Bioaccumulation and vertical transfer of pollutants in long-finned pilot whales stranded in Chilean Patagonia

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Introduction

- Pilot whales (*Globicephala* spp.) are the most reported cetacean species involved in mass mortalities worldwide. In the last two decades, hundreds of southern hemisphere long-finned pilot whales (LFPW – *G. melas*) have died along New Zealand, Tasmanian and Australian shorelines.
- In most cases, the cause behind mass stranding is not determined, but it might be linked to strong social structure, pollution or other anthropogenic threats.
- In northern Patagonia, 124 LFPW died in July 2016 due to unknown causes. It is possible that elevated POPs and TEs may have contributed to this mortality, but information regarding pollutant concentrations in cetaceans in Chile is scarce.
- Given a raising concern over marine mammals massive stranding, there is a need to identify the factors that may influence LFPW to suffer mass mortalities.

Objectives

- To analyse the concentrations of Trace Elements (THg, Se, Cd, and As) and POPs (PCBs, DDXs, HCH and HCB) on blubber from stranded LFPW.
- To analyze social structure of LFPW by *mit*DNA and microsatellite DNA
- To stablish feeding ecology in stranded LFPW by stable isotopes.
- Explore how POPs and TEs levels are related to body size, social structure and feeding ecology in stranded LFPW, and assessed the potential role of these contaminants in the mass stranding occurred in Southern Chile.

Methods

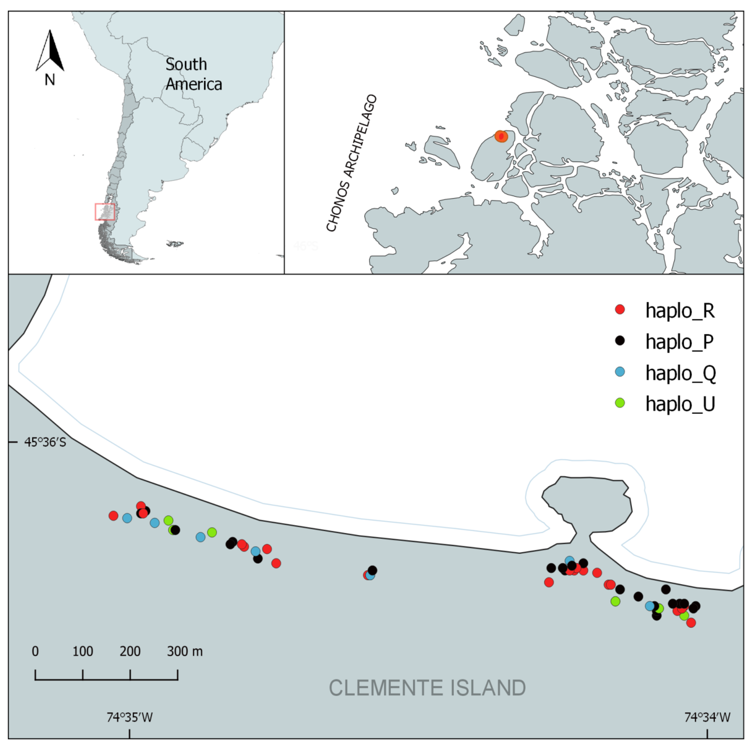


Figure 1. Location of long-finned pilot whale mass stranding in Aysen Region, Northern Patagonia (n = 74). Dots indicate individuals and colors indicate *mtDNA* haplotypes (haplo_R=red; haplo_P=black; haplo_Q=blue; haplo_U=green).

