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Maternal mercury transfer from pregnant spiny (Squalus acanthias) and smooth (Mustelus canis) dogfish to their pups through differing reproductive strategies

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Introduction

- Mercury (Hg) is a pervasive contaminant that bioaccumulates in marine biota.
- Hg may be transferred from pregnant females to developing embryos (intrauterine maternal Hg offloading), leading to health deficits in offspring.
- Spiny dogfish (*Squalus acanthias*) are ovoviviparous and developing pups are nourished by a yolk sac (Fig. 1). In contrast, smooth dogfish (*Mustelus canis*) are viviparous and pups are nourished via a placental connection to the mother.
- This study examined maternal Hg transfer in spiny and smooth dogfish to assess how differing reproductive strategies affect Hg burdens in intrauterine pups.

Objectives

- Measure total [Hg] in muscle tissue excised from pregnant smooth and spiny dogfish and their intrauterine pups
- Compare mean maternal and pup [Hg] between smooth and spiny dogfish
- Evaluate Hg-size and -age relationships (bioaccumulation) in male and female dogfish, with differences in [Hg] across sexes evidence of maternal Hg offloading
- Examine pup [Hg] as a function of their body size and maternal [Hg]

Methods

- Female dogfish collected from Narragansett Bay and Rhode Island Sound via rod & reel, gillnet, and trawling (Jul-Jul 2011-2024), iced for transport, and frozen at -20°C until dissection.
- Dogfish total length (TL, cm) measured in lab, after which intrauterine pups were extracted and muscle tissue excised from mothers and pups.
- All samples freeze-dried for 48 hr, homogenized, and analyzed for total [Hg] (ppm dry weight) using a Direct Mercury Analyzer (Milestone Inc.).
- Parametric statistics used to examine: (i) mean differences in maternal and pup [Hg] between dogfish species (t-test), (ii) sex-specific Hg-size and -age relationships (linear regression and ANCOVA), and (iii) pup [Hg] as a function of body size and maternal [Hg] (Exponential regression).

References: Baró-Camarasa et al. 2022. Mar Pollut Bull 179: 11367; Lyons & Lowe. 2013. Can J Fish Aquat Sci 70: 1667-1672; van Hees & Ebert. 2017. Sci Total Environ 590-591: 154-162.

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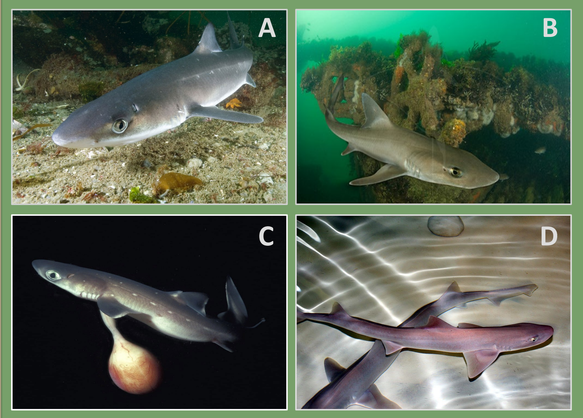

Figure 1. Mature female spiny dogfish (A), mature female smooth dogfish (B), spiny dogfish pup (C), and smooth dogfish pup (D).

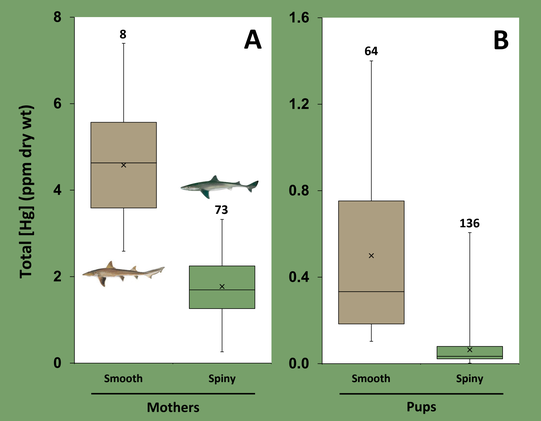

Figure 2. Total [Hg] of smooth and spiny dogfish mothers (A) and pups (B). Mean Hg denoted by " × " and numbers = sample sizes

