

Ecological factors differentially affect mercury levels in two species of sympatric pinnipeds from the Southern Indian Ocean

Paco Bustamante, Justine Thébault, Maud Brault-Favrou, Carine Churlaud, Sabine Azemard, Christophe Guinet, Yves Cherel



ICMGP, July 24th 2024, Cape Town



Natural

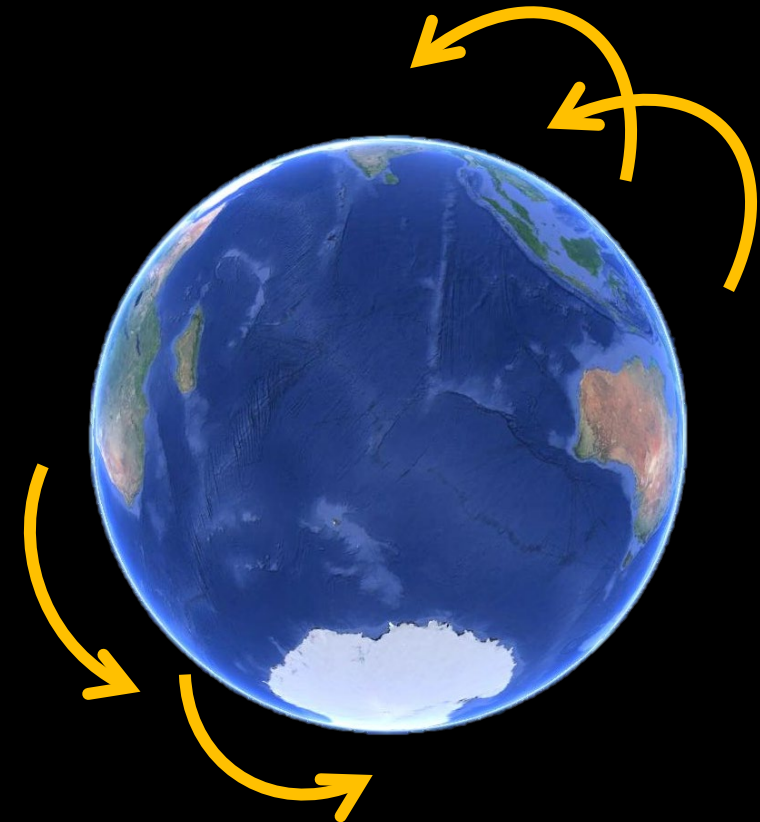
Anthropogenic



→ Atmospheric emissions

Southern Hemisphere
Poorly documented

Highly mobile



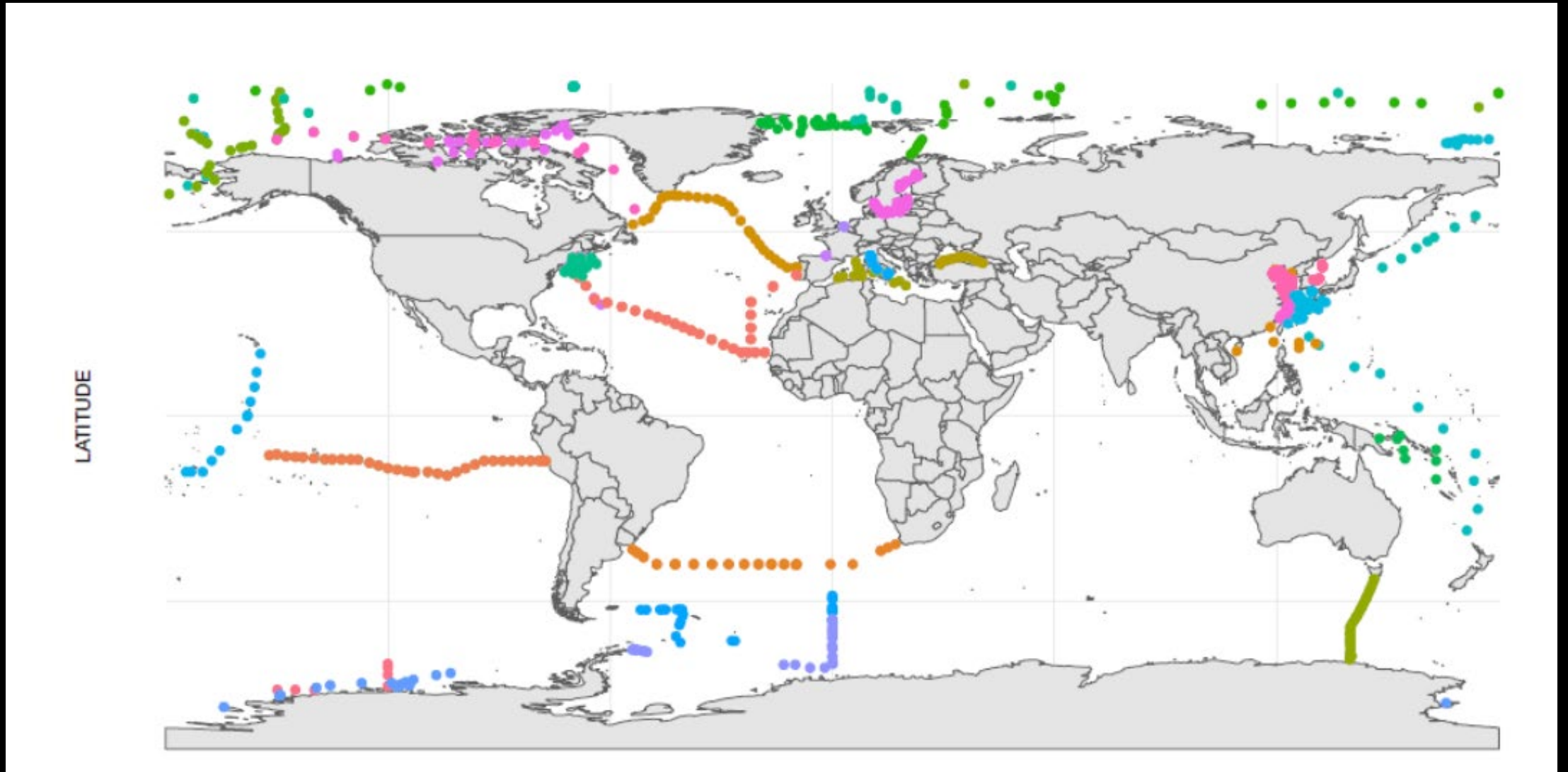
Monitoring Hg deposition

Global Mercury Observation System



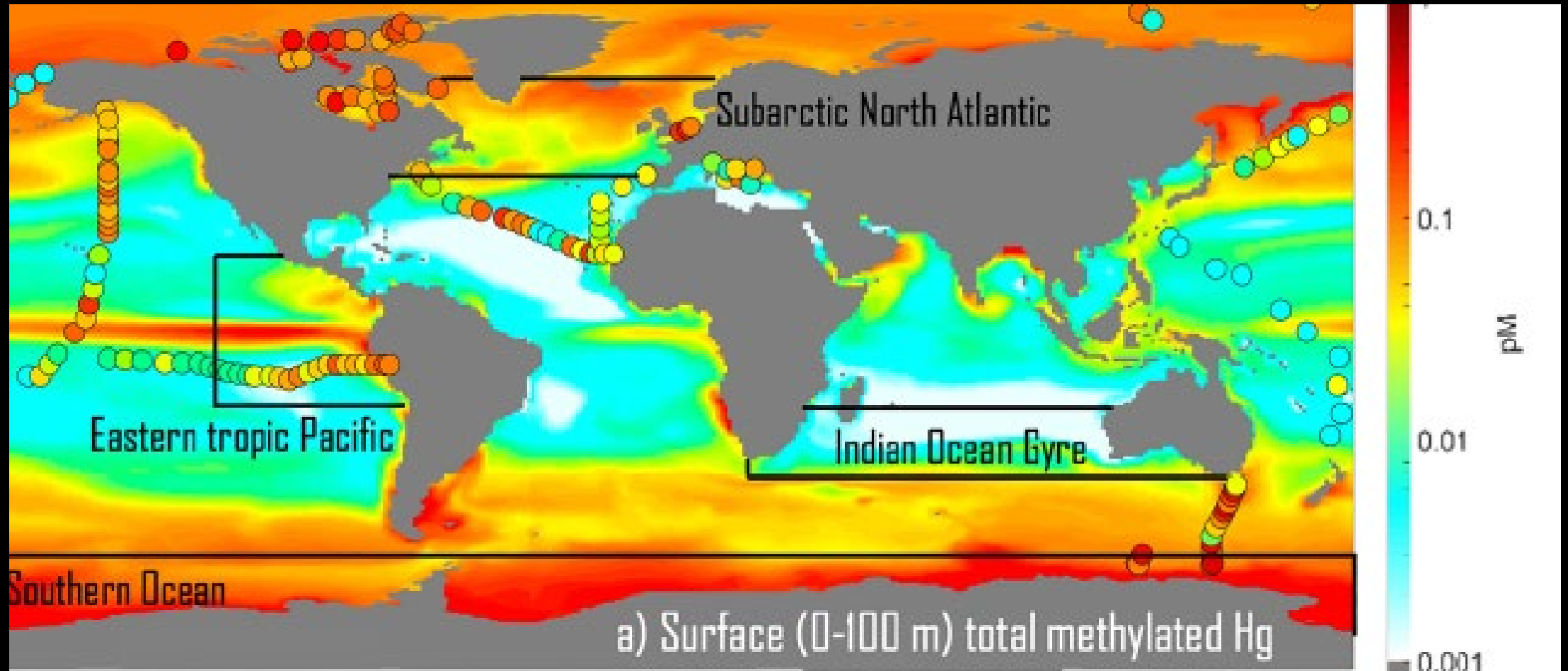
Courtesy of Aurélien Dommergue, Paris 2017

Monitoring Hg in the Ocean



THg and MeHg marine sampling locations during the past ~15 years showing a global coverage (from Daastor et al. 2024)

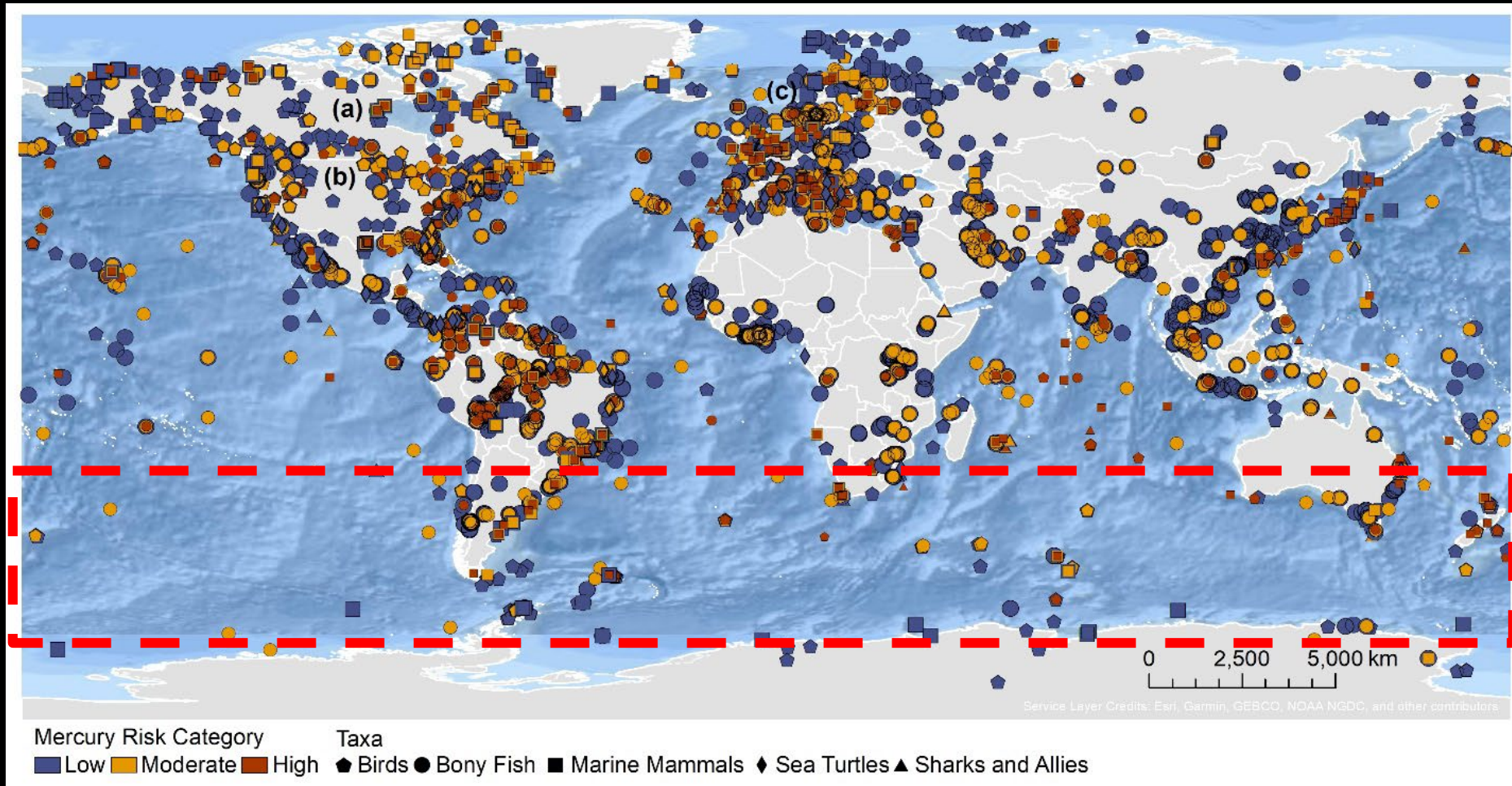
Monitoring Hg in the Ocean



Modeled annual mean MeHg concentrations in seawater at depths 0–100 m

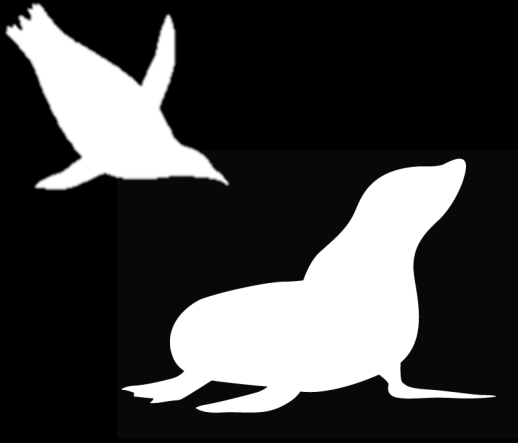
From Zhang et al. 2020 Global Biochem Cycles

