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Polychlorinated dibenzo-p-dioxins, dibenzofurans and polychlorinated biphenyls in New Zealand cetaceans*

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ABSTRACT

Limited information is available on the concentrations of halogenated aromatic hydrocarbons (HAHs) in cetaceans from the Southern Hemisphere. This paper presents data on blubber concentrations of polychlorinated dibenzo-p-dioxins (PCDDs), polychlorinated dibenzofurans (PCDFs) and polychlorinated biphenyls (PCBs) in Hector's dolphins, dusky dolphins, southern right whale dolphins, blue whales, minke whales, Gray's beaked whales, Cuvier's beaked whales and pygmy right whales stranded in New Zealand. Both HAH concentrations and toxic equivalents (TEQs) are found to be higher in Hector's dolphins, a species with an inshore distribution, than in other odontocetes, which are more oceanic. Baleen whales, which are oceanic and feed at lower trophic levels, present the lowest levels of pollutants, with PCDD and PCDF concentrations usually below detection limits. The PCB profiles of the various species suggest that they are exposed to different PCB sources. Overall, HAH levels detected are lower than those reported for comparable species in the Northern Hemisphere. The relative abundance of low chlorinated PCB congeners in New Zealand cetaceans, as compared to those from northern waters, suggests that the origin of these compounds is mostly atmospheric deposition.

KEYWORDS: POLLUTION; SOUTHERN HEMISPHERE; SOUTH PACIFIC; AREA-NEW ZEALAND; HECTOR'S DOLPHIN; DUSKY DOLPHIN; SOUTHERN RIGHT WHALE DOLPHIN; BLUE WHALE; MINKE WHALE; PYGMY RIGHT WHALE; GRAY'S BEAKED WHALE; CUVIER'S BEAKED WHALE

INTRODUCTION

Limited information is available on the occurrence and distribution of halogenated aromatic hydrocarbons (HAHs) such as polychlorinated dibenzo-p-dioxins (PCDDs), polychlorinated dibenzofurans (PCDFs) and polychlorinated biphenyls (PCBs) in Southern Hemisphere cetaceans (Tanabe *et al.*, 1983). HAHs are known to bioaccumulate and biomagnify, with recent studies linking these compounds to reproductive deficiencies in some wildlife species (Reijnders, 1986; Colborn and Clement, 1992; Giesy *et al.*, 1994) and other adverse biological effects in cetaceans (Béland *et al.*, 1993). Cetaceans have been shown to bioaccumulate high concentrations of some HAHs (Tanabe *et al.*, 1988; Muir and Norstrom, 1991) and are, therefore, at risk from the effects of these contaminants. This ability to accumulate high levels of some HAHs also makes cetaceans potential indicator species for

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monitoring the contamination of the marine environment (Muir and Norstrom, 1991). We present data on concentrations of HAHs in a number of cetaceans collected around the coast of New Zealand.

MATERIALS AND METHODS

PCDD, PCDF and PCB congeners were analysed following the methodology of Buckland *et al.* (1990) and Hannah *et al.* (1993). $^{13}C_{12}$ dioxin, furan and PCB congeners were added to each sample, before extraction, to act as surrogate internal standards for the calculation of 'native' congener concentration. Samples were then extracted four times by blending with 30ml 2:1 acetone:hexane. Extracts were dried by passage through anhydrous Na_2SO_4, concentrated to near dryness and redissolved in 50ml of hexane. A 5.0ml portion of the extract was removed for gravimetric lipid determination. The remaining extract, after any sub-sampling, was transferred to a separating funnel and washed eight times with concentrated H_2SO_4 followed by three washes with H_2O. The extract was again dried through Na_2SO_4 before being chromatographed sequentially on columns of H_2SO_4/silica:NaOH/silica, Al_2O_3, and Carbopac C dispersed on Celite. PCB congeners pass through the Carbopac column while PCDDs and PCDFs are retained and eluted into a separate fraction. The PCB fraction was chromatographed on Florisil to isolate the three non-*ortho* substituted congeners (Lazar *et al.*, 1992). All analytes were determined by HRGC/HRMS on a VG 70S mass spectrometer.

Toxic Equivalency Factors (TEFs) express the potency of individual HAH congeners relative to 2,3,7,8-TCDD, the most potent HAH congener. The concentration of each congener in the extracts was multiplied by its TEF (Ahlborg *et al.*, 1988; 1994) and the sum of these values gives the total toxic equivalents (TEQs) concentration in the extract.

QUALITY ASSURANCE

The dioxin laboratory maintains World Health Organisation (WHO) and TELARC (Testing Laboratory Registration Council of New Zealand) accreditation for the analysis of PCDD, PCDF and PCB congeners in a variety of environmental matrices. Laboratory blanks were run with each batch of samples. All data analysis was subject to strict quality assurance procedures as previously described (Buckland *et al.*, 1990).

SAMPLES AND SPECIES

All samples analysed in this study were obtained from dead stranded cetaceans.

Hector's dolphin (*Cephalorhynchus hectori*) is an inshore dolphin with a small home range feeding on a variety of fish species (Slooten and Dawson, 1988). In contrast, the other odontocetes studied, i.e. the common dolphin (*Delphinus delphis*), the dusky dolphin (*Lagenorhynchus obscurus*), the southern right whale dolphin (*Lissodelphis peronii*), Gray's beaked whale (*Mesoplodon grayi*) and Cuvier's beaked whale (*Ziphius cavirostris*) are open ocean species and are believed to feed on a variety of fish, squid and crustacea (e.g. see summary in Martin, 1990).

