofjord, Froan and Spitsbergen were much lower (Figure 1). In Norwegian waters 8 to 70 times lower concentrations of BDE47 were detected, and 9 to 150 lower concentrations of HBCD than in the Western Scheldt.

It should be noted that the concentrations of PBDEs in mature male harbour seals from the outer Oslofjord were in the same order of magnitude as the concentrations in mature male harbour seals from the Wadden Sea (Figure 2). This pattern was also seen for HBCD, levels in harbour seals were lowest at Svalbard, followed by seals from Froan, and highest in the Oslofjord and Wadden Sea. The HBCD levels in Oslofjord and Wadden Sea are about one order of magnitude higher than in the seals from Spitsbergen (Figure 2).

In conclusion, although PBDEs and HBCD are present in the Arctic, the levels of these compounds here are much lower than along the Norwegian and Dutch coast. The highest levels for both PBDEs and HBCD are found in the Western Scheldt estuary, which is probably related to the use. More information on the PBDE and HBCD levels for the Norwegian locations can be found in Gaustad, et al., Sørmo et al., Jenssen (2007), Bytingsvik et al., (2004).

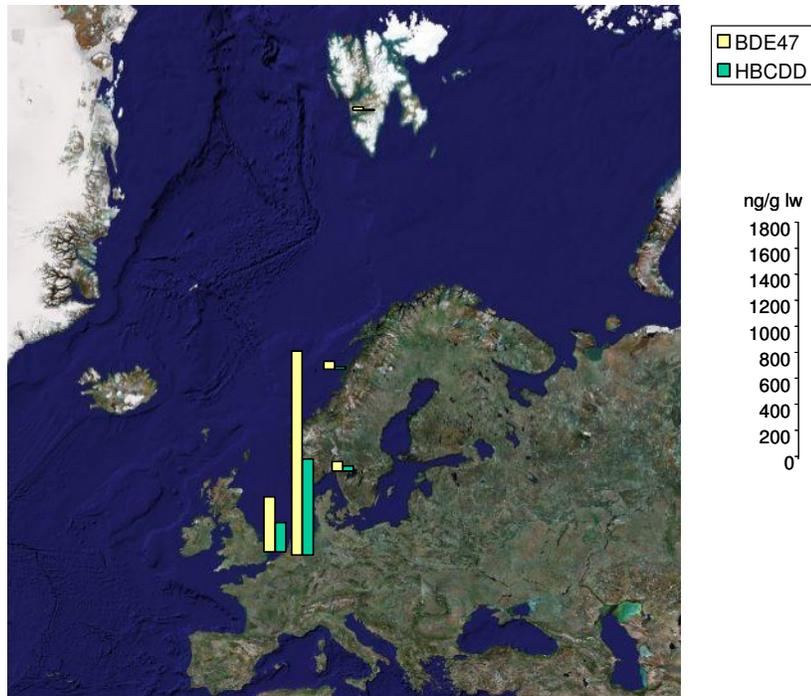


Figure 1: Mean concentrations (ng g^{-1} lipid weight) of BDE47 and HBCD in Arctic and common tern eggs from Spitsbergen, Froan, Oslofjord, Western Scheldt (Terneuzen and Saeftinghe).

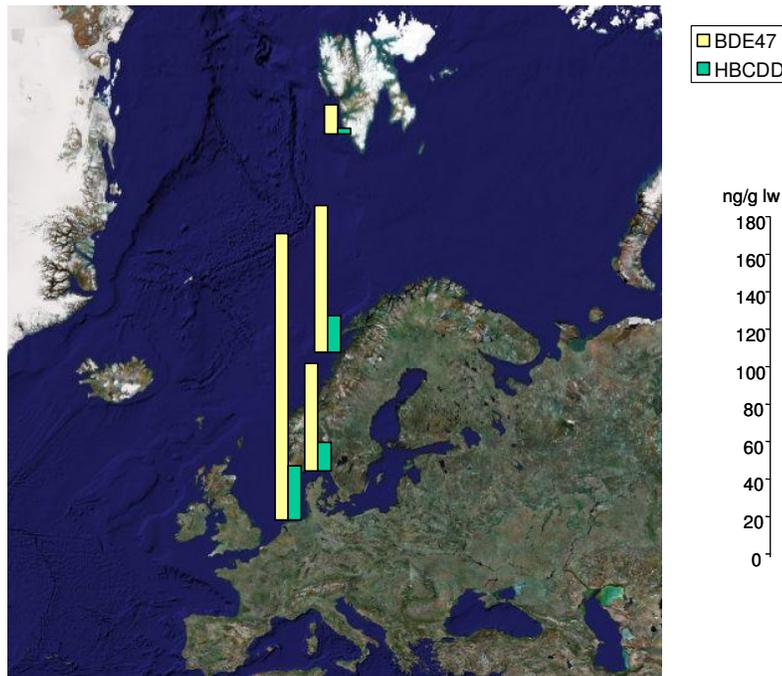


Figure 2: Mean concentrations (ng g^{-1} lipid weight) of BDE47 and HBCD in harbour seals from Spitsbergen, Froan, Oslofjord, and Wadden Sea.

Acknowledgements

This study was supported by the European Union project FIRE, contract no. QRLT-2001-00596. The content herein does not represent the opinion of the European Community. We want to thank C. Kwadijk, S. Brandsma, J. van Hesseligen, and A. Kruijt for the chemical analysis. J. Jol is acknowledged for collecting the samples in the Wadden Sea and Western Scheldt.

References

- de Boer J, Wester PG, van der Horst A, Leonards PEG. 2003. *Environ Pollut* 122 (1): 63-74.
- Bytingsvik J, Gaustad H, Salmer MP, Sørmo EG, Bæk K, Føreid S, Ruus A, Skaare JU, Jenssen BM, 2004. *Organohalogen compounds* 66: 3918-3922.
- Gaustad H, Jenssen BM, Sørmo EG, Bæk K, Ruus A, Skaare JU. submitted. Biomagnification of brominated flame retardants from Atlantic cod (*Gadus morhua*) to Harbour seals (*Phoca vitulina*)
- Jenssen, BM, EG Sørmo, K Bæk, J. Bytingd vik, H Gaustad, A. Ruus, JU Skaare. 2007. *Environ. Health Persp.* 115
- Jenssen, BM. Sørmo EG, Bæk K. Bytingsvik J, Gaustad H Ruus, A, Skaare JU. 2007. *Environ Health Perspect.* Vol 115.
- Sørmo EG, Gaustad H, Jenssen BM, Ruus A, Bæk K. Skaare JU. submitted. Age- and gender-specific bioaccumulation of polybrominated diphenyl ether and hexabromocyclo-dodecane flame retardants in herring gulls.
- Sørmo EG, Salmer MP, Jenssen BM, Hop H, Kovacs KM, Lydersen C, Falk-Petersen S, Gabrielsen GW, Lie E, Skaare JU. 2006. *Environ Toxicol Chem.* *Environ Toxicol Chem.* 25 (9), 2502-2511.