Monitoring Hg in the Ocean



Distribution of five major taxa and their [THg] in three risk categories

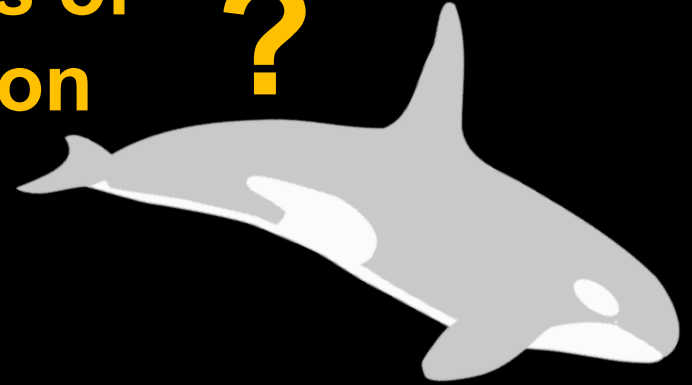
From Evers et al. 2024 Ecotoxicology



**Predators as
Bioindicators**



**Sources of
variation**

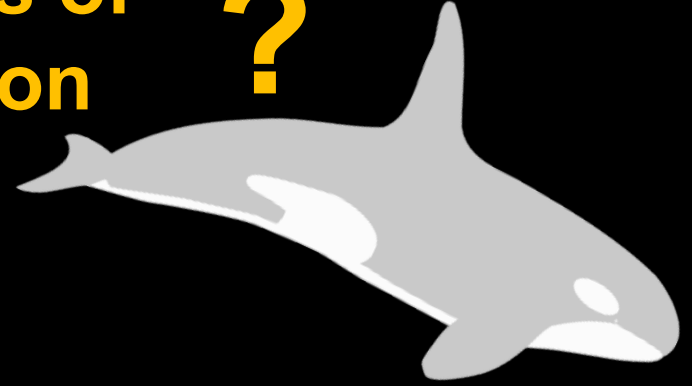




**Predators as
Bioindicators**



**Sources of
variation**



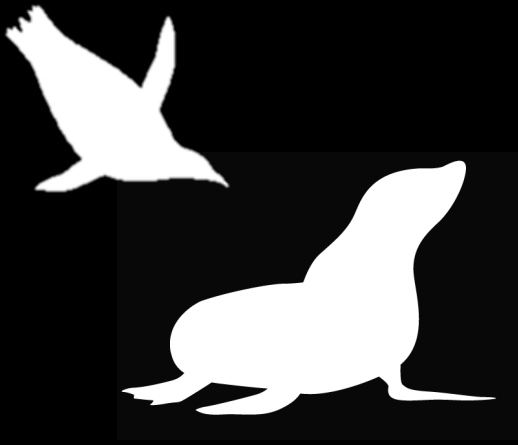
Intrinsic factors

Species, individual

Sex

Age

Physiology



**Predators as
Bioindicators**

Intrinsic factors

Species, individual

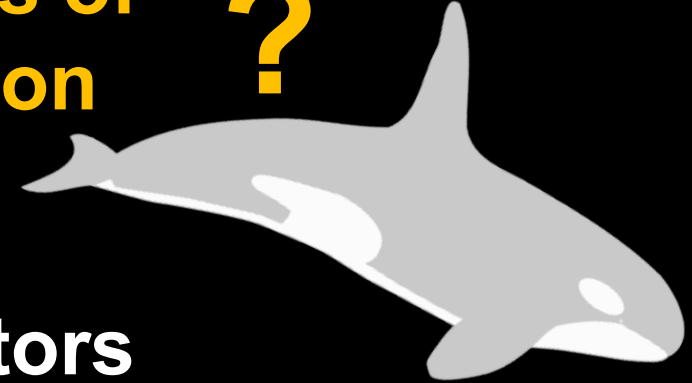
Sex

Age

Physiology



**Sources of
variation**



Extrinsic factors

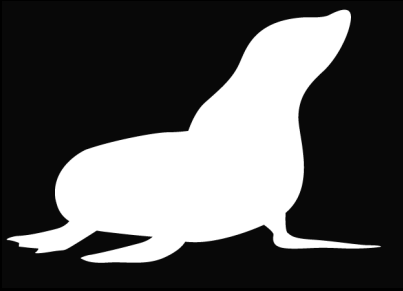
Environment

Prey type



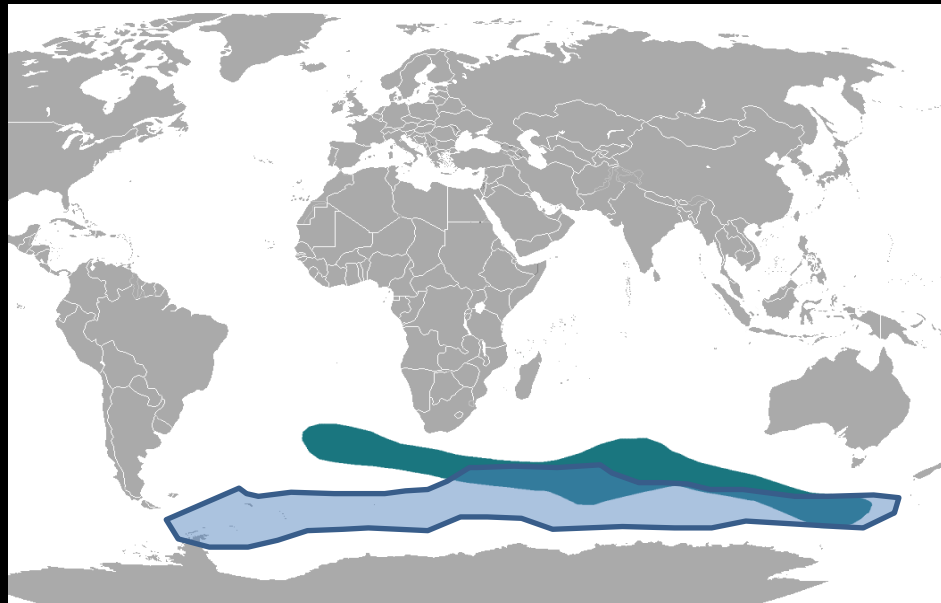
Habitat

Season



Monitoring Hg in the Southern Ocean

2 species largely distributed



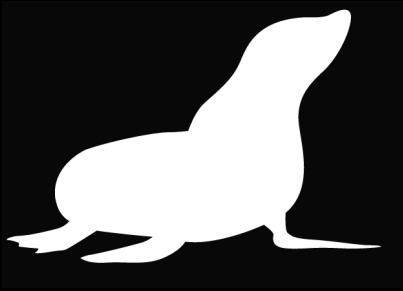
Subantarctic fur seal (*Arctocephalus tropicalis*)



Antarctic fur seal (*Arctocephalus gazella*)

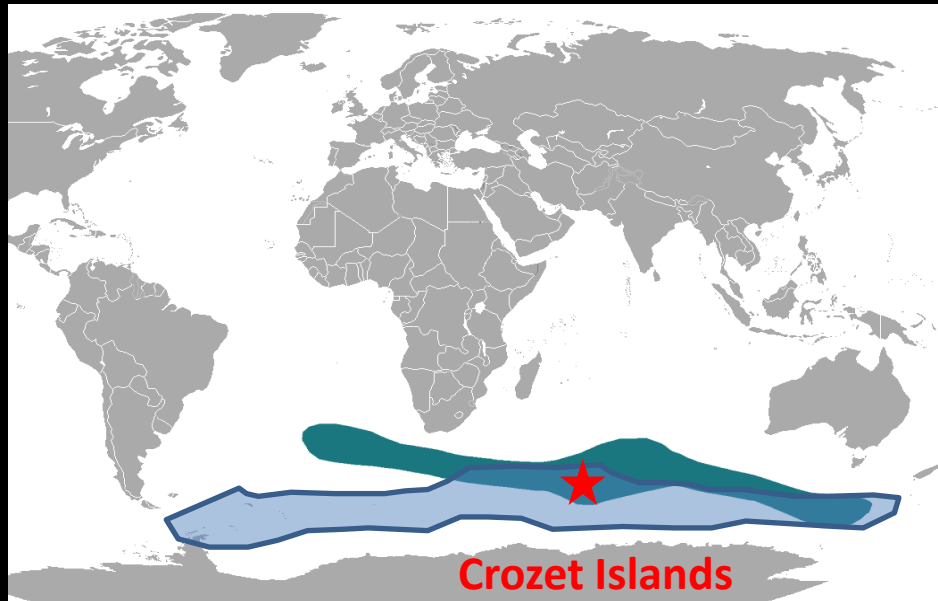


- Sympatric in the Southern Indian Ocean
- Females smaller than males => foraging exclusion



Monitoring Hg in the Southern Ocean

2 species largely distributed



Subantarctic fur seal (*Arctocephalus tropicalis*)



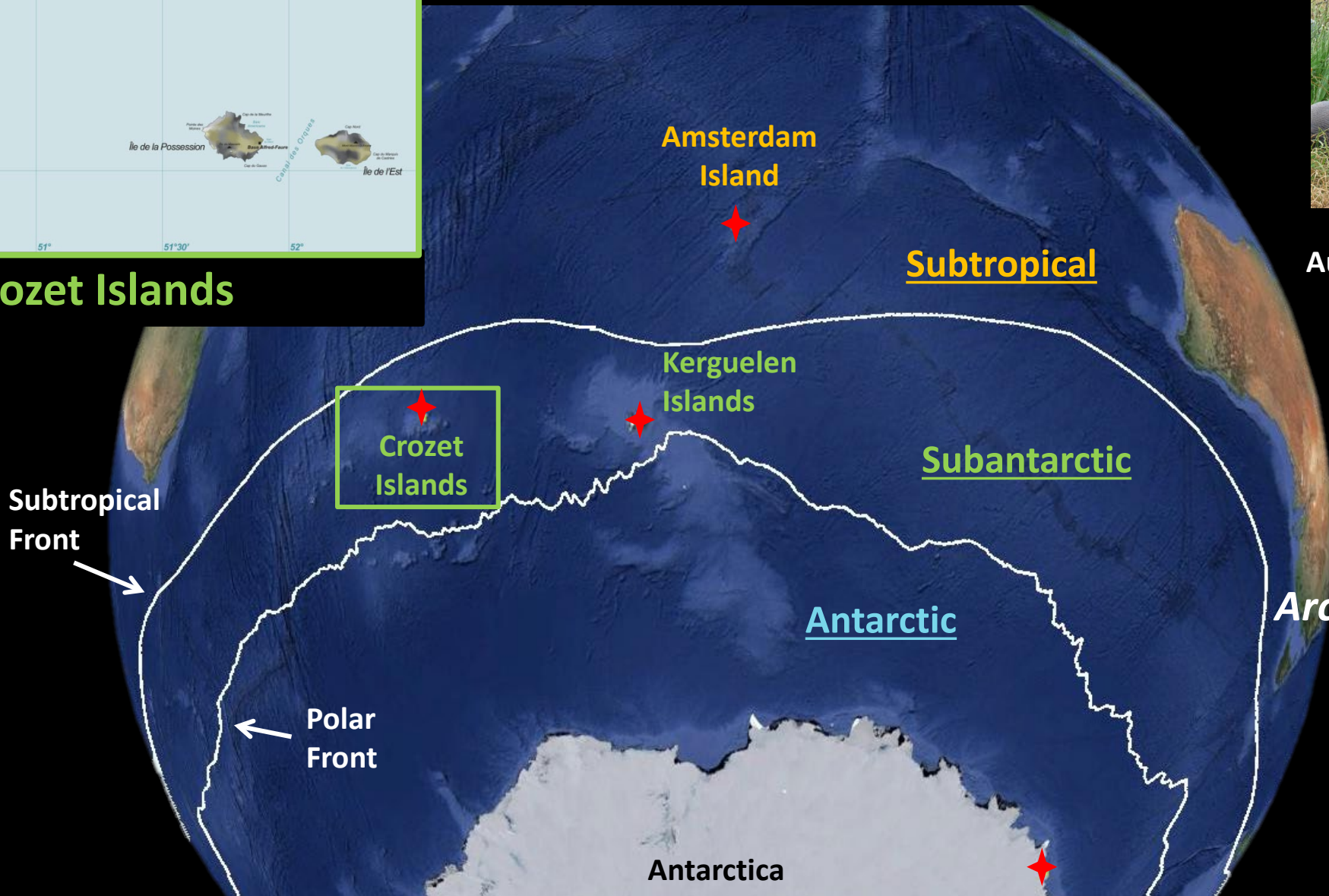
Antarctic fur seal (*Arctocephalus gazella*)



