Assessing Global Threats of Pollution and Climate Change to Marine Mammals Across Three Oceans

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Introduction

Marine mammals (whales, dolphins, seals) are confronted with complex stresses including ocean pollution and climate change, and an estimated 40% of their species face extinction by 2050.[1] As top predators, marine mammals bioaccumulate a wide range of pollutants including banned industrial chemicals (PCBs), pesticides (DDT), as well as flame retardants, heavy metals, petroleum, and highly fluorinated compounds.[2-6] These chemicals are linked with serious health effects in marine mammals, such as endocrine disruption, immune suppression, and decreased survival.[7-9]

Climate change is an increasing stress for marine mammals, particularly for those from northern latitudes with rapid warming rates.[10] Global warming is causing a reduction in ice cover, critical breeding grounds for several species, as well as radical shifts in prey availability.[11] Climate change also affects the distribution and toxicity of chemical pollutants in the marine environment in complex ways.[10]

This study reports on the occurrence, distribution, and time trends of legacy (banned) and novel flame retardants in nine species of marine mammals inhabiting the coasts of the eastern US, Sweden, Iceland, and Greenland. These data, combined with climate change data, will help predict the health and survival of these populations and inform policy to sustain life in the oceans.

Methods

Figure 1. Map of sampling regions.

Table 1. Sample numbers for species per region.

Species	US	Sweden	Iceland	Greenland
Harbor Seal	72	85	11	
Grey Seal	8	11	10	
Ringed Seal		10	2	21
White-sided Dolphin	9			
White-beaked Dolphin				15
Harbor Porpoise	9			
Long-finned Pilot Whale	4			9
Minke Whale	2			6
Humpback Whale	1			13

Table 2. Compounds analyzed in marine mammal tissues and their commercial uses.

	Compound		Uses
PBDEs	BDE-17	2,2',4-Tribromodiphenyl Ether	Constituents of PentaBDE commercial mixture. Mainly used as additive flame retardants (FR) in flexible polyurethane foam and fabrics. Banned in Europe and withdrawn from US commerce in 2004. [12]
	BDE-28	2,4,4'-Tribromodiphenyl Ether	
	BDE-47	2,2',4,4'-Tetrabromodiphenyl Ether	
	BDE-49	2,2',4,5'-Tetrabromodiphenyl Ether	
	BDE-66	2,3',4,4'-Tetrabromodiphenyl Ether	
	BDE-99	2,2',4,4',5-Pentabromodiphenyl Ether	
	BDE-100	2,2',4,4',6-Pentabromodiphenyl Ether	
	BDE-153	2,2',4,4',5,5'-Hexabromodiphenyl Ether	
	BDE-154	2,2',4,4',5,6'-Hexabromodiphenyl Ether	
	BDE-183	2,2',3,4,4',5',6-Heptabromodiphenyl Ether	Constituents of OctaBDE commercial mixture. Mainly used as additive FR in hard plastics and thermoplastic resins. Banned in Europe and withdrawn from US commerce in 2004. [12]
	BDE-201	2,2',3,3',4,5',6,6'-Octabromodiphenyl Ether	
	BDE-202	2,2',3,3',5,5',6,6'-Octabromodiphenyl Ether	
	BDE-196	2,2',3,3',4,4',5,6'-Octabromodiphenyl Ether	
	BDE-197	2,2',3,3',4,4',6,6'-Octabromodiphenyl Ether	
Dechloranes	Syn-DP	Syn-Dechlorane Plus	Constituents of commercial Dechlorane Plus. Additive FR in wire coatings, plastic roofing, computer parts [13]
	Anti-DP	Anti-Dechlorane Plus	
	DEC-602	Dechlorane 602	FR use information very limited. Also found as impurities in pesticides [13]
	DEC-603	Dechlorane 603	
	DEC-604	Dechlorane 604	
	Cplus	Chlordene Plus	
	CL11-DP	Mono-dechlorinated Dechlorane Plus	Breakdown product of Dechlorane Plus [13]
Other BFRs	ATE	2,4,6-tribromophenyl allyl ether	Additive FR in expandable polystyrene and foam [14]
	TBPX	2,3,5,6-tetrabromo-p-xylene	Additive FR in paints, textiles, plastics [15]
	TBOCT	Tetrabromo-o-chlorotoluene	Additive FR, Use information very limited [15]
	PBT	Pentabromotoluene	Used in plastics, polystyrene, rubbers and textiles [14]
	PBEB	Pentabromoethylbenzene	Additive in polyester resins for electronics, textiles and foam [14]
	HBBZ	Hexabromobenzene	Additive to paper, wood, textiles, and electronics mostly in Japan [14]
	BB-101	2,2',4,5,5'-pentabromobiphenyl	Legacy flame retardant. PBBs banned in US in 1974 [16]
	BTBPE	1,2-bis-(2,4,6-tribromophenoxy)ethane	Replacement for OctaBDE. Additive FR in plastics, resins, coatings [14]
	EHTBB	2-ethylhexyl-2,3,4,5-tetrabromobenzoate	Constituents of Firemaster 550. Replacement for PentaBDE in polyurethane foam [14]
	BEHTBP	Bis(2-ethyl-1-hexyl)tetrabromophthalate	

