Reply to the Comment on "Exposure to mercury and Aroclor 1268 congeners in least terns (Sternula antillarum) in coastal Georgia, USA" by P. Fuchsman, M. Henning and V. Magar, Environmental Science: Processes & Impacts, 2016, 18, DOI: 10.1039/C5EM00489F

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Abstract

This article provides our response to the comment by Fuchsman *et al*. regarding the interpretation of results presented in our recent publication (Robinson *et al.*, *Environmental Science: Processes & Impacts*, 2015, **17**, 1424) reporting on concentrations of Aroclor 1268 congeners in least tern eggs in coastal Georgia, USA.

Introduction

We appreciate the comment by Fuchsman *et al*.,[1] however, we are steadfast in believing that the interpretation of our results[2] does not misguide the reader. We have addressed the specific concerns raised in their letter below.

Aroclor 1268 Toxicity

We do not dispute that experimental studies and the general consensus in the literature have found that chickens and other Galliformes are more sensitive to effects of PCBs than tern species; however, it is important to note several weaknesses in the comparison between the responses of least terns and chickens to toxicants: 1) studies that compare physiological responses of chickens with those of wild birds may not be appropriate; in fact, the EPA has specifically approved mallard ducks (*Anas platyrhynchos*) and northern bobwhite (*Colinus virginianus*) as models for wildlife studies and are thus preferred for comparisons[3]; 2) studies that only use chickens as models for PCB contaminant effects on chick growth or development have ignored the developmental pattern differences among species. See Scanes and McNabb[3], in Avian Models for Research in Toxicology and Endocrine Disruption, 2003: "The timing of exposure to toxicants, the developmental stage of particular organs and tissues, and its associated maturation of endocrine and nervous control can all interact in critical ways to influence the nature of the toxicant effect." Furthermore, chickens are highly precocial, whereas least terns are semi-precocial and thus, considerably less mature at the time of hatching and with different developmental maturation rates compared to chicken embryos; 3) the husbandry of adult and young chickens used in controlled laboratory studies, referenced by Fuchsman et al., does not reflect or represent the additional physiological stressors that are typically experienced by wild birds. For example, temperature fluctuations can be extreme for least terns nesting on beaches, and even more so for those nesting on artificial substrate such as rooftops or dredge spoil islands, as many do in Georgia. Responses to predators are a significant stressor for least terns because predation threats are extremely high for this species. Also, variations in nutritional intake, parental care, competition, and many other ecological features are additive factors that influence the assimilation, distribution, and expression of contaminants. These additive effects have been shown repeatedly for other contaminants and other study systems[4]. Thus, in our paper, we determined that it was more appropriate to compare effects of Aroclor 1268 concentrations in least terns to effect thresholds of other PCBs in other tern species rather than in chickens. We acknowledge we were not comparing effects of Aroclor 1268 in each tern species, but effects of PCBs; there are no other studies that specifically examine Aroclor 1268 in another closely related species, which calls for more studies on this question.

Lastly, it is important to note that in the Discussion of Robinson et al., we do not state that the concentrations of Aroclor 1268 found in least terns in this study were directly responsible for any adverse effect. We do claim that similar concentrations have been associated with adverse effects in other studies in related species. High variability of effects thresholds is reported in the literature among species and even among individuals of the same species, and dry weight vs. wet weight of contaminants is not always clear. For example, Fisk et al. 2005[5] cite 2.3 ppm wet weight in eggs as a NOEL for hatching success in Forster's terns (*Sterna forsteri*; Table 2; based on Bosveld and van den Berg 1994[6]), and least tern eggs in our study exceeded this concentration. Furthermore, least terns are a state-listed species of conservation concern in most of the eastern USA, and a federally endangered species in the rest of its range. Given the amount of variability in effects thresholds among species, even a 7 ppm (wet weight) effects threshold of PCBs in terns in other studies may be cause to investigate adverse effects in least terns exposed to 5.4 ppm in Georgia.

Sources of Aroclor 1268 Contamination

Fuchsman et al. correctly point out that Aroclor 1268 was a component in many materials used in Navy submarines and surface ships constructed before 1977. They conclude that shipbuilding and maintenance facilities likely contributed to environmental contamination of Aroclor 1268 from naval operations near Brunswick, GA and elsewhere along the southeastern US coast. However, published reports of Aroclor 1268 contamination in estuaries on the east cost of the US conclude that the most likely source was release from manufacturing facilities and not from shipbuilding and maintenance operations. For example, studies[7, 8] on PCB contamination in Narragansett Bay, RI, which historically housed shipbuilding and maintenance operations at several Navy facilities around the bay, indicated that Aroclor 1268 contamination was likely derived primarily from release by an industrial facility near the Taunton River and not from naval operations. Aroclor 1268 concentrations in dated sediment core depth profiles chronologically correlated with recorded Aroclor 1268 use at the manufacturing facility on the Taunton River. The ecological risk from PCB leaching from a sunken Navy war ship (Vermillion) near the coast of South Carolina was evaluated by Johnson et al.[9]. Empirical PCB leaching rates for felt gaskets, electric cable, paint, rubber, foam insulation, oils and greases, bulkhead insulation, and pure Aroclor mixtures were used to simulate the release of PCBs from the Navy vessel and then estimate the instantaneous steady state concentration of total PCB around the ship. The model simulation predicted total PCB concentrations (wet/dry weight not reported) ranging from 0.06-4.85 ng/g in fish near the ship. Tissue data from fish samples collected near the ex-Vermillion reef created by the sunken ship generally ranged from 10-500 ng/g dry wt.; however, these concentrations were total PCBs which were dominated by lower chlorinated congener mixtures (e.g., Aroclor 1254 and 1260). The concentrations of higher chlorinated congeners present in Aroclor 1268 would be considerably lower. In conclusion, based on the published reports cited above, we maintain that the most likely source of Aroclor 1268 in least tern eggs reported in our study is contamination at the Linden Chemical Plant (LCP) site. Future studies may provide a better understanding of the contribution of contaminants, including Aroclor 1268, from naval operations in and near estuaries on the southeastern coast of the US.

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