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POPs in the South Latin America: Bioaccumulation of DDT, PCB, HCB, HCH and Mirex in blubber of common dolphin (*Delphinus delphis*) and Fraser's dolphin (*Lagenodelphis hosei*) from Argentina

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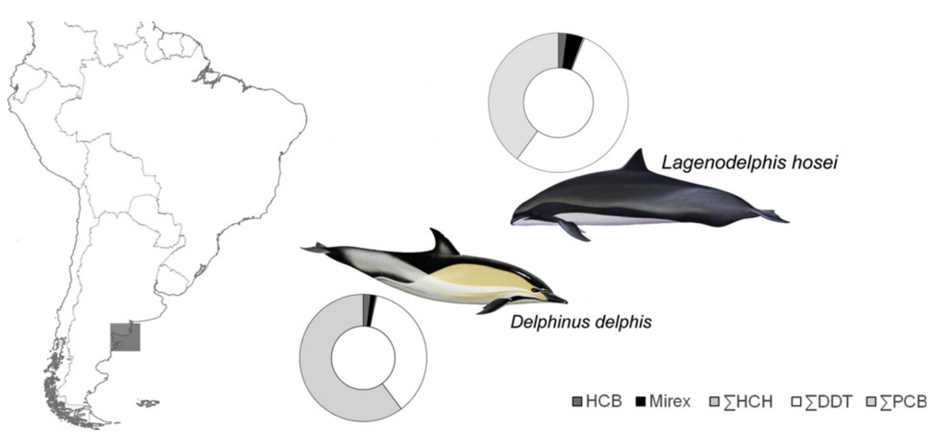
HIGHLIGHTS

- Organochlorine were found in *Delphinus delphis* and *Lagenodelphis hosei*.
- PCBs and DDTs were the predominant POPs in *D. delphis* and *L. hosei*, respectively.
- DDTs were the predominant pesticides in both species and HCHs were the minority.
- *D. delphis* didn't show relation between POPs concentration and biological parameters.

GRAPHICAL ABSTRACT



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ABSTRACT

Organic compounds, in particular organochlorines, are highly persistent compounds which accumulate in biotic and abiotic substrates. Marine mammals bioaccumulate and biomagnify persistent organic pollutants (POPs) through diet. ∑PCB (26 PCB congeners), ∑DDT (pp-DDT, pp-DDD, pp-DDE), ∑HCH (α-HCH, β-HCH, γ-HCH, δ-HCH), HCB and mirex were analyzed from samples of subcutaneous adipose tissue of common dolphins, *Delphinus delphis*, and Fraser's dolphins, *Lagenodelphis hosei*, obtained in 1999 and 2012. The aim of this study was to determine the concentrations of POPs to get baseline information on the current state of pollution by these compounds in these two species in South Atlantic. At the same time, to assess concentrations of POPs in relation to age, the total length and sexual maturity in *common dolphins*. Organochlorine pesticides dominated Fraser's dolphins, DDT being the most abundant, while PCBs were mostly present in common dolphins. In both species, the distributions of isomers or metabolites followed the order: β-HCH>δ-HCH>γ-HCH>α-HCH and pp-DDE>pp-DDD>pp-DDT. As for ∑PCB, the largest contribution was given by congeners of high molecular weight,

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Cetaceans
South America

particularly by hexa and hepta - CBs. Common dolphins did not show effects on sexual maturity, age and standard length in the concentration of organochlorines. The mean concentrations found in this study are lower compared to those reported in other studies performed in dolphins elsewhere. This study provides new information regarding levels of organochlorines in common dolphins for the Southwestern Atlantic.

1. Introduction

In the last decades, marine pollution became a growing problem affecting species and populations of marine mammals (Borrell et al., 2010). Conservation of cetaceans and other wildlife species is an ongoing process that cannot be considered complete. The best-known threats to cetacean populations include bycatch in fishing gear and exposure to toxic chemicals, which appear to be intensifying. There are areas where cetaceans have been heavily affected due to fishing and effects of toxic pollutants (Reeves et al., 2003).

Among the wide variety of contaminants the most important for their effects on organisms are the persistent organic pollutants (POPs). These compounds are not easily degraded by chemical oxidation or bacterial action, and remain long periods in the marine environment (Clark, 2001). POPs are semi-volatile compounds, therefore they suffer the "global transport of pollutants", being able to travel long distances and accumulate in remote ecosystems including polar regions (Bidleman et al., 1989; Commendatore et al., 2015; Hargrave et al., 1988; Muir et al., 1988; Norstrom et al., 1990; Patton et al., 1989; Wania, 2003). In addition, differences in POPs volatility makes them migrate in the global atmosphere at different speeds (Wania and MacKay, 1996). Water circulation and migratory species also contribute to global transport of these pollutants (Harrad, 2009).

