

## VARIATIONS OF ORGANOCHLORINE RESIDUES WITH AGE AND SEX IN ANTARCTIC MINKE WHALE

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**Abstract:** Concentrations of polychlorinated biphenyls (PCBs) and *p, p'*-DDE were determined in the blubber of Antarctic minke whale collected during the 1984-1985 whaling season and found to be in the ranges of 3.1 to 29 ng/g and 13 to 140 ng/g on wet weight basis, respectively. These values were much lower in comparison with those of this species in the northern hemisphere. The female animals older than 15 years of age revealed the low residue levels in contrast to mature males, probably due to the lactational excretion of these organochlorines. However, such excretion seems to be lesser in minke whales than in small cetaceans because of the smaller difference of organochlorine levels between mature males and females of the former. The concentration ratios of DDE to PCBs were found to be higher in immature minke whale than in mature animal, indicating the possibility that the feeding grounds of immature animal extend further north from the Antarctic Ocean.

### 1. Introduction

The persistent organochlorines such as PCBs (polychlorinated biphenyls) and DDT compounds are ubiquitous pollutants in our environment, which extends the boundaries of their distribution all over the global environment, being evidenced by their occurrence in Antarctic atmosphere, hydrosphere and biosphere (HIDAKA *et al.*, 1983; SUBRAMANIAN *et al.*, 1983; TANABE *et al.*, 1983a, 1984; SUBRAMANIAN *et al.*, 1986a). The major concern about these two organochlorines has been focused on the environmental contamination and resulting harmful effects on the wildlife and man. Recently, interest has been growing in the use of these pollutants as chemical tracers for elucidating the ecology and physiology of wild animals, which are still unclarified.

In view of these two categories, we determined PCBs and *p, p'*-DDE in the blubber of Antarctic minke whales *Balaenoptera acutorostrata*. This species has a wide range of migratory area between Antarctic and tropical waters in the southern hemisphere and feeds principally on euphausiids in the Antarctic Ocean during the austral summer (OHSUMI *et al.*, 1970; WILLIAMSON, 1975; OHSUMI, 1979). Hence, the Antarctic minke whale is an excellent bioindicator to know the status of marine pollution in the southern hemisphere, particularly the Antarctic Ocean. Moreover, it is interesting that these animals are suspected to form geographical segregation with age and sex (WILLIAMSON, 1975; BEST, 1982; BROWN and LOCKYER, 1984) and the age at sexual maturity is declining year by year during the last few decades (MASAKI, 1979; BEST, 1982; KATO, 1983, 1984, 1985). The present study regarding variations of persistent organochlorines with age

and sex can be expected to give more evidence in the light of these biological aspects as well as others in the minke whale.

## 2. Materials and Methods

Minke whales were caught in the Antarctic Ocean during the whaling season of November 1984 to March 1985, of which 20 males and 17 females were used for the present study. The sampling locations of these animals are shown in Fig. 1. The blubber samples collected from the specimens were wrapped in polyethylene bags and immediately frozen on board. The samples were transported to the laboratory in the same condition and were kept at  $-20^{\circ}\text{C}$  until analysis.

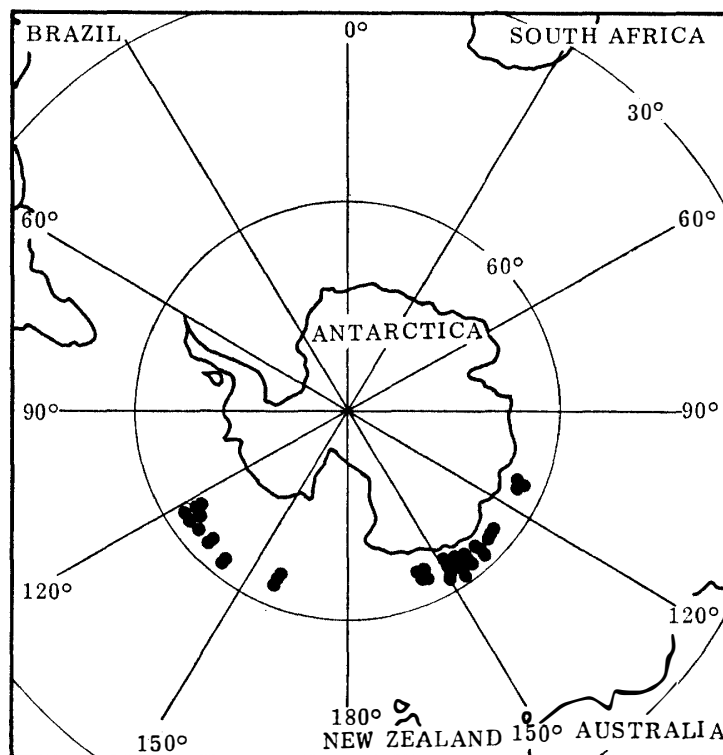


Fig. 1. Sampling locations of minke whales.

