GLOBAL PATTERNS OF MERCURY CONTAMINATION IN CETACEANS

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Introduction

The continuous accumulation of heavy metals in the aquatic environment is a serious threat to marine organisms. Next to other prominent examples, mercury (*Hg*) is one of the most toxic ones because of its persistence and consequent bioaccumulation potential (O'Shea, 1999). Due to many anthropogenic sources, the amount of *Hg* in the oceans has almost tripled compared to the preindustrial period (Lamborg et al., 2014). Mercury enters the marine food web through its most toxic, organic form, methylmercury (*MeHg*), which has a high affinity for lipids and long half-life (Cardellicchio et al., 2002; UNEP, 2013). Hence, the bio-accumulation of *Hg* via food ingestion is the most important uptake route for marine animals and especially organisms at the top of the food chain, i.e. cetaceans, are particularly vulnerable (Bilandžić et al., 2012). Cetaceans cope with *Hg* contamination with the help of the essential trace-element selenium (*Se*), which is able to inhibit the toxic effects of *MeHg* by binding it into insoluble compounds (*HgSe*; Ralston 2008). It has been suggested that a ratio of *Se* to *Hg* above 1 is necessary to protect the organism against *Hg* toxicity (Ralston, 2008). Although there have been many studies on the *Se*:*Hg* relationship in different cetacean species, little is known about the global patterns of this relationship in cetaceans. Here, we examined the global patterns of *Hg* (and *Se*) accumulation in cetaceans and depicted how this group of organisms is coping with high levels of contamination. We included samples from different regions of the world, which provides us with a synoptic view on the health hazards caused by high *Hg* concentrations in the marine environment.

Methods

We obtained information on the *Hg* concentration found in liver tissue of 32 cetacean species. In total, we compiled 788 samples from individuals stranded in different regions across the global oceans. For a subset of the stranded individuals (i.e. 362 individuals belonging to 20 cetacean species), we also have information on *Se* concentrations in their liver tissue. We explored the patterns of *Hg* accumulation in stranded individuals against the suggested toxic threshold for cetaceans liver tissue (87 µg/g dry weight; Rawson et al. 1993). We divided sampling regions according to the 2013 global *Hg* assessment that published the global mercury inventory of 2005 as the level of elementary *Hg* in the air in different regions of the world (UNEP, 2013). Additionally, we used linear models to describe the relationship between *Se* and *Hg* and how this can differ from the predicted 1:1 theoretical relationship (Ralston, 2008). Samples are separated according to the different cetacean families and to the regions defined in the UNEP report (2013).

Results

Almost half of the *Hg* emissions in 2005 are produced by Japan and China (47.4 %; UNEP, 2013). Europe produced 10.6 % of the emissions, while Africa shows one of the lowest percentages of emission with 5 %. Mercury concentrations of stranded cetaceans present contrasting patterns and significant differences among regions. Cetaceans sampled in Antarctica, North and South America as well as South East Asia displayed the smallest *Hg* levels, while the highest concentrations were detected in animals sampled at the coast of Africa, North East Asia and Europe. Comparing concentrations (µg/g dry weight) of *Se* and *Hg* in individuals stranded at different coastlines in the world, revealed a sublinear relationship with a slope of 0.73 (± 0.019). At overall low *Hg* values more individuals showed higher *Se* than *Hg* concentrations, which is observed by the regression line above the 1:1 ratio line. This trend is shifting at higher concentrations, i.e. above 7.94 µg/g dry weight of *Hg*, where the regression line changes from supralinear to sublinear values.

At the highest measured *Hg* values almost no individual has higher *Se* than *Hg* concentrations. Summarizing the relationship between *Hg* and *Se* concentrations according to the UNEP regions classification, Africa (i.e. Canary Islands) shows the only value above the 1:1 ratio line. Moreover, the highest investigated values for *Hg* compared to *Se* concentrations are found in the samples originating from: Europe, North East Asia (i.e. China and Japan) and North America.

Conclusion

Mercury concentrations in cetaceans are mainly influenced by the contamination of the habitat. Individuals sampled in the Mediterranean Sea, North Atlantic and North East Asia show the highest *Hg* concentrations due to natural sources and high anthropogenic input. Individuals sampled at the Canary Islands are the only ones with *Se* concentrations higher than corresponding *Hg* values, indicating an efficient protection against its toxicity. However, our comprehensive analysis showed that cetaceans in most of the sampling regions are under threat due to the high accumulation of *Hg* found in these stranded organisms.

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