Table 1.- Objectives, activities and methods for the study

Mitocondrial DNA (*N = 74*) AQUATOX Chile Lab BIOGEMME France	*Control Region*	• Mother lineage - Genetic diversity		- Alingment: GENEIOUS - Haplotype & nucleotidic diversity: DNAsp - Haplotype network: NETWORK
Microsatelite *Loci* (*N = 74*) BIOGEMME Lab France	23 microsatelite *loci* previously described for cetaceans	- Populatin structure - Parenthood		- Observed heterozygosity: ARLEQUIN - HW equilibrium: ARLEQUIN - Parenthood: MLRelate - Population structure: STRUCTURE, DAPC pachake *adegenet* R studio
Stable Isotopes (*N = 32*) Radioisotopes Lab Brazil	$\delta^{13}C$ & $\delta^{15}N$	Foraging habitat and trophic level	Compare between age classes (Adults, juveniles, calfs) & linages	Software Rstudio SIBER package
POPs and Tes concentrations (*N = 32*) McMater University, Canada Radioisotopes Lab, Brazil RECETOX ,Czech Republic	**POPs** - 7 congeners **PCB**: *28, 52, 101, 118, 138, 153, 180* - 5 congeners **HCH**: *A, B, G, D, E* - **HCB** - 6 congeners op' & pp' **DDX**: *DDT, DDE, DDD* **Trace Elements** - **THg, Se, Cd, As.**		Assess pollutant levels and relationship between age classes, lingage and parenthood	- ANOVA in Rstudio, - Multivariate analysis PRIMER: PCA, cluster

Results & Discussion

Table 2.- Persistent organic pollutants (POPs) and trace elements (TEs) of blubber tissue of Chilean long-finned pilot whales (*Globicephala melas*) stranded in southern Chile. Average, standard deviation (±SD), maximum and minimum PCBs, DDXs, HCB, *β*-HCH, PCB and trace elements: THg = Total mercury, Se = Selenium, Cd = Cadmium and As = Arsenic. POPs are expressed in ng/g dry weight (dw), THg is expressed in mg/Kg (lw) and Se, Cd and As are expressed in mg/kg, dw. *One-way ANOVA statistically significant at *P*<0.05 among different age classes.

Age class	Σ PCBs (7 congeners)	HCB	β-HCH	Σ p,p' DDXs	Σ o,p' DDXs	THg	Se	Cd	As
	mean ±SD (min-max)	mean ±SD (min-max)	mean ±SD (min-max)	mean ±SD (min-max)	mean ±SD (min-max)	mean ±SD (min-max)	mean ±SD (min-max)	mean ±SD (max-min)	mean ±SD (max-min)
All individuals	53.60 ±22.61 (11.50 - 92.10)	32.79 ±12.95 (12.50 - 60.70)	0.44 ±0.17 (0.21 - 0.83)	214.74 ±96.61 (40.10 - 361)	229.87 ±102.85 (43.30 - 387)	8.05 ±5.68 (0.98 - 22.72)	5.20 ±2.19 (2.66 - 10.66)	1.00 ±0.82 (0.23 - 3.67)	0.93 ±0.34 (0.36 - 1.49)
Adults (n = 6)	76.37* ±11.52 (58.10 - 92.10)	31.01 ±8.73 (16.50 - 39.40)	0.49 ±0.16 (0.24 - 0.69)	322.50* ±25.33 (279 - 355)	342.83* ±27.32 (279 - 355)	8.64 ±5.55 (4.99 - 18.49)	6.25 ±1.34 (4.08 - 7.68)	1.35 ±0.82 (0.79 - 2.74)	0.96 ±0.30 (0.44 - 1.21)
Juveniles (n = 8)	51 ±25.90 (11.50 - 87.8)	31 ±16.46 (12.50 - 60.70)	0.47 ±0.22 (0.21 - 0.83)	197 ±105.3 (40.10 - 361)	211 ±112.76 (43.3 - 387)	6.2 ±5.11 (1.1 - 17.5)	4.9 ±2.46 (2.7 - 10.4)	0.7 ±0.24 (0.2 - 1.0)	1.0 ±0.33 (0.5 - 1.3)
Undetermined (n = 16)	46.80 ±19.40 (17.90 - 83.10)	34.26 ±12.93 (15.70 - 57.30)	0.42 ±0.16 (0.26 - 0.83)	184.99 ±83.67 (62.40 - 359)	198.99 ±89.72 (66.90 - 385)	8.91 ±6.29 (0.98 - 22.72)	5.15 ±2.32 (3.10 - 10.66)	1.11 ±0.84 (0.35 - 3.38)	0.88 ±0.39 (0.36 - 1.49)