High concentrations of POPs have been associated with neurotoxic and carcinogenic effects, immunosuppression and endocrine disruption, affecting reproductive success and in many cases causing death (Aguilar and Borrell, 1994a; Costa and Giordano, 2007; Helle et al., 1976; Jepson et al., 2005; Reddy et al., 2001; Van Loveren et al., 2000). Concern about these effects triggered an international agreement between countries, which currently includes 26 persistent organic pollutants in the list of the Stockholm Convention at its fifth meeting in Geneva (UNEP/POPS/COP.5/36, 2011), regulating the use, production, import and export of pollutants, except in some countries under certain restrictions.

Given its lipophilic nature, POPs accumulate mainly in organism's fatty tissues. Cetaceans present large lipid reserves in proportion to their body size. They are at the top of the food chain and accumulate contaminants through diet, making evident bioaccumulation and biomagnification processes (Clark, 2001). Therefore, they could be considered good bio-indicators of ecosystem pollution (Cáceres-Saez et al., 2013).

Borrell and Aguilar (1999) identified the need for study contaminants in marine mammals along the coast of South America, to ensure a better management of local populations. Thus, in the last ten years the number of studies has increased, especially on the Brazilian coast. In other areas of the South Atlantic this information is scarce (Dorneles et al., 2010; Dorneles et al., 2013; Lailson-Brito et al., 2012). Particularly in Argentina, general pollution studies have not been profoundly developed being reported a few studies of contaminants in marine mammals, particularly in South American sea lions (*Otaria flavescens*) and southern right whales (*Eubalaena australis*) (Borrell et al., 2010; Fossi et al., 1997a; Marcovecchio et al., 1994; Peña et al., 1988; Rosas et al., 2012; Torres et al., 2015). For this reason, in the present study, we chose two species of small cetaceans: common dolphin (*Delphinus delphis*) and Fraser's dolphin (*Lagenodelphis hosei*), both with oceans habits and different distributions, in orden to know their status with regard to pollution by POPs.

The common dolphin is a cosmopolitan species and their distribution reaches 50° S in the southern hemisphere (Jefferson et al., 1993). This species has mainly oceanic habits, although it can be observed in neritic environments (Pusineri et al., 2007). Particularly in northern Patagonia, the main prey items are the argentine anchovy, *Engraulis anchovy*, and South American long-finned squid, *Loligo sanpaulensis* (Romero et al., 2012).

Fraser's dolphin is another species of oceanic habits, with a diet based mainly on mesopelagic fish, crustaceans and cephalopods, with hatchetfish *Polyipnus stereope* as the main prey species (Wang et al., 2012). The Fraser's dolphin is a tropical species with distribution between 30° N and 30° S (Jefferson et al., 1993). The International Union for Conservation of Nature (IUCN) catalogues these two species as "Least Concern" (Hammond et al., 2008; Hammond et al., 2012).

Therefore, the aim of this study was to determine the concentrations of POPs in common dolphin and Fraser's dolphin to get baseline information on the current state of pollution by these compounds in these two species in South Atlantic. In addition, the concentrations of POPs in relation to age, the total length and sexual maturity in common dolphin was studied.

2. Materials and methods

Twelve common dolphin's and three Fraser's dolphin's samples were collected from individuals found dead on the coast or in fishing nets between 40° 30′ and 43° 30′ S, region that includes the northern Patagonian Gulfs (Fig. 1). However, Fraser's dolphins in this study beached at Golfo Nuevo, Peninsula Valdes, very far of the normal distribution of the species (Perrin et al., 2002), fact that was associated to oceanographic anomalies such as El Niño (Mignucci-Giannoni et al., 1999). Researchers from Laboratorio de Mamíferos Marinos (LAMAMA) at the Centro Nacional Patagónico (CENPAT) performed sampling since 1999 to present. Subcutaneous adipose tissue was taken and preserved in glass jars at −20 °C until analysis. During necropsies, date and georeferencing collection was recorded, as well as sex and total length of individuals, according to the method proposed by Norris (1961). Tooth samples were collected for age determination, according to the methodology of Crespo et al. (1994). Sexual maturity (MS) was estimated according to the information available in literature, differentiating between adults (A) and juveniles (J).

2.1. Analytical procedure

Chemical analyses were conducted at the Universidade do Estado do Río do Janeiro, RJ, Brazil, based on an adaptation of method suggested by Lailson-Brito et al. (2010). The extraction was performed using Soxhlet continued extraction for 8 h with 100 mL of hexane: dichloromethane (1: 1). Previously, the sample was homogenized with Na_2SO_4 (1: 6) and internal standards solutions were added (PCB 103 and PCB 198). Once this process was complete and after the determination of lipid by gravimetry from a 2 mL aliquot, the extract was reduced with pressure and nitrogen gas then. The extract was treated with H_2SO_4. After centrifugation and phase separation, an internal standard, 2,4,5,6-tetrachloro-meta-Xylene (TCMX) was added.

The analyses were performed on an Agilent Technologies 7890 chromatograph with a 63Ni electron capture detector (GC-ECD) and an automatic injector (Agilent Technologies 7683B). Santos-Neto et al.