The ages of the specimens were determined by Dr. KATO, Whale Research Institute, following the earplug method based on ROE (1967) and BEST (1982), assuming that one growth layer (one pale and one dark lamina) is formed every year.

Analysis of PCBs and *p,p'*-DDE was carried out following the alkaline alcohol digestion method of WAKIMOTO *et al.* (1971). About 20 g of blubber was refluxed in 1 N KOH- $\text{C}_2\text{H}_5\text{OH}$  solution for 1 h. PCBs and DDE thus extracted into ethanol were transferred to 100 ml hexane by shaking in a separating funnel (*p,p'*-DDE values reported here also include *p,p'*-DDT, because DDT is converted to DDE during alkaline alcohol digestion). Subsequently, the hexane layer was concentrated and cleaned up by passing through 1.5 g of Silica gel (Wako gel S-1) packed in a glass column (10 mm i.d.  $\times$  20 cm).

PCBs and DDE were eluted with 200 ml of hexane at an elution rate of one drop a second. The eluate was concentrated to 5 ml in a Kuderna-Danish concentrator and further cleaned up with 5% fuming H<sub>2</sub>SO<sub>4</sub> in concentrated sulfuric acid. These solutions were further microconcentrated whenever necessary in a stream of nitrogen.

Aliquots of these samples were used for injection by splitless technique glass capillary gas chromatography with <sup>63</sup>Ni electron capture detection (GC-ECD) using Shimadzu 7A and 9A gas chromatograph. The column consisted of 0.23 mm i.d. × 30 m glass capillary WCOT OV-101 for both DDE and PCB analysis. Operating conditions for PCBs were as follows. Temperature program 180° to 230°C at a rate of 0.5°C/min with an initial 8 min and final 32 min hold. Both injector and detector temperatures were kept at 250°C. For DDE the column temperature was 230°C isothermal. Injector and detector temperatures were the same as in the PCB analysis. Nitrogen was used as both carrier and make-up gas.

### 3. Results and Discussion

Concentrations of PCBs and *p,p'*-DDE in the blubber of Antarctic minke whales were found to be in the ranges of 3.1 to 29 ng/g and 13 to 140 ng/g on wet weight basis, respectively (Table 1). In our knowledge, this is a first report on the detection of PCBs in the blubber of Antarctic minke whale.

It has been well studied in water samples and small cetaceans of western North and South Pacific that the concentrations of these two organochlorines are much lower in the southern hemisphere, reflecting smaller amounts of PCB and DDT usage in the countries of this hemisphere (TANABE *et al.*, 1983b). The same situation was also found in the comparison of minke whales from both hemispheres, where lower levels of these organochlorines can be seen in the southern minke whale (Table 2). The lowest values of PCBs and DDT compounds have been also reported in Antarctic fish (SUBRAMANIAN *et al.*, 1983), bird (SUBRAMANIAN *et al.*, 1986a) and seal (HIDAKA *et al.*, 1983) in comparison with those animals in other oceans. These facts indicate that the region surrounding the south pole is relatively pristine and least affected by industrial and human activities.

Many authors have pointed out in several species of marine mammals that the large quantities of persistent organochlorines are excreted from mother animals through lactation and, in consequence, lower levels of these chemicals were found in adult females than in males (ANAS and WILSON, 1970; GASKIN *et al.*, 1971; ADDISON and BRODIE, 1977; TANABE *et al.*, 1981). Similarly, different levels of PCBs and DDE between both sexes were observed in the minke whale (Fig. 2). In male animals, PCB and DDE concentrations increased with age, in contrast to the decreased levels in females of older age, probably due to the lactational loss of these organochlorines. Considering from these age trends (Fig. 2), it can be safely mentioned that most of the female animals in ages older than 15 years are sexually matured. KATO (1985) has examined the relationship between the sexual maturity and the transition phase of earplugs in Antarctic minke whales and found a declining trend in age at sexual maturity from 13–14 years in the 1940s to 7 years at the end of the 1960s. Unfortunately, we could not make clear this trend by means of organochlorines due to the smaller number of samples in the range of 7 to 14 years old.

Table 1. Concentrations (ng/g) of DDE and PCBs in the blubber of Antarctic minke whale.