All of the mysticetes (baleen whales) examined are open ocean filter feeders. The minke (*Balaenoptera acutorostrata*) and blue whale (*B. musculus*) feed largely on krill (e.g. Kawamura, 1994) and the rare pygmy right whale (*Caperea marginata*), the smallest of the baleen whales, appears to feed mainly on copepods (Best *et al.*, 1992).

Numbers of specimens and available biometric data for the individuals analysed are provided in Table 1. As these specimens were collected by several people over several years not all biometric data are available, in particular data on age and other biological information was often lacking. As contaminant concentrations in cetaceans are known to vary with age and sex, the data are presented and discussed primarily as 'group' averages. Groups are defined in Table 1. Individual data are given in Appendix 1.

Table 1
Biometric data for cetacean specimens analysed.

Sample type	Common name	Age	Sex
Oceanic dolphins	Common dolphin	Mature	Male
	Common dolphin	Mature	Male
	Dusky dolphin	Mature	Male
	S. right whale dolphin	1yr	Male
Baleen whales	Minke whale	Mature	Female
	Minke whale	Mature	Male
	Blue whale	Sub-adult	Male
	Pygmy right whale	< 1yr	Female
	Pygmy right whale	< 1yr	Female
Beaked whales	Gray's beaked whale	Mature	Male
	Gray's beaked whale	Mature	Female
	Gray's beaked whale	Mature	Female
	Cuvier's beaked whale	Mature	Male
	Gray's beaked whale	Mature	Male
	Gray's beaked whale	Mature	Female
Hector's dolphin	Hector's dolphin	1yr	Male
	Hector's dolphin	1yr	Male
	Hector's dolphin	10yrs	Male
	Hector's dolphin	11yrs	Male
	Hector's dolphin	< 1yr	Female
	Hector's dolphin	8yrs	Female

RESULTS AND DISCUSSION

PCB congeners were detectable in all samples analysed. The 'group'-average sum of PCB congener concentrations was lowest (< 50ng/g wet weight) in the open ocean mysticetes (minke, blue and pygmy right whales), intermediate (100 to 500ng/g wet weight) in open ocean odontocetes (beaked whales and open ocean dolphins) and highest (750 to > 1,000ng/g wet weight) in the inshore Hector's dolphin (Table 2). PCB profiles from the open ocean baleen and beaked whale species show an abundance of lower chlorinated PCB congeners relative to the inshore Hector's dolphin (Fig. 1). The principle source of these congeners is believed to be atmospheric deposition. However, the difference is much less apparent when comparing inshore and offshore dolphins.

PCDD and PCDF congeners were only commonly detected in the inshore feeding Hector's dolphin (Table 2). The concentrations of almost all PCDD and PCDF congeners were below detection limits in the baleen whale species. In open ocean dolphins and beaked whales hepta- and octa-chlorinated PCDD and PCDF congeners were the most commonly detected congeners.

Toxic Equivalency Factors (TEFs) can be used to calculate the biological potency of HAH mixtures relative to 2,3,7,8-TCDD, the most potent HAH congener (Ahlborg *et al.*, 1988; 1994). Using this method, the total concentration of TCDD-Equivalents (TEQs) were calculated for the different cetacean groups (Table 2). TEQs were lowest in the baleen whales, higher in the open ocean odontocetes and highest in the inshore Hector's dolphin. By calculating the TEQ contributed by specific compounds analysed it is possible to assess their relative toxicological significance (Fig. 2). The contribution of PCDD and PCDF to the TEQ

Table 2

Mean chlorinated hydrocarbon congener concentrations in blubber of different groups of southern ocean cetaceans (PCBs in ng/g wet weight; PCDD and PCDF in pg/g wet weight). Where values less than the detection limit occurred, one half of that detection limit was used to calculate the mean. TEFs from Ahlborg *et al.*, 1988; Ahlborg *et al.*, 1994. na = not analysed. nd = not detected. * PCDD and PCDF data from Buckland *et al.*, 1990.