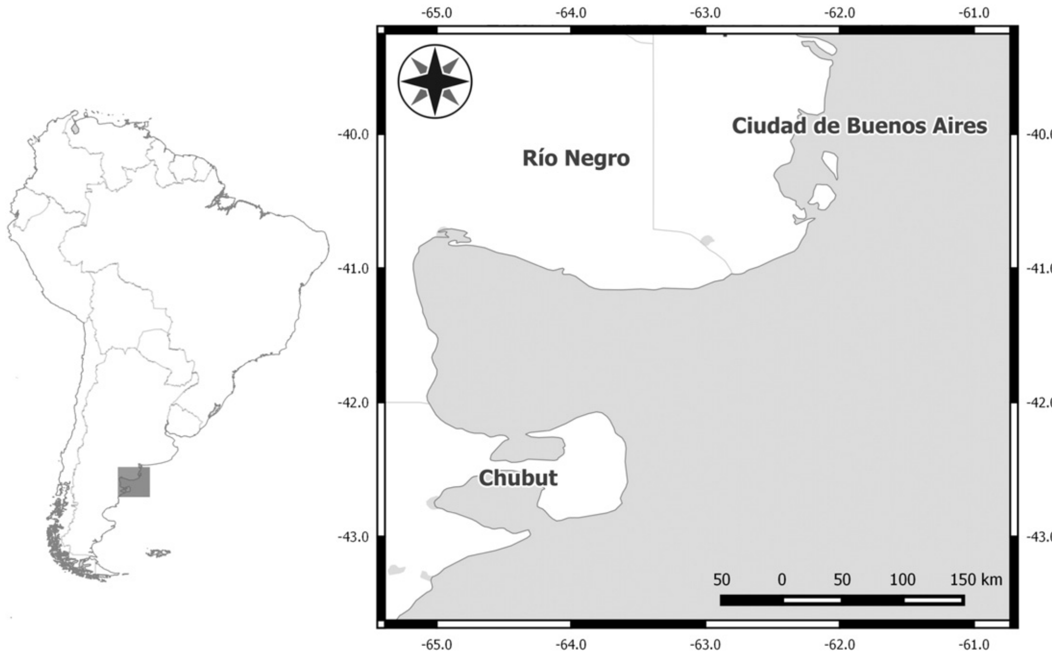

Fig. 1. Study area showing region the northern Patagonian where were sampled.

(2014) explain in detail the programming of the analyses. Hydrogen (99.999% pure) was used as the carrier gas at 13 psi, nitrogen was used as an auxiliary gas (make up) and a fused silica DB-5 capillary column (Agilent Technologies, 30 m × 0.25 i.d. mm and film thickness 1 μm) was used for the analyses. The acquisition, integration, and calculation of the data were performed with the Ezchrom 3.2.1 Software System.

In the present study contaminants organochlorines (OCs) were analyzed: 26 PCB congeners (8, 28, 44, 52, 101, 105, 118, 132, 138, 141, 151, 153, 156, 158, 170, 174, 177, 180, 183, 187, 194, 195 , 199, 203, 206 and 209), 3 DDT metabolites (p,p′-DDT, p,p′-DDE and p,p′-DDD), 4 HCH isomers (α-HCH, β-HCH, γ- HCH and δ-HCH), HCB and mirex.

2.2. Quality control and quality assurance (QA/QC)

In order to validate the methodology applied for the determination of organochlorines in adipose tissue of dolphins, was used a certified standard (SRM 1945, from the National Institute of Standards and Technology – NIST). The validation criteria were based on Wade and Cantillo (1994), accepting concentrations between 65 and 135%. In this study, the recoveries of internal standards solutions (PCB 103 and PCB 198) ranged from 82 to 113%. The equipment detection limits ranged between 0.15 and 1.68 $ng\cdot L^{-1}$ for PCBs and between 0.05 and 0.52 $ng\cdot L^{-1}$ for the rest of the compounds. Of the total compounds analyzed 18 were found in blanks, whose concentrations ranged between 2.09 and 11.69 $ng\cdot L^{-1}$.

2.3. Statistical analyses

All analyses were performed using the R Software (R Core Team, 2014). Nonparametric tests were performed due to violation of the assumptions of homocedasticity and normality. Mann-Whitney *U* test was used to assess the existence of sexual maturity effects on the concentration of organochlorines. For assessing the existence of a relationship between the concentration of organochlorines with age and the length of the individual, the Spearman Correlation Ranges test was used for each variable.

3. Results and discussion

Total concentrations of organochlorine groups analyzed for each species measured as $\mu g\cdot g^{-1}$ lipid weight basis, characterization of samples and lipid content are shown in Table 1. All samples tested shown levels of HCB, Mirex and at least one congener or degradation product of $\sum$PCB, $\sum$DDT, $\sum$HCH. Of the total concentration of organochlorines, organochlorine pesticides (POCs) were mostly found in Fraser's dolphins (60.08%). On the other hand, PCBs with more than 60% were mainly found in common dolphins. These differences between species were not tested by statistical test due to the small sample size for Fraser's dolphin. In both species, the group of DDTs represented the largest percentage of pesticides, while the group of HCHs represented the lowest. The contribution of Mirex and HCB varied among species (Figs. 2 and 3).

