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Killer whales call for further protection

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It is widely accepted that persistent environmental contaminants are present at levels to cause concern in top predators (see, for example, R. J. Letcher et al. *Sci. Tot. Environ.* **408**: 2995–3043; 2010). The long banned industrial chemical polychlorinated biphenyls (PCBs) remains a major threat to marine top predators such as killer whales because of its persistence and empirically demonstrated adverse effects on almost all physiological systems in the mammalian body, including importantly reproduction and immunity (J.-P. Desforges et al. *Environ. Internat.* **86**:126–139; 2016).

Now, our recent modelling study published in *Science* has suggested that the long-term viability of over half of the worlds studied killer whale (*Orcinus orca*) populations is at risk because of PCBs (J.-P. Desforges et al. *Science*, **361**, 6409: 1373–1376; 2018). These new findings support previous suggestions of population-level effects in killer whales as well as reproductive effects on striped dolphin (*Stenella coeruleoalba*) and bottlenose dolphin (*Tursiops truncatus*) (P. D. Jepson et al. *Scient. Rep.* 6:18573; 2016). Our modelling study also provides an important framework to model future cumulative effects of anthropogenic stressors at the population-level. While our work was intended to highlight the potential risk of only one important chemical stressor, it is imperative for future studies to consider the complex mixture of stressors facing killer whales in the real world. PCBs is but one stressor, and we know that human disturbance and underwater noise from boat traffic as well as food limitations are two other critical factors influencing different populations of killer whales (J. K. Ford et al. *Biol. Lett.*, **6**(1): 139–142; 2009; DFO, Canada, *https://www.canada.ca/en/environment-climate-change/services/species-risk-public-registry/related-information/southern-resident-killer-whale-imminent-threat-assessment.html*; 2018). Individual population dynamic studies require a case-by-case assessment of the cumulative impacts from the various factors influencing those populations.

Among the killer whale populations highly exposed and threatened by PCBs, are those foraging on marine mammals along the coast of East Greenland (J.-P. Desforges et al. *Science*, **361**, 6409: 1373–1376; 2018). Due to their recent appearance in the area, no hunting regulations exist for the local subsistence hunt, and more than 43 killer whales have been legally landed since 2009, creating an additional stressor to this population (Piniarneq, Ministry of Fisheries & Hunting, Government of Greenland; 2017). Unknown hunting losses (animals shot and sinking before being secured for transport to shore) are also likely to contribute to greater mortality rates than reported. To preserve this population, regulations or a provisional hunting ban would be appropriate until basic information on population structure and numbers is available. While efforts to reduce PCB contamination in killer whales may take some time, action on hunting in Greenland will have immediate effects to protect this population.

The Greenland Health Authorities (The Greenland Nutrition and Exercise Council, Veterinary and Food Authorities of Greenland), promptly (within a week) responded to the Desforges et al. (2018) paper. The Authorities recommended that the hunters and general population stop consuming killer whales due to high concentrations of PCBs (Government of Greenland, https://naalakkersuisut.gl/da/Naalakkersuisut/Nyheder/2018/10/0510_spaekhuggere; 2018). Such fast action and recommendations, if followed by the hunters, should reduce the hunters as well as the sled dog (likewise being fed killer whale tissue) exposure to PCBs, with the added benefit of reducing the hunting stress on the killer whale population bordering Southeast Greenland.

The IUCN Red List currently lists killer whales as 'data deficient', rather than a more protective "endangered" listing (IUCN Red list, 2018). While population numbers and genetics are missing for many populations of killer whales, we argue that known population stress from underwater noise and food limitations, combined with the recent findings on hunting and our modeled predictions of PCB affects at the population-level, warrants further efforts to update the status of this vulnerable species. However, from the reviews of this correspondence it is evident that other stressors like food limitation, underwater noise and even inbreeding loads, potentially all could impact fitness and fecundity, and for some populations be even more severe than the predicted PCB effects.

One piece of recent information that adds to the contamination issue for killer whales and other toothed whales is linked with reduced enzymatic CYP-450 activity that reduces the ability to metabolize organochlorine (S. Kim et al. *Gen. Biol.* **17**:211.; 2016; M. A. McKinney et al., *Environ. Toxicol. Chem.* **30**:1506–1514; 2011; C. Sonne et al. *Science* **361**, 6498: 1208; 2018).

This story reveals that PCBs, despite been regulated since the 1970s, still appear to be a problem for long-lived top predators such as killer whales (J.-P. Desforges et al. *Science*, **361**, 6409: 1373–1376; 2018) and presumably other toothed whales at the population-level. In cases where humans consume toothed whales, this elevated exposure may negatively affect the health of these hunters and their families. Hence, continued research into physiological and fitness consequences of PCB exposure in marine mammals and improvements of modelling techniques to predict population effects are needed. This combined with additional regulatory efforts at the national and international level for rapid and permanent elimination of major PCB contamination (S. J. Stuart-Smith and P. D. Jepson, P.D., 2017. *Mar. Policy* **84**, 69–75; 2017)

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as well as outreach and participation across academic, governmental, non-governmental (stakeholders), and industrial partners is needed to improve environmental quality for human and wildlife health.

Rune Dietz[a,*], Christian Sonne[a], Jean-Pierre Desforges[a], Igor Eulaers[a], Robert J. Letcher[b], Paul D. Jepson[c]
[a] *Aarhus University, Roskilde, Denmark*
[b] *Carleton University, Ottawa, Canada*
[c] *Institute of Zoology, London, UK*
E-mail address: rdi@bios.au.dk (R. Dietz).

* Corresponding author.