Analyte	TEF	Pygmy right	Baleen whales	Oceanic dolphins	Beaked whales	Hector's dolphin*
PCB #28	0	0.25	0.03	0.93	0.95	3.78
PCB #52	0	0.34	1.30	14.5	4.90	9.93
PCB #77	0.0005	0.005	0.002	0.08	0.06	0.09
PCB #101	0	0.42	1.87	60.1	19.7	32.5
PCB #99	0	0.23	1.41	44.0	23.3	56.9
PCB #118	0.0001	0.20	0.79	37.5	14.7	56.1
PCB #105	0.0001	0.11	0.23	10.9	4.25	28.7
PCB #126	0.1	0.003	0.01	0.06	0.08	0.43
PCB #153	0	0.58	2.89	267	64.5	330
PCB #138	0	0.85	2.64	232	48.7	240
PCB #169	0.01	0.002	0.02	0.14	0.07	0.09
PCB #187	0	0.28	0.80	46.8	24.8	77.7
PCB #183	0	0.02	0.23	16.3	6.97	29.4
PCB #180	0.00001	0.14	0.77	68.1	21.1	86.2
PCB #170	0.0001	0.17	0.34	22.6	13.7	64.3
PCB #202	0	0.001	0.03	5.46	1.43	1.6
PCB #194	0	0.001	0.02	8.50	1.64	na
Congener sum (ng/g)		3.61	12.9	833	251	1,018
2,3,7,8-TeF	0.1	0.06	0.10	0.10	0.15	9.12
non-2,3,7,8-TeF	0	0.11	0.18	3.70	1.30	nd
2,3,7,8-TeD	1.0	0.10	0.08	0.10	0.06	7.83
non-2,3,7,8-TeD	0	0.18	0.08	0.10	0.10	nd
1,2,3,7,8-PeF	0.05	0.06	0.05	0.10	0.12	0.77
2,3,4,7,8-PeF	0.5	0.13	0.10	0.02	0.22	24.6
non-2,3,7,8-PeF	0	0.18	0.20	6.44	1.79	nd
1,2,3,7,8-PeD	0.5	0.13	0.10	0.10	0.09	9.08
non-2,3,7,8-PeD	0	0.23	0.13	0.15	0.09	nd
1,2,3,4,7,8-HxF	0.1	0.13	0.08	0.10	0.10	nd
1,2,3,6,7,8-HxF	0.1	0.10	0.12	0.10	0.09	0.56
2,3,4,6,7,8-HxF	0.1	0.13	0.12	0.10	0.17	0.51
1,2,3,7,8,9-HxF	0.1	0.18	0.15	0.10	0.06	0.27
non-2,3,7,8-HXF	0	0.20	0.20	2.96	0.82	nd
1,2,3,4,7,8-HpD	0.1	0.15	0.12	0.04	0.07	nd
1,2,3,6,7,8-HpD	0.1	0.15	0.17	0.04	0.15	2.83
1,2,3,7,8,9-HpD	0.1	0.18	0.12	0.04	0.08	0.23
non-2,3,7,8-HpD	0	0.30	0.20	0.10	0.15	nd
1,2,3,4,6,7,8-HpF	0.01	0.28	0.43	0.05	0.19	0.30
1,2,3,4,7,8,9-HpF	0.01	0.18	0.15	0.04	0.05	0.08
non-2,3,7,8-HpF	0	0.43	0.85	0.20	0.10	nd
1,2,3,4,6,7,8-HpD	0.01	0.65	0.98	0.15	0.53	3.15
non-2,3,7,8-HpD	0	0.68	0.76	0.50	0.27	nd
OCDF	0.001	0.52	2.33	0.15	0.26	1.54
OCDD	0.001	2.75	10.2	0.50	3.91	12.5
TEQ (pg/g)		0.77	1.9	15.7	12.5	81.4

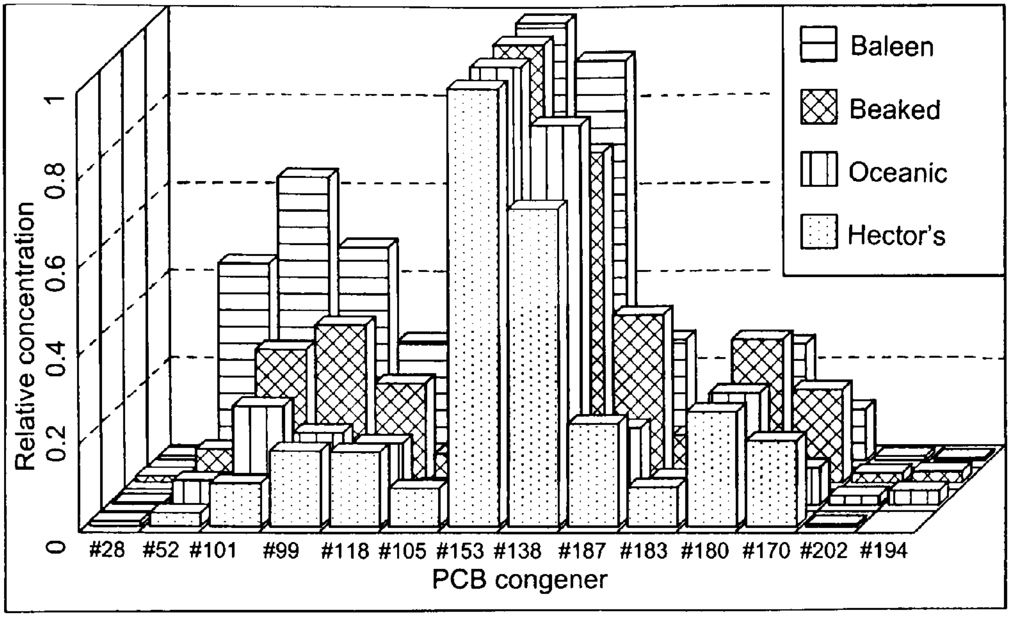

Fig. 1. PCB congener profiles for different cetacean groups. Baleen = baleen whales, Beaked = beaked whales, Oceanic = oceanic dolphins, Hector's = Hector's dolphin. Concentrations are expressed relative to CB153.

was less than 20% of the total TEQ in all open ocean groups except the pygmy right whale. The higher contribution of PCDD and PCDF in this group can be explained by the low levels of TEQs found (< 1pg/g wet weight) which resulted in a high number of 'non-detect' values. For calculation of TEQs, half the detection limit is taken for these non-detect values. Therefore, at low contaminant levels TEQ can be overestimated because of the high number of non-detect values. The levels of TEQs detected in Hector's dolphin are higher than in the other groups and the contribution of PCDD and PCDF to total TEQs is also greater.