Few studies have been done in Argentine Sea waters concerning persistent organic pollutants. Particularly in Peninsula Valdes and surroundings, analysis of organochlorines were performed only in South American sea lions (Borrell et al., 2010; Fossi et al., 1997a; Fossi et al., 1997b) and southern right whales (Torres et al., 2015). In both species, organochlorine concentrations detected were several orders of magnitude below the values reported in other studies such as lethal or sublethal with adverse effects on marine mammals (Aguilar and Borrell, 1994a; Béland et al., 1993; Costa and Giordano, 2007; Helle et al., 1976; Jepson et al., 2005; Kannan et al., 2000; Reddy et al., 2001; Van Loveren et al., 2000). This paper reports the first average concentrations of common dolphin in the area, and compared to those reported in Argentina by Borrell et al. (2010) in South American sea lions (ΣDDT: 0.686 $\mu g\cdot g^{-1}$; ΣPCB: 0.735 $\mu g\cdot g^{-1}$) are one order of magnitude higher. Although in the northern hemisphere organochlorine levels declined in the 1970s and stabilized in the 1980s due to the prohibition of use in industrialized countries (Weber and Goerke, 2003), export to developing countries continued at least until 1999 (Kim and Smith, 2001) so it is possible to make a comparison with recent studies in time. Lailson-Brito et al. (2012) and Santos-Neto et al. (2014) made a compilation of average organochlorine's concentrations in different species of dolphins in the last two decades (Table 2). On one hand, comparing the results with those of the same species, the levels found in this study of HCB in Fraser's dolphin are the highest, even one order of magnitude higher compared to those found in the Philippines. On the other hand,

Table 1
Total organochlorine compounds (HCB, Mirex, ΣHCH, ΣDDT and ΣPCB) for specie. Mean ± standard deviation (mean ± SD), median and minimum and maximum (min-max) values are presented. Information sex, standard length (SL), age, sexual maturity (MS), collected date (date) and lipid content (%) of the subcutaneous adipose tissue are shown. Organochlorine concentrations were expressed as $\mu g \cdot g^{-1}$lip.

Code	Sex	SL (cm)	Age (years)	SM	Date	HCB	Mirex	∑HCH	∑DDT	∑PCB	Lipid content (%)
Delphinus delphis											
Dd 003	M	210	18	A	1999	0.208	0.119	0.014	4.034	6.388	71.3
Dd 004	M	212	9	A	1999	0.165	0.109	0.086	2.347	5.763	23.4
Dd 006	M	209	9	A	1999	0.178	0.168	0.017	9.502	7.484	81.5
Dd 007	M	200	9	A	1999	0.172	0.119	0.021	2.581	5.545	72.8
Dd 009	M	192.5	10	A	1999	0.239	0.134	0.015	2.866	5.960	68.1
Dd 010	M	197	10	A	1999	0.225	0.083	0.041	1.863	4.563	61.4
Dd 012	M	192	4	J	1999	0.165	0.086	0.019	1.565	3.866	75.7
Dd 014	M	206	10	A	1999	0.159	0.177	0.019	5.795	6.616	70.7
Dd 016	M	196	6	J	1999	0.173	0.094	0.014	2.078	4.732	63.5
Dd 018	M	187	7	J	1999	0.345	0.152	0.036	3.141	7.541	43.1
Dd 019	M	170	2	J	1999	<DL	0.091	0.038	3.194	6.580	80.1
Dd 020	M	219.5	11	A	1999	0.184	0.130	0.034	3.949	5.956	76.1
Mean ± SD						0.184 ± 0.078	0.121 ± 0.031	0.029 ± 0.020	3.576 ± 2.194	5.916 ± 1.122	
Median						0.175	0.118	0.019	3.003	5.958	
Min-max						<DL–0.344	0.083–0.177	0.013–0.085	1.564–9.502	3.866–7.541	
Lagenodelphis hosei											
Lh 002	M	237.5	10	A	1999	0.345	0.699	0.057	10.218	6.216	32.4
Lh 003	M	242.5	9	A	2012	0.119	0.186	0.025	2.389	2.857	55.9
Lh 005	M	250	9	A	2012	0.064	0.179	0.017	2.336	1.977	45.2
Mean ± SD						0.175 ± 0.148	0.354 ± 0.298	0.032 ± 0.020	4.981 ± 4.535	3.683 ± 2.237	
Median						0.118	0.185	0.024	2.388	2.856	
Min-max						0.064–0.344	0.179–0.699	0.017–0.056	2.336–10.218	1.977–6.216	

DL = detection limit; M = male; A = adult; J = juvenile.

both species showed lower concentrations of organochlorines compared to those found in other species of dolphins around the world. The only exception are the values of mirex that were the second highest after the reported by Alonso et al. (2010). Aguilar et al. (2002) carried out a geographical and temporal analysis of the variation in levels of organochlorines in marine mammals worldwide, which are in agreement with the results found in present paper. According to these authors in the southern hemisphere concentrations of these pollutants are generally the lowest. Therefore, there is a decrease in the concentrations of DDTs, PCBs and mirex while HCB and HCH increase as we approach the polar regions. In fact, these authors suggest that in the future the Antarctic and Arctic will be the main sinks of organochlorine of the world as a result of global atmospheric transport.

