Seminário sobre Mercúrio
Cooperação bilateral Brasil x Suécia
Mercury Exposure in the Madeira River-Amazon Basin

Sandra Hacon

Why are we worried with Hg in the Brazilian Amazon?

- Because in the Peruvian Andes we had the largest Hg processing in the Western Hemisphere. It is a legacy of 500 years,

- The mine closed 30 years ago, mining continues on small scales with about 30,000 miners producing at least 16 tons of the metal annually (Eco Americas 2013),

- Nowadays the gold artisan mining is a important economic activity in Peru, Bolivia, Equator releasing Hg to the Amazon Basin.

- Mercury is known by its long range transport in the atmosphere and in waterways, its persistence and ability to bioaccumulate in ecosystems,

Mercury bioaccumulates in fish.

•Fish is key source of protein to riverine population;

● Fish consumption is high across all Amazon riverine population;

●It is the main pathway for human exposure to methyl mercury in the Amazon region.

GOLD MINING IN AMAZON BASIN

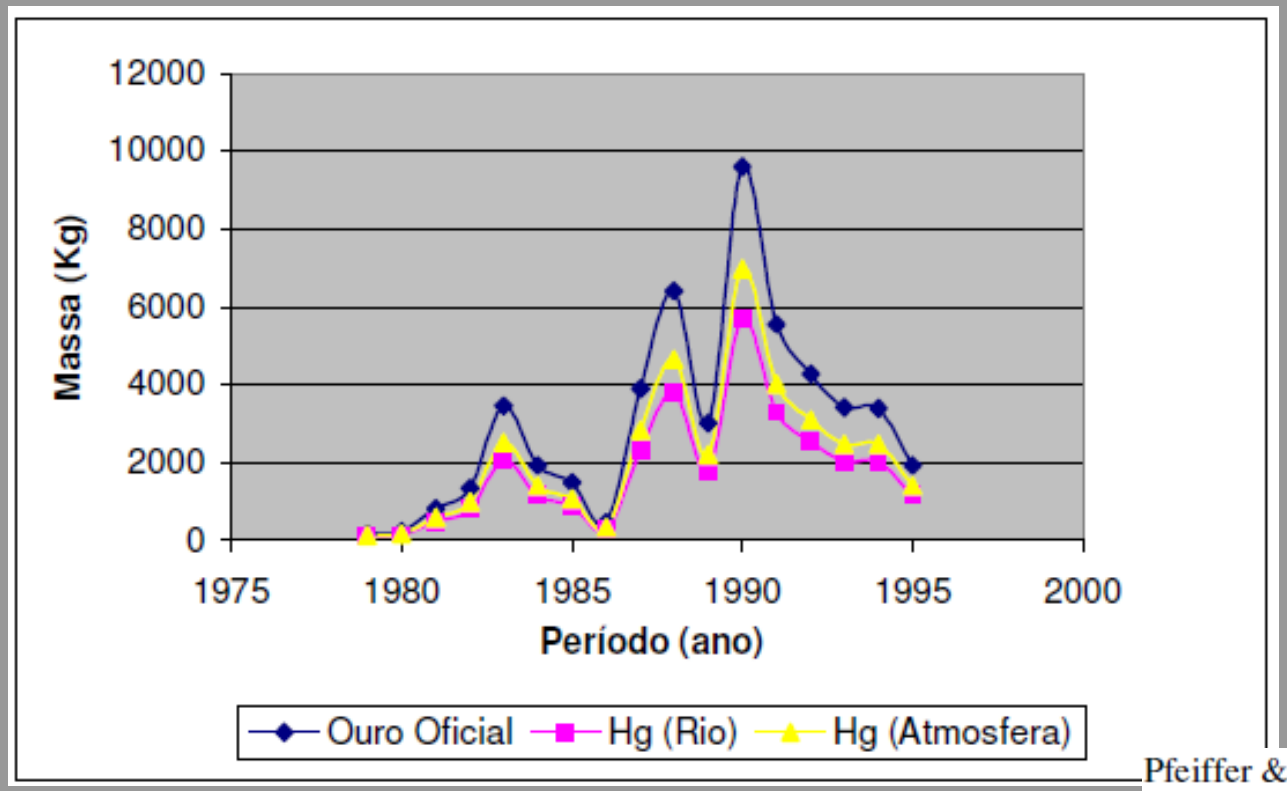
- During the 80`s decade the gold mining activities used intense and extensively metalic mercúry to amagalmate gold;
- During the period of 1979 to 1997 the average losses of metalic Hg to the Amazon basin was estimated in 1.500 t;
- During 80`s decade about 45%

of metalic Hg were lost to the aquatic system.

- (Lodenius & Malm, 1998; Pfeiffer & Lacerda, 1988)

GOLD MINING IN AMAZON BASIN

- The gold production in RO state during the period of 1979 to 1995 was about of 50 t;
- It was estimated that 68 t of metalic Hg were discharged into Madeira Basin.



Pfeiffer & Lacerda (1988).





- Why are we worried with Hg in the new scenario in the Amazon basin?

- The economic development projects in the Amazon basin, including other countries of the basin have caused important environmental impacts, increasing the Hg load in the Amazon Basin;
- Amazonian has the ecological conditions for the Hg metilation and since the 80`s, several studies have shown MeHg in this ecosystem.

Why study mercury in the Amazon region?

- Gold mining extraction history (decrease in the last decade in Brazilian Amazon, but increased in Peru, Bolivia, Equator
- Deforestation
- Biomass burning
- Changing in the economic profile.

Why is important to study this region now?

Changing in the economic profile.

➢Increasing the Amazon Energy Generation Program

•Energy Production in the Madeira River

• Jirau Hydroelectric Plant (3.150MW)
Santo Antonio Hydroelectric Plant (3.300MW)

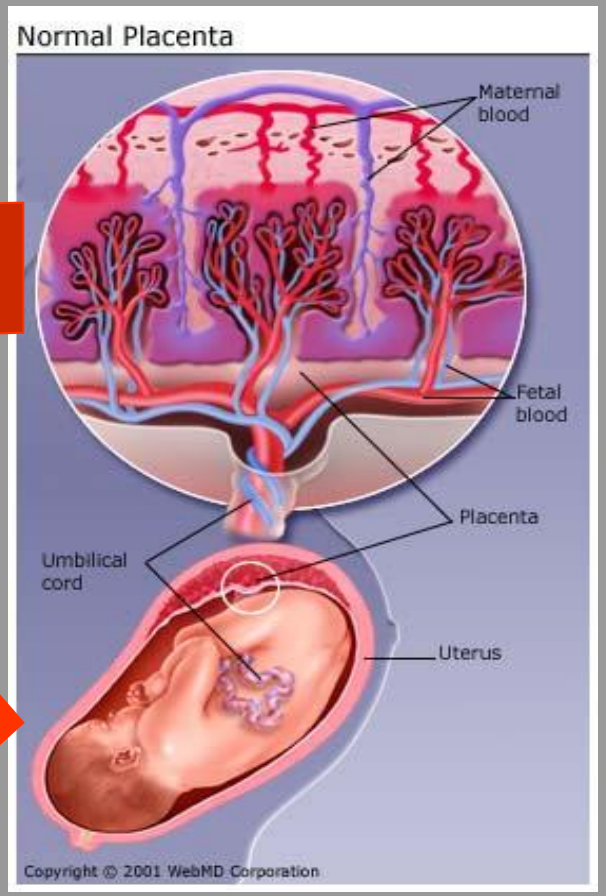
New Threats and challenges

- ➢ Changes in mercury exposure patterns
- ➢ Climate change (increase temperature- droughts)
- ➢increased Hg load

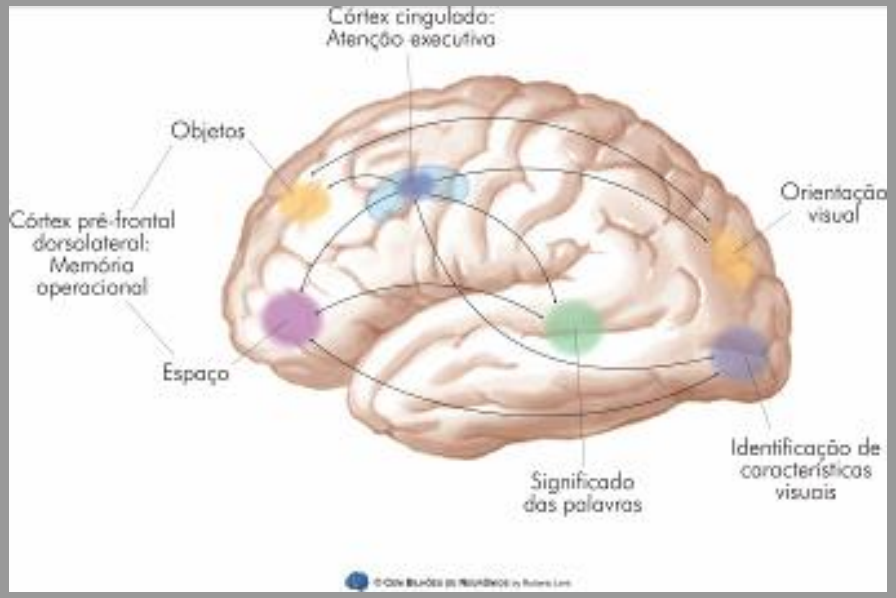
Is MeHg in fish safe for women?

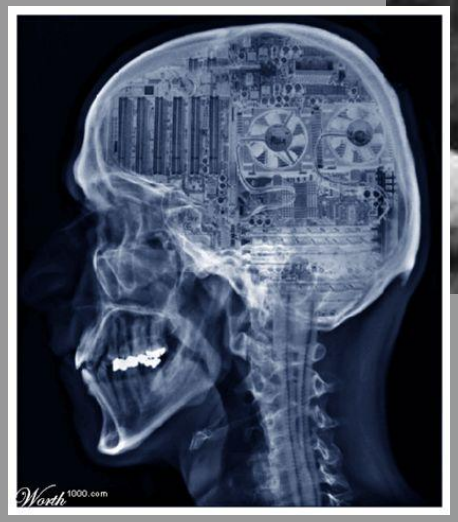
Transport across the placenta

Central nervous system...



