Presence of mercury in river dolphins *(Inia and Sotalia)* in the Amazon and Orinoco basins: evidence of a growing threat for these species

Mosquera Guerra Federico, Trujillo Fernando, Oliveira-da-Costa Marcelo, Marmontel Miriam, Van Damme Paul A, Franco Nicole, Mantilla-Meluk Hugo, Carvajal-Castro Juan David, Cordova Leslie, Caballero Susana, Armenteras-Pascual Dolors.

Context

Gold mining

Deforestation from the commercialization of timber

Agricultural expansion and more recently

The construction of hydropower dams

Goulding et al. 2003, Lasso et al. 2004, 2009, 2011, Mosquera-Guerra et al. 2015, 2018, Forsberg et al. 2017, Latrubesse et al. 2017.

Context

Mercury tends to accumulate bioaccumulate, biotransfer and biomagnification

Fish with pscivorous and ominovores habits

Top predators such as the giant otter, river dolphins (*Inia* and *Sotalia*) and coastal dolphins (*S. guianensis* and *Pontoporia blainvillei*)

Rosas & Kesä, 1996; Lebel et al. 1997; Malm et al. 1995, 1997; Dias Fonseca et al. 2005; Markert 2007; Siciliano et al. 2008; Molina et al. 2010; Panebianco et al. 2011; Salinas et al. 2013; Nuñez-Avellaneda et al. 2014; Mosquera-Guerra et al. 2015a y b.