The correlation between average 'group' PCB congener sums and TEQs in different cetacean species (Fig. 3) supports the hypothesis that these groups are exposed to different PCB sources. Any single source of HAHs will have a relatively fixed profile and therefore a fixed potency expressed as TEQ per mass of PCB. As the ratio of TEQ accumulated per mass of PCB is higher in Hector's dolphin than in the open ocean species, this suggests that this species is exposed to an HAH source of higher potency. This is also evident from the higher contribution of PCDD and PCDF to total TEQ in Hector's dolphin, previously mentioned.

A cluster analysis (Fig. 4) was performed using the PCB congener data only. PCDD and PCDF congener concentrations were not used in this statistical analysis due to the high number of non-detect values for these congeners in the open ocean cetaceans. This analysis demonstrated the similarity among the individuals of the various cetacean groups, particularly for Hector's dolphin and Gray's beaked whale. Interestingly, the Gray's beaked whale cluster is quite distinct from the open ocean dolphin cluster which also includes the single Cuvier's beaked whale. Little information is available on the dietary habits of Gray's beaked whale. However, this analysis may indicate a diet distinct from the open ocean dolphins and more similar to that of Hector's dolphin (e.g. Slooten and Dawson, 1988). Cuvier's beaked whale appears to be a catholic feeder on deep sea-fish and squid (Nishiwaki and Oguro, 1972).

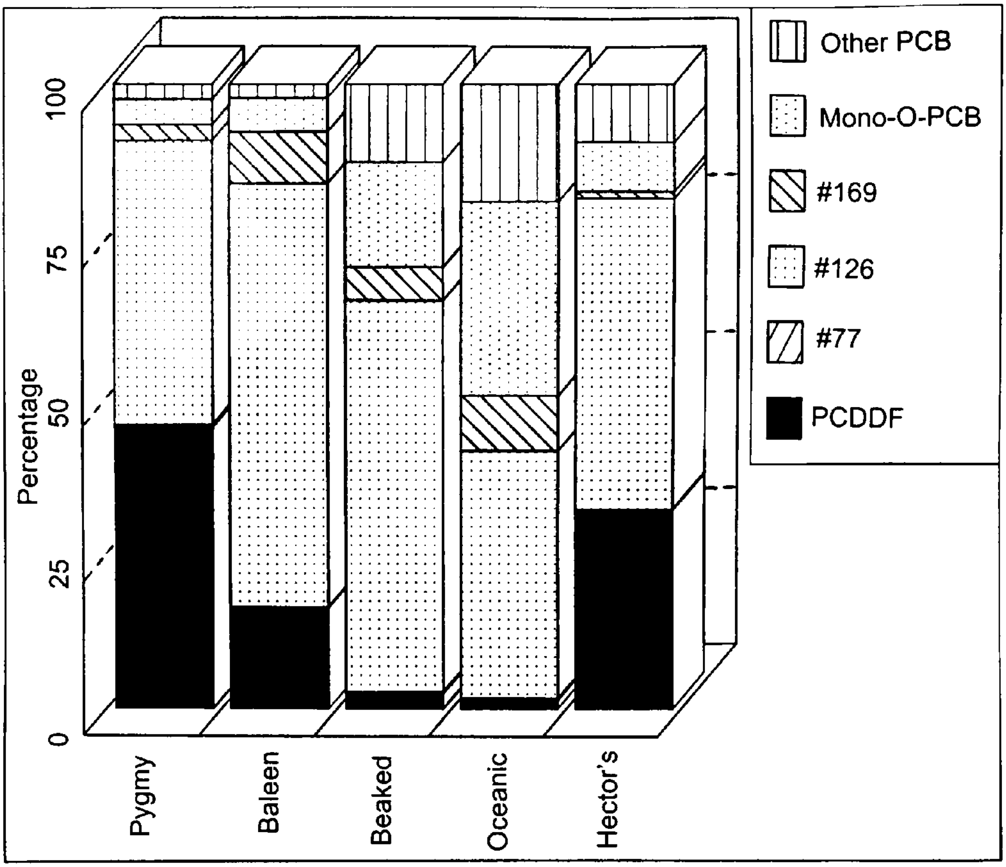

Fig. 2. Percent contribution of HAH classes and individual PCB congeners to total 2,3,7,8-TCDD toxic equivalents (TEQ).

CONCLUSIONS

The relative concentrations of chlorinated hydrocarbons in the different species examined indicates that their accumulation is related to both food habit and proximity to the coast. For example, total PCB concentrations are greater in beaked whales than in baleen whales - both are open ocean species but the latter feed lower in the food web. Higher concentrations of PCBs in Hector's dolphin as compared to common dolphins indicate higher exposure in inshore species.

Concentrations of PCBs detected in common dolphins, beaked whales and baleen whales in New Zealand are lower than those reported for similar species in the Northern Hemisphere (Table 3). This observation is to be expected considering the relative remoteness of the area from the major sources of PCB contamination that are mainly located in the Northern Hemisphere.