For HCHs and DDTs, the distribution percentage of each metabolite or isomer was in two species of dolphins as follows: β-HCH>δ-HCH>γ-HCH>α-HCH (Fig. 4) and p,p′-DDE>p,p′-DDD>p,p′-DDT (Fig. 5). There are different indices that relate isomers, metabolites or groups of pollutants each other. These allow infer if contributions to the environment were recent or past, or what human activities were causing a greater impact. According to Kim et al. (2002) the value of the relationship between α and γ isomers in commercial HCH goes from 4 to 7 and can be used as an indicator of the degree of degradation of commercial αHCH. Ratios below 4 indicate an α-HCH degradation in its isomers. In this paper, the index in both species varied between 0 and 0.53, showing a high rate of degradation of the α isomer and a past contribution of HCH commercial into the environment, being the major degradation product β-HCH. The ΣDDT/ΣPCB relationship allows assessing which sector, agricultural or industrial, contributes largely to the total concentration of organochlorine compounds (Santos-Neto et al., 2014). Ratios below 1, as in the case of samples common dolphin (0.60), indicate a greater influence of industrial pollution or high population densities to the accumulation of organochlorines in the species. Fraser's dolphins, a species with lower latitudes distribution, have shown an average ratio greater than 1 (1.35), indicating that the agricultural sector would be contributing largely to the concentration of chlorinated hydrocarbons, similar to those reported by Lailson-Brito et al. (2010) in other species of dolphins in southern Brazil. The largest proportion of pp.-DDE compared with pp.-DDT in both species, accounts for a past contribution of DDT into the environment, because the pp.-DDT is degraded in pp.-DDD, in the first moment, and then in pp.-DDE (Aguilar, 1984; Strandberg et al., 1998). Similar results were recently found in *Eubalaena australis* in the southwest Atlantic (Torres et al., 2015) and in various parts of the world (Hobbs et al., 2002; Lailson-Brito et al., 2010; Santos-Neto et al., 2014), indicating a decline in the use of this pesticide worldwide.

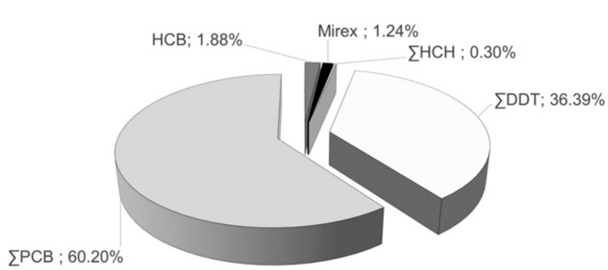

Fig. 2. Percentage of the total concentration of each pollutant group on the total concentration of organochlorines in common dolphins.

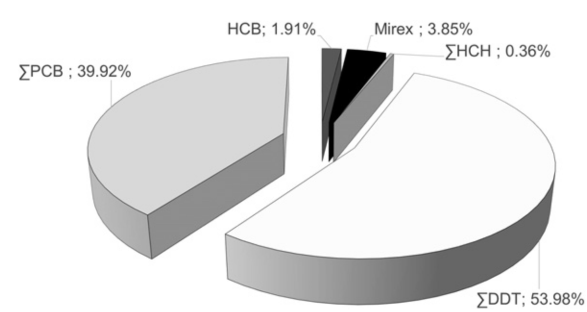

Fig. 3. Percentage of the total concentration of each pollutant group on the total concentration of organochlorines in Fraser's dolphins.

Table 2
Mean concentrations of organochlorines (μg·g^{-1} Lip.) in other dolphins in the world, obtained from Lailson-Brito et al. (2012) and Santos-Neto et al. (2014).