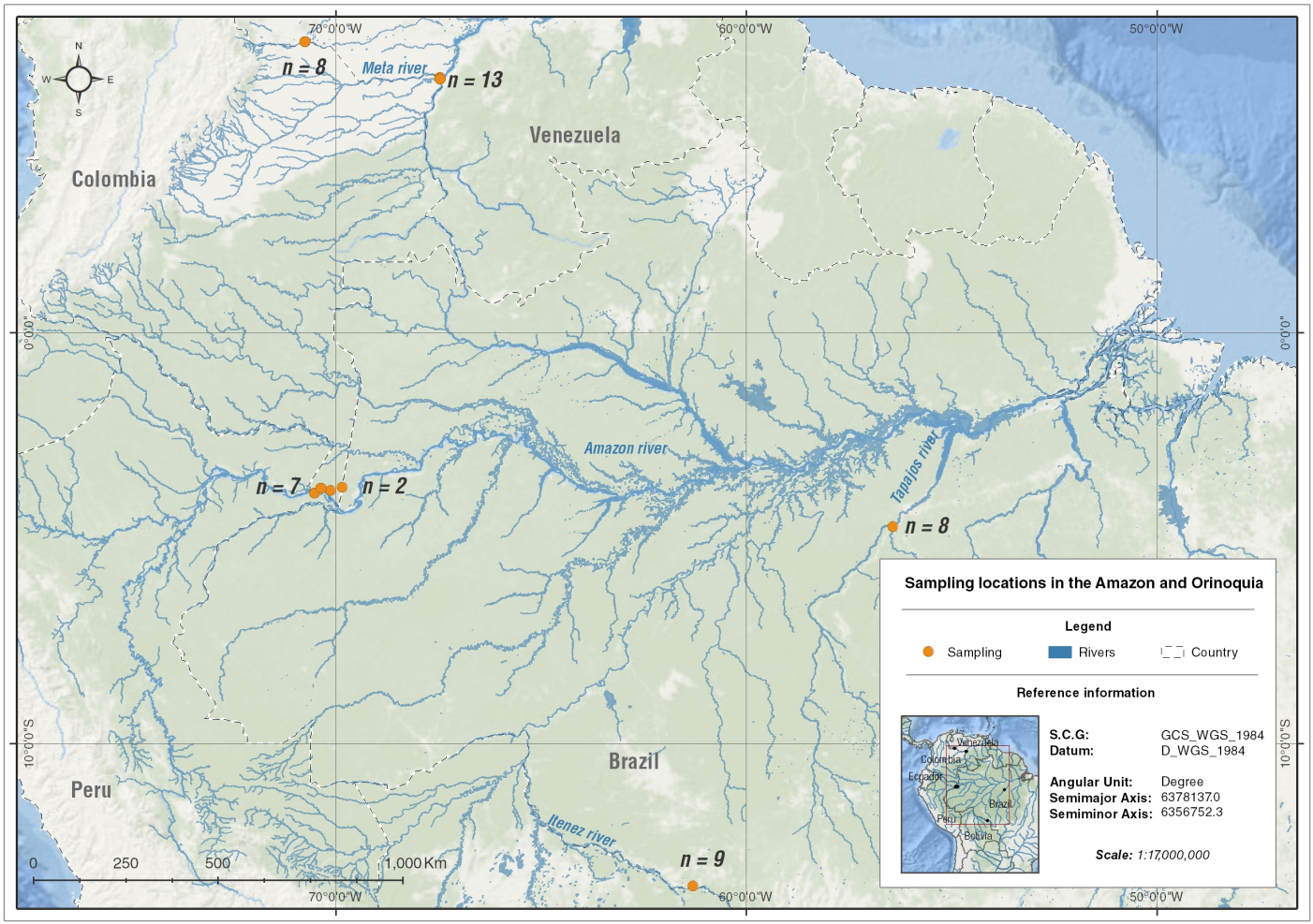
Introduction

In this work we demonstrate the existence of **biomagnification** of total mercury (Hg) in wild populations of river dolphins

Material and Methods

Study area

1. Amazon (Colombia),
2. Caballococha (Peru),
3. San Martin (Bolivia) and
4. Tapajos (Brazil) rivers in the Amazon basin and
5. Arauca and Orinoco rivers in the Colombian Orinoco basin



Material and Methods

The mercury samples were taken from 46 tissue samples coming from dead animals that were found floating in the river (n= 19, 41,3%), or had stranded (n= 4, 8,7%) and from individuals captured for the deployment of satellite transmitters (n= 23, 50%)

Each animal was weighed and measured

We extracted between 1 and 2 gr^{-1}

1 gr^{-1} of the sample was used cold vapor atomic absorption

Material and Methods

We apply statistical tests such as:

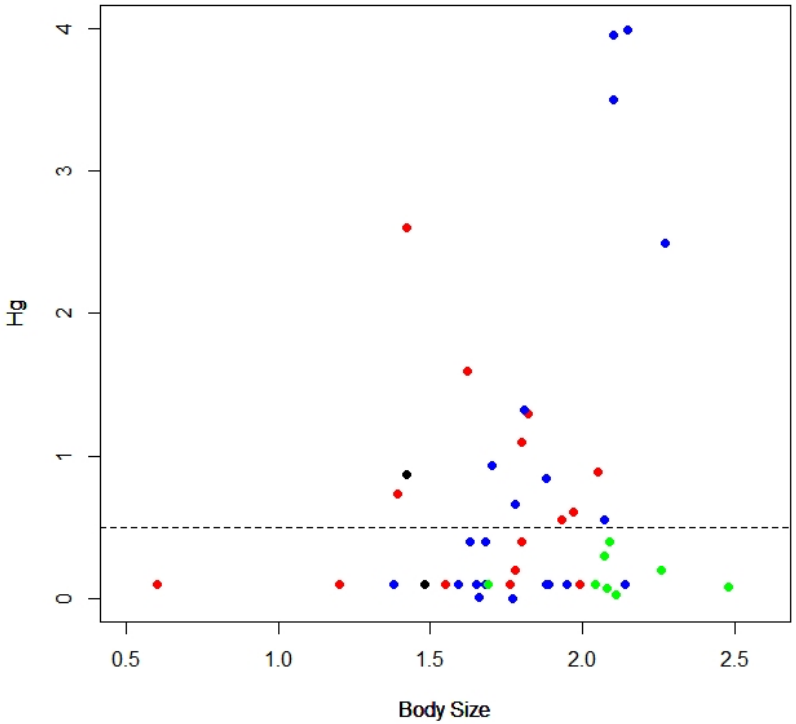
Shapiro-Wilk to test the normality of the data set (Hg, size and weight of the dolphins), and Kruskal-Wallis to compare the Hg levels in the tissues of dolphins from the basins (Amazonas, Orinoco and Itenez).

