Marine Pollution Bulletin 168 (2021) 112398

Contents lists available at ScienceDirect

Marine Pollution Bulletin

journal homepage: www.elsevier.com/locate/marpolbul

Negative metal bioaccumulation impacts on systemic shark health and homeostatic balance

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ARTICLE INFO

Keywords:
Conservation physiology
Ecotoxicology
Biomagnification
Sharks
General health

ABSTRACT

Contamination by metals is among the most pervasive anthropogenic threats to the environment. Despite the ecological importance of marine apex predators, the potential negative impacts of metal bioaccumulation and biomagnification on the health of higher trophic level species remains unclear. To date, most toxicology studies in sharks have focused on measuring metal concentrations in muscle tissues associating human consumption and food safety, without further investigating potential impacts on shark health. To help address this knowledge gap, the present study evaluated metal concentrations in the gills, muscle, liver and rectal gland of coastal sharks opportunistically sampled from Brazilian waters and tested for potential relationships between metal bioaccumulation and general shark health and homeostatic balance metrics. Results revealed high metal concentrations in all four tissue types, with levels varying in relation to size, sex, and life-stage. Metal concentrations were also associated with serum biomarkers (urea, lactate, ALT, triglycerides, alkaline phosphatase, and phosphorus) and body condition, suggesting potential negative impacts on organismal health.

1. Introduction

As a taxonomic group, sharks are particularly vulnerable to anthropogenic stressors, such as exploitation, habitat degradation and climate change, due to life-history traits that feature late maturity and relatively low reproductive output (Gallagher et al., 2012; Worm et al., 2013; Pacoureau et al., 2021). While research into threats to sharks has primarily focused on mortality due to fishing, a growing concern on the possible sublethal impacts of bioaccumulated toxic pollutants (e.g., metals) on shark health and fitness is noted (Turoczy et al., 2000; Rumbold et al., 2014). While previous research has tested shark tissues for the presence and concentration of metals (e.g., Shipley et al., 2021), this has usually been addressed from a food safety perspective to ascertain whether metal levels would be safe for human consumption (e.g., Souza-Araujo et al., 2021; Hammerschlag et al., 2016; Anandkumar et al., 2018).

Some studies have evaluated the mechanistic consequences of metal contamination on shark physiological processes, including alterations in osmoregulatory function (Kinne-Saffran and Kinne, 2001; De Boeck et al., 2001, 2010; Grosell et al., 2003) as well as cellular and fluid composition (Ballatori and Boyer, 1996; De Boeck et al., 2001, 2010; Grosell et al., 2003). For example, Pb accumulation in the gills, rectal gland, muscle and liver has been shown to affect osmoregulation, respiratory capacity and energy metabolism in the dogfish shark (*Squalus acanthias*) (Eyckmans et al., 2013), while Ag and Cu accumulation in the gills, liver, kidney, rectal gland, intestine, muscle and skin tissues have been reported to cause respiratory disturbance, hyperventilation, blood alkalosis, altered anaerobic metabolism, lactate accumulation,

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https://doi.org/10.1016/j.marpolbul.2021.112398
Received 22 August 2020; Received in revised form 28 February 2021; Accepted 1 April 2021