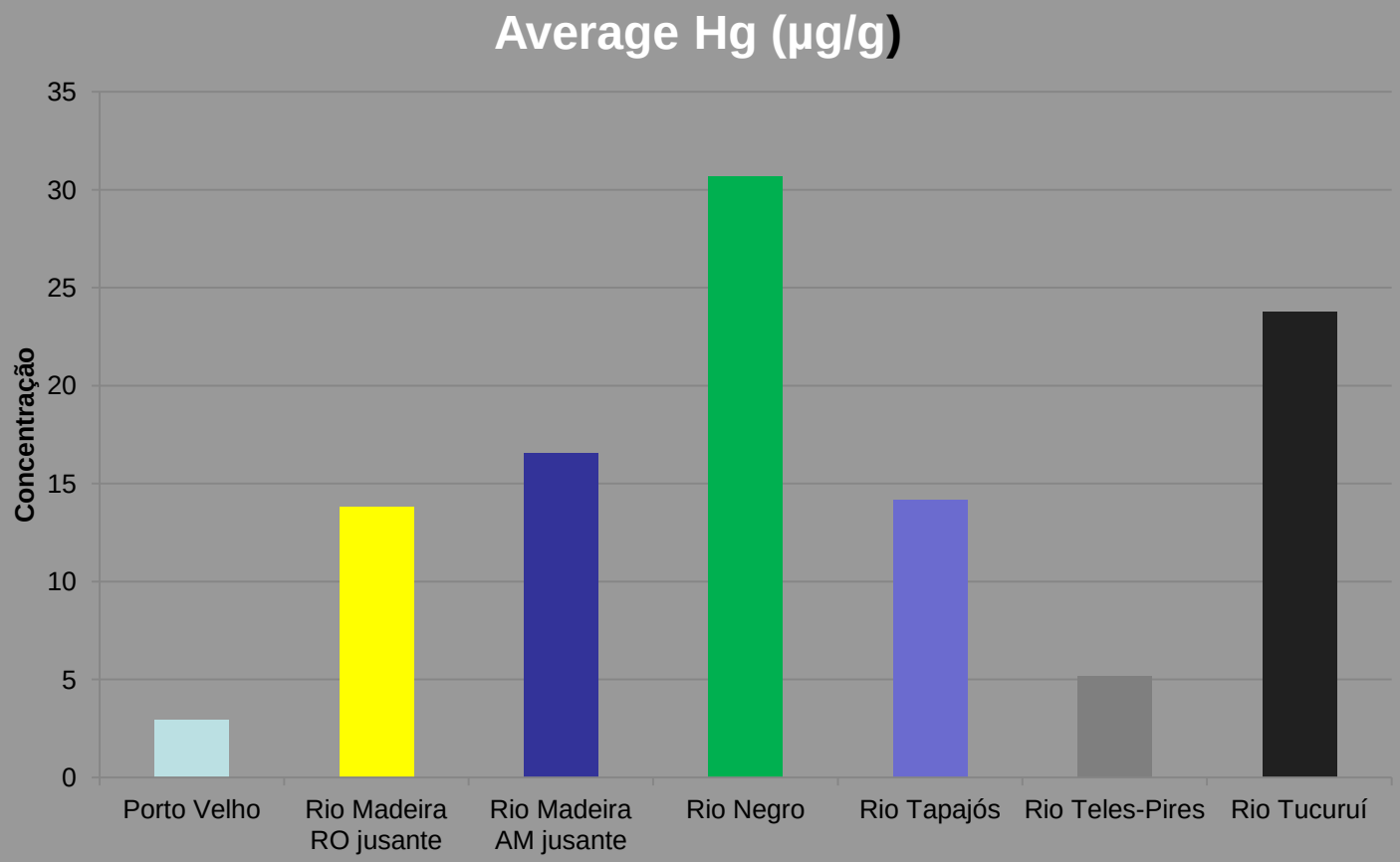
Cognitive function





Modificado de M.I. Posner e M.E. Raiche (1994) Images of Mind. W.H. Freeman & Co., EUA. Figura retirada da obra de Roberto Lent: Cem bilhões de neurônios: conceitos fundamentais de neurociências. Ed. Atheneu. 2004. Pág. 677.

Hg-Levels in the riverine population studies at Brazilian Amazon



- **WHO &UNEP 2008**: 2 to 5 µg/g in hair are acceptable reference levels for riparian communities

Hg-hair levels from studies at the Madeira River ***downstream*** Porto Velho city (90's studies)

Population Studied	Year of study	n	mean	SD	Range	Refereces
Madera River		241	17		NA-303	Boishio e Barbosa, 1993
Familly members	1991	10			7-303	Boishio et al., 1995
Familly members	July 1993	10			8-339	Boishio et al., 1995
Cuniã Lake Resex		75	17.2		ND-31.9	Barbosa et al., 1995
Madeira river		169	8.98		0.22-71	Malm et al., 1996
Madeira River (< 32 years old)		98	14.1	10.7	2.6-94.7	Boischio e Cernichiari, 1998
Madeira River		28			4-84.4	Barbosa et al., 1998
37 communities (mothers) until140 Km from Porto Velho city	july 1993	90	12.6	6.5	0.8-28.3	Boischio e Henshel, 2000
37 communities (childs 0-7,5 years old) until140 Km from Porto Velho city	july 1993	89	10.2	7.2	1-34.2	Boischio e Henshel, 2000

Hg-hair (µg/g) levels from studies at the Madeira River ***downstream*** Porto Velho city

Population Studied	Year of study	n	mean	SD	Range	Refereces
Calama (RO)	2001-2003	34	9.02	5.78	0.5-22.48	Bastos et al., 2006
Boa Vitória (RO)	2001-2003	3	13.82	3.1	10.86-17.05	Bastos et al., 2006
Cujubim (RO)	2001-2003	12	6.3	4	1.55-14.67	Bastos et al., 2006
Firmeza (RO)	2001-2003	4	11.21	2.54	9.4-14.8	Bastos et al., 2006
Itacoã (RO)	2001-2003	6	11.97	4.33	5.28-16	Bastos et al., 2006
Nazaré (RO)	2001-2003	64	10.65	5.65	0.63-22.6	Bastos et al., 2006
Papagaios (RO)	2001-2003	13	13.72	7.71	4.76-27.22	Bastos et al., 2006
Santa Rosa (RO)	2001-2003	19	13.99	3.12	7.68-20.78	Bastos et al., 2006
São Carlos (RO)	2001-2003	15	9.51	6.36	1.84-22.83	Bastos et al., 2006
Terra Caída (RO)	2001-2003	7	9.61	3.61	5.01-14.61	Bastos et al., 2006
Santo Antonio do Pau Queimado (RO)	2001-2003	14	14.69	6.45	5.87-26.86	Bastos et al., 2006
Riverine	2006	396	12.12		1.02-130.72	S.M. Viera et al., 2013
Rural	2006	67	7.82		2.56-41.1	S.M. Viera et al., 2013
Tin Miners	2006	294	4.45		1.53-11.94	S.M. Viera et al., 2013
9 Riverine Communities downstream Porto Velho city	2010-2011	75	8.24		0.76-20.08	S.M. Viera et al., 2013

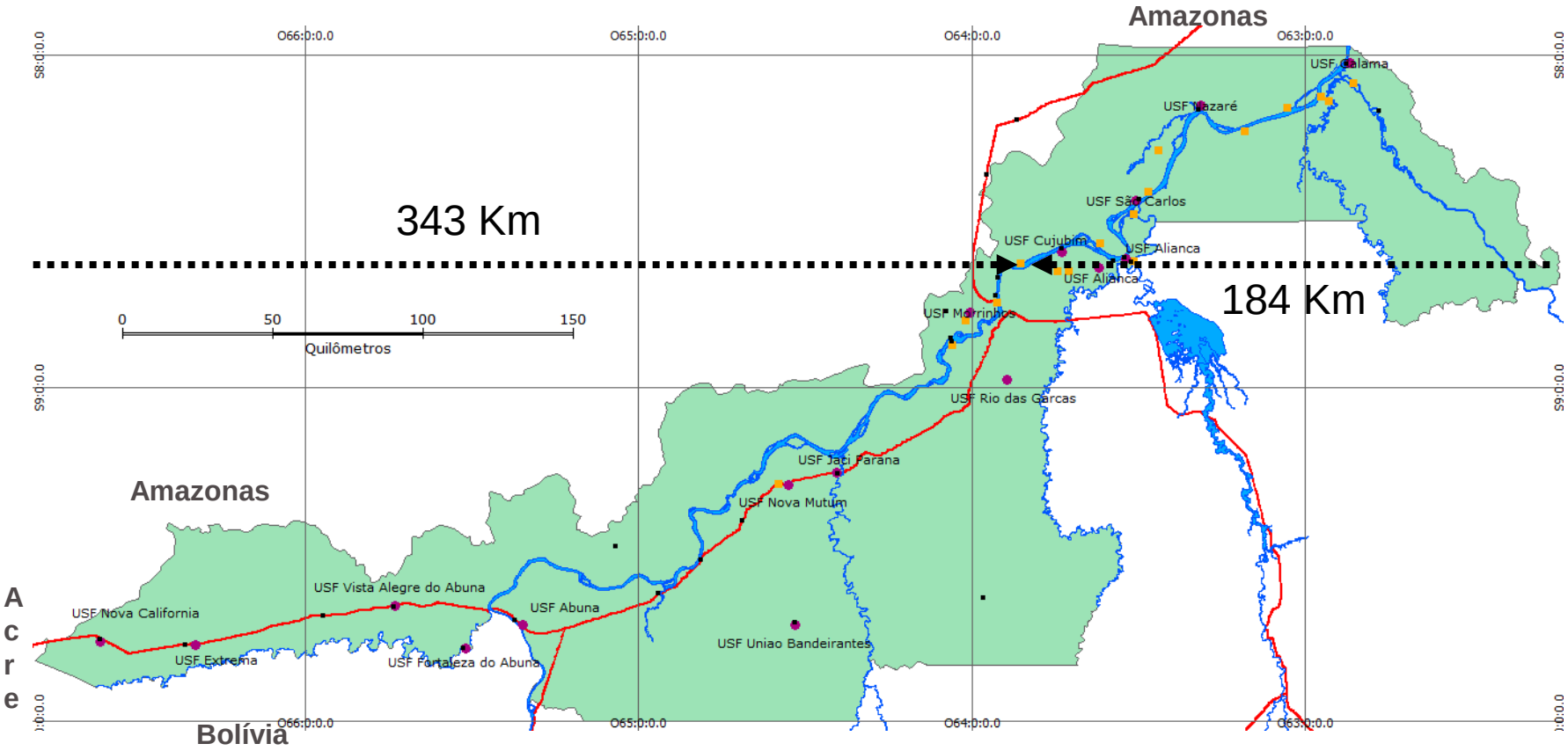
Hair Hg-Levels in the riverine communities from studies in Madeira River