- Sympatric in the Southern Indian Ocean
- Females smaller than males => foraging exclusion



Crozet Islands



Subantarctic fur seal
Arctocephalus tropicalis



Australia

Antarctic fur seal
Arctocephalus gazella



Main objectives

1. **Examine** the significance of various factors (species, sex, feeding habitats [$\delta^{13}\text{C}$] and trophic position [$\delta^{15}\text{N}$]) on THg and OHg concentrations in whole blood of the two fur seal species
2. Investigate **the relationship between mother exposure and Hg levels in pups**

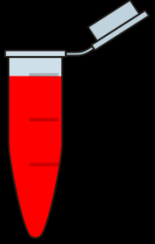


Analyses of Hg and stable isotopes in blood and milk

Sampling December 2001- January 2002

Analyses of Hg and stable isotopes in blood and milk

Sampling December 2001- January 2002



Whole blood

N = 10 females and 10 pups (pairs) for each species

N= 11 males *A. gazella* and 4 *A. tropicalis*



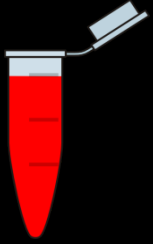
Milk

N= 10 *A. gazella*

N= 9 *A. tropicalis*

Analyses of Hg and stable isotopes in blood and milk

Sampling December 2001- January 2002



Whole blood

N = 10 females and 10 pups (pairs) for each species

N= 11 males *A. gazella* and 4 *A. tropicalis*



Milk

N= 10 *A. gazella*

N= 9 *A. tropicalis*

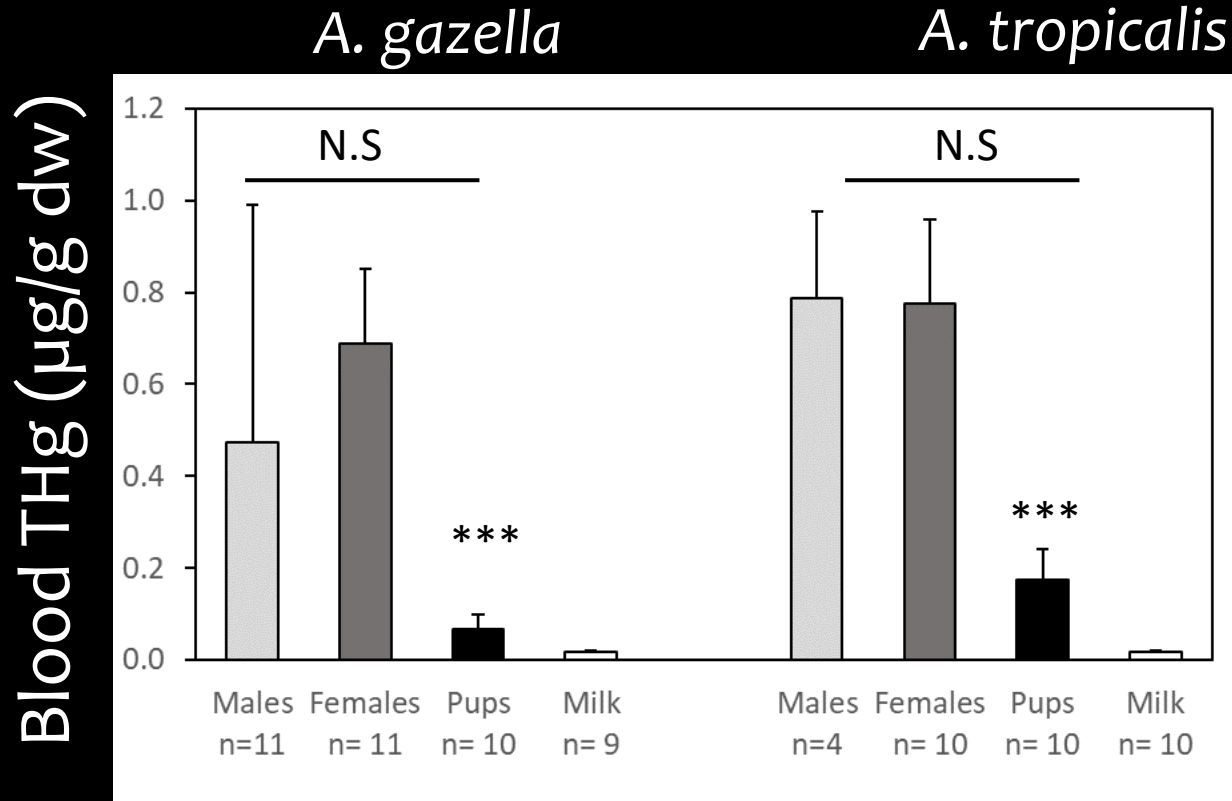
THg & OHg → exposure through the **diet**

$\delta^{13}\text{C}$ → proxy of feeding habitat

$\delta^{15}\text{N}$ → proxy of trophic position

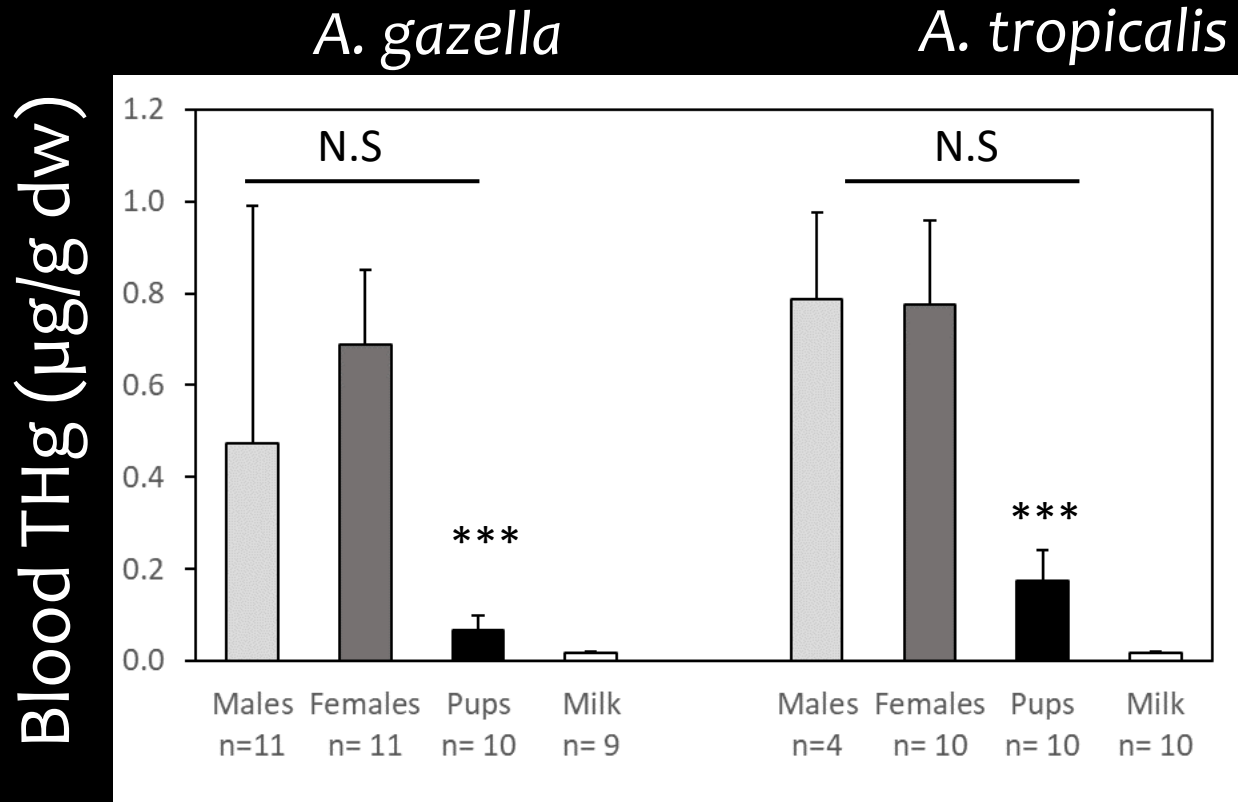
1) Levels of concentrations

1) Levels of concentrations



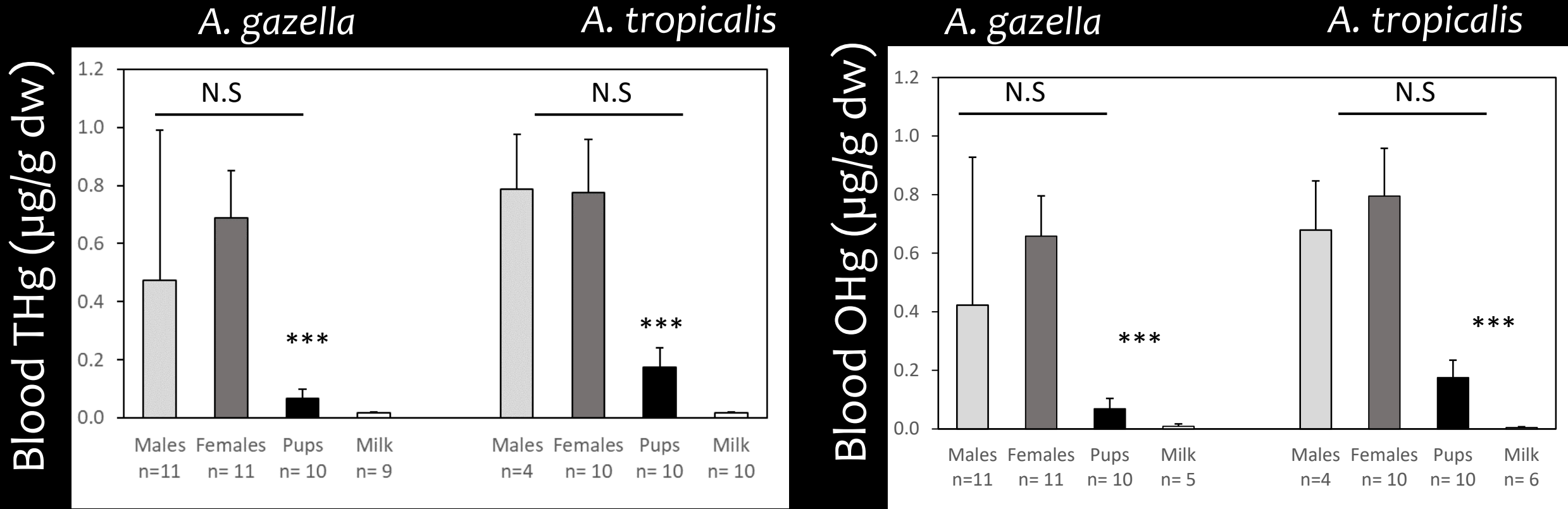
- Adults have 5-10 times higher Hg concentrations than pups
- No difference between males and females in both species