PCB profiles from open ocean marine mammals show an abundance of lower chlorinated PCB congeners. This abundance is most noticeable in the baleen whales which feed near the bottom of the food chain. However, the pattern is still detectable in other open ocean species. The abundance of the lower chlorinated, therefore more volatile, PCBs suggests that the principle source of these congeners is atmospheric deposition.

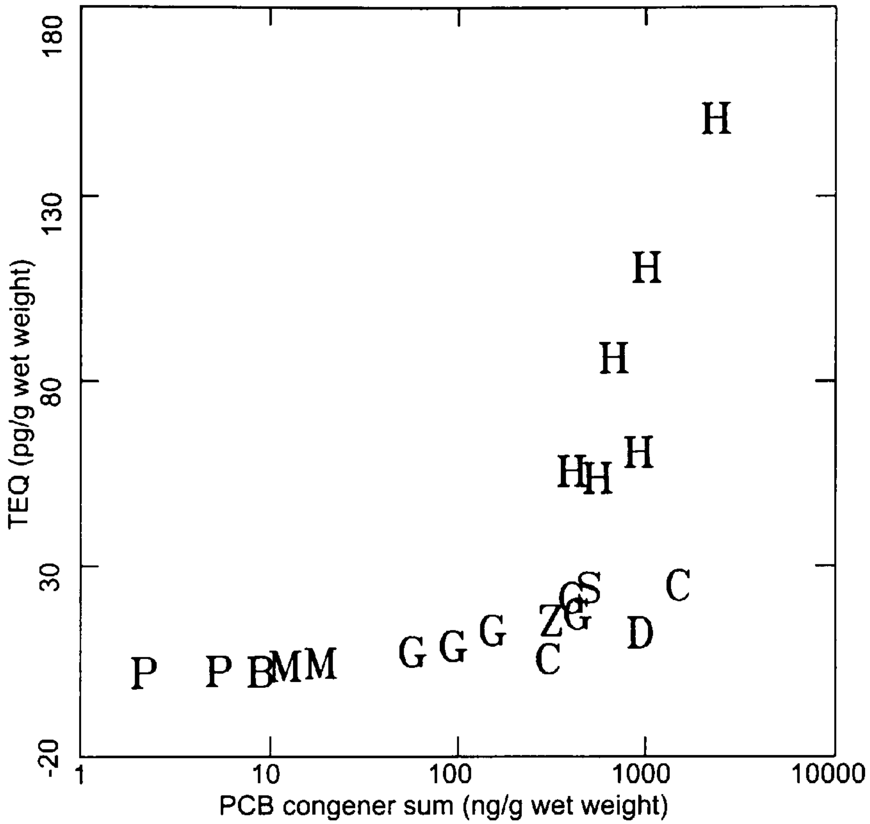

Fig. 3. Concentration of 2,3,7,8-TCDD equivalents as a function of the sum of PCB congeners for southern ocean cetaceans. H = Hector's dolphin, C = common dolphin, D = dusky dolphin, S = southern right whale dolphin, G = Gray's beaked whale, M = minke whale, B = southern blue whale, P = pygmy right whale, Z = Cuvier's beaked whale.

With the exception of the Hector's dolphin, PCDD and PCDF did not contribute a significant level of TEQs. In all the southern ocean cetaceans analysed to date PCBs contribute the major portion of TEQ calculated using the TEF values of Ahlborg *et al.* (1994). This situation may arise due to the ability of cetaceans to metabolise PCDD and PCDF congeners (Muir and Norstrom, 1991; Norstrom *et al.*, 1994) but, mostly, because of the limited atmospheric transport and deposition of these HAHs into the southern oceans.

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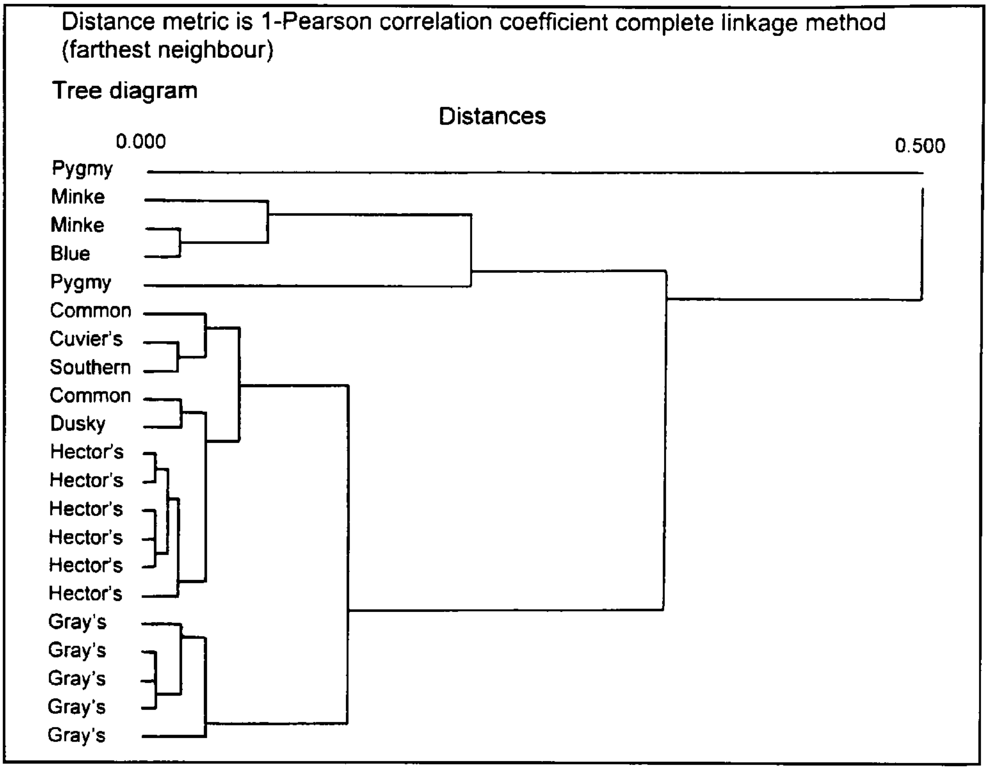