Population Studied	Year of study	n	mean	Range	Refereces
Mothers		82	5.4	0.39-62.43	Marques et al., 2007
New borns		82	1.59	0.05-19.65	Marques et al., 2007
Children of 6 months		82	1.81	0.02-32.95	Marques et al., 2007
Urban woman from 5 city of Rondônia state	2006	676	5.36	0.73-24	Marques et al., 2013
Women	2010	82	1.32	0.28-6.09	Viera et al., 2013

Study of Madeira River- Amazon Basin

Mercury exposure in riverine population of Madeira River nearby the hydroelectric power- plant, before flooding of reservoir, to support future researches for monitoring potential adverse effects on human health.

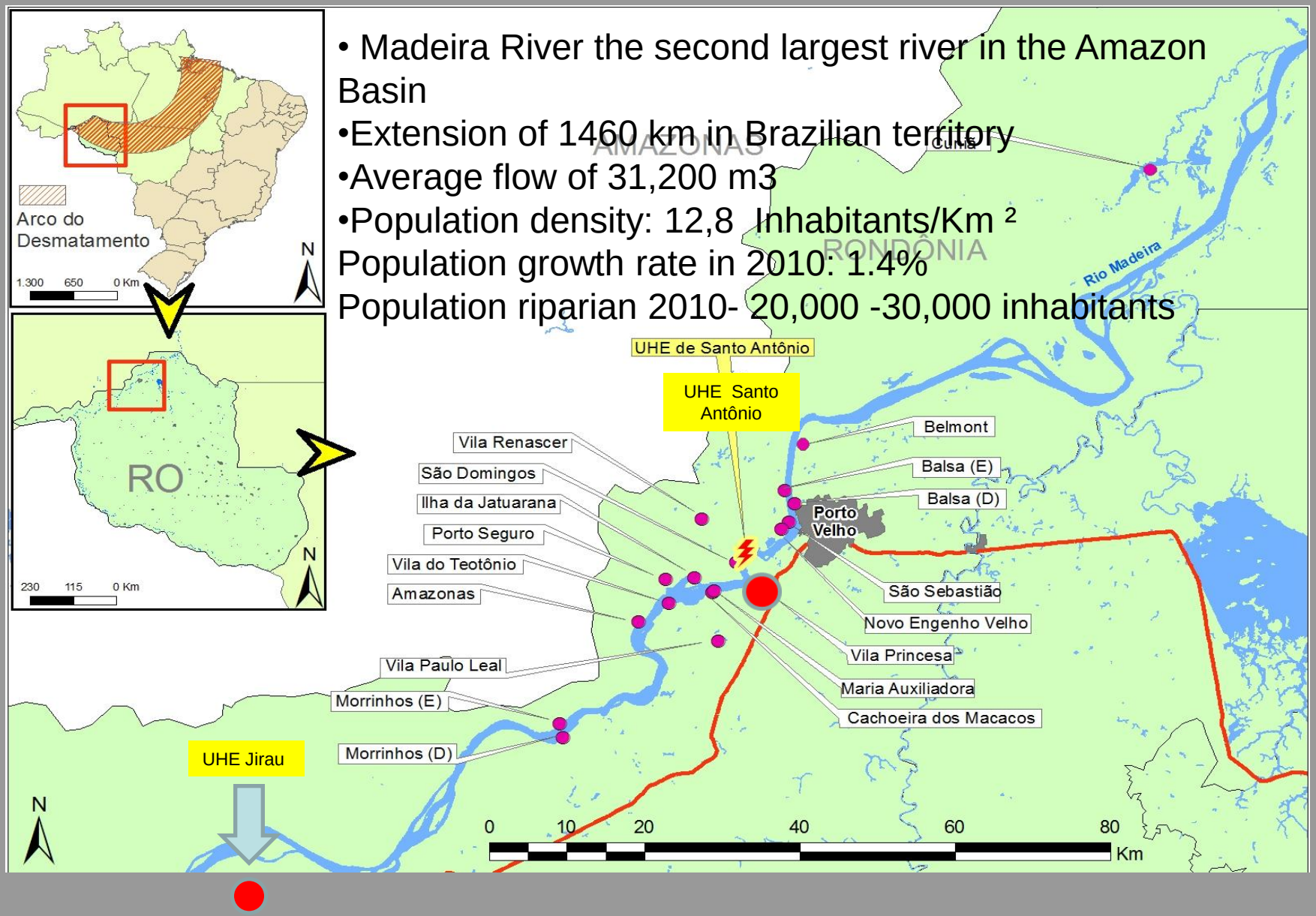
Municipality of Porto Velho



Land area: 34,094 km^2
Population in 2011: 435,730
Population density: 12,77 inhabitants / Km ^{2}
Population growth rate in 2010: 1.4%
Population growth between 1996 to 2010: 45%

Fonte: IBGE Cidades. Dados acessados em julho de 2012.

Western Brazilian Amazon



- Madeira River the second largest river in the Amazon Basin
- Extension of 1460 km in Brazilian territory
- Average flow of 31,200 m3
- Population density: 12,8 Inhabitants/Km ²

Population growth rate in 2010: 1.4%

Population riparian 2010- 20,000 -30,000 inhabitants

Madeira River Communities 2009 to 2012

- Direct and indirect Influence of Hydroelectrical Power Plant: *Upstream*

  Downstream

- *Reference Area* (180 km from Hydroelectrical Power Plant

Childrens and teenagers: < 15years old

Female(reproductive age) > 15 to 49

Men:16 to 70 years old

Sample about 1950 individuals.

Typical food habits (manioc and fish);

endemic chronic diseases; poor sanitary conditions and limited health care

PARTICIPATORY APPROACH

Data and Sample Collection

- Interview- with questionnaires: Adults and children (diet survey)
- Hair and blood samples for Hg and Se and biochemical parameters.