Sample No.	Age	Body length (m)	Blubber thickness (cm)	Lipid content (%)	Wet wt basis		Lipid wt basis		DDE/PCBs
					DDE	PCBs	DDE	PCBs	
Male									
687	1	7.1	3.7	61.9	28	5.0	45	8.0	5.6
246	3	7.0	3.3	52.1	57	7.0	110	13	8.1
1932	3	7.1	4.1	72.2	46	5.3	64	7.3	8.8
71	3	7.2	3.0	45.7	98	11	210	24	8.9
1929	3	7.7	4.0	74.5	32	6.7	43	8.9	4.8
245	4	7.8	3.5	64.8	38	7.6	59	12	5.0
50	5	7.7	3.2	42.9	45	8.2	110	19	5.5
1910	6	8.7	5.4	78.8	36	7.9	46	10	4.6
694	7	7.8	4.0	62.7	54	5.5	87	8.7	9.9
46	9	7.6	3.7	75.9	87	11	50	14	8.2
533	15	7.7	3.8	52.6	89	14	170	27	6.4
535	16	8.6	4.2	74.5	100	29	140	39	3.5
839	16	8.6	5.5	70.5	76	17	110	24	4.6
1349	17	8.9	3.2	56.6	100	15	180	27	6.6
1907	17+n	8.8	4.6	58.9	77	24	130	40	3.2
849	18	8.5	3.2	54.4	86	14	160	25	6.4
551	19	8.8	4.2	63.9	89	20	140	31	4.5
17	21	8.6	3.4	48.6	140	18	290	38	7.7
1341	24	8.4	4.0	73.2	76	22	100	31	3.4
6	25	8.5	3.0	48.4	120	22	260	45	5.7
Female									
35	3	7.6	7.0	71.3	31	7.5	44	11	4.2
8	3	7.8	3.7	77.5	65	14	84	19	4.5
682	3+n	7.7	4.7	72.3	28	4.2	39	5.9	6.7
792	4	7.8	3.1	72.8	56	8.6	78	12	6.6
607	5	7.9	3.6	68.9	31	8.2	45	12	3.8
619	9	7.2	4.3	74.0	46	6.5	62	8.8	7.0
5	11	8.4	3.8	73.6	76	14	100	19	5.4
12	15+n	8.8	3.5	32.9	32	7.4	98	23	4.4
4	16	9.0	5.5	68.4	13	3.1	20	3.3	4.4
1331	17	8.9	3.5	62.3	33	11	52	18	2.9
531	18	9.1	5.8	75.8	76	15	100	20	5.0
832	20	8.9	5.5	66.9	24	8.3	35	12	2.8
835	20	9.1	4.7	47.7	29	7.5	62	16	3.9
1912	22	9.0	4.0	57.2	20	5.6	36	9.7	3.7
249	—	7.2	3.1	74.7	42	8.2	57	11	5.2
575	—	7.6	4.3	66.2	38	4.7	58	7.1	8.1
540	—	8.7	3.7	42.1	28	7.0	66	17	4.0

—: not determined

When comparing the concentration ratios of PCBs in mature females with those in mature males of minke whale (present study), striped dolphin (TANABE *et al.*, 1981) and Dall's porpoise (SUBRAMANIAN *et al.*, 1986b), the highest mean value (0.42) was obtained in minke whale, whereas the values were considerably lower in striped dolphin (0.24) and Dall's porpoise (0.25). These facts suggest that the excretory rate of organochlorines

Table 2. Comparison of DDT and PCB concentrations (ng/g on wet weight basis) in the blubber of minke whale.

Location	DDT compounds	PCBs	Reference
Northern Hemisphere			
Umanak, W. Greenland	210-2600	140-1100	JOHANSEN <i>et al.</i> (1980)
St. Lawrence estuary	1100	27000	SERGEANT (1980)
Mediterranean	—	4800	ALZIEU and DUGUY (1979)
Southern Hemisphere			
Durban, South Africa	ND-820	ND	HENRY and BEST (1983)
Antarctic Ocean	13-140	3.1-29	Present study