Results

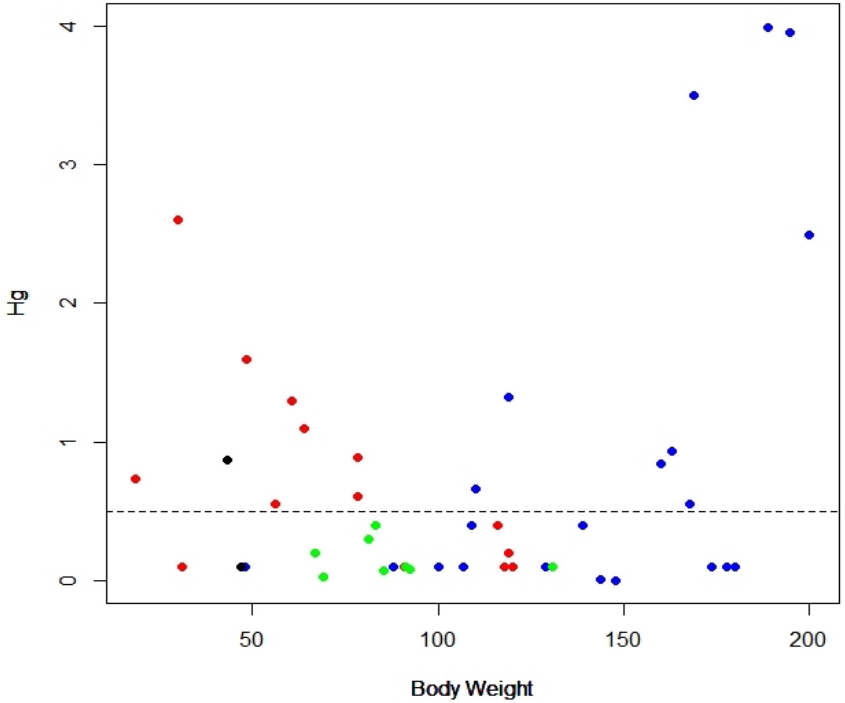
Tabla 1. Descriptive statistics for body length and mercury concentrations in the muscle of male and female river dolphins (*Inia* and *Sotalia*) in the Amazon and Orinoco river basins.

Species/ Subspecies	Hg concentration (mg/kg^{-1})				Body length (cm)		
	Sex	M	F	All	M	F	All
I. g. geoffrensis	Mean	0,75	0,6	0,7	165,2	163,2	165
	SD	0,75	0,71	0,71	0,42	0,29	0,38
	Median	0,58	0,1	0,55	179	162	178
	Maximum	2,6	1,6	2,6	205	199	205
	Minimum	0,1	0,1	0,1	60	120	60
I. g. humboldtiana	Mean	0,99	0,84	1,03	183,7	186,2	187,7
	SD	1,4	1,3	1,45	0,2	0,25	0,22
	Median	0,4	0,1	0,4	173,5	190	188
	Maximum	3,99	3,5	3,99	227	214	227
	Minimum	0,004	0,1	0,004	159	138	138
I. g. boliviensis	Mean	0,15		0,16	208	210	210
	SD	0,13		0,12	0,22	0,22	
	Median	0,1		0,1	2,08	208,5	
	Maximum	0,4	0,2	0,4	248	226	248
	Minimum	0,03		0,03	169		
Sotalia fluviatilis	Mean						
	SD						
	Median						
	Maximum	0,1	0,87	0,87	142	148	148
	Minimum						