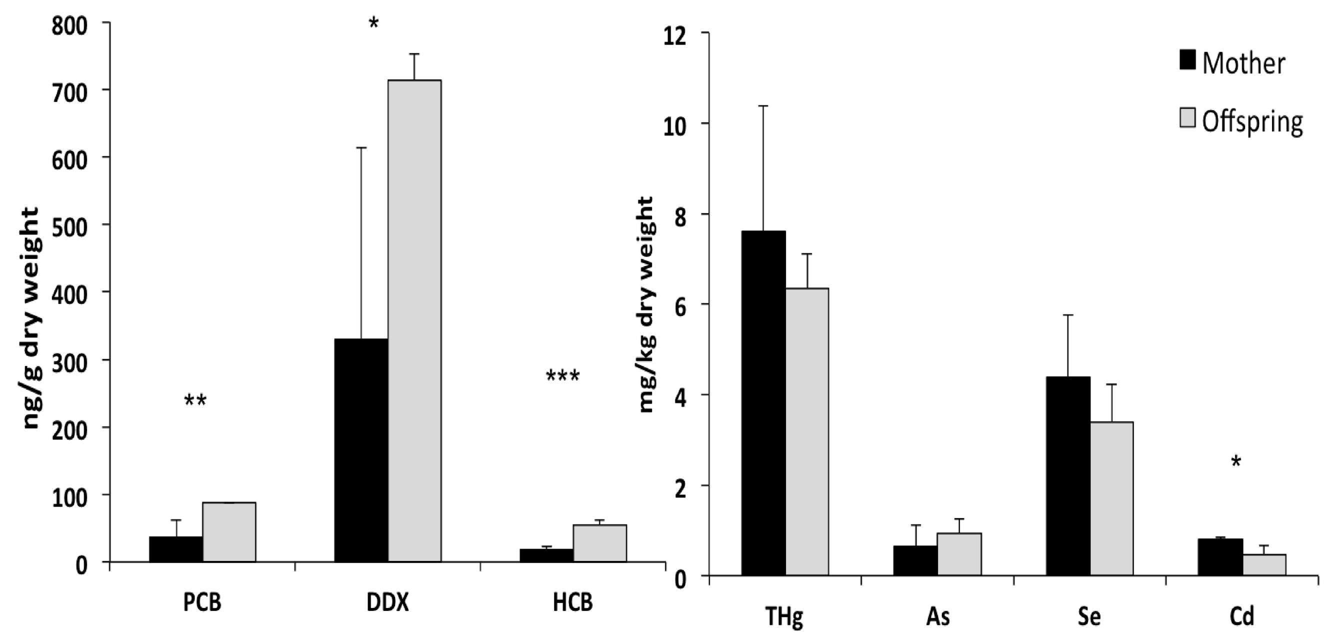
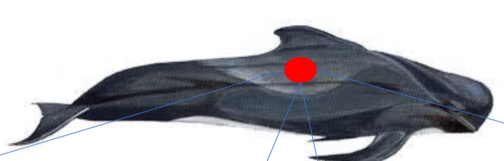


Figure 2. Comparative Persistent organic pollutants and trace elements bubbler concentrations related to Mother/Offspring relatedness analysis in Chilean stranded long-finned pilot whales. One-Way ANOVA showing significant differences at *P*< 0.05*; *P*<0.01**; *P*<0.005***.



ΣDDTs *(229.87 ng/g,dw)* **> *Σ7PCBs*** *(53.6 ng/g,dw)* **> *HCB*** *(32.79 ng/g,dw)* **> *HCH*** *(0.44 ng/g,dw)*

THg *(8.05 mg/Kg)* > ***Se*** *(5.2 mg/Kg)* > ***Cd*** *(1.0 mg/Kg)* > ***As*** *(0.93 mg/Kg)*