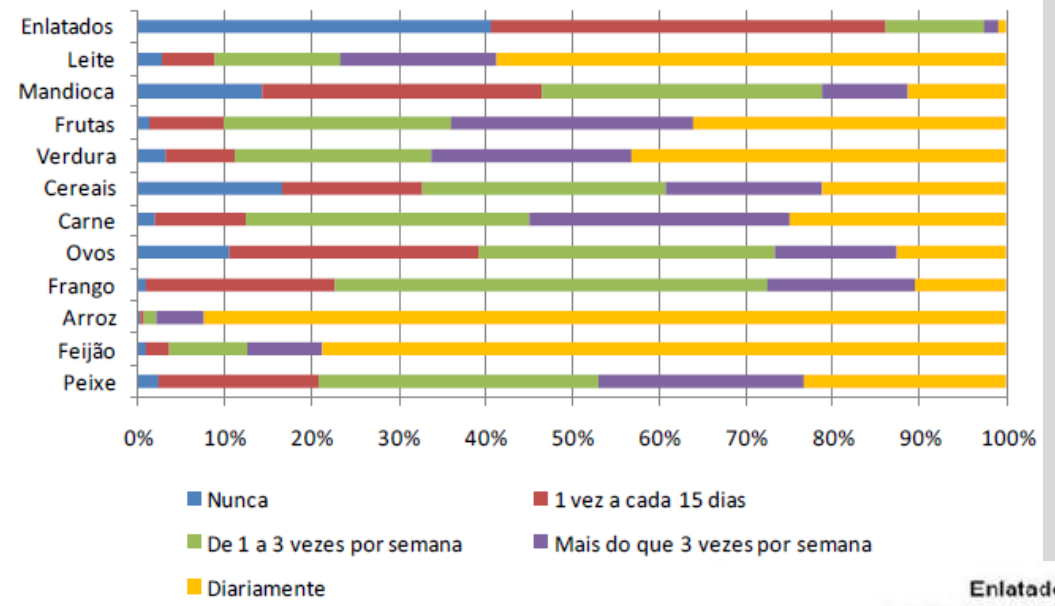
THE MAIN RESULTS




Characteristics of the riverine Population

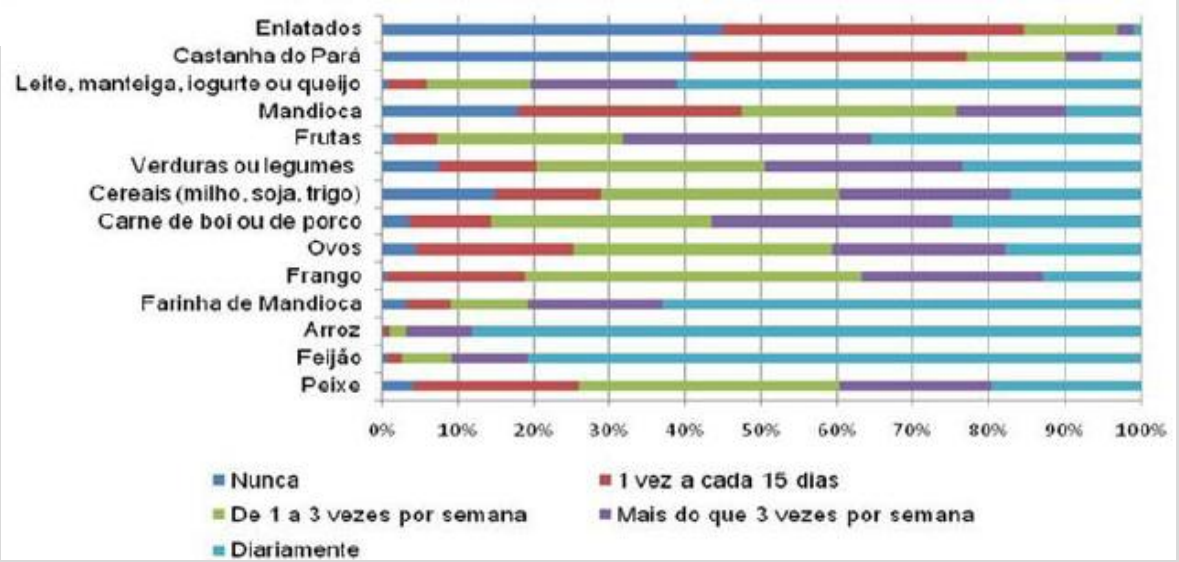
Grouped villages	Area 1	Area 2	Resex Cuniã
Position along the Madeira River	Upstream the Santo Antônio waterfall	Downstream the waterfalls	Downstream the Santo Antônio waterfall
Access to urban area in Porto Velho city	20-50 km away; road available in dry seasons until the ferry	7-15 km away, road available in dry seasons; viable by bike (ferry available daily)	180 km away; no road; viable only by boat (very difficult in dry season)
Main source of fish	Madeira River	Belmont lake and Madeira River	Cuniã Lake
Assessed individuals (total; %children, %women in reproductive age)*	(1138; 40% and 26%)	(619; 41% and 32%)	(251; 44% and 28%)
Residence time on site (years)	15 (2 - 52)	19 (1 - 47)	30 (4 - 63)
Local primary-health-care	No	Yes	No
Family income (R$/month)***	930 (300-6000)	1000 (460-2750)	600 (200-3500)
Main occupation of adults			
Fishing	23.50%	8.60%	29.30%
Goldmining	0.20%	3.10%	0%
Farming	20.20%	8.50%	11.40%
Studying	5.30%	6.10%	6.40%
Home	24.90%	28.30%	20.00%
Variable (seasonal)	25.20%	43.60%	32.10%