Results



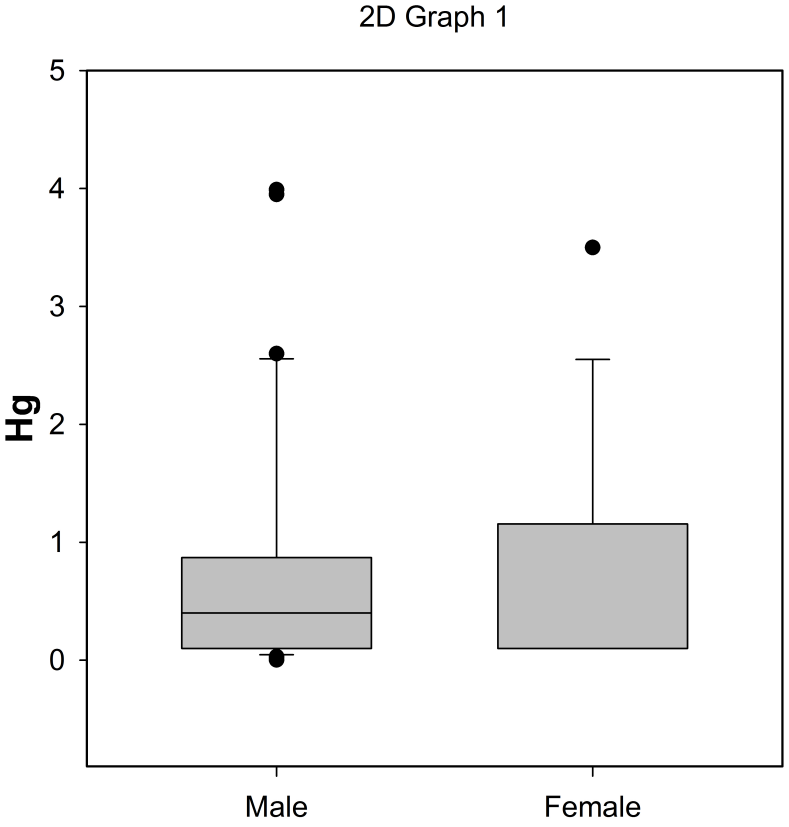
Body size (W = 0.93903, p-value = 0.018)



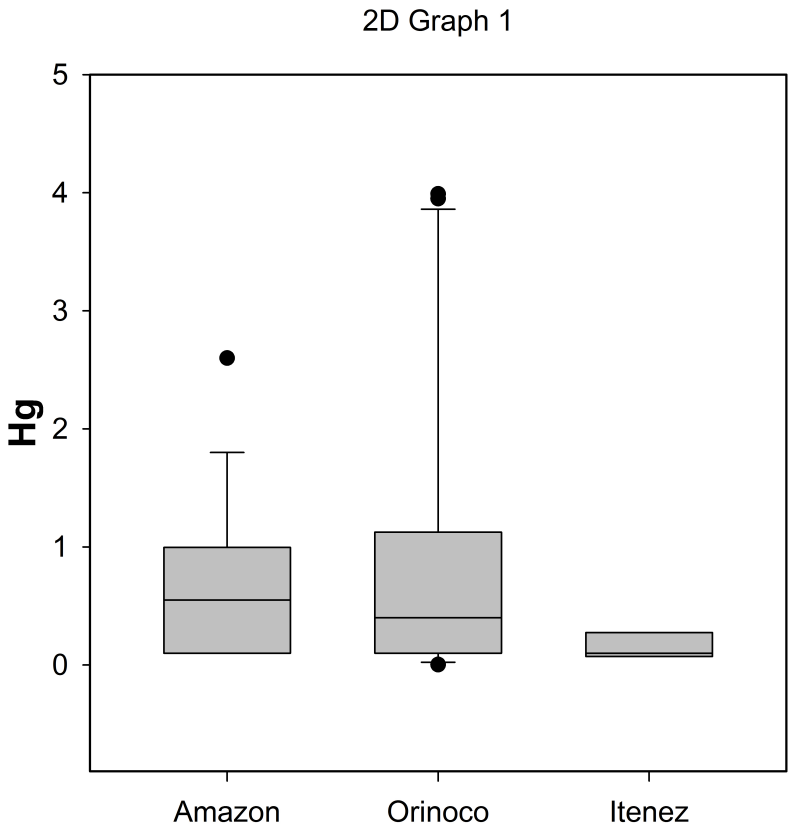
Body Weight (W = 0.97166, p-value = 0.3188)

Figure 2. (a) and (b) Relationship between Hg concentration in tissues, size, and body weight of the river dolphins sampled in the Amazon and Orinoco basins. Nomenclature: Red dots represent: *I. g. geoffrensis*, blue dots: *I. g. humboldtiana*, green dots = *I. g. boliviensis*, and black dots: *S. fluviatilis*.

Results



Body size and weight between males and females (Kruskal-Wallis chi-squared = 0.18473, df = 1, p-value = 0.6673; ANOVA: F-Value: 0.0103; p-value: 0.749)



Hg levels reported among basins (Kruskal-Wallis chi-squared = 5.366, df = 2, p-value = 0.06836; Anova p-value= 0.749)

Figure 2. (c) and (d) Box-plot of the variation in Hg concentration from specimens among sampling locations. Box-plot of the variation in Hg concentration from specimens among sex and sampling locations.