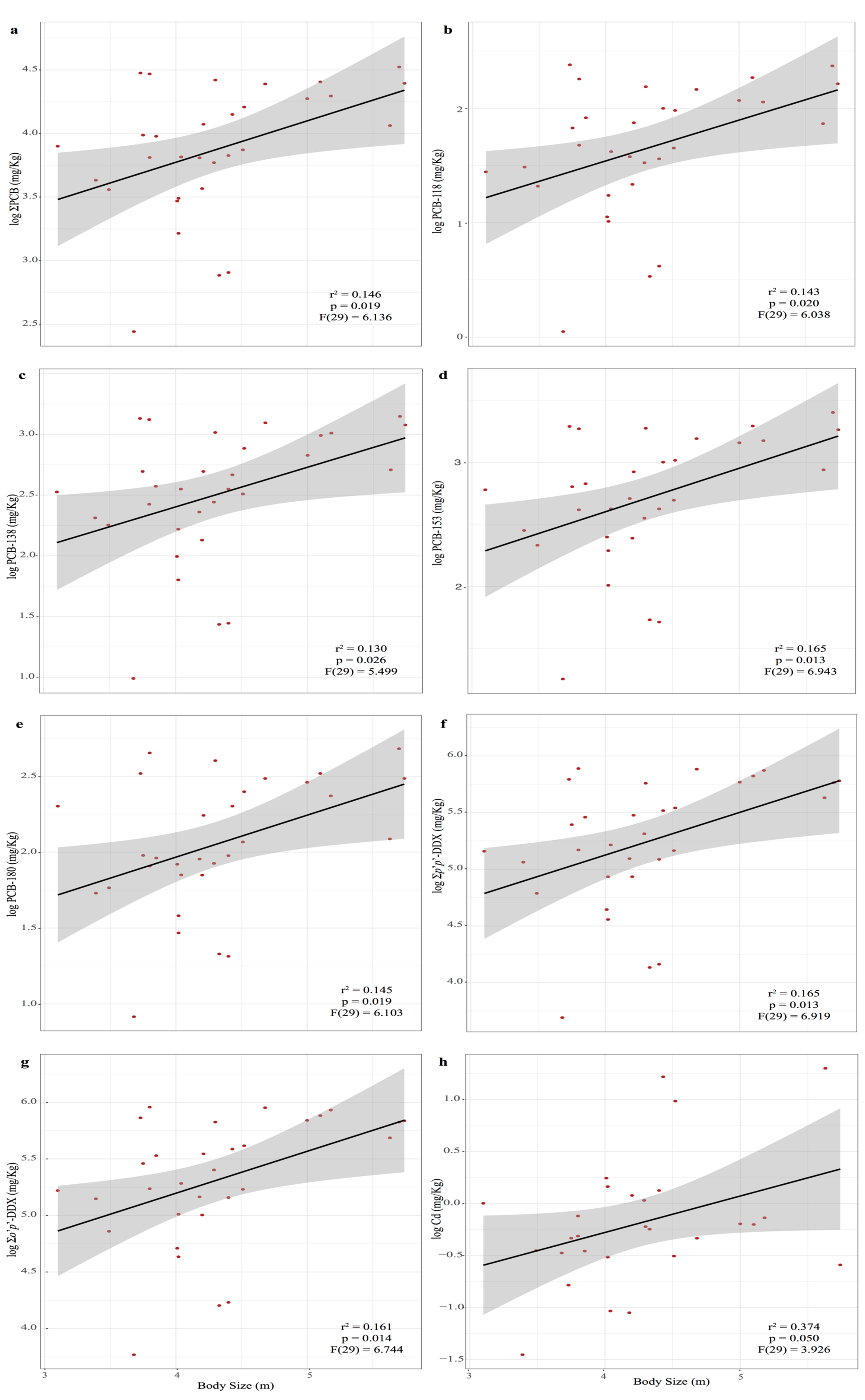


Figure 3. Linear regression analysis and Spearman rank-order correlation tests of the relationship between blubber tissue concentrations of organic persistent pollutants and cadmium with body size of stranded pilot whales in southern Chile; **a,** ΣPCBs **b,** PCB-118 **c,** PCB-138 **d,** PCB-153 **e,** PCB-180 congeners **f,** Σ*p,p'*-DDX **g,** Σ*o,p'*-DDX and **h,** Cd (*P*<0.05).