1) Levels of concentrations



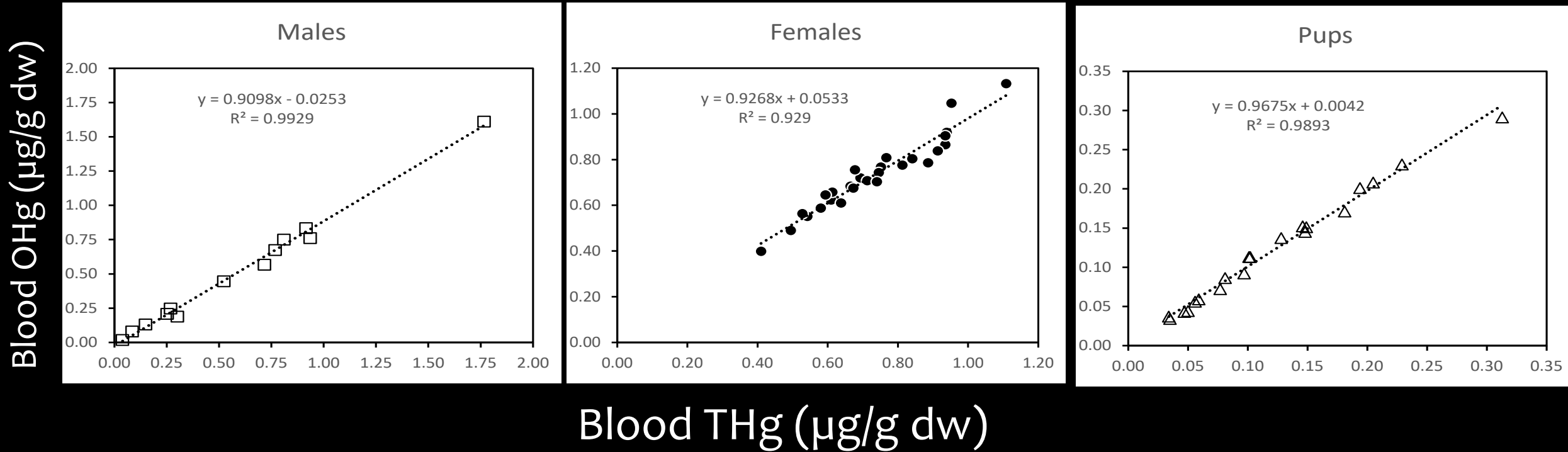
- Large variations in Hg concentrations in males of *A. gazella* (0.039 – 1.767 µg/g, CV= 109%)
- Very low concentrations in the milk (0.017 µg/g)

1) Levels of concentrations



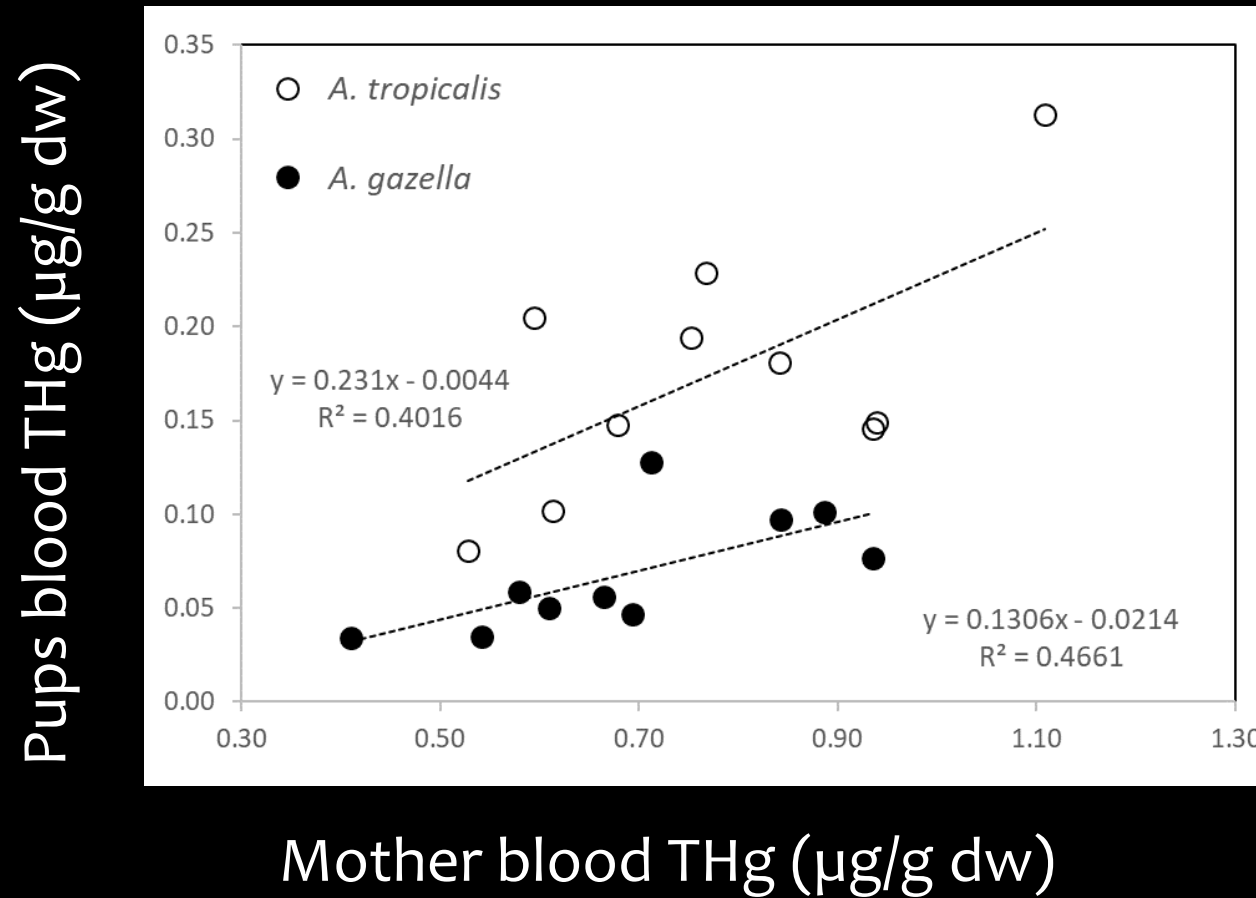
- Large variations in [Hg] in males of *A. gazella* (0.039 – 1.767 µg/g, CV= 109%)
- Very low concentrations in the milk (0.017 µg/g)

2) Speciation in the blood



- Strong correlation between blood [OHg] and [THg] in adults and pups of both species
- Independently of the [Hg], most of the Hg is under organic form

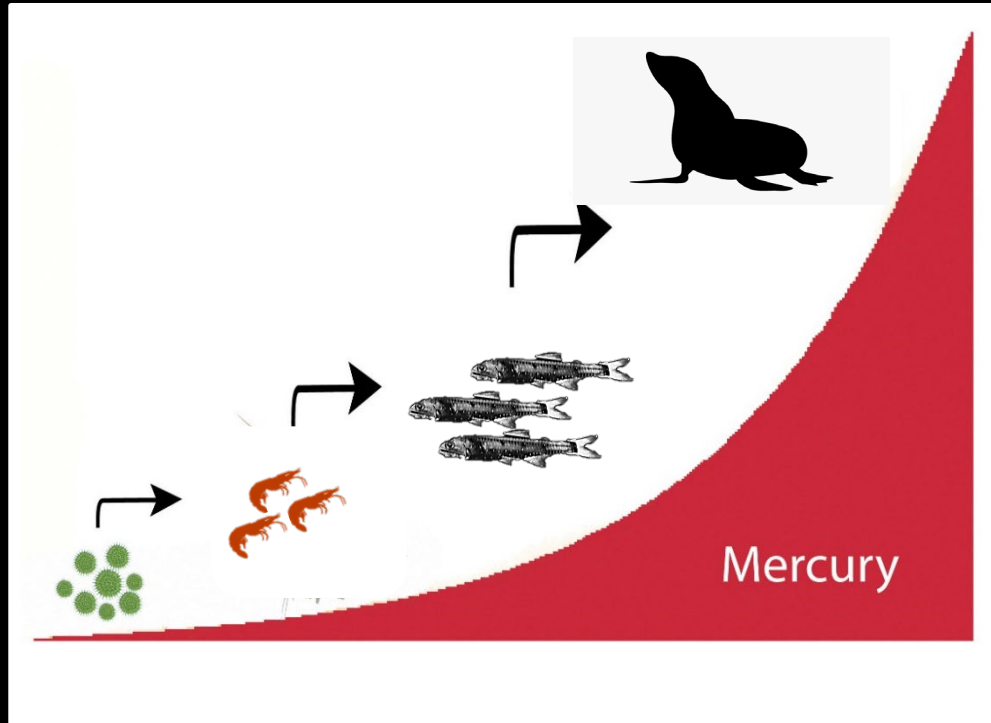
3) Relationship pups/mothers



- Despite low [Hg] in milk, exposure of the mothers influences blood [Hg] of the pups

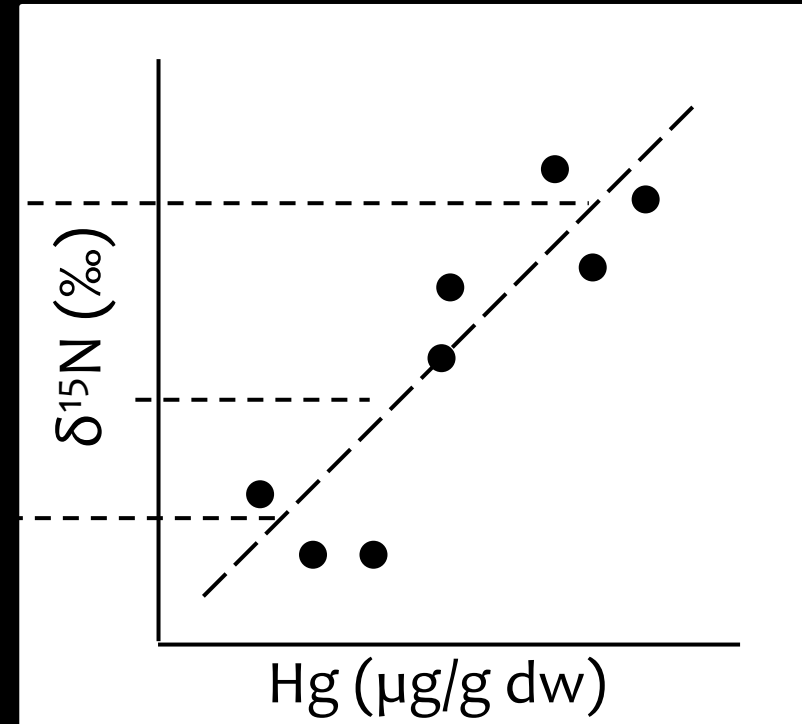
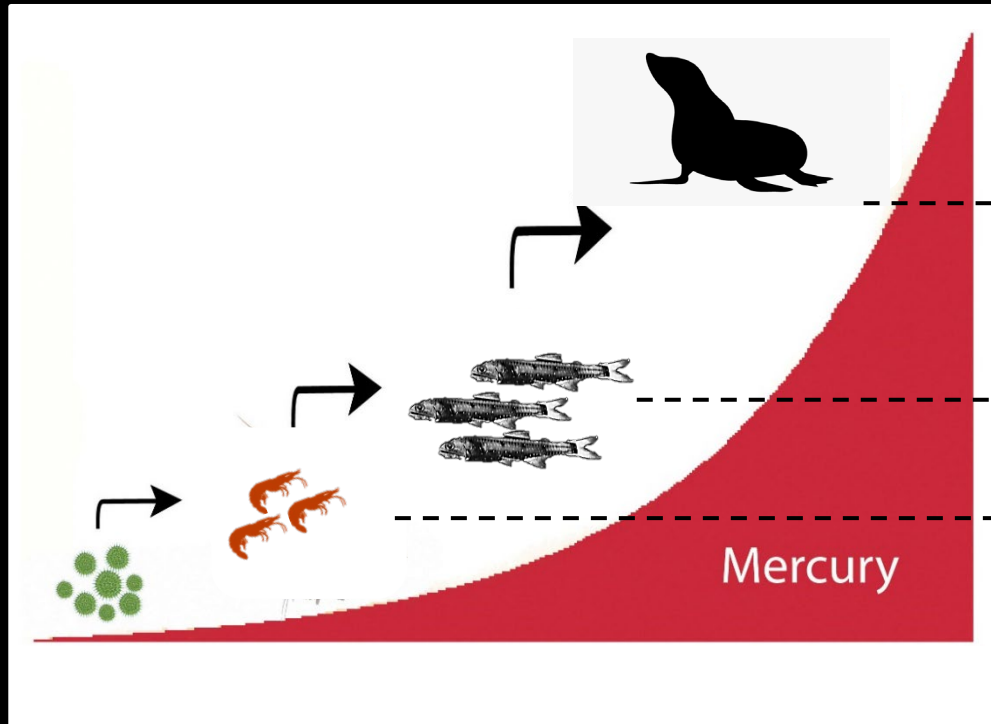
4) Influence of the trophic ecology