DIETARY SURVEY



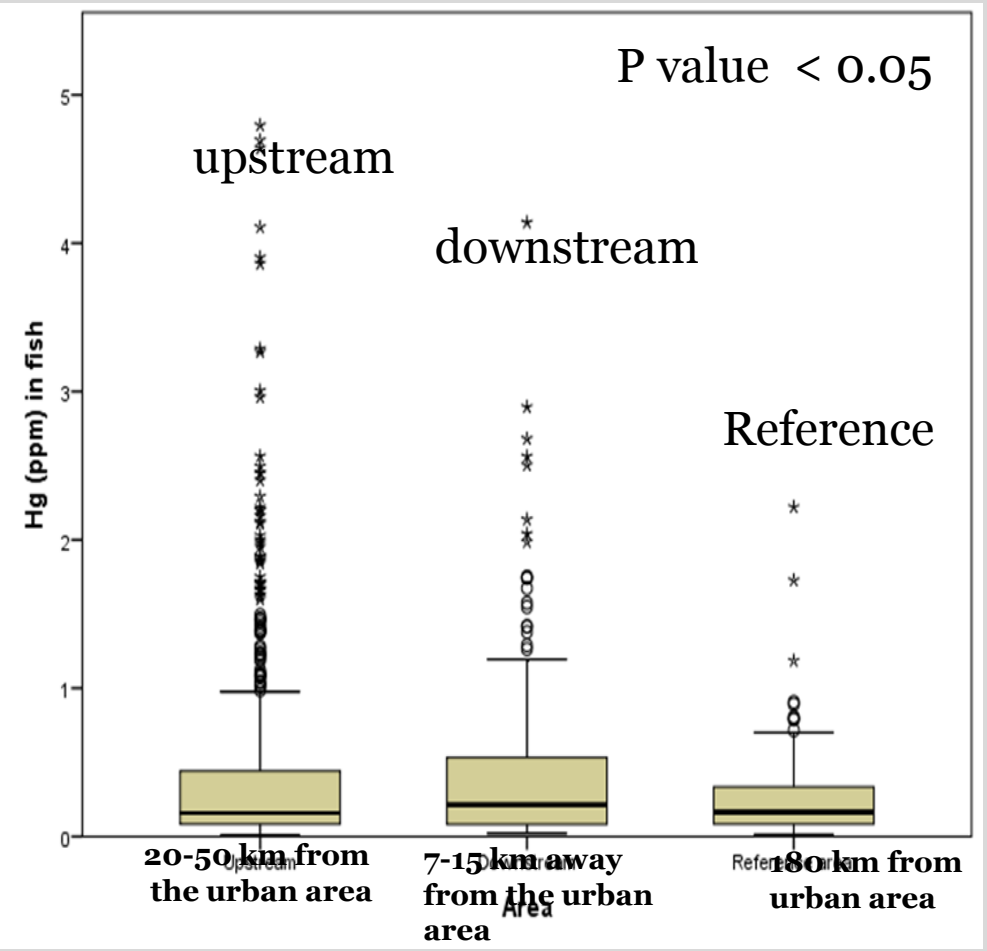
WOMEN 16- 49 YEARS OLD

CHILDREN POPULATION

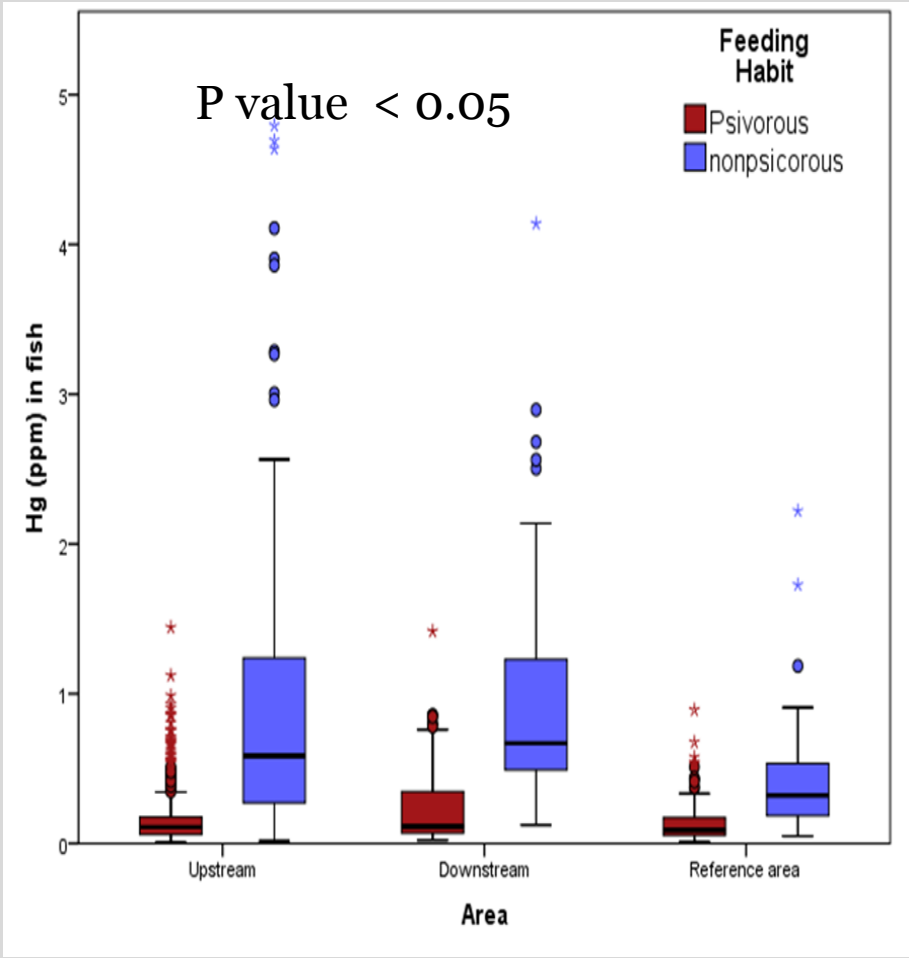


Mercury in Fish

Areas od Study



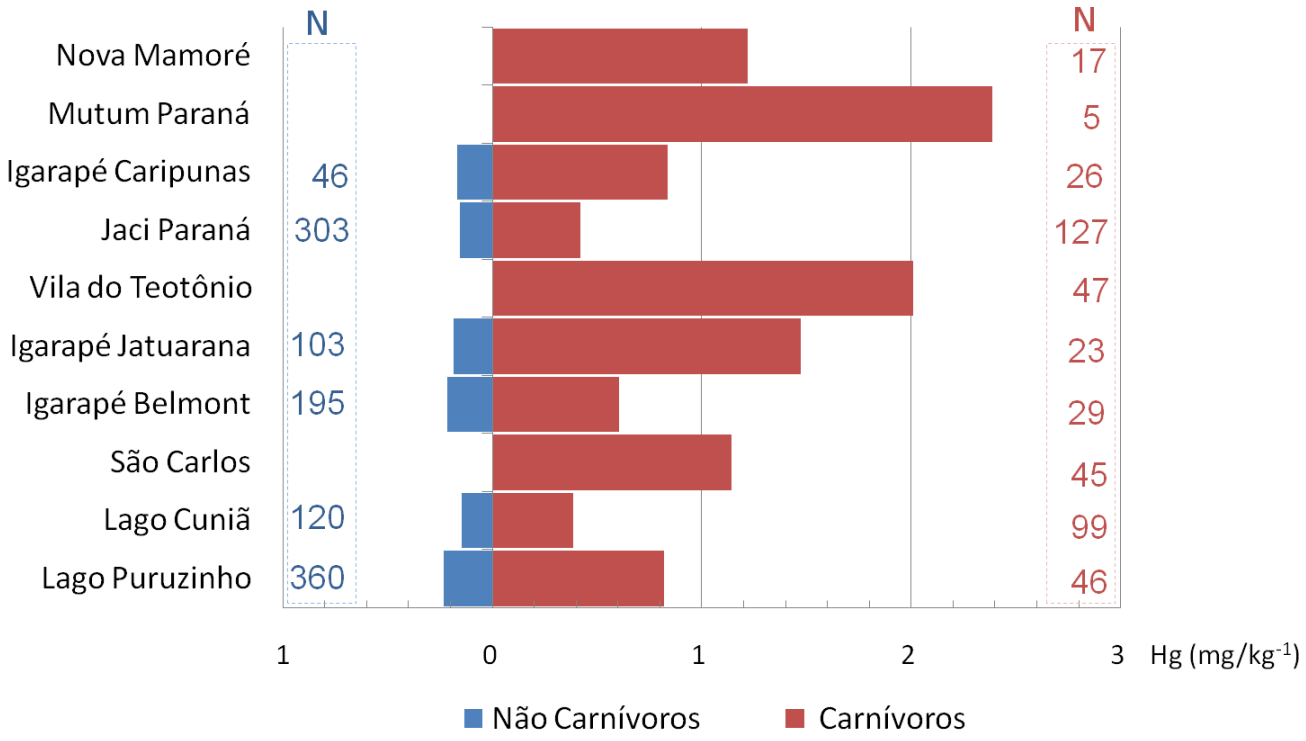
Fish type



Hg in fish

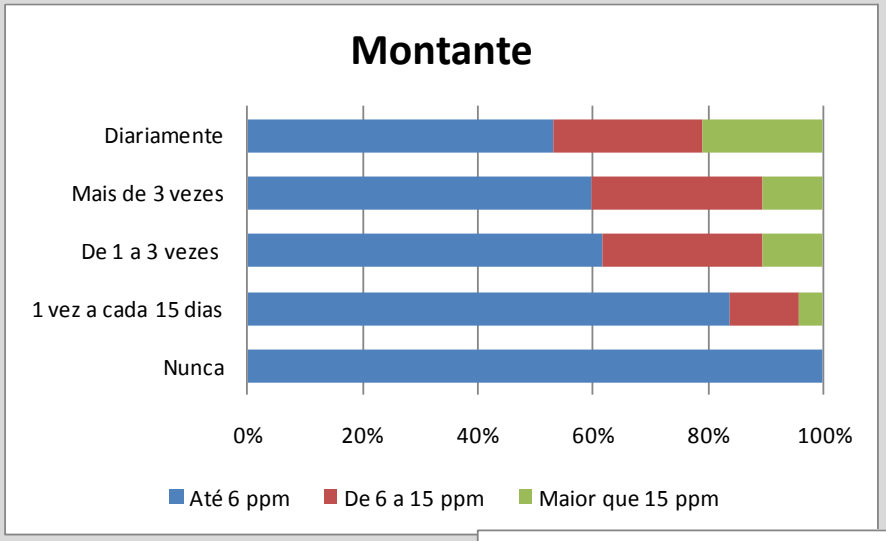
Fis is the main source of protein.

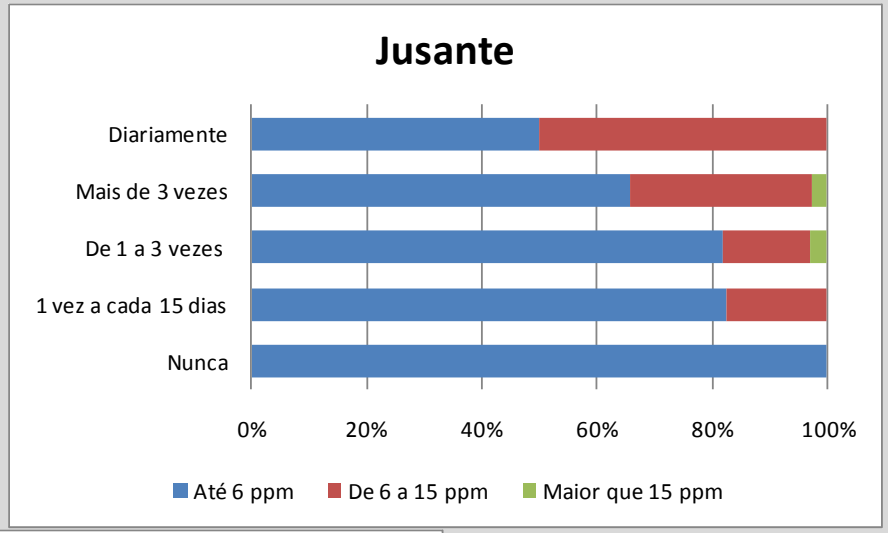
Mercury in fish in communites of the Madeira river.

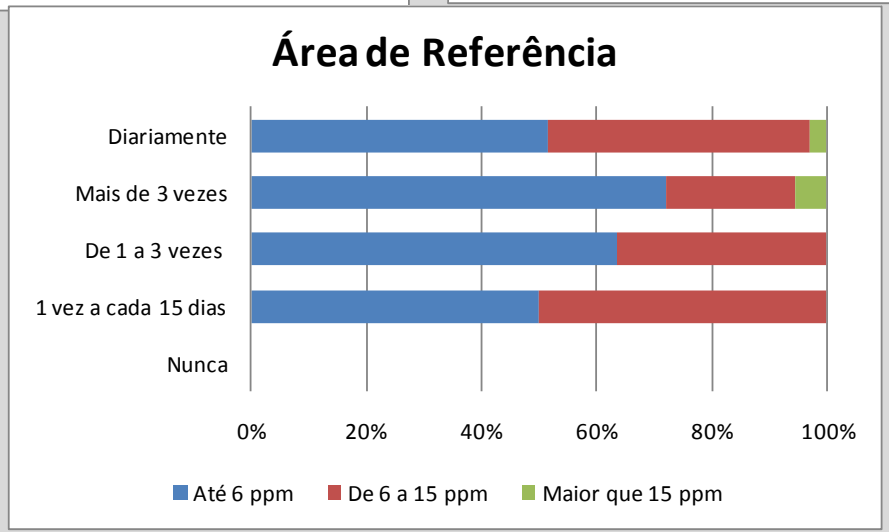


Analyses carried out in the lab of Biogeochemistry **Wolfgang C. Pfeiffer-UNIR**.....

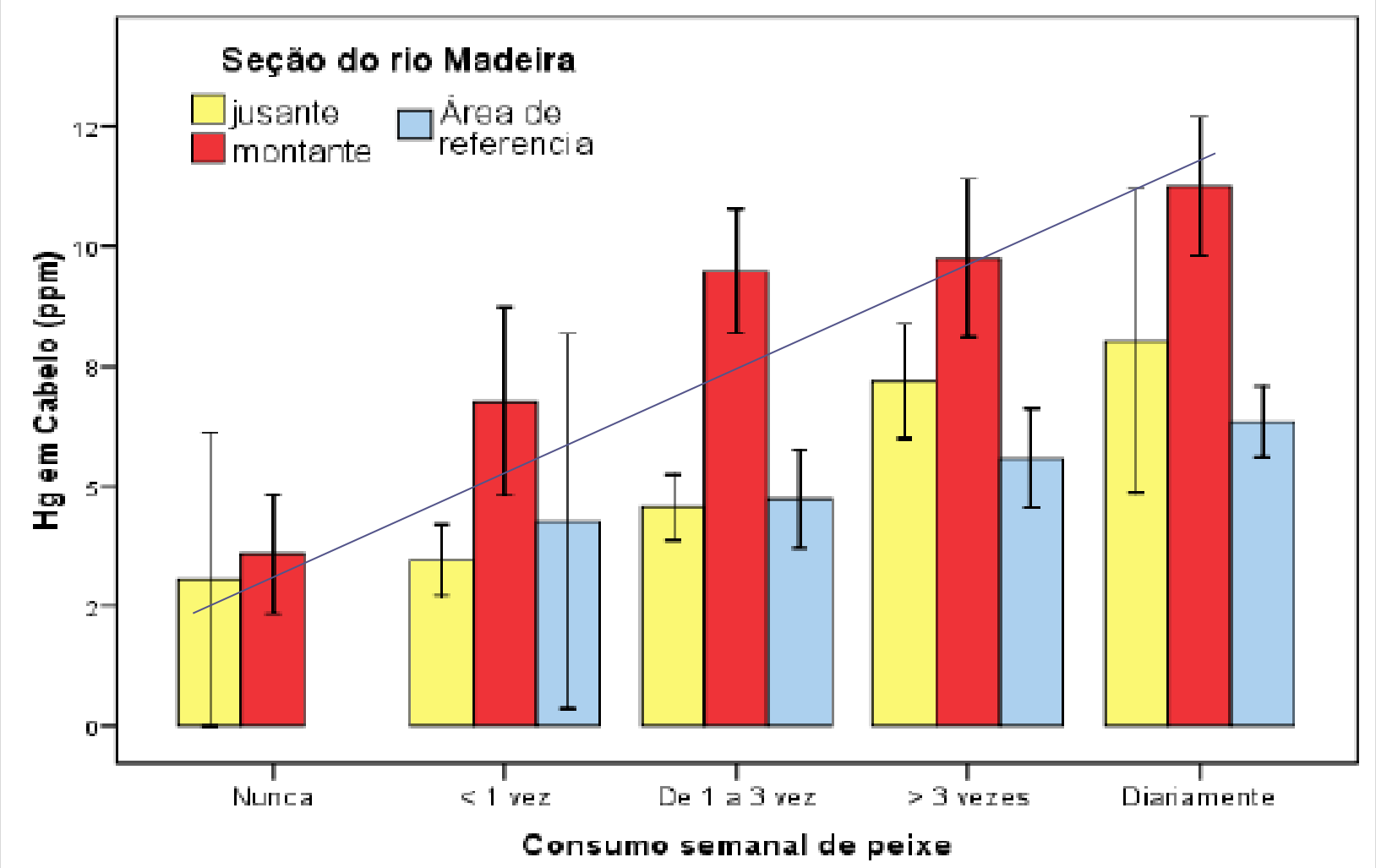
Frequency of fish consumption and Hg-levels in hair in women (Reproductive age)