Fig. 4. Cluster analysis of Southern ocean cetaceans using PCB congener profiles. Hectors = Hector's dolphin, Pygmy = pygmy right whale, Minke = minke whale, Blue = blue whale, Grays = Gray's beaked whale, Common = common dolphin, Dusky = dusky dolphin, Cuviers = Cuvier's beaked whale, Southern = southern right whale dolphin.

Table 3

Comparison of total PCB concentrations in cetaceans.

Species	Location	PCBs (μg/g)	Reference
Bottlenose dolphin	South Africa	13.8	Cockroft *et al.*, 1989
Dall's porpoise	North Pacific	8.6	Tanabe *et al.*, 1983
White-sided dolphin	Japan	37.6	Tanabe *et al.*, 1983
Bottlenose dolphin	East USA	81.4	Kuehl *et al.*, 1991
Common dolphin	East USA	36.5	Kuehl *et al.*, 1991
White-sided dolphin	East USA	50.1	Kuehl *et al.*, 1991
Harbour porpoise	UK	55.5	Morris *et al.*, 1989
Dusky dolphin	South of NZ	1.4	Tanabe *et al.*, 1983
Baleen whales	NZ	< 0.05*	This study
Minke whales	West USA	3.3	Varanasi *et al.*, 1993
Beaked whales	NZ	0.1 - 0.5*	This study
Baird's beaked whales	Japan	3.0	Subramanian *et al.*, 1988
Common dolphin	NZ	0.75 - >1.0*	This study
Hector's dolphin	NZ	0.4 - 4.5*	This study

*Measured as the sum of 16 predominant and biologically active congeners.

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APPENDIX 1a

Concentrations of PCB congeners in individual marine mammal blubber samples. Concentrations are ng/g wet weight. n.a. = not analysed; Ma = mature adults, exact age unknown; SA = Sub-adult; and CS = Congener Sum. Sample 8729 was analysed in duplicate.

	Age		PCB#																	CS
Specimen	(yr)	Sex	28	52	77	101	99	118	105	126	153	138	169	187	183	180	170	202	194	(ng/g)
Pygmy right whale																				
NMNZ 204	<1	F	0.46	0.46	0.009	0.52	0.3	0.28	0.15	0.004	0.86	1.38	0.002	0.14	0.03	0.25	0.32	0	n.a	5
G152	<1	F	0.05	0.22	0.0003	0.32	0.16	0.13	0.08	0.003	0.3	0.31	0.002	0.42	0.01	0.04	0.02	0.001	0.001	2
Hector's dolphin																				
8733	<1	F	6.08	6.71	0.13	30.3	30.3	25.3	12	0.25	187	153	0.03	44.3	15.1	39.1	28.9	0.83	n.a.	579
8729	1	M	3.35	7.7	0.08	33.8	32.2	31.4	16.7	0.41	223	166	0.1	61	22.3	66.2	49.7	1.14	n.a	715
8729	1	M	4.04	8.63	0.1	35.3	33.2	34.8	19.5	0.49	243	180	0.13	65.9	24.7	73	58.2	1.31	n.a.	782
8731	11	M	3.77	17	0.04	35.2	178	167	82.9	0.68	881	600	0.12	162	69.1	212	161	3.39	n.a.	2,573
8615	1	M	0.63	13.9	0.09	51.8	50.5	49.7	25.5	0.55	346	258	0.11	93.5	33.6	90.2	72.6	1.96	n.a.	1,089
8617	8	F	2.55	7.77	0.07	19.8	53.7	60.7	32.7	0.32	295	229	0.09	82.5	29.3	91.3	57.6	1.81	n.a.	964
8503	10	M	6.04	7.82	0.15	21.3	20.2	23.7	11.9	0.28	133	95	0.06	34.8	12	31.9	22.4	0.6	n.a.	421
Dusky dolphin																				
DD1	Ma	M	0.35	13.96	0.08	44.2	37.5	26.2	8.28	0.03	331	281	0.11	43.6	16.8	113	23.4	8.49	13.1	961
Common dolphin																				
G149	Ma	M	0.1	4.16	0.007	8.78	16.5	4.9	2.58	0.005	92.9	81.6	0.03	31.5	10.8	34.3	16.9	1.22	2.06	308
CD1	Ma	M	1.04	23.4	0.06	155.9	86.2	96.4	14.5	0.07	515	436	0.19	65.8	12.9	87.5	31.8	11	10.4	1,548
Southern right whale dolphin																				
SRWD	1	M	2.22	16.5	0.17	31.4	35.8	22.7	18.1	0.14	131	129	0.22	46.4	24.7	37.3	18.5	1.19	n.a.	515
Gray's beaked whale																				
E174/1	Ma	M	0.95	3.9	0.03	13.8	16.9	9.2	4	0.08	40.3	28.7	0.08	14	4	11	8.5	0.72	0.89	157
E168/1	Ma	F	0.49	2.3	0.09	9.7	10.1	5.1	2.2	0.05	23.2	16.5	0.06	9.56	2.6	7.3	5.6	0.52	0.55	96
E198	Ma	F	0.36	1.6	0.07	5.3	5.5	2.1	0.98	0.04	13	8.7	0.06	7.5	1.9	5.7	3.7	0.66	0.61	58
G101	Ma	M	1.7	9	0.12	32.5	44.7	27.4	5.7	0.13	113	75.1	0.09	42.2	11.3	33.1	21.7	2.5	2.8	423
E197	Ma	F	1	5.4	0.03	25.9	41.9	24.1	6.9	0.09	117	85.3	0.05	50.5	14.4	42.6	29.3	2.4	2.7	450
Cuvier's beaked whale																				
G151	Ma	M	1.2	7.2	0.02	30.7	20.5	20.3	5.7	0.09	80.6	78	0.06	24.8	7.6	26.8	13.5	1.79	2.31	321
Minke whale																				
E208	Ma	M	0.06	1.19	0.004	2.4	1.73	1.06	0.33	0.02	4.23	3.87	0.02	1.22	0.37	1.2	0.59	0.05	0.04	18
G103	Ma	F	0.01	1.4	0.002	2.28	1.28	0.59	0.18	0.01	2.31	2.13	0.02	0.67	0.18	0.55	0.21	0.03	0.001	12
Blue whale																				
G111	SA	M	0.03	n.a.	0.002	0.93	1.21	0.73	0.19	0.003	2.14	1.9	0.003	0.5	0.14	0.56	0.24	0.02	0.02	9