4) Influence of the trophic ecology



- MeHg biomagnifies along food webs

4) Influence of the trophic ecology

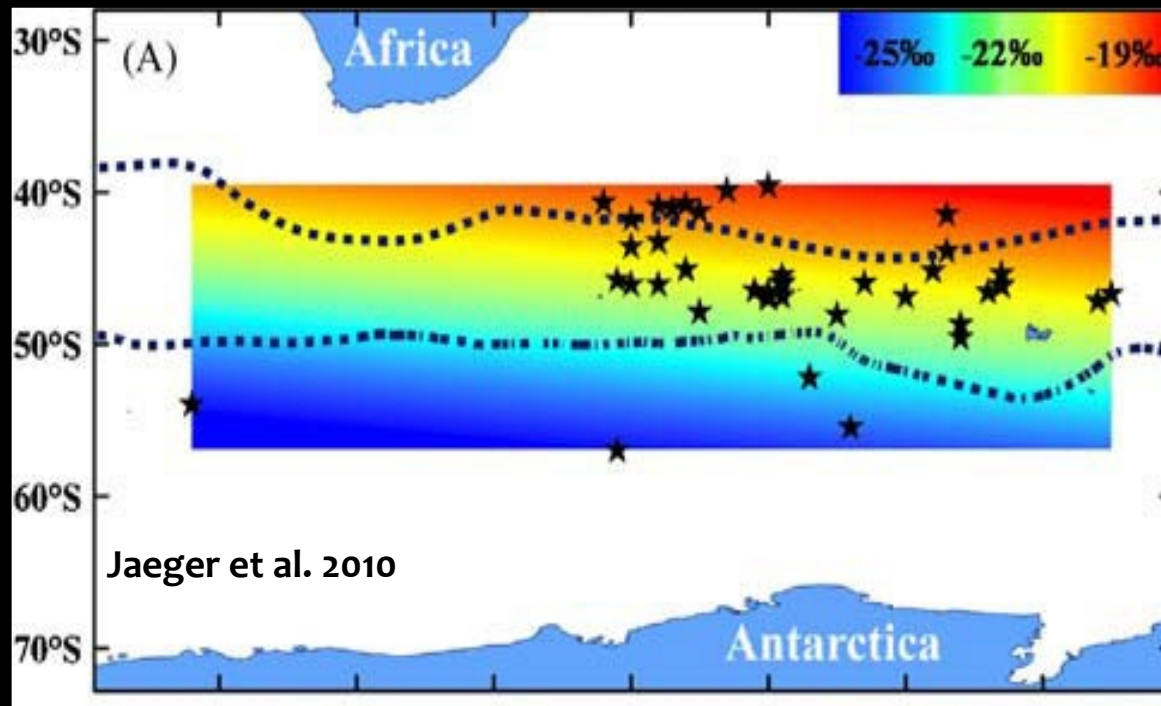


- MeHg biomagnifies along food webs
- Biomagnification can be proxied using $\delta^{15}\text{N}$

4) Influence of the trophic ecology

Southern Ocean

Carbon stable isotope values reflect the feeding habitat



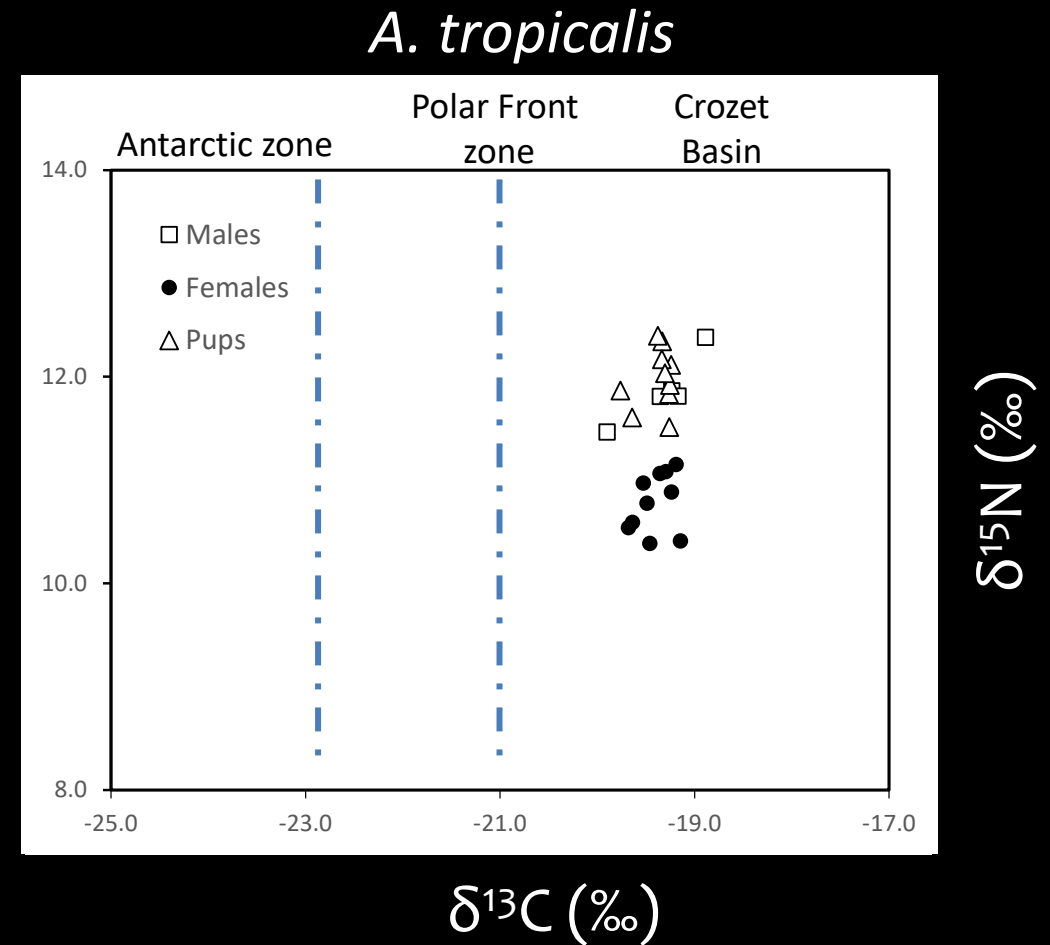
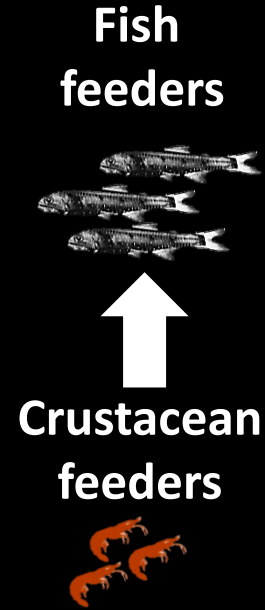
$\delta^{13}\text{C}$

Subtropics

Subantarctic

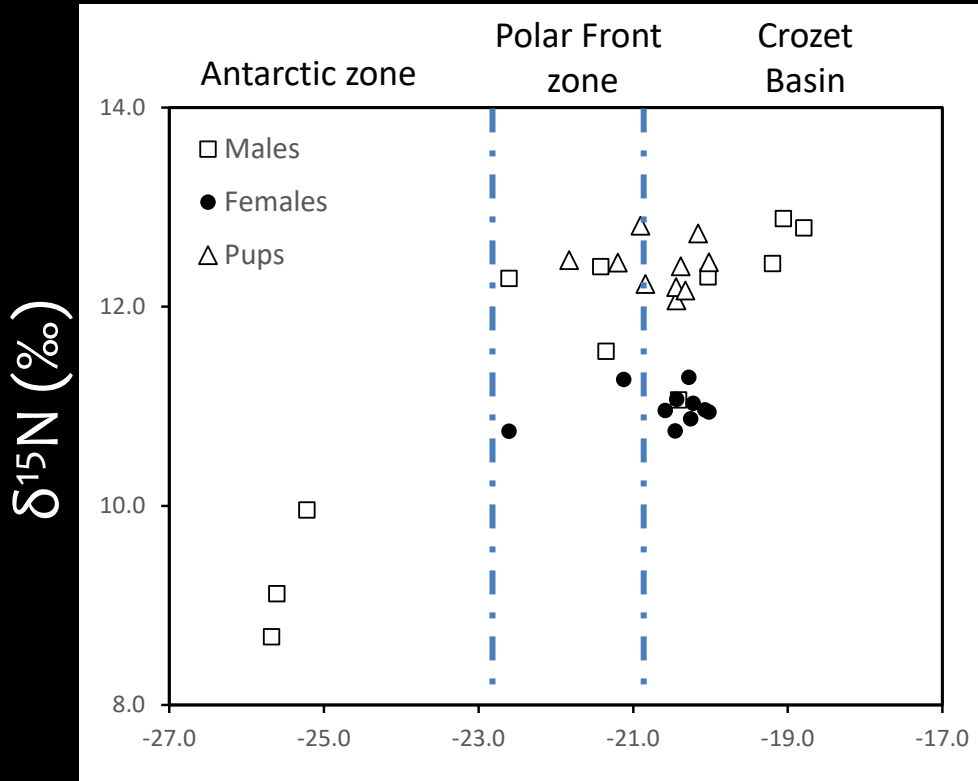
Antarctic

4) Influence of the trophic ecology



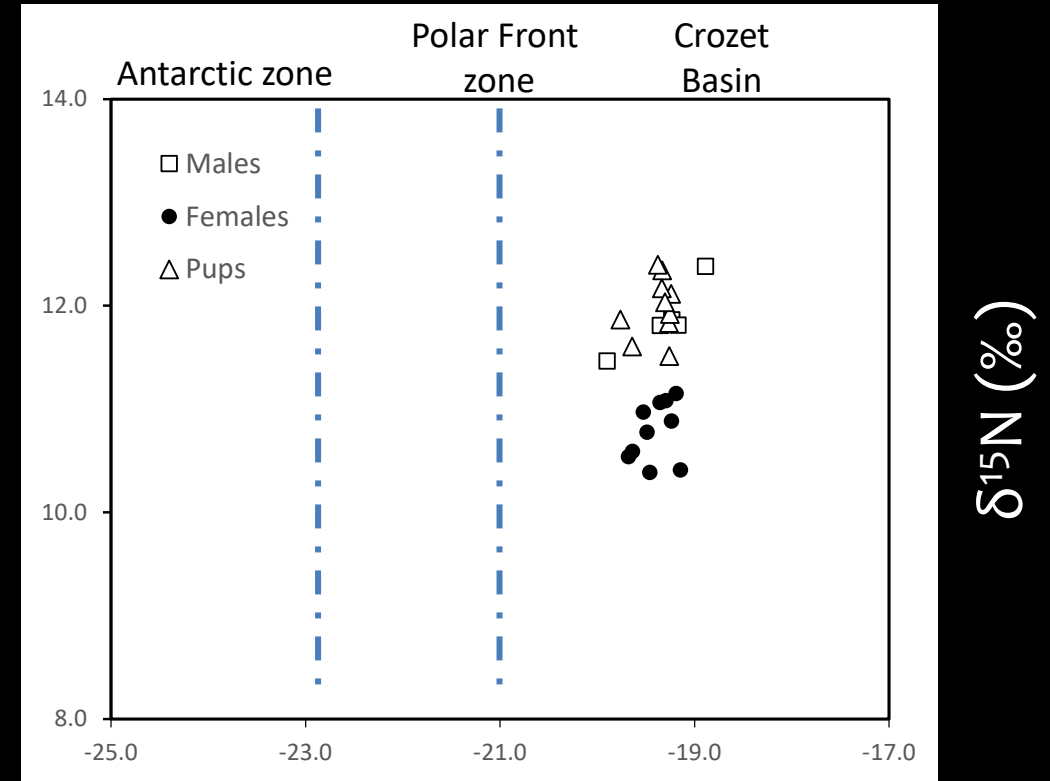
4) Influence of the trophic ecology

A. gazella

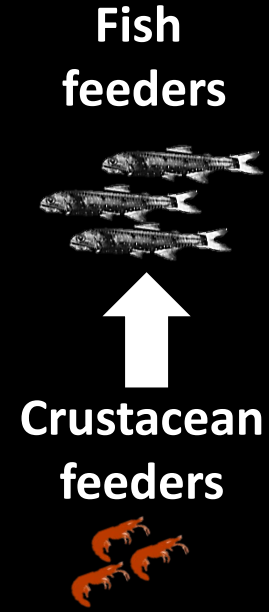


$\delta^{13}\text{C}$ (‰)