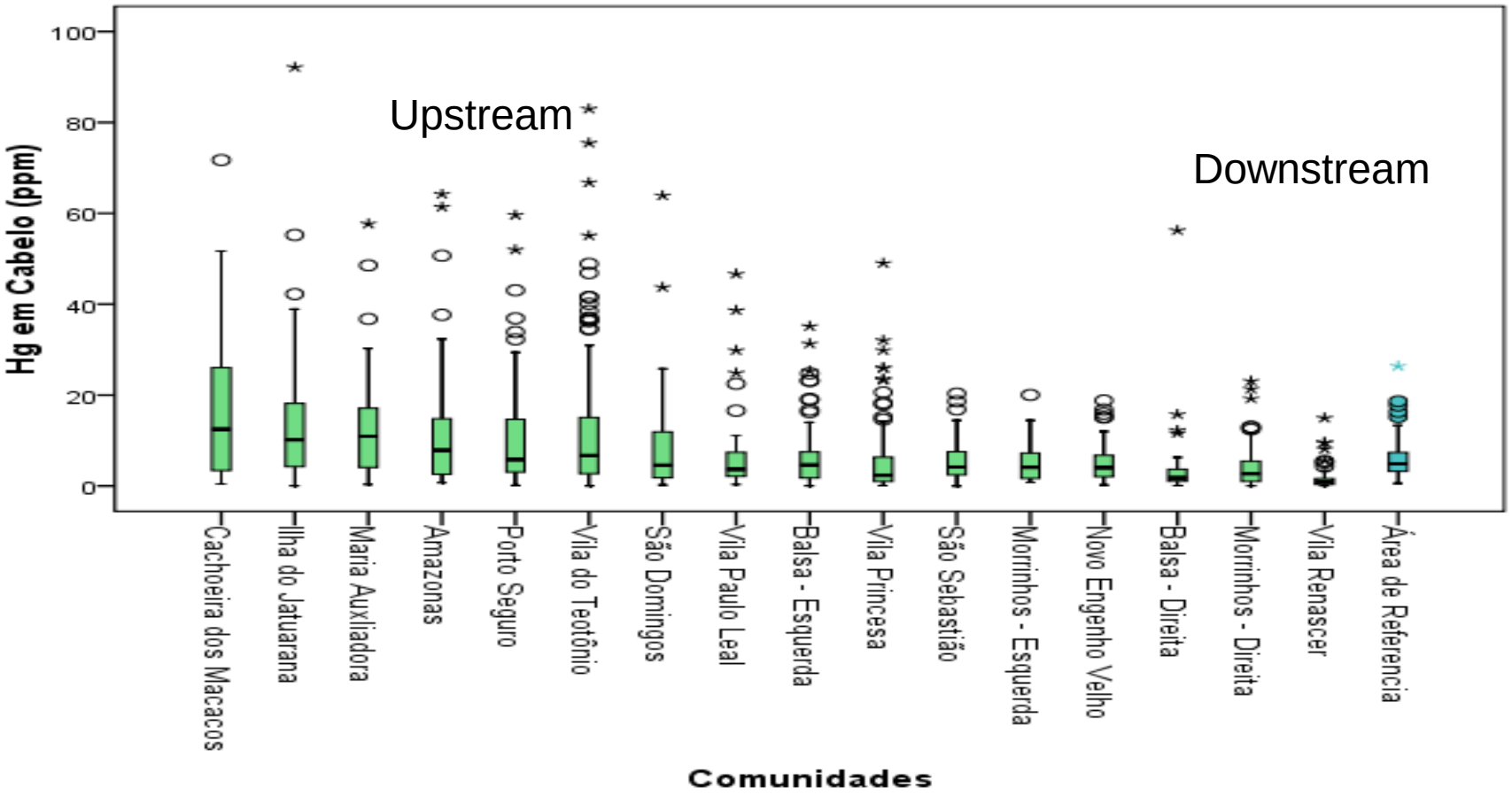




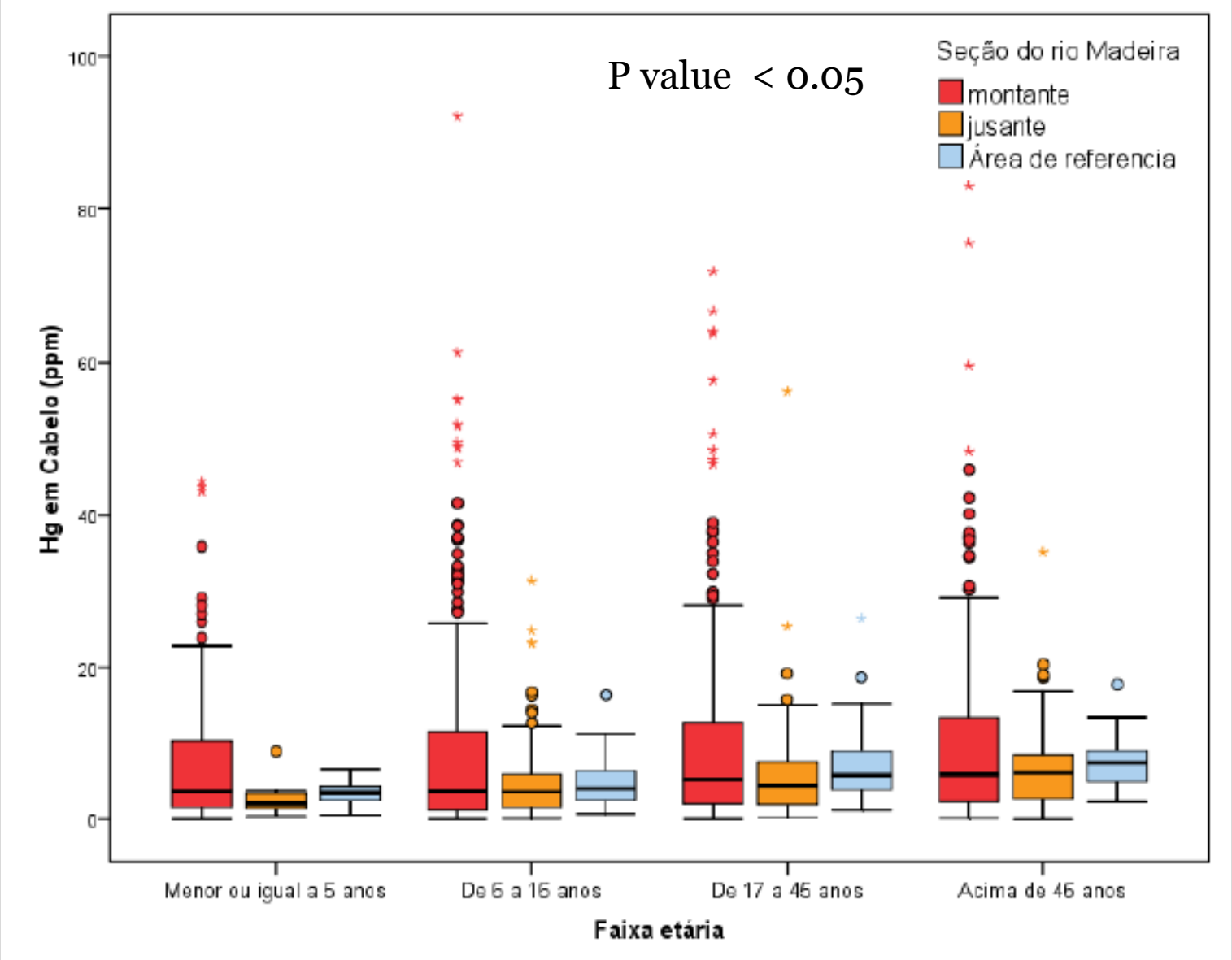
Mercury levels among the area by fish intake frequency