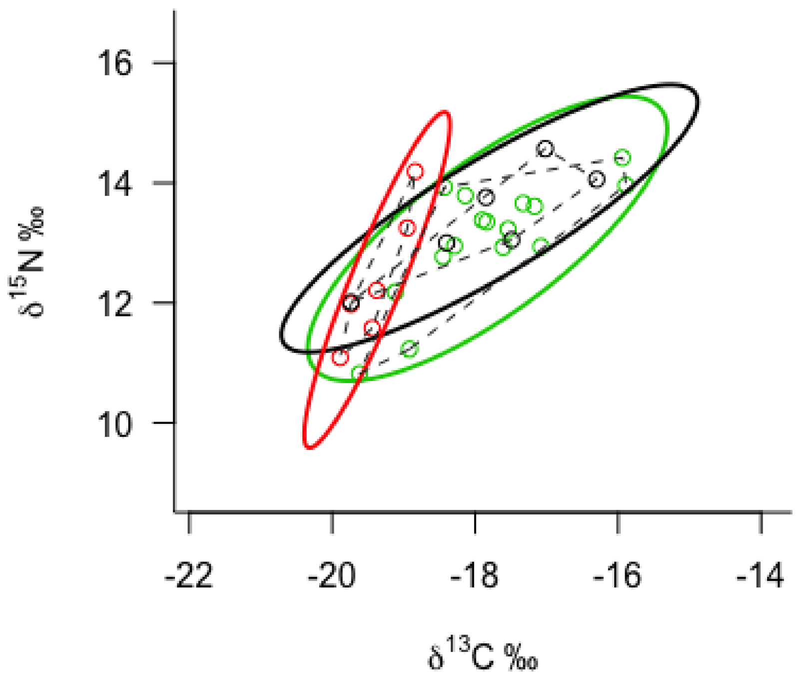


Figure 4. Values of stable isotopes $\delta^{15}N$ and $\delta^{13}C$ in stranded long-finned pilot whales by age classes. Standard ellipse area corrected (SEA_C) solid lines: red = juvenile, green = adults, black = not determined. Dotted line = convex hull area.

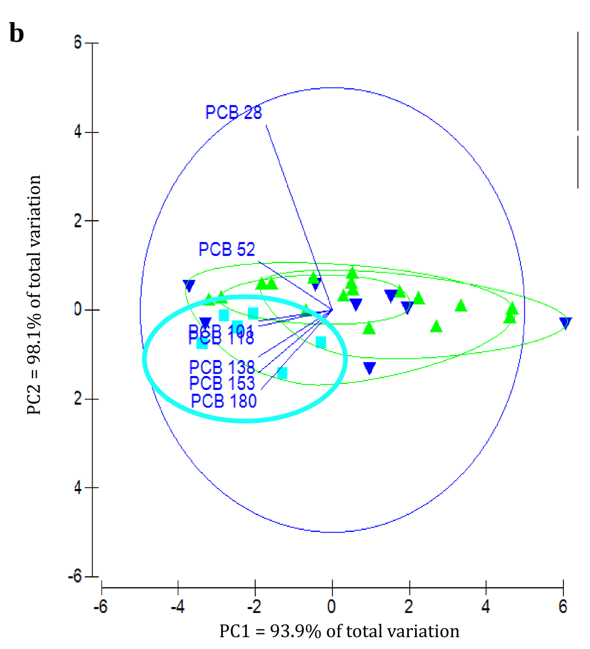


Figure 5. Principal components analysis of PCBs concentrations and age classes. Adulto* (*p<0.05*) Juveniles Non Determinated

Conclusions

- The POPs and TEs analyzed were found in the organism of LFPW, but their concentration was lower than the limit considered toxic for cetaceans, so that pollutants cannot be attributed as a cause of mass mortality in Chile (Table 2).
- The congeners of DDTs and PCBs and the Cd bioaccumulate in the organism of LFPW (Fig. 3).
- The juvenile LFPW feed at lower trophic level and their prey were of pelagic origin while adults feed at higher and general trophic level (Fig. 4).
- There were 4 matrilineal lineages in the mass stranding (Fig. 1) but the concentration of contaminants does not differ significantly between the lineages.
- There is a maternal transfer of POPs to the young LFPW, however the Cd is acquired with the diet and life history (Fig. 2)

Acknowledgements

CONICYT/Fondecyt regular 1161504