A. tropicalis



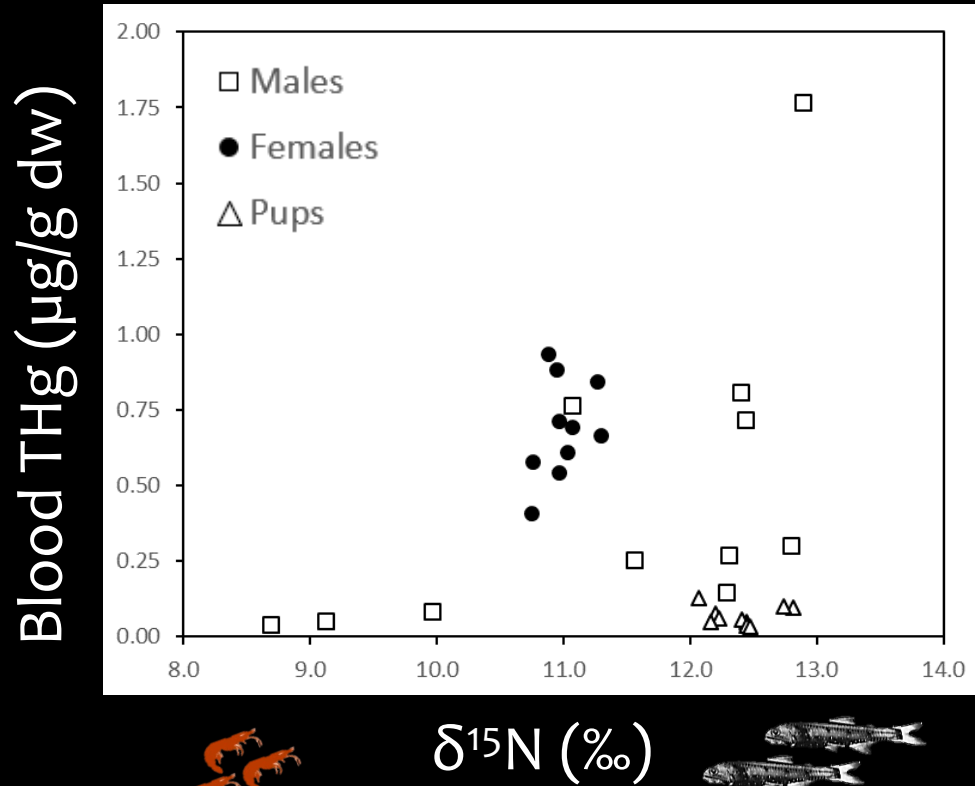
$\delta^{13}\text{C}$ (‰)



- *A. gazella* shows both larger trophic position range and latitudinal gradient than in *A. tropicalis*
- $\delta^{15}\text{N}$ and $\delta^{13}\text{C}$ explain larger [Hg] in males *A. gazella*?

i) Trophic position

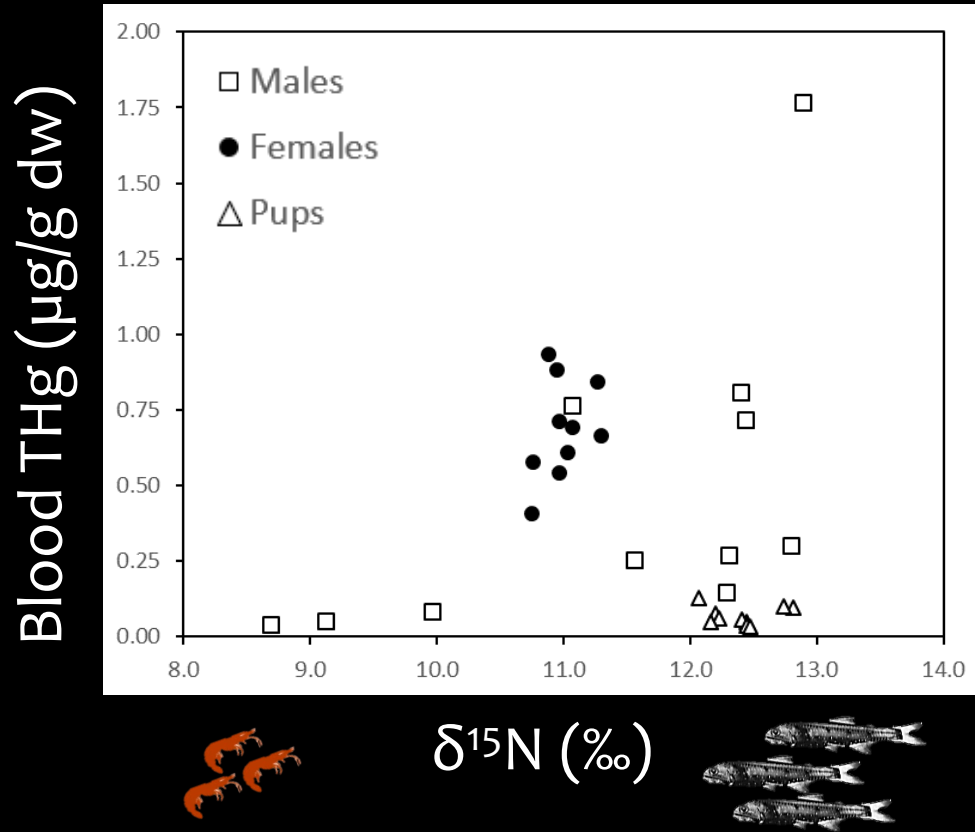
A. gazella



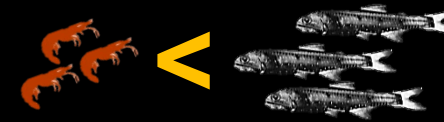
➤ In contrast to females, males feed over a large range of prey

i) Trophic position

A. gazella



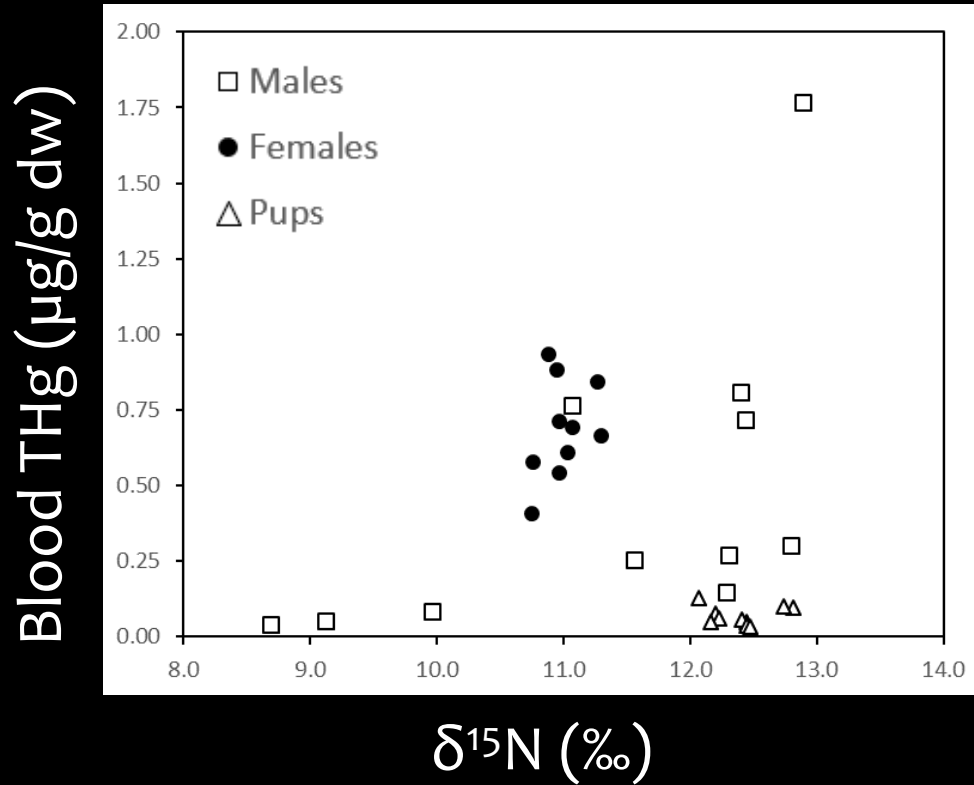
Prey type influences Hg exposure



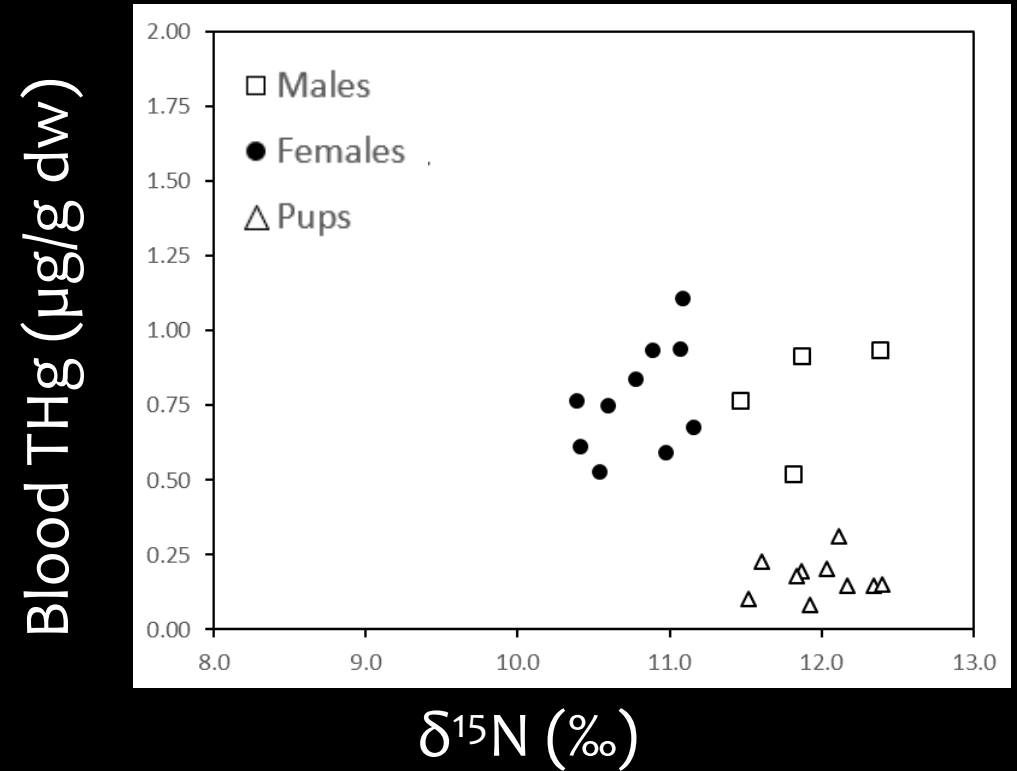
- In contrast to females, males feed over a large range of prey
- Lower [Hg] when feeding crustaceans