APPENDIX 1b

Concentrations of PCDD and PCDF congeners in individual marine mammal blubber samples. Concentrations are pg/g wet weight. n.a. = not analysed. Values in italics are less than the method detection limit, the values provided are half of the method detection limit. Data for specimens 8733, 8729, 8731, 8615, 8617 and 8503 are from Buckland *et al.*, 1990.

	NMNZ 204	G152	8733	8729	8731	8615	8617	8503	DD1	G149	CD1
2,3,7,8-TeF	*0.1*	*0.025*	15.4	12.6	1.6	6.7	7.1	11.3	n.a.	*0.1*	n.a.
non-2,3,7,8-TeF	*0.2*	*0.025*	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	3.7	n.a
2,3,7,8-TeD	*0.15*	*0.05*	6.2	8.5	11	10.4	4	6.9	n.a.	*0.1*	n.a.
non-2,3,7,8-TeD	*0.3*	*0.05*	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	*0.1*	n.a.
1,2,3,7,8-PeF	*0.1*	*0.025*	1.1	1.4	0.2	1.1	0.1	0.7	n.a.	*0.1*	n.a.
2,3,4,7,8-PeF	*0.1*	*0.15*	15.6	31.1	43.9	37.5	6.1	13.2	n.a.	*0.02*	n.a.
non-2,3,7,8-PeF	*0.2*	*0.15*	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	6.44	n.a.
1,2,3,7,8-PeD	*0.15*	*0.1*	7.9	11.7	8.1	13.4	5.5	7.9	n.a.	*0.1*	n.a.
non-2,3,7,8-PeD	*0.35*	*0.1*	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	*0.15*	n.a.
1,2,3,4,7,8-HxF	*0.15*	*0.1*	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	*0.1*	n.a.
1,2,3,6,7,8-HxF	*0.15*	*0.05*	0.9	*0.95*	*0.05*	*0.65*	*0.25*	*0.55*	n.a.	*0.1*	n.a.
2,3,4,6,7,8-HxF	*0.15*	*0.1*	0.6	0.8	0.3	0.9	*0.15*	*0.3*	n.a.	*0.1*	n.a.
1,2,3,7,8,9-HxF	*0.25*	*0.1*	*0.1*	*0.35*	*0.05*	*0.25*	*0.3*	*0.55*	n.a.	*0.1*	n.a.
non-2,3,7,8-HxF	*0.3*	*0.1*	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	2.96	n.a
1,2,3,4,7,8-HxD	*0.2*	*0.1*	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	*0.035*	n.a.
1,2,3,6,7,8-HxD	*0.2*	*0.1*	4.3	4.6	0.4	5.3	*0.5*	1.9	n.a.	*0.04*	n.a.
1,2,3,7,8,9-HxD	*0.25*	*0.1*	0.3	0.2	0.2	*0.2*	*0.15*	*0.35*	n.a.	*0.04*	n.a.
non-2,3,7,8-HxD	*0.45*	*0.15*	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	*0.1*	n.a.
1,2,3,4,6,7,8-HpF	*0.15*	0.4	0.3	*0.1*	0.7	*0.1*	0.4	*0.2*	n.a.	*0.05*	n.a.
1,2,3,4,7,8,9-HpF	*0.3*	*0.05*	0.05	*0.05*	*0.15*	*0.05*	*0.05*	*0.1*	n.a.	*0.035*	n.a.
non-2,3,7,8-HpF	*0.5*	0.36	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	*0.2*	n.a.
1,2,3,4,6,7,8-HpD	*0.3*	0.99	3.3	3	4.5	1.6	2	3.5	n.a.	*0.15*	n.a.
non-2,3,7,8-HpF	*0.5*	0.85	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	*0.5*	n.a.
OCDF	*0.5*	0.54	2.5	*2.1*	*0.5*	*1.05*	2.9	*2.1*	n.a.	*0.15*	n.a.
OCDD	*1.5*	4	14.6	15	7.1	7.5	15.8	15	n.a.	*0.5*	n.a.