Specie	Location	HCB	∑HCH	∑DDT	∑PCB	Mirex	Source
Delphinus capensis	Brazil	0.05 (0.04)	–	4.43 (4.42)	14.6 (15.3)	–	Lailson-Brito et al. (2012)
Delphinus delphis	**Argentina**	**0.18 (0.08)**	**0.03 (0.02)**	**3.58 (2.19)**	**5.92 (1.12)**	**0.12 (0.03)**	**Present study**
	Spain	–	–	9.51 (4.17)	37.8 (18.9)	–	Borrell et al. (2001)
	Spain	–	–	118.7 (54.7)	88.2 (37.7)	–	Borrell et al. (2001)
	Spain	–	–	2.07 (1.69)	24.6 (16.1)	–	Tornero et al. (2006)
	Korea	0.11 (0.06)	–	14.0 (6.9)	15.0 (7.6)	–	Moon et al. (2010)
Lagenodelphis hosei	**Argentina**	**0.17 (0.15)**	**0.03 (0.02)**	**4.98 (4.53)**	**3.68 (2.24)**	**0.35 (0.3)**	**Present study**
	Brazil	–	–	0.41	0.62	–	Lailson-Brito et al. (2012)
	Japan	0.12	–	27.0	51.0	–	Minh et al. (2000)
	Philippines	0.06	–	7.10	4.10	–	Minh et al. (2000)
Tursiops truncatus	Brazil	0.05 (0.02)	–	5.01 (0.65)	11.8 (2.42)	–	Lailson-Brito et al. (2012)
	Brazil	0.08	–	2.42	5.91	–	Yogui et al. (2010)
	USA	0.06 (0.03)	–	51.5 (123.0)	98.6 (159.0)	–	Yordy et al. (2010)
	India	–	0.1	12.9	0.5	–	Karuppiah et al. (2005)
Orcinus orca	Canada	0.71 (0.37)	–	65.9 (38.5)	62.1 (50.1)	–	Krahn et al. (2007)
Pseudorca crassidens	EEUU	–	–	63.0 (28.0)	33.0	–	Ylitalo et al. (2009)
Steno bredanensis	Brazil	0.49	–	27.5	119.3	–	Lailson-Brito et al. (2012)
	Brazil	0.02	–	118.0	26.8	–	Yogui et al. (2010)
	USA	0.06 (0.03)	–	22.2 (12.3)	47.6 (21.4)	–	Struntz et al. (2004)
Sotalia guianensis	Brazil	0.02 (0.009)	0.02 (0.02)	35.9 (46.8)	4.61 (3.31)	0.15 (0.09)	Yogui et al. (2003)
	Brazil	0.12	0.09	36.9	39.7	0.76	Alonso et al. (2010)
	Brazil	0.04 (0.04)	–	5.76 (5.84)	4.56 (3.97)	–	Lailson-Brito et al. (2010)
	Brazil	0.02 (0.02)	–	0.33 (0.26)	2.23 (1.74)	0.08 (0.04)	Santos-Neto et al. (2014)
Sotalia guianensis	Brazil	0.007 (0.004)	0.04 (0.01)	1.11 (0.66)	7.35 (6.27)	0.09 (0.03)	Santos-Neto et al. (2014)
	Brazil	0.005	0.03 (0.03)	0.30 (0.28)	1.12 (1.32)	0.07 (0.05)	Santos-Neto et al. (2014)
Lagenorhynchus acutus	USA	0.18	0.22	14.05	12.97	0.05	Weisbrod et al. (2001)
Sousa chinensis	China	0.07	0.8	46	24	–	Minh et al. (1999)
Pontoporia blainvillei	Brazil	0.03 (0.01)	–	1.04 (0.94)	5.12 (3.12)	0.06 (0.02)	(Leonel et al. (2010))

The values correspond to the mean concentration (standard deviation).
Bold data in the table correspond to the present paper.

The percentage contribution of PCB congeners to the total concentration of PCBs is shown in Fig. 6, while the percentage contribution of PCB congeners of total PCBs grouped according to the number of chlorine is shown in Fig. 7. Of total PCB congeners analyzed, low molecular weight (di-, tri-, tetra- and penta-CBs) accounted for 28.86% in common dolphin and 12.69% in Fraser's dolphin, being the majority in both species of high molecular weight PCBs, in particular the hexa- and hepta-CBs (Fig. 7). Of the latter, the PCB 138, 153, 151 congeners were the

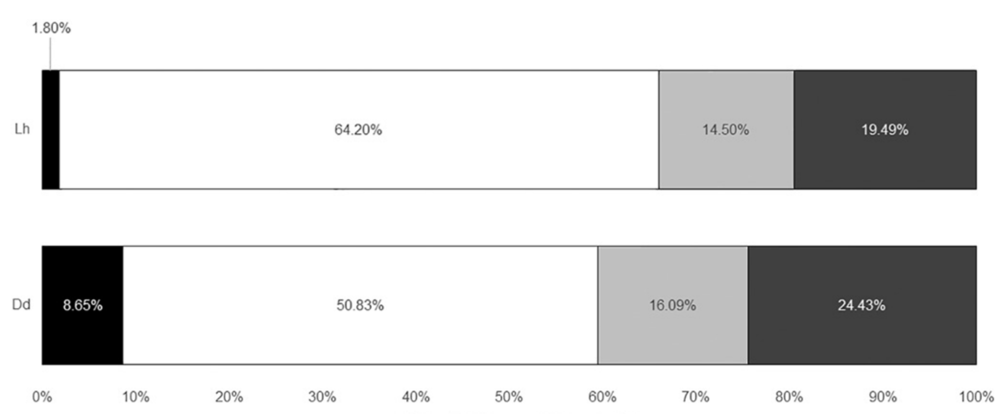

Fig. 4. Percentage contribution of each HCH's isomer to the total concentration of HCHs in *Lagenodelphis hosei* (Lh) and *Delphinus delphis* (Dd).