i) Trophic position

A. gazella



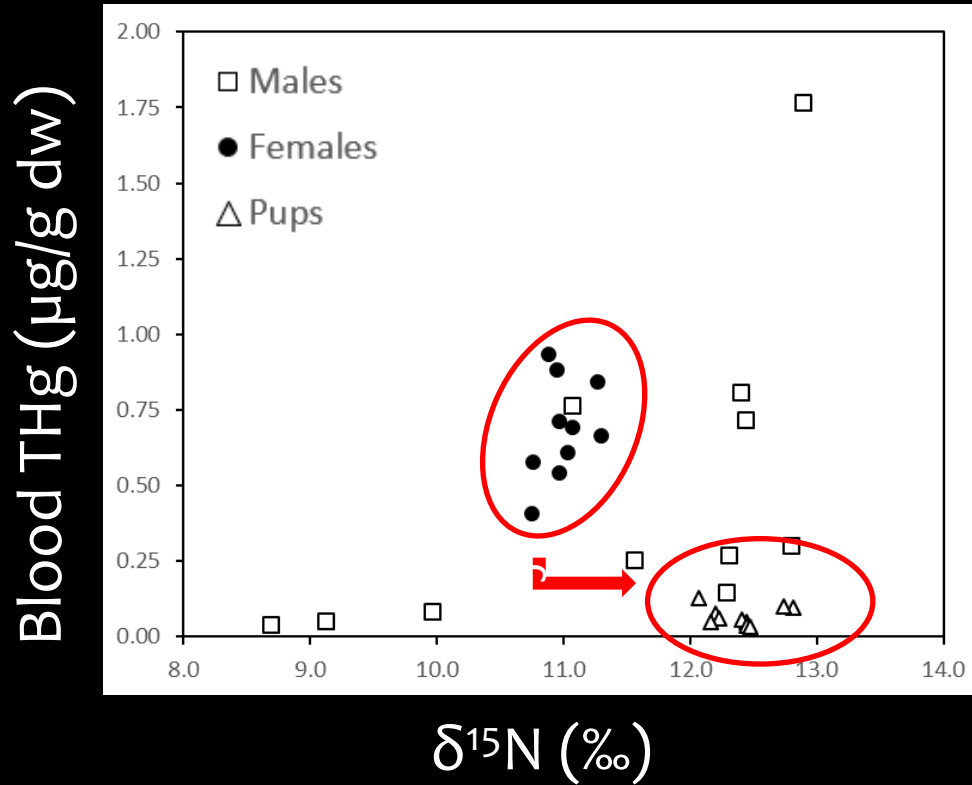
A. tropicalis



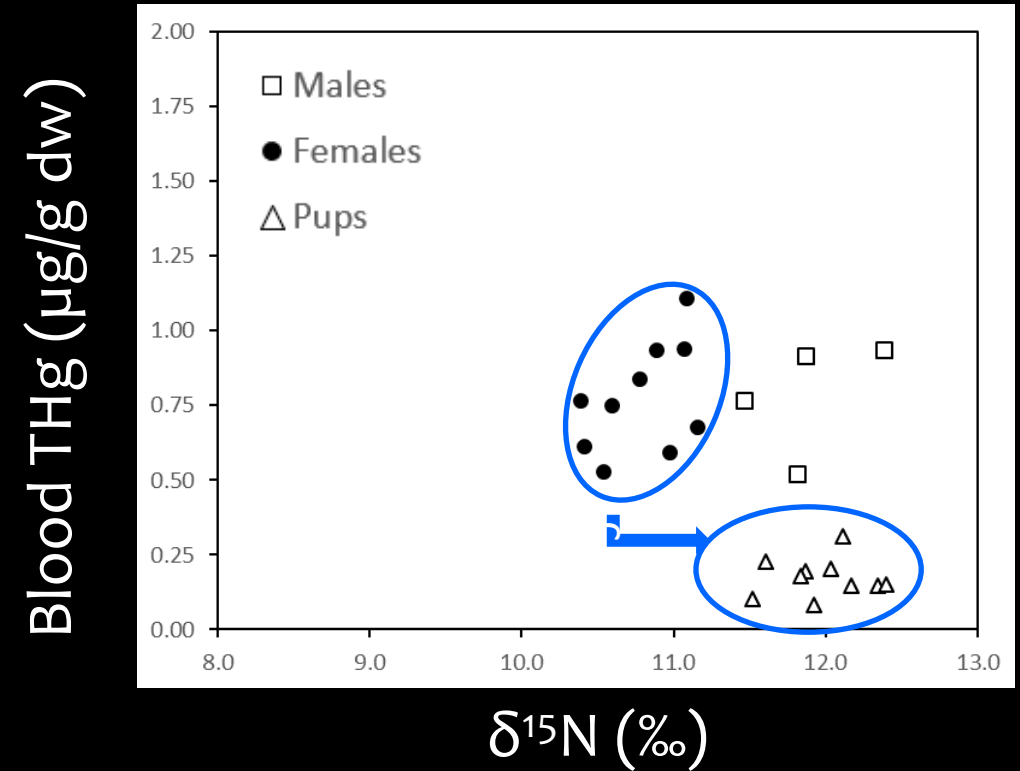
➤ Piscivorous diet in *A. tropicalis* leads to similar exposure

i) Trophic position

A. gazella



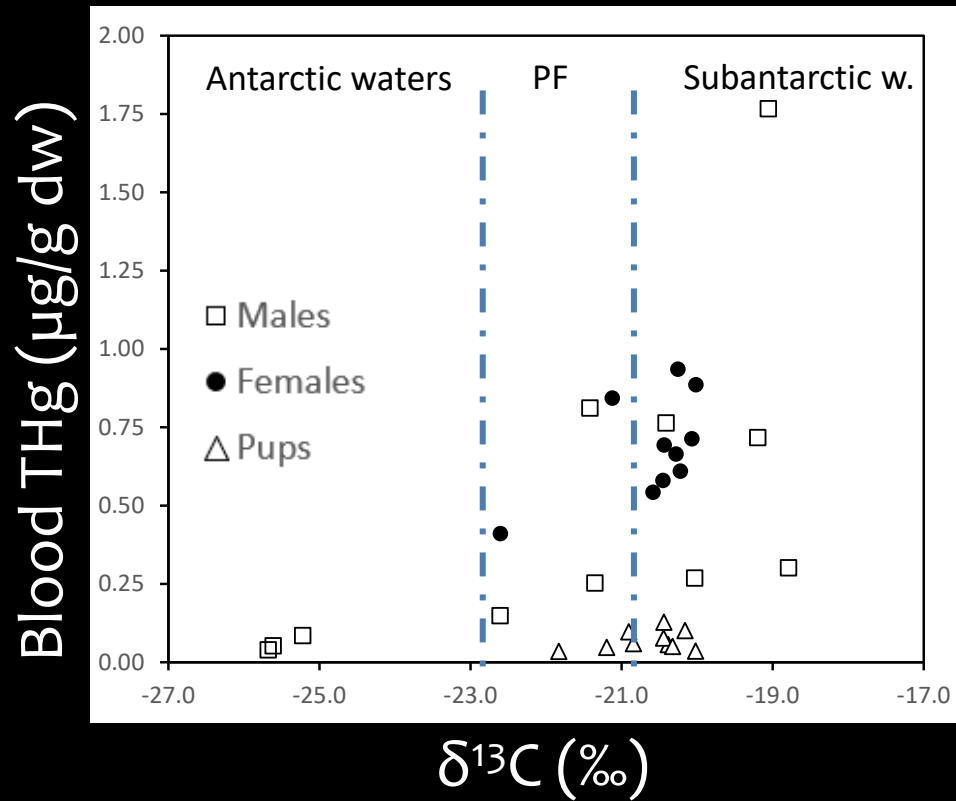
A. tropicalis



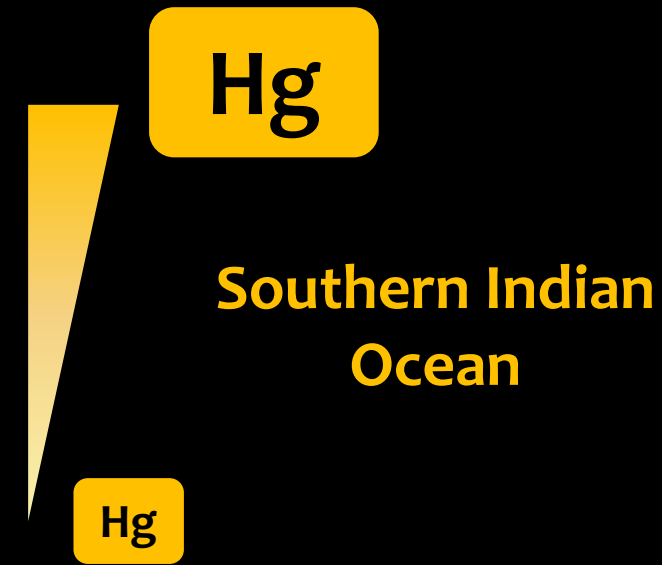
- Piscivorous diet in *A. tropicalis* leads to similar exposure
- In both species, pups “feed” on their mothers (1.5 ‰ enrichment on average)

ii) Feeding habitat

A. gazella



Feeding location influences
Hg exposure

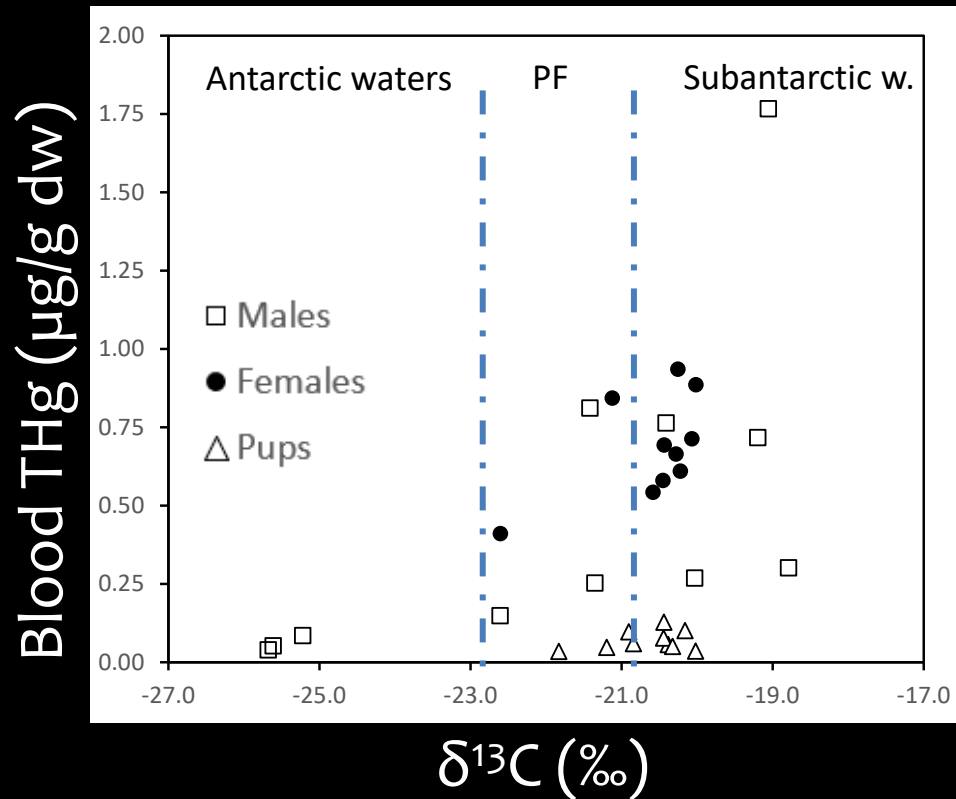


➤ Strong effect of the feeding habitat in *A. gazella*

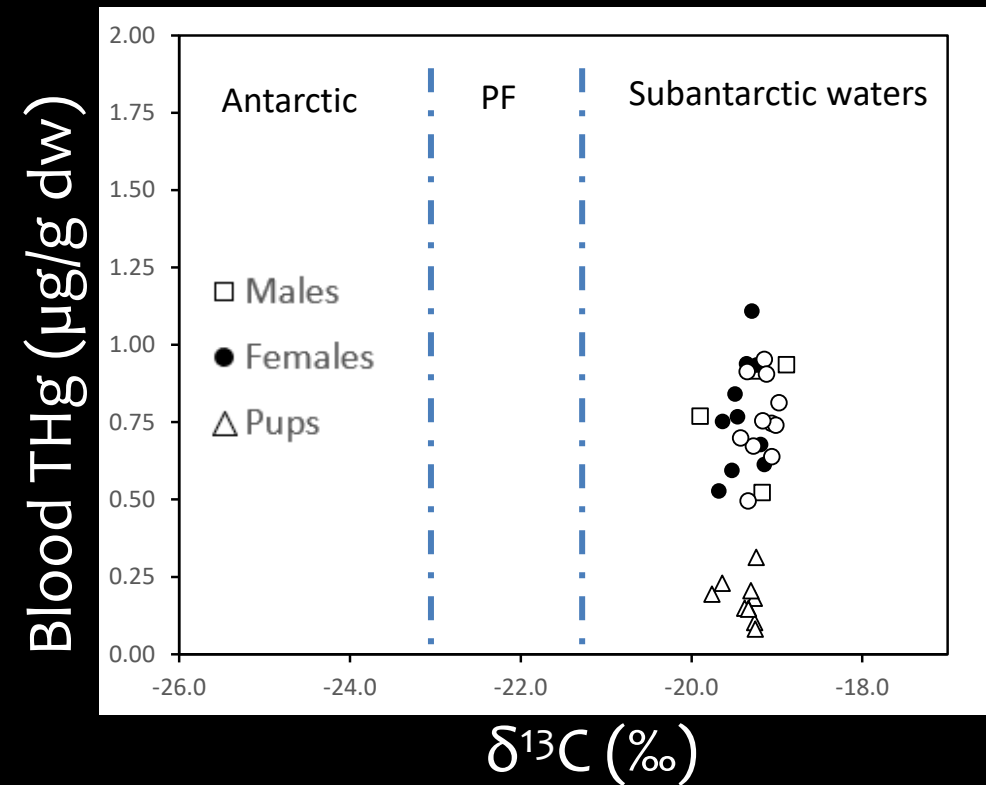
➤ Males foraging in Antarctic waters show the lowest [Hg]

ii) Feeding habitat

A. gazella

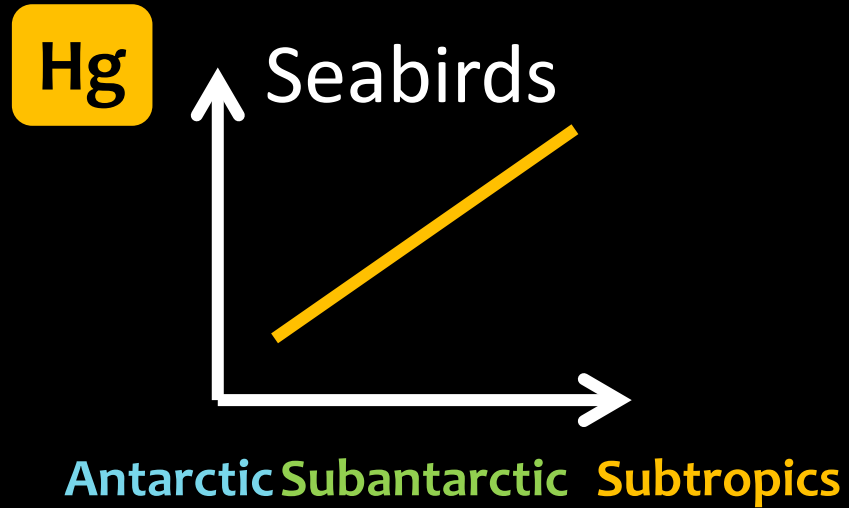


A. tropicalis



- Males and females *A. tropicalis* forage in the same water mass
- Limited enrichment in $\delta^{13}\text{C}$ between mothers and pups