Results

Flame retardants in seals from different regions

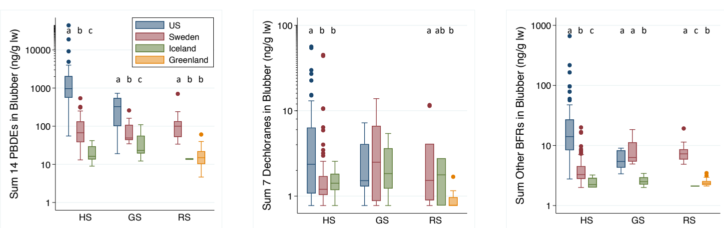

Figure 2. Box plots of concentrations of sum PBDEs, sum Dechloranes, and sum other BFRs in harbor seals (HS), grey seals (GS), and ringed seals (RS) from the US, Sweden, Iceland, and Greenland. Letters above the bars indicate significant differences among countries by Kruskal-Wallis and post hoc Mann-Whitney U tests (p<0.05).

Flame retardant concentrations in US marine mammals

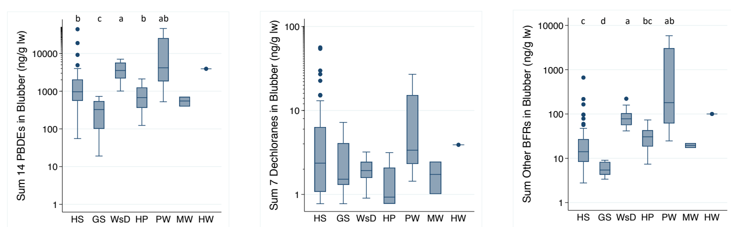

Figure 3. Box plots of concentrations of sum PBDEs, sum Dechloranes, and sum other BFRs in harbor seals (HS), grey seals (GS), white-sided dolphins (WsD), harbor porpoises (HP), pilot whales (PW), minke whales (MW), and a humpback whale (HW) from the US. Letters above the bars indicate significant differences among species by Kruskal-Wallis and post hoc Mann-Whitney U tests (p<0.05).

Patterns of flame retardant chemicals in US species

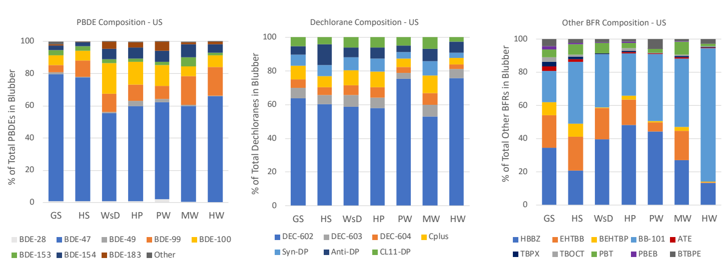

Figure 4. Average composition of sum PBDEs, sum Dechloranes and sum other BFRs in blubber of US harbor seals (HS), grey seals (GS), white-sided dolphins (WsD), harbor porpoises (HP), pilot whales (PW), minke whales (MW), and a humpback whale (HW).

Time trends in US and Sweden harbor seals

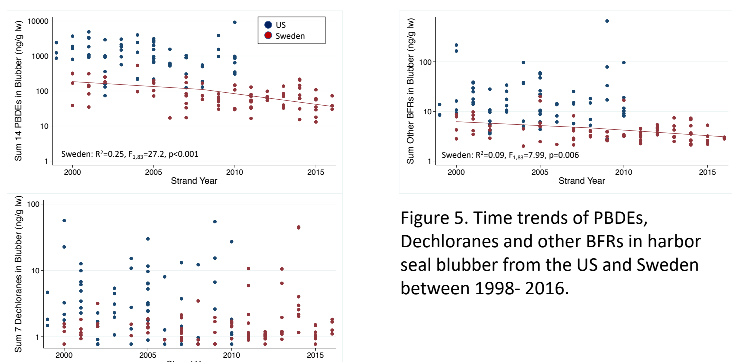

Figure 5. Time trends of PBDEs, Dechloranes and other BFRs in harbor seal blubber from the US and Sweden between 1998- 2016.

Conclusions

- Toothed whales (dolphins, porpoises, pilot whales) had higher contaminant concentrations than the seals or baleen whales (minke, humpback), reflecting their higher position on the food web.
- Compared to other regions, US Atlantic harbor seals had the highest concentrations of PBDEs, Dechloranes, and other BFRs including HBBZ, BB-101, and Firemaster 550 components.
- In US species, PBDEs were the predominant flame retardants reflecting their higher volume use in the US than in Europe.
- PBDEs and other BFRs were decreasing in Swedish harbor seals, but not in US harbor seals between 2000-2016.

References

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