ND: not detected

—: not reported

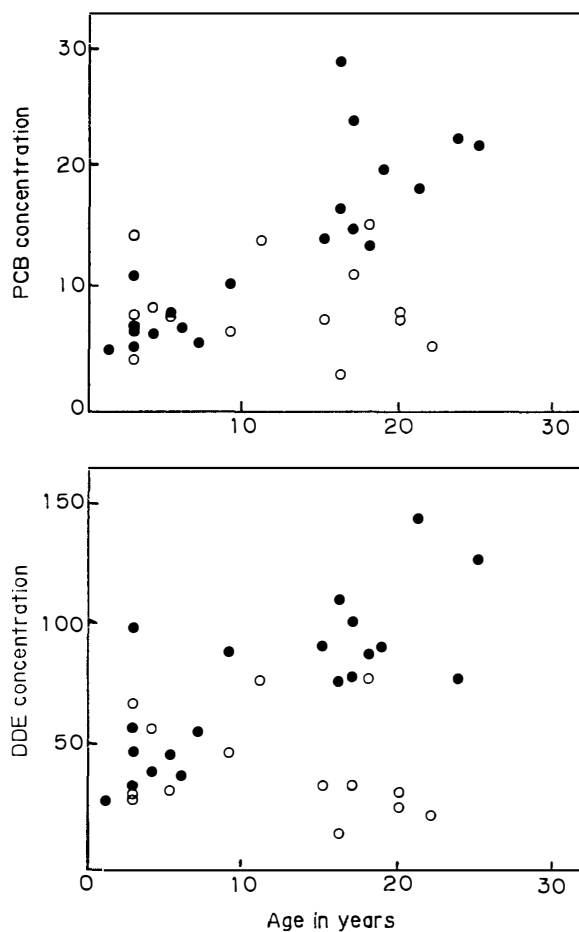


Fig. 2. Age trends of PCB and DDE concentrations (ng/g on wet weight basis) in the blubber of male (●) and female (○) minke whales.

through lactation is smaller in minke whale than in other two small cetaceans. In striped dolphin, lactational loss rate of PCBs was estimated to be about 60% in their whole body burdens of mature females (TANABE *et al.*, 1981). In comparison with this, smaller percentage of excretion is expected in minke whale, which may imply that the

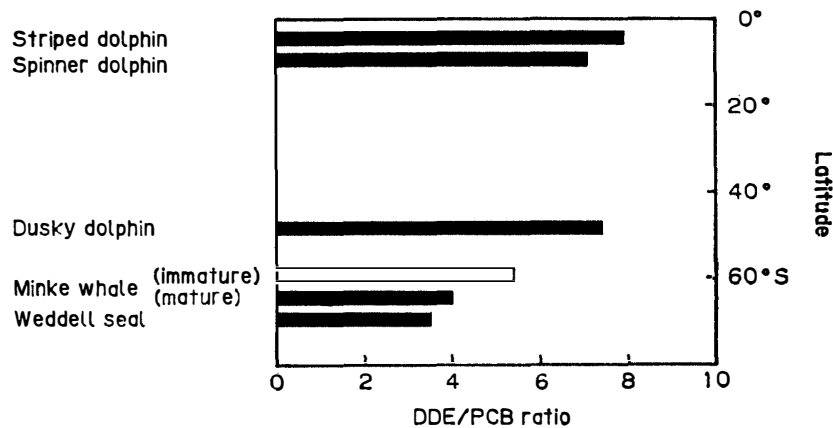


Fig. 3. Latitudinal variations of DDE and PCB concentration ratios in the blubber of marine mammals.

lower fat content in milk and/or shorter weaning period of this animal.

In our previous study on the atmospheric organochlorines, the increasing concentrations of DDT compounds towards lower latitudes from Antarctica were found to be more intense in comparison with those of PCBs (TANABE *et al.*, 1983a). The same trend is also expected in water and biological materials. In order to examine this, concentration ratios of DDE to PCBs were calculated in the blubber of marine mammals from the southern hemisphere, as well as the Antarctic minke whale. As a result (Fig. 3), higher ratios were observed in spinner and striped dolphins of tropical waters and Dusky dolphin of temperate waters than in mature minke whale (>15 years old) and Weddell seal from the Antarctic Ocean, which agreed well with the atmospheric pattern of these organochlorines. However, this ratio in immature minke whale (<6 years old) was found to be intermediate between small cetaceans and Antarctic mammals (mature minke whale and Weddell seal). These facts are susceptible of the idea that the immature minke whale has differential ecological niches from mature animals and probably the same applies partly to the spinner, striped and Dusky dolphins. GAMBELL *et al.* (1975) and BEST (1982) reported that many immature minke whales remain for longer periods in lower latitudes (north of 30°S) in summer and feed not only on euphausiids in the Antarctic Ocean but also on copepods and fish in tropical and temperate waters. The present approach using organochlorines as chemical tracers favorably supports this and suggests that the feeding grounds of mature minke whales are strictly restricted in the Antarctic Ocean, whereas those of immature animal extend further north.

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