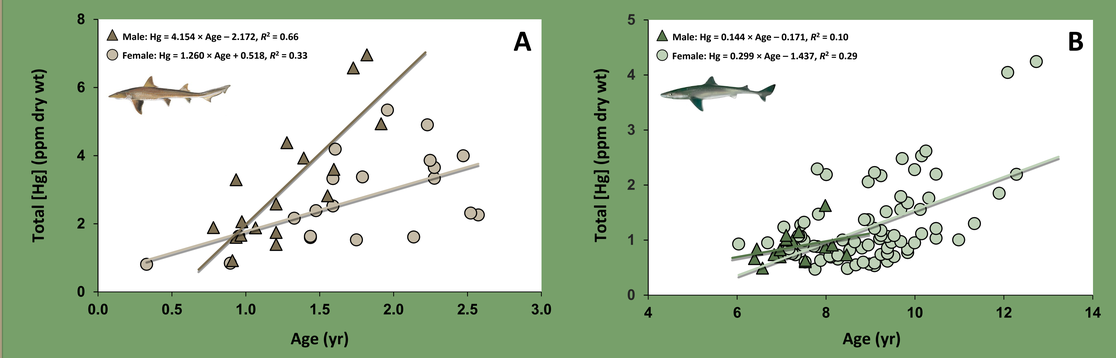

Figure 3. Total [Hg] of smooth (A) and spiny (B) dogfish as a function of age (years). Linear regression models fit to each data set with equations and R^2-values displayed.

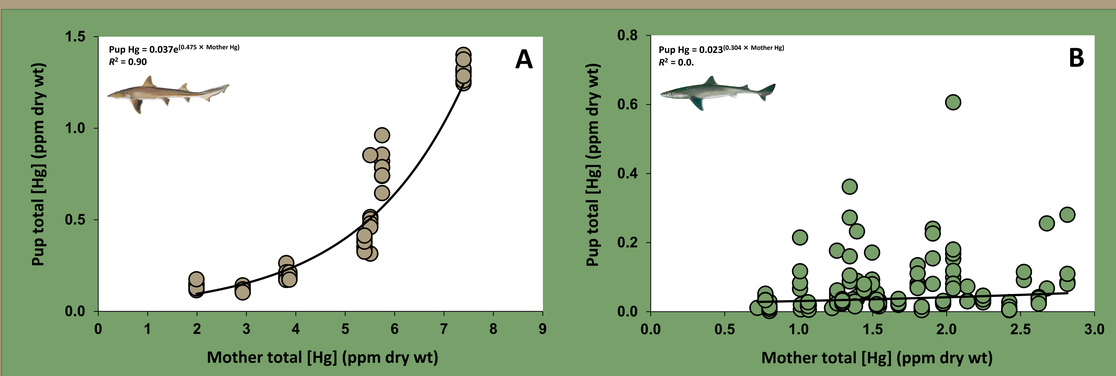

Figure 4. Total [Hg] of smooth (A) and spiny (B) dogfish pups as a function [Hg] of their respective mothers. Exponential regression models fit to each data set with equations and R^2-values displayed.

Results

- Adult female smooth and spiny dogfish [Hg] were positively related to total length (Linear regression: $p < 0.0001$ and $p < 0.05$, respectively); however, this relationship was not observed in pups.
- Smooth dogfish mothers and pups had higher [Hg] than spiny dogfish of similar life stages (t-test: $p < 0.0001$) (Fig. 2).
- Smooth dogfish [Hg] was positively related to age (Linear regression, Age: $p < 0.0001$), but accumulation rates were significantly faster in males relative to females (ANCOVA, Sex × Age: $p < 0.05$) (Fig. 3A).
- Spiny dogfish [Hg] was positively related to age, and accumulation rates were the same across sexes (ANCOVA, Age: $p < 0.0001$, Sex: $p = 0.71$) (Fig. 3B).
- Pup muscle [Hg] was positively related to mother [Hg] in smooth dogfish but not spiny dogfish (Exponential regression: $p < 0.0001$ and $p = 0.06$, respectively) (Fig. 4).

Discussion

- Mature male and female smooth and spiny dogfish bioaccumulate Hg, and female smooth dogfish have lower [Hg] at older ages than males, indicating possible contaminant offloading to pups.
- Pup muscle [Hg] was positively related to maternal [Hg] in smooth dogfish, indicating increased Hg offloading in larger smooth dogfish mothers.
- Smooth dogfish pups had higher [Hg] than spiny dogfish pups, indicating that viviparity results in increased Hg offloading compared to ovoviviparity.
- Placental nourishment to smooth dogfish pups likely provides a constant source of contamination to offspring resulting in pups with higher Hg compared to yolk sac nourishment of spiny dogfish.

Future Research

- Measure maternal liver [Hg] and yolk [Hg] and relate contaminant levels to yolk and pup [Hg].
- Measure percent lipid content of liver, ovarian yolk, and uterine yolk, and assess effect of lipid levels on sample-specific [Hg].
- Investigate sex-specific Hg-age relationships in other viviparous and ovoviviparous elasmobranch species.