	SRWD	E174/1	E168/1	E198	G151	G101	E197	E208	G103	G111
2,3,7,8-TeF	n.a.	*0.25*	*0.1*	*0.2*	*0.1*	*0.2*	*0.15*	*0.15*	*0.1*	*0.04*
non-2,3,7,8-TeF	n.a.	*0.6*	0.75	0.76	1.04	6.56	0.44	*0.15*	*0.3*	*0.1*
2,3,7,8-TeD	n.a.	*0.1*	*0.05*	*0.045*	*0.04*	*0.05*	*0.05*	*0.1*	*0.1*	*0.05*
non-2,3,7,8-TeD	n.a.	*0.1*	*0.05*	*0.045*	*0.1*	*0.05*	*0.05*	*0.1*	*0.1*	*0.05*
1,2,3,7,8-PeF	n.a.	*0.05*	*0.1*	0.2	*0.1*	0.35	*0.16*	*0.05*	*0.05*	*0.05*
2,3,4,7,8-PeF	n.a.	*0.15*	*0.1*	0.38	*0.15*	*0.2*	*0.15*	*0.15*	*0.05*	*0.1*
non-2,3,7,8-PeF	n.a.	*0.15*	*0.15*	0.88	*0.25*	4.52	*0.15*	*0.25*	*0.25*	*0.1*
1,2,3,7,8-PeD	n.a.	*0.1*	*0.05*	*0.1*	*0.1*	0.49	*0.1*	*0.1*	*0.1*	*0.1*
non-2,3,7,8-PeD	n.a.	*0.1*	*0.05*	*0.1*	*0.1*	*0.2*	*0.1*	*0.1*	*0.2*	*0.1*
1,2,3,4,7,8-HxF	n.a.	*0.1*	*0.1*	*0.1*	*0.15*	*0.2*	*0.1*	*0.05*	*0.15*	*0.05*
1,2,3,6,7,8-HxF	n.a.	*0.1*	*0.1*	*0.045*	*0.1*	*0.35*	*0.1*	*0.1*	*0.2*	*0.05*
2,3,4,6,7,8-HxF	n.a.	*0.15*	*0.1*	*0.22*	*0.15*	*0.2*	*0.1*	*0.1*	*0.2*	*0.05*
1,2,3,7,8,9-HxF	n.a.	*0.05*	*0.045*	*0.04*	*0.1*	*0.1*	*0.04*	*0.15*	*0.15*	*0.15*
non-2,3,7,8-HxF	n.a.	*0.1*	*0.1*	*0.15*	*0.3*	8	0.83	*0.05*	*0.5*	*0.05*
1,2,3,4,7,8-HxD	n.a.	*0.1*	*0.05*	*0.05*	*0.1*	*0.1*	*0.03*	*0.1*	*0.15*	*0.1*
1,2,3,6,7,8-HxD	n.a.	*0.2*	*0.15*	*0.05*	*0.3*	*0.25*	*0.1*	*0.15*	*0.25*	*0.1*
1,2,3,7,8,9-HxD	n.a.	*0.1*	*0.1*	*0.045*	*0.1*	*0.2*	*0.03*	*0.1*	*0.15*	*0.1*
non-2,3,7,8-HxD	n.a.	*0.15*	*0.1*	*0.1*	*0.3*	*0.35*	*0.1*	*0.1*	*0.4*	*0.1*
1,2,3,4,6,7,8-HpF	n.a.	*0.15*	*0.2*	0.16	*0.15*	*0.1*	*0.1*	*0.15*	1.04	*0.1*
1,2,3,4,7,8,9-HpF	n.a.	*0.05*	*0.03*	*0.04*	*0.05*	*0.03*	*0.03*	*0.15*	*0.15*	*0.15*
non-2,3,7,8-HpF	n.a.	*0.1*	*0.1*	0.09	*0.1*	2.6	*0.1*	*0.15*	2.29	*0.1*
1,2,3,4,6,7,8-HpD	n.a.	*0.4*	*0.4*	*0.35*	0.88	*0.3*	*0.4*	*0.35*	2.34	*0.25*
non-2,3,7,8-HpF	n.a.	*0.25*	*0.2*	*0.2*	0.5	*0.1*	*0.2*	*0.15*	1.87	*0.25*
OCDF	n.a.	0.46	0.27	*0.15*	*0.15*	*0.15*	0.36	*0.35*	6.25	*0.4*
OCDD	n.a.	5.32	4.59	3.96	4.7	3.66	5.33	*1*	27.7	*2*