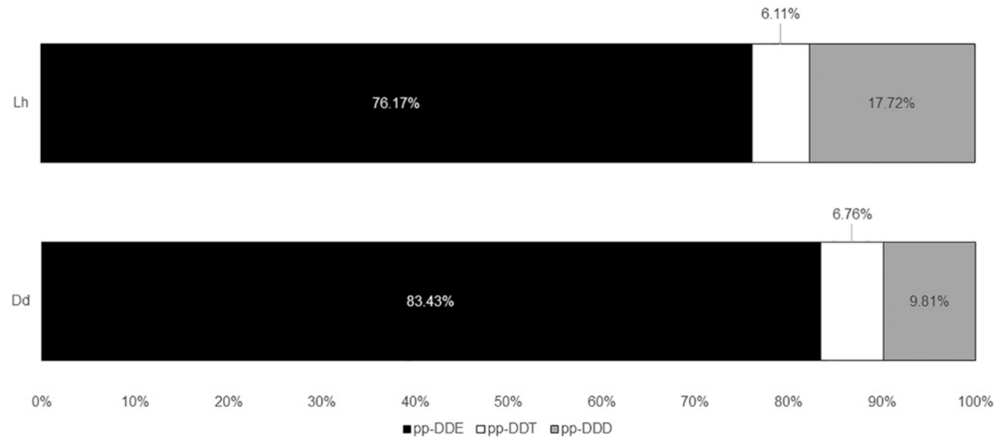

Fig. 5. Percentage contribution of each DDT's metabolite to the total concentration of DDTs in *Lagenodelphis hosei* (Lh) and *Delphinus delphis* (Dd).

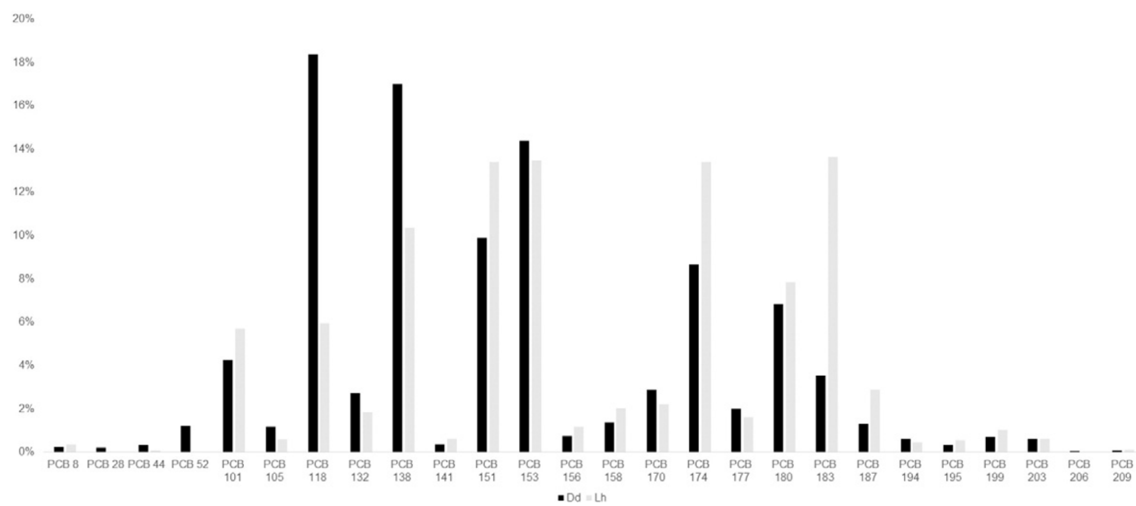

Fig. 6. Percentage contribution of each PCB's congeners to the total concentration of PCBs in *Lagenodelphis hosei* (Lh) and *Delphinus delphis* (Dd).

most abundant in common dolphins, and PCB 138, 153, 151, 174 and 183 congeners in Fraser's dolphins. With respect to low molecular weight, the PCB 118 was the dominant congener in common dolphin, while in Fraser's dolphin it was the PCB 118 and 101, in similar proportions (Fig. 6).

In both species of dolphins, the largest relative contribution was given by PCBs high molecular weight, particularly for hexa- and hepta-CBs. This is consistent with other reports published for the same species or similar (Lailson-Brito et al., 2012; Santos-Neto et al., 2014), raising also the issues by Wania and MacKay (1996) with respect