Latitudinal gradient in Hg consistent with other studies on seabirds such as skuas, albatrosses, penguins & petrels



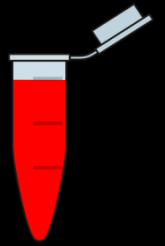
Carravierri et al. 2014, 2016, 2017

Cherel et al. 2018

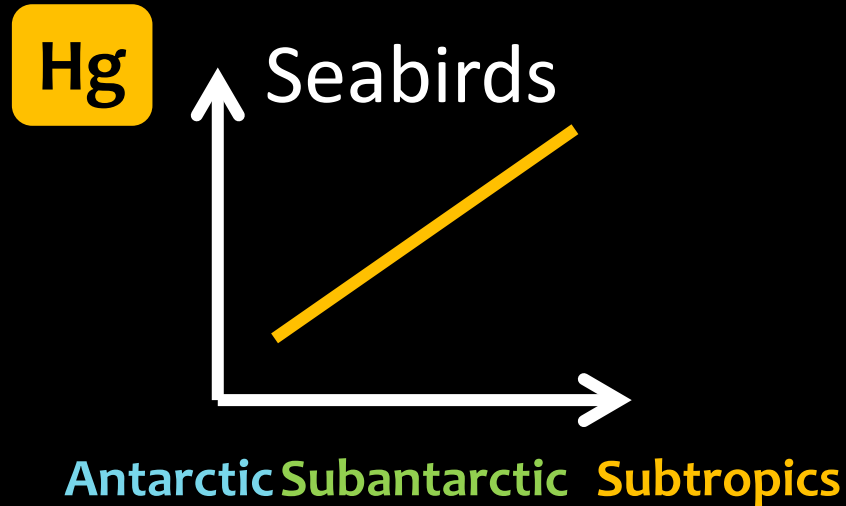
Mills et al. 2024



or



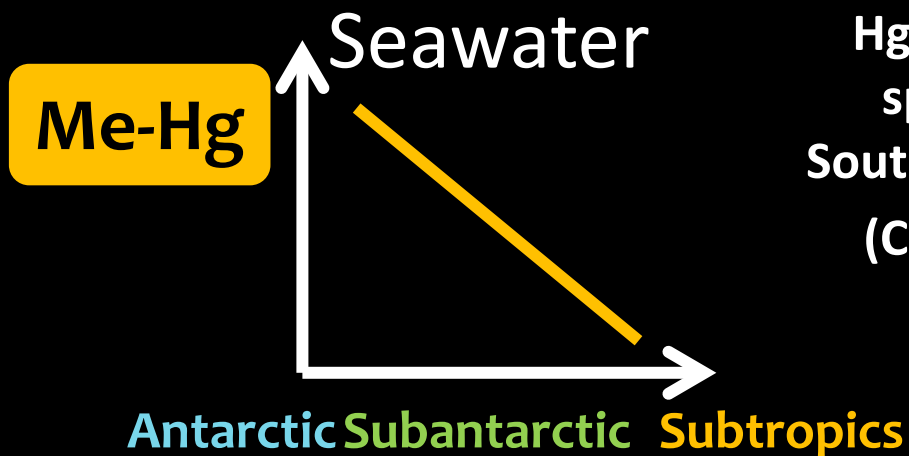
Latitudinal gradient in Hg consistent with other studies on seabirds such as skuas, albatrosses, penguins & petrels



Carravierri et al. 2014, 2016, 2017

Cherel et al. 2018

Mills et al. 2024



Hg distribution and speciation in the Southern Ocean waters (Cossa et al. 2011)

➤ The Southern Ocean “paradox”

Conclusions

- Similar Hg levels in adults of both species but larger variation in males of *A. gazella*
 - larger foraging range ($\delta^{13}\text{C}$)
 - more diverse diet ($\delta^{15}\text{CN}$)

Fur seals feeding on krill in Antarctic waters are less exposed to Hg

Conclusions

- Similar Hg levels in adults of both species but larger variation in males of *A. gazella*
 - larger foraging range ($\delta^{13}\text{C}$)
 - more diverse diet ($\delta^{15}\text{CN}$)

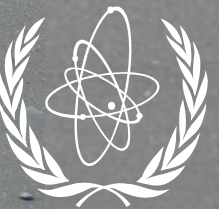
Fur seals feeding on krill in Antarctic waters are less exposed to Hg

- In *A. tropicalis*, no differences between males and females
 - ecological segregation between sexes **seems limited during the reproduction period**

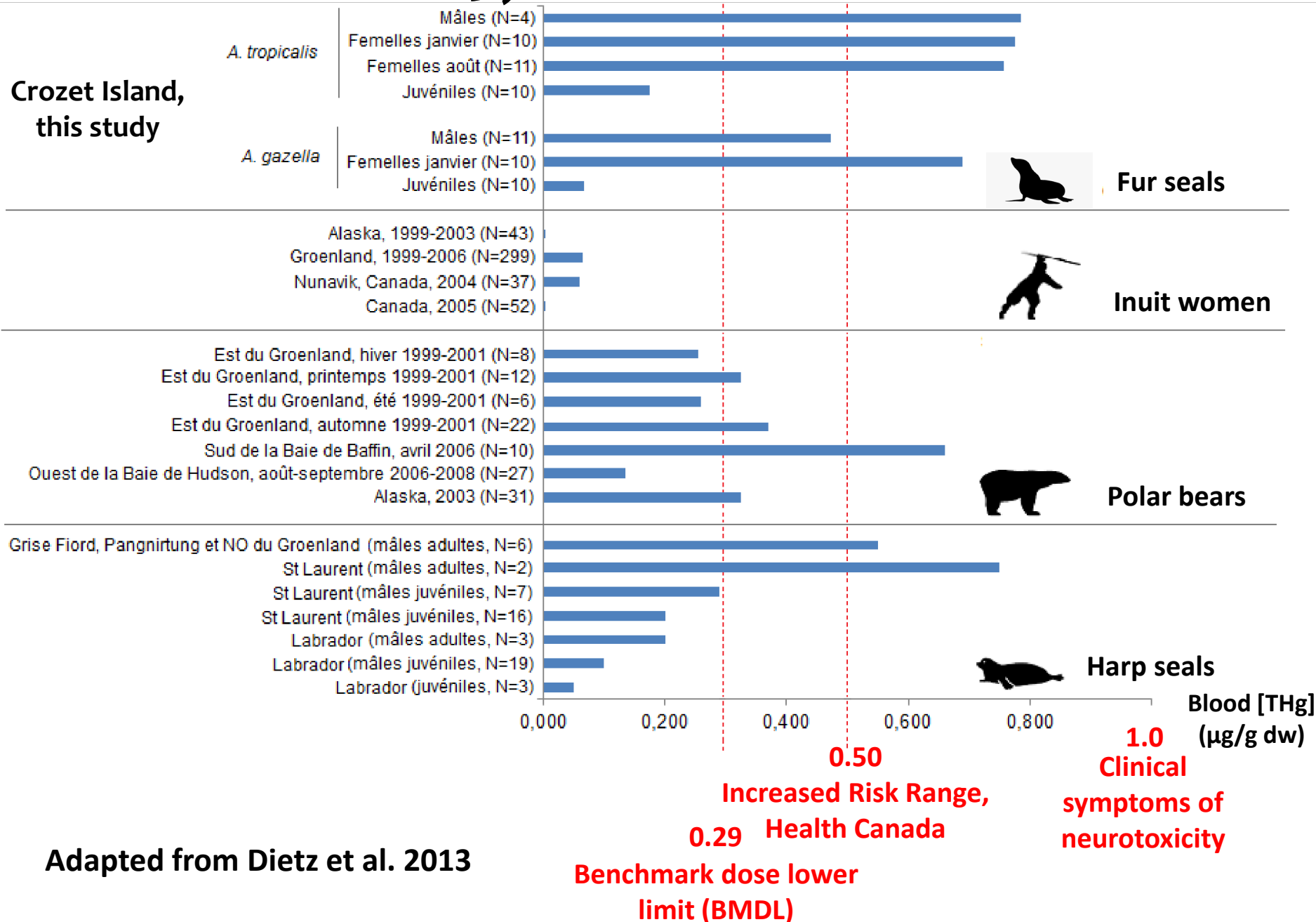


ICMGP 2024
CAPE TOWN • SOUTH AFRICA • 21 - 26 JULY
CAPE TOWN INTERNATIONAL CONVENTION CENTRE

Thank you !

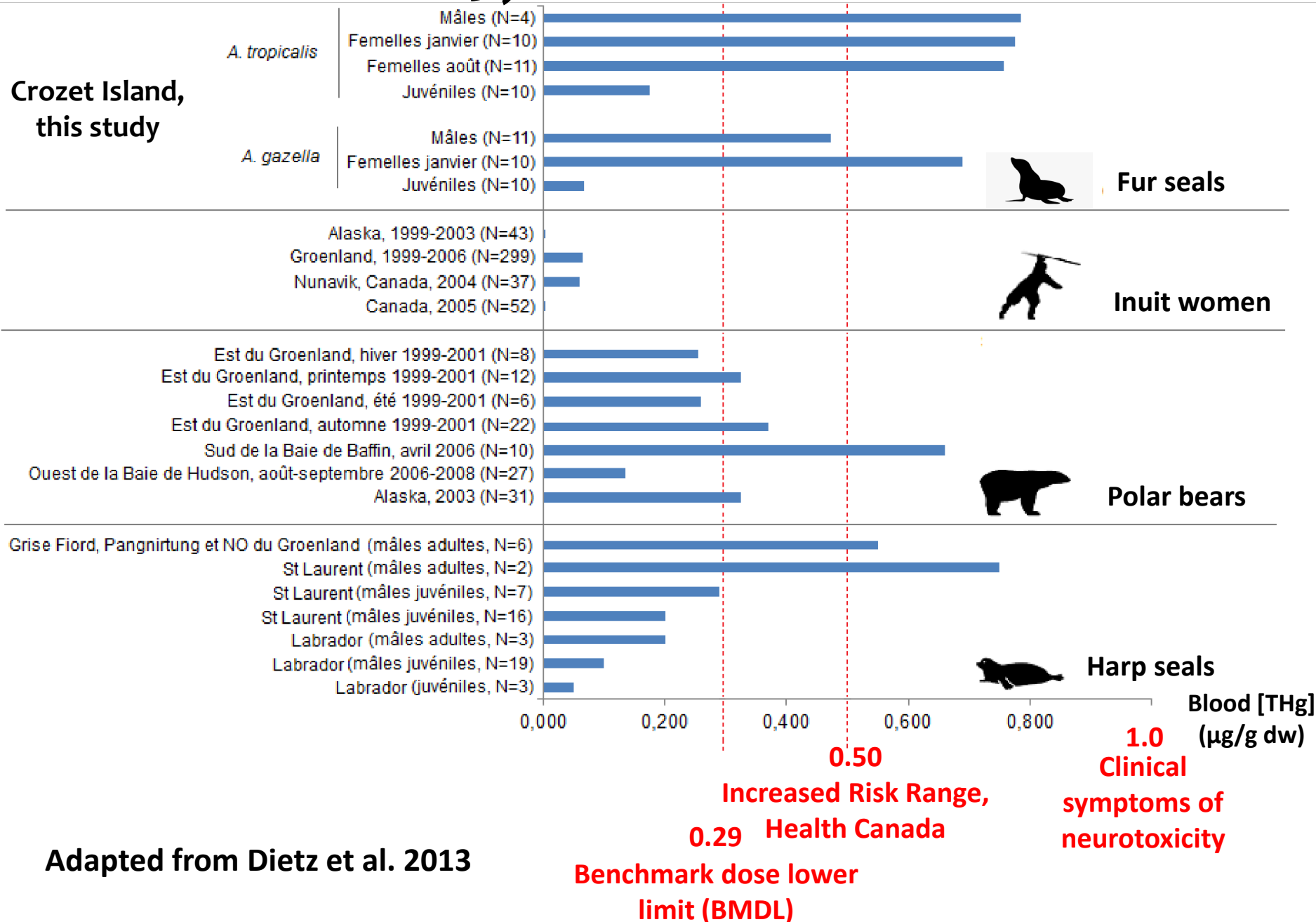


5) Toxic risk ?



Adapted from Dietz et al. 2013

5) Toxic risk ?



Adapted from Dietz et al. 2013

A. tropicalis

➤ 100% of ♂ & ♀ are > IRR

A. gazella

➤ 36% of ♂ and 10% of ♀ are > IRR
 => Effects???

Conclusions

1. Similar Hg levels in adults of both species but larger variation in males of *A. gazella*
 - larger foraging range ($\delta^{13}\text{C}$)
 - more diverse diet ($\delta^{15}\text{CN}$)

Fur seals feeding on krill in Antarctic waters are less exposed to Hg
2. In *A. tropicalis*, no differences between males and females
 - ecological segregation between sexes **seems limited during the reproduction period**
3. Levels of Hg over threshold values in all adult individuals *A. tropicalis*
 - **effects** need to be investigated