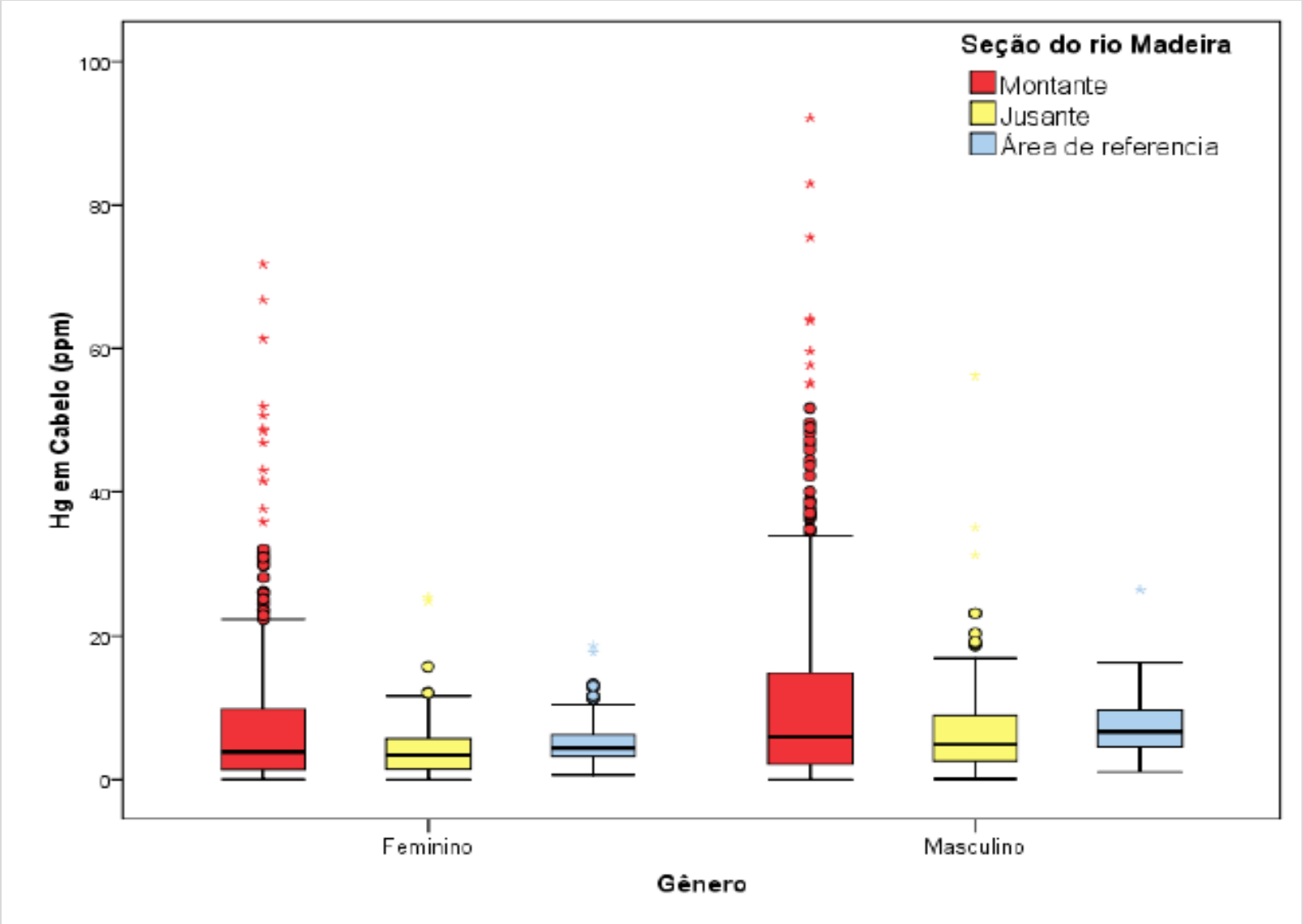
Mercury levels in hair



Mercury levels in hair among areas by age



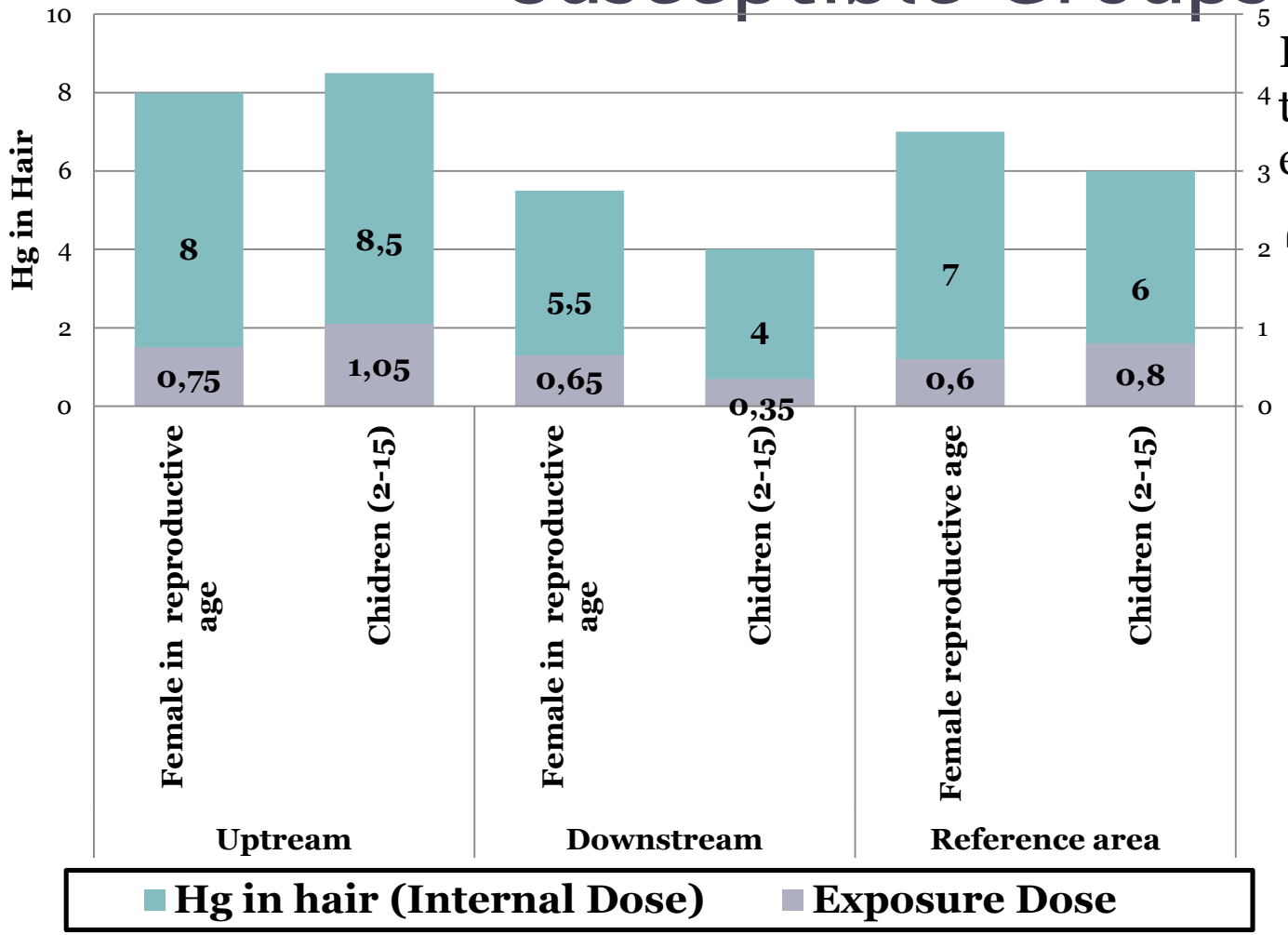
Hair mercury levels among the areas by Gender



Distribuition of Hg in hair (µg/g) by gender in different areas of Madeira river.

Madeira River	Gender	6 ppm	6 to 10 ppm	10 to 20 ppm	**Acima de 20 ppm**
Downstrean	Female	78,7%	14,7%	5,5%	1,0%
	Male	57,5%	21,5%	17,5%	3,5%
	Total	68,3%	18,0%	11,5%	2,2%
Uptream	Female	64,1%	11,3%	16,5%	8,0%
	Male	51%	11%	21,5%	17%
	Total	57,0%	11,9%	19,2	12,8%
Reference Area	Female	72,2%	19,5%	8,3%	0,0%
	Male	39,7%	42,6%	16,2%	1,5%
	Total	61,2%	27,4%	10,9%	0,5%

Exposure Dose and Internal dose in Susceptible Groups



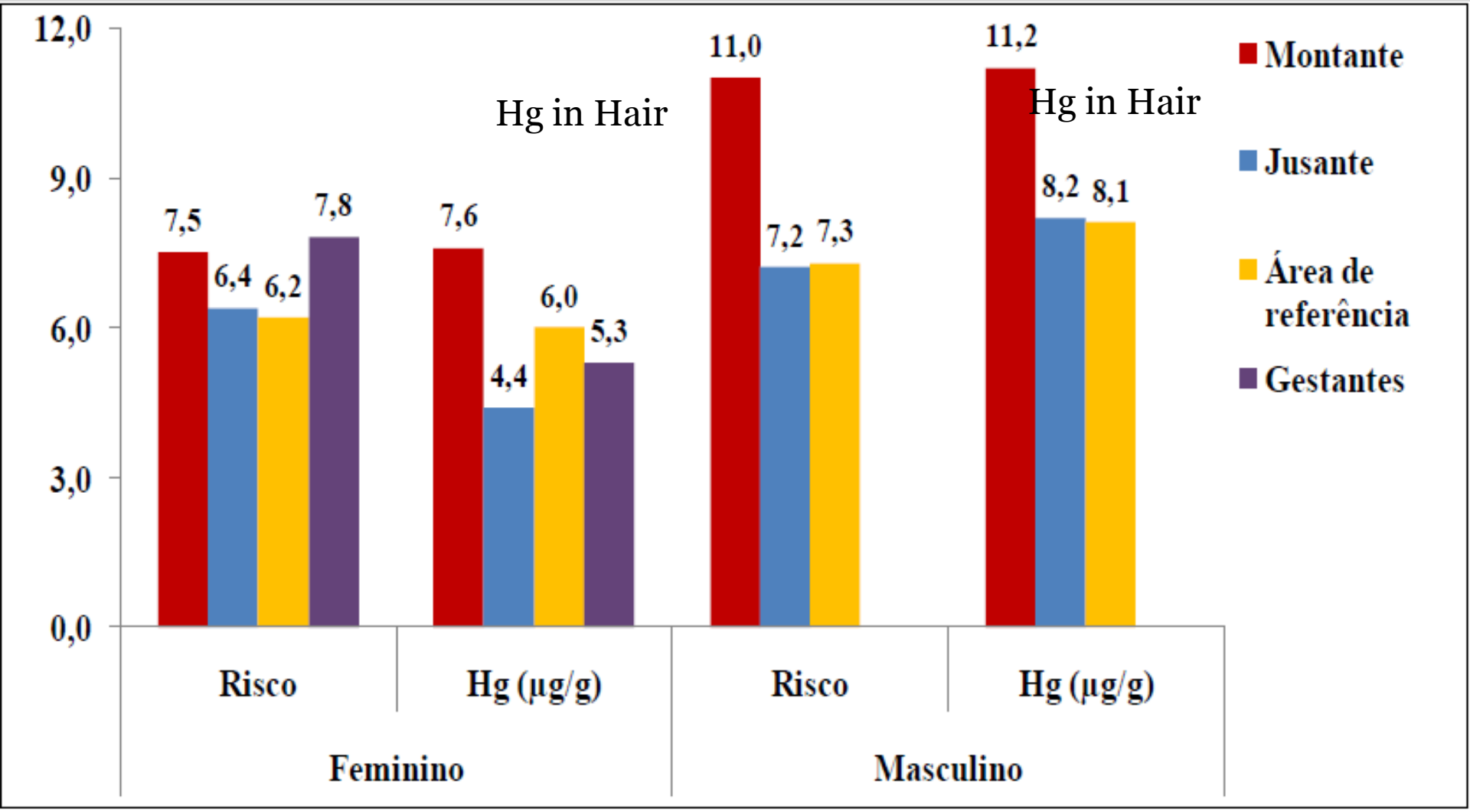
Hg in hair is about 10 times higher than exposure dose

(p- value of 0.005) between exposure Hg dose and Internal dose (Hg in hair). As expected increasing hair Hg levels is associated with increased piscivorous fish consumption for all groups.

