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ORGANOCHLORINE CONTAMINANTS IN MARINE MAMMALS FROM THE NORWEGIAN ARCTIC

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Abstract

The synthetic organochlorine (OC) compounds, including pesticides such as DDT, as well as the industrial pollutants, polychlorinated biphenyls (PCBs), have for many years been of great concern as environmental pollutants in the marine ecosystems. OCs are lipophilic and persistent and may be stored in body fats and increasingly concentrated along food webs. Environmental pollutants are known to be transferred to the Arctic by air (and water) currents, and the OC levels in marine mammals, polar bears, sea birds, etc., occupying high trophic levels, are orders of magnitude greater than levels found in terrestrial wild life. Toxic effects related to exposure to such compounds have been found in marine mammals living in particularly polluted waters. However, little is known about sublethal effects. Thus, monitoring environmental pollutants is of great importance.

During the last 6 years we have studied the occurence and levels of selected OCs (PCBs, DDTs, chlordanes, HCH-isomers and HCB) in a large number of different marine mammals as a part of the Norwegian Marine Mammal Programme. Results from this work have given us information on the exposure levels of different OC-compounds in seal species like harp seal (Phoca groenlandica), *ringed seal* (Phoca hispida), *hooded seal* (Cystophora cristata), *grey seal* (Halichoerus grypus), *harbour seal* (Phoca vitulina) *and walrus* (Odobenus rosmarus rosmarus), *harbour porpoise* (Phocoena phocoena) *and minke whale* (Balaenoptera acutorostrata) *from the Norwegian coast, the Barents Sea and the West Ice area and polar bear* (Ursus maritimus) *from Svalbard. Altogether, samples from about 800 individuals have been analysed.*

Alarmingly high PCB-levels were found in polar bear at Svalbard (mean 25 ppm in fat) and in harbour porpoise along the Norwegian coast (mean 20 ppm in blubber). Low OC-levels were found in ringed and harp seal (3 ppm PCB in blubber), while somewhat higher levels were found in grey seal, particularly in Varanger near the Russian border (6 ppm PCB) and in hooded seal from the West Ice (5 ppm PCB), though the individual differences were large. On average minke whale contained about 3 ppm PCB, but variation and differences were observed between groups taken at different locations. Geographical differences in OC-levels were registered with decreasing contamination from south to north in harbour seal along the Norwegian coast, and increasing levels for harp seal from west to east in Arctic areas.

INTRODUCTION

The presence of organochlorine (OC) contaminants in the Arctic marine food webs are well documented over the last 20 -25 years (Addison *et al.*, 1973; Clausen *et al.*, 1974; Jones *et al.*, 1976; Born *et al.*, 1981; Barrett *et al.*, 1985; Muir *et al.*, 1988; Norstrom *et al.*, 1988; Luckas *et al.