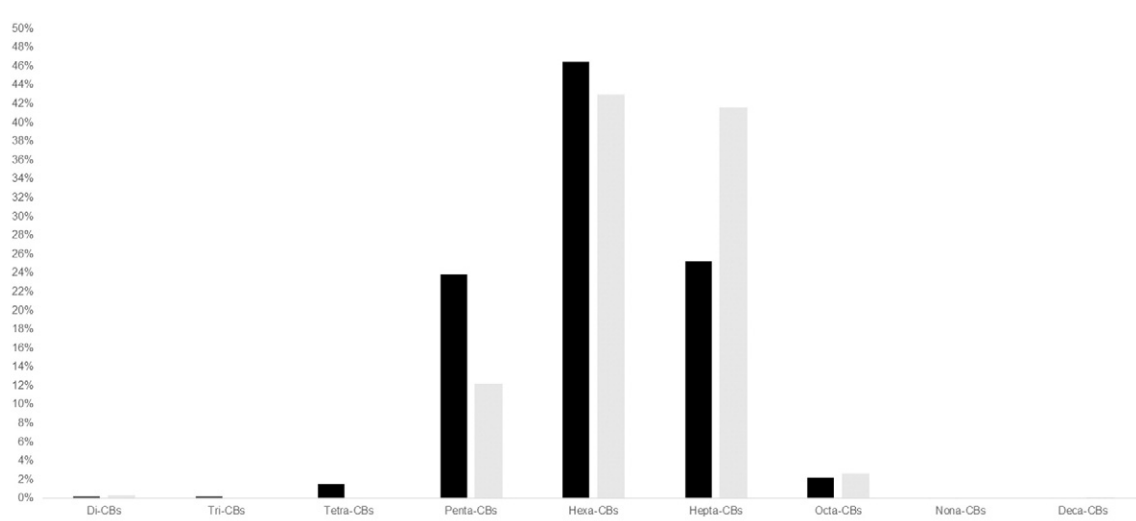

Fig. 7. Percentage contribution of each PCB's congeners to the total concentration of PCBs grouped according to the number of chlorine in *Lagenodelphis hosei* (Lh) and *Delphinus delphis* (Dd).

to increased deposition of high molecular weight PCBs in mid-latitudes, due to global atmospheric transport. Regarding congeners of low molecular weight, it is expected that common dolphins may have a greater relative contribution of these congeners to ΣPCBs compared with Fraser's dolphins. On one hand, common dolphin has a southernmost distribution and according with Wania and MacKay (1996) these high molecular weight congeners reach longer distances either by air or water, increasing its concentration toward the poles. On the other hand, the two species of dolphins have a different diet; Fraser's dolphins feeds mainly in depth on mesopelagic fish, which could be largely accumulating high molecular weight PCBs according to the above hypothesis by Takahashi et al. (2000). This author suggests the existence of a split in the water column due to the association of organochlorine with suspended particulate matter, reaching deeper waters those contaminants with higher molecular weight and/or lower solubility in water. Although PCBs profiles were different between species, PCBs 138 and 153 were present in both species, accounting for much of the total concentration of PCBs. These congeners, along with four others (PCB 28, 52, 101 and 180), are considered "PCBs indicators" by the European Food Safety Authority (EFSA, 2005) and prevailing over the other in biotic and abiotic substrates, therefore they are used in numerous papers and reports (Elnar et al., 2012; Liu et al., 2011; Lorán et al., 2010).

In contrast to males, the females of marine mammals can transfer some of the load of pollutants to the offspring during the stages of pregnancy and lactation (Addison and Brodie, 1987; Berghe et al., 2010; Berghe et al., 2012; Borrell et al., 1995; Sørmo et al., 2003). Therefore, one expect to find in individual adult males major concentrations that in juveniles (Aguilar and Borrell, 1994b) and any relationship with age or size evidencing the bioaccumulation. However, in this study we have not found results of any substantiate effect of age, sexual maturity or length standard on concentrations of organochlorines in common dolphins (Tables 3 and 4). This is possibly due to the low number of samples used in this study, together with a bias toward adult individuals and therefore larger age classes, making it impossible to evaluate these effects covering most variability possible.

4. Conclusion

It was determined that all samples had some organochlorine pesticides and polychlorinated biphenyls, which accounts for the availability of such contaminants in food chains occupied by both species. The PCBs were the majority in Fraser's dolphin, while organochlorine pesticides were for the common dolphins.

This study provides the baseline information on the current state of pollution by organochlorines in common dolphins in the Southwest Atlantic, more precisely in the Argentine Sea. However, there was no correlation between the analyzed biological parameters and the concentration of POPs in common dolphins. With respect to Fraser's dolphins, the results serve as a complement to the work in tropical waters of the South Atlantic where the species is distributed, although given the low number of samples this should be taken with caution.

The common dolphin could be used as a sentinel species in order to track the status of the southwestern Atlantic in mid latitudes, with regard to contamination by persistent organic pollutants, thus contributing to conservation, not only of the species but also the marine environment in general. However, further studies should be conducted in the southwestern Atlantic, in marine mammals and other organisms given the scarcity of studies related to pollution by POPs to contribute to the conservation. We consider fundamental studies focused on locating point sources of pollution in order to help minimize the contributions of POPs to the marine environment.

Table 3
Results of Mann-Whitney U tests to assess the difference in the concentration of OCs between adults and juveniles in *Delphinus delphis*.

OCs	N - adults	N - juveniles	Rank A	Rank J	U	p
HCB	8	4	55	23	13	0.610
Mirex	8	4	59	19	9	0.234
∑ HCH	8	4	53	25	15	0.865
∑ DDT	8	4	59	19	9	0.234
∑ PCB	8	4	53	25	15	0.865

Table 4
Results of test Spearman Correlation Ranges to assess the relationship between OCs with age and length standard (LS) in *Delphinus delphis*.

Var	OCs	N	$R_{Spearman}$	p
Age	HCB	12	0.432668	0.160069
	Mirex	12	0.340460	0.278860
	HCH	12	−0.127672	0.692535
	DDT	12	0.397203	0.201062
	PCB	12	0.099301	0.758812
LS	HCB	12	−0.020979	0.948402
	Mirex	12	0.272727	0.391097
	HCH	12	0.000000	1.000000
	DDT	12	0.363636	0.245265
	PCB	12	−0.013986	0.965590

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