Discussion

Tabla 3. Means, standard deviations and ranges of total mercury concentrations (µg g-1 wet weight) in muscle tissues of *Sotalia guianensis* from Brazilian Atlantic coast and *Inia g humboldtiana* (Arauca) and *Inia g geoffrensis* (Amazonas) from Colombia (Moura et al. 2012 and Mosquera-Guerra et al. 2015b).

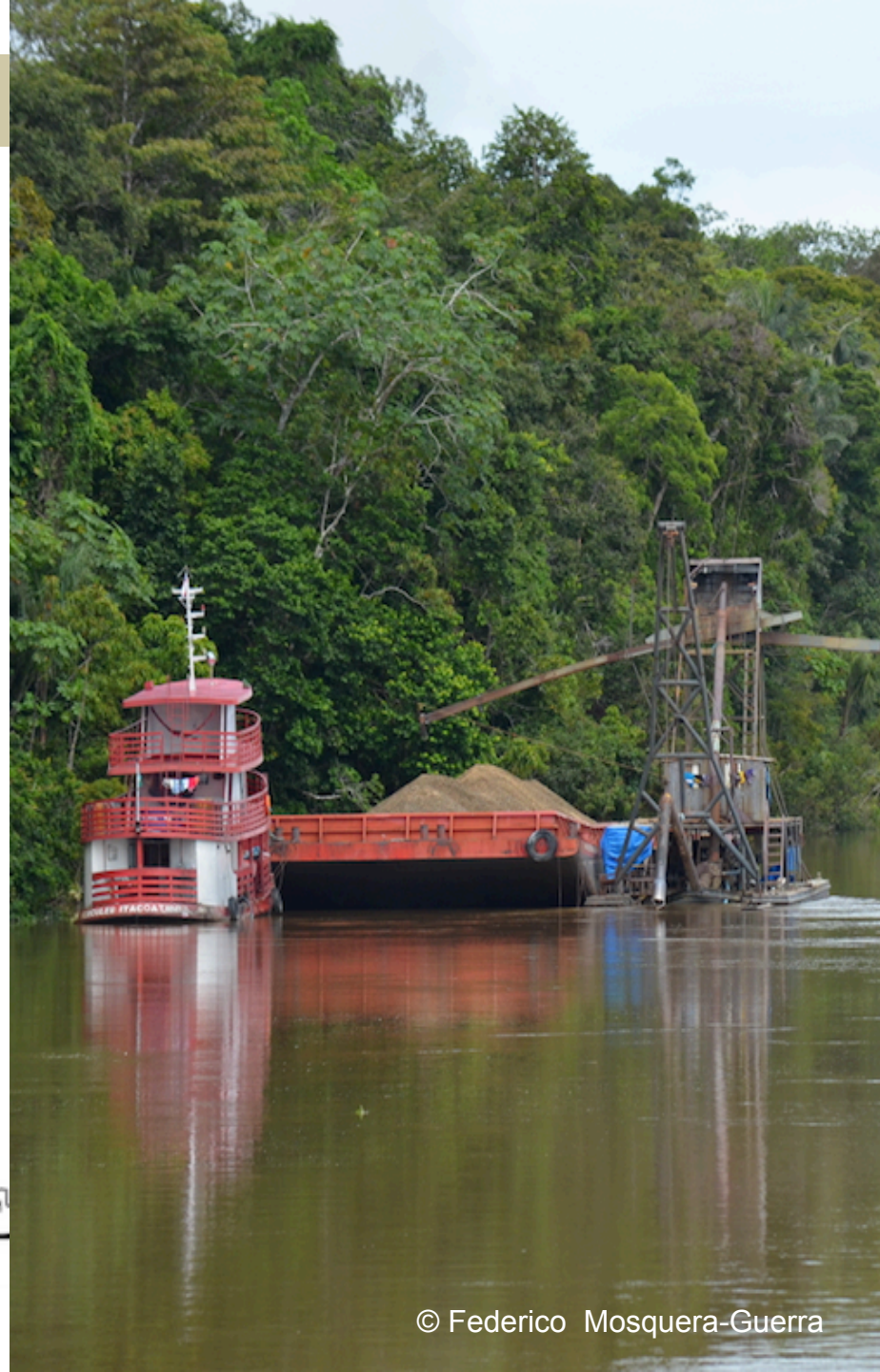
Species	Hg	Localities	N	Referens
S. guianensis	0.7 (0.2–2.5)	New Caledonia Guanabara Bay, RJ, Brazil.	15	Kehrig et al. (2004)
S. guianensis	1.8 ± 0.46	Espírito Santo state, Brazil	5	Lopes et al. (2008)
S. guianensis	0.73 (0.34–1.42)	Northern Rio de Janeiro state, Brazil.	6	Carvalho et al. (2008)
S. guianensis	0.98	Northern Rio de Janeiro state, Brazil.	21	Kehrig et al. (2009)
S. guianensis	1.07 ± 0.35 (0.2–1.66)	Rio de Janeiro state, Brazil.	20	Moura et al. (2011)
S. guianensis	0.4 ± 0.16 (0.07–0.79)	Amazon coast, Brazil.	27	Moura et al. (2012)
I. g. humboldtiana	3,51	Arauca (Orinoco), Colombia.	1	Mosquera-Guerra et al. 2015b
I. g. geoffrensis	0,16	Amazonas (Amazonas), Colombia.	1	Mosquera-Guerra et al. 2015b