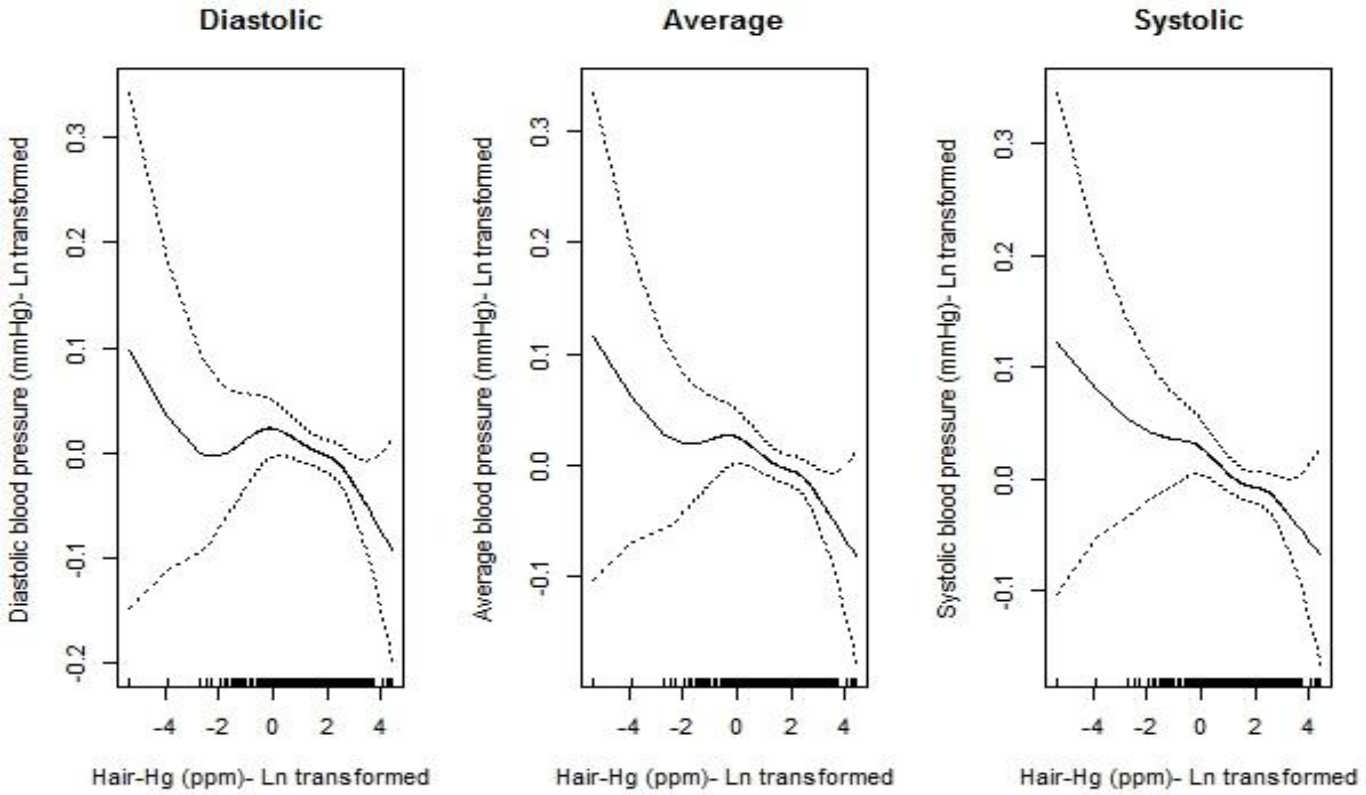
Exposure dose in Susceptible groups (Children and women)

Madeira river	Group age	N	Exposure Dose	P95	Hg in Hair (Internal Dose)	Hg_P95 %	Ratio
			Mean (mg/kg/d)	Mean (mg/kg/d)	(ppm)	(ppm)	Internal/Exposure Dose
Upstream	Female in reproductive age	288	0.75(0.14-4.1)	3.3(1.03-8.8)	8(0.02-176.8)	23.6	10.5
	Chidren (2-15)	430	1.04(0.18-7.7)	4.3(1.1-19.3)	8.5(0.02-92.1)	34.9	8.3
Downstream	Female in reproductive age	196	0.64(0.13-2.7)	2.1(0.64-4.6)	5.5(0.01-71.4)	16.9	8.4
	Chidren (2-15)	239	0.35(0.4-3)	3.2(0.72-8.7)	4(0.02-31.3)	11.4	10.9
Reference area	Female reproductive age	69	0.6(0.15-2.4)	1.8(0.7-4)	7(0.43-23.3)	13.3	11.5
	Children (2-15)	110	0.8(0.13-2.8)	1.5(0.23-10)	6(0.43-23.3)	12.4	7.5

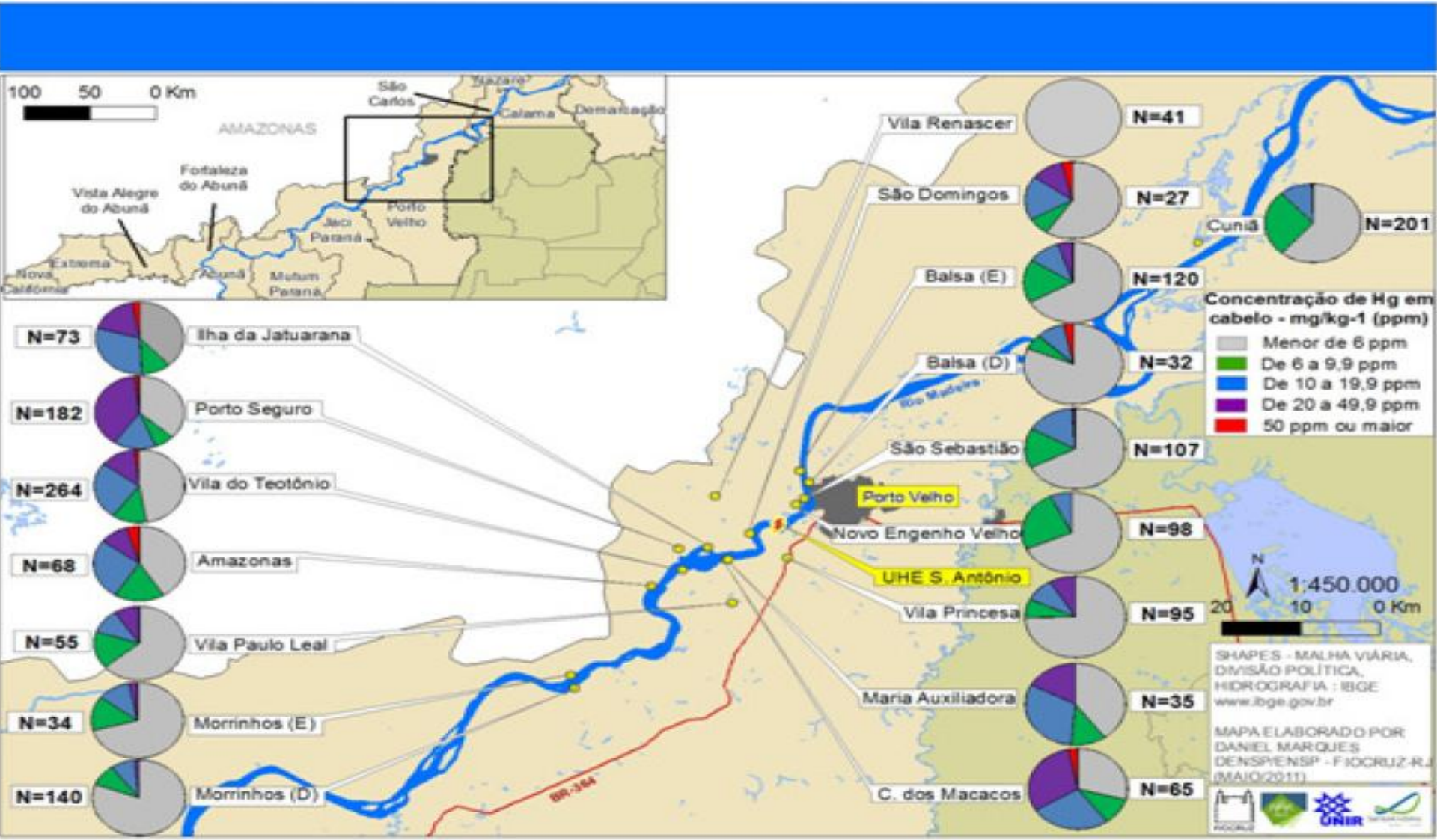
Estimated Risk among the areas by gender



Association between blood pressure and Hg-levels (ppm)



Mercury Exposure in the Riverine Population



CONCLUSIONS

- High Hg levels in piscivorous and carnivorous species have wide variability, and together constitute about 30% of the catch, whereas fish with much lower [Hg] (omnivorous and detritivorous) make up 53% of the catch,

- 40% of the riverine communities showed [Hg] in hair > than 6ppm. For communities with high fish consume, 10 ppm of Hg is an expected concentration in hair.

- These results show the current Hg exposure scenario of the reparian communities in Madeira river before flooding the resevoir and the HPP starts to supply energy.

CONCLUSIONS

- Madeira riverine population have a high fish consumption and fish also represent a income source for fishermen communities.
- Fish is a high nutritional item with health benefits and also the main way of Hg-exposure
- Human exposure to MeHg at Madeira region is a real challeng for Public Health because Hg exposure may increase after 5 to 8 years of the reservoir to be flooded
- At the Madeira river Brazilian nut consumption is associate with lower hair Hg. This could explain the equilibrium between high Hg levels and low hair Hg levels like Cuniã RESEX.
- Residents of Madeira river did not shown signs of MeHg poisoning as Minamata disease;
- Our preliminary results suggest that Se has is an important factor to excretion / absorption of MeHg.

RESEARCH GROUP

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SantoAntônio
ENERGIA

THANK YOU