Discussion

Rosas & Kesä (1996) evidenced the presence of this heavy metal in maternal milk *of I. g. geoffrensis* in the vicinity of the city of Manaus, Brazil, and

Mosquera-Guerra et al. (2015), reported the presence of this pollutant in individuals stranded in the Arauca (Orinoco) and Amazon rivers in Colombia.

In this study, 18 animals, (39,1%) sampled, exceeded the mercury guideline for humans set by World Health Organization (WHO) (0.5 mg/kg-1).



Discussion

The subspecies *I. g. humboldtiana* (n = 9, 19,6%) in the Orinoco basin, *I. g. geoffrensis* (n = 8, 17,4%) in the Tapajós river and *Sotalia fluviatilis* (n = 1) in the Amazon reported the highest concentration values for this heavy metal within the samples analysed.

Total mercury (Hg) tends to accumulate (bio accumulate), transfer (bio transfer) and magnify its concentration (bio magnification) in aquatic food chains by increasing in the trophic level.

Markert, 2007; Molina et al. 2010

Discussion

Abnormalities

Death

Central nervous system

Behavioural deficiency

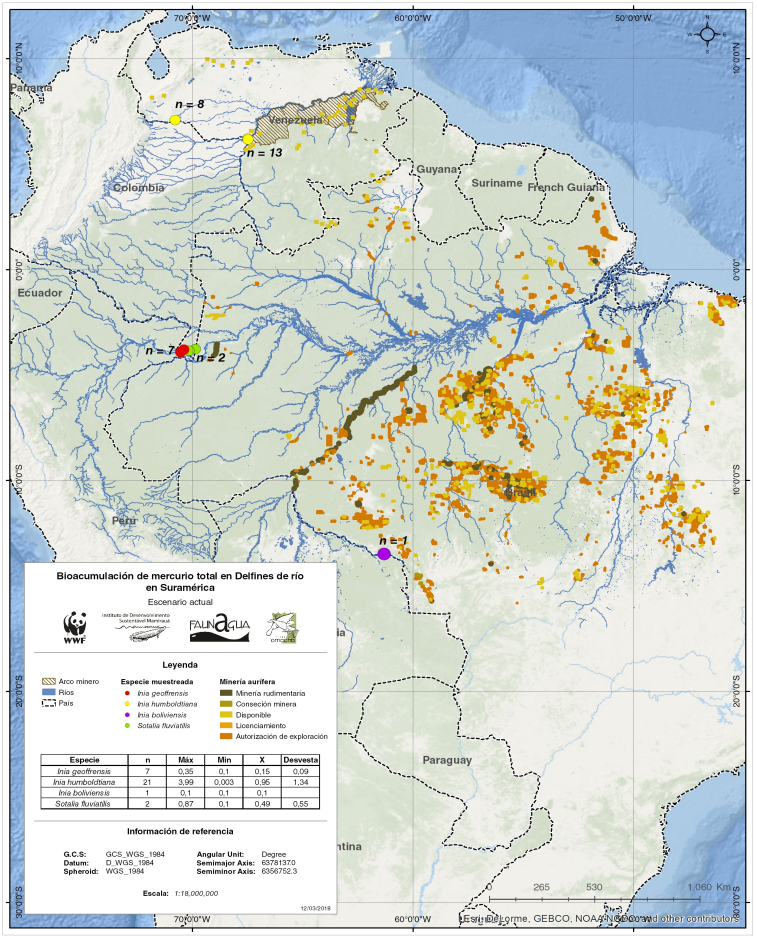
Anorexia

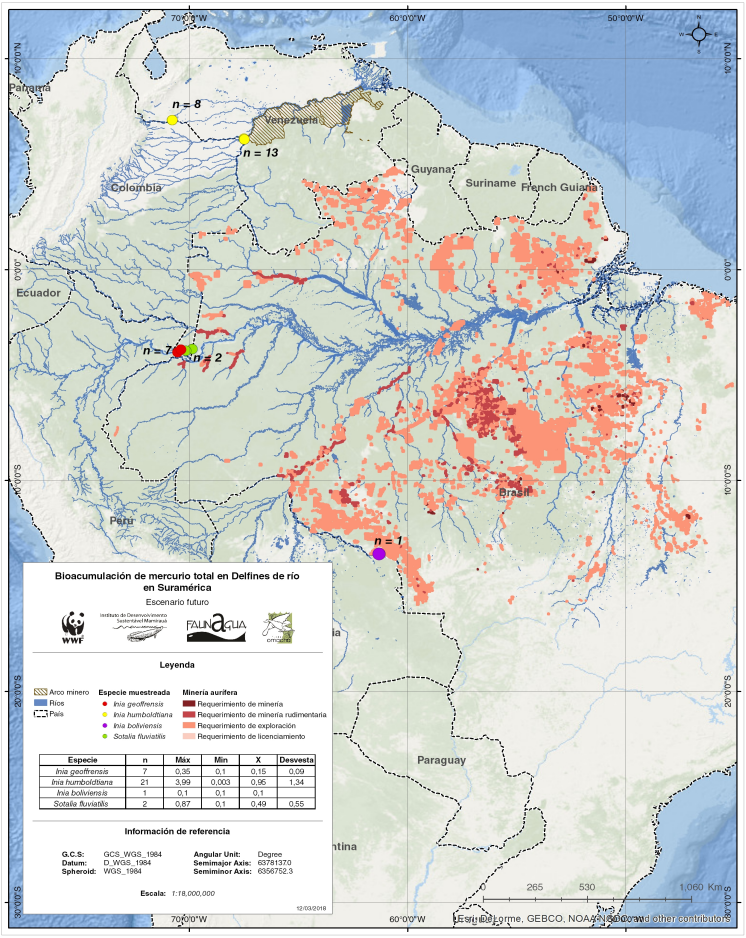
Reproductive disorders and death of foetuses

As well as deficiencies of the immune system, facilitating the appearance of infectious diseases and pneumonia

Krishna et al. 2003, Cardellicchio et al. 2002, Augier et al. 1993.

Discussion





WWF
omacha
Instituto de Desenvolvimento Sustentável Mamirauá
PRO DELPHINUS PERU
FAUNAGUA

Conclusions

Biotransfer processes and bioaccumulation of mercury (Hg) are occurring in aquatic food webs in the Amazon and Orinoco regions/ river basin

Our data supports that populations of *I. g. humboldtiana*, distributed across the Orinoco basin have the highest concentration values of Hg, when compared with other river dolphin subspecies and species evaluated in the upper Amazon basin

Mercury contamination further exacerbates the conservation status of these aquatic mammals

Acknowledgments

This research was conducted as part of the South America River Dolphins Conservation Programme, sponsored by the Whitley Fund for Nature, Foundation Segré, and Colciencias through the National Doctorate Scholarship 785. It is part of the strategic plan set by the South American River Dolphin Initiative, supported by WWF offices in Brazil, Colombia, Peru, Ecuador and Bolivia. Special gratitude goes to Saulo Usma, Diego Amorocho, Daphne Willems, Lila Sainz, Jorge Rivas, Jose Luis Mena, and Karina Berg from the WWF network. The authors would also like to express their gratitude to the fishing communities, and the local and national authorities who participated and gave their aid and attention to the strandings and the process of capture of river dolphins during the satellite tracking programme, aiming to study the ecology of movement in the Amazon and Orinoquia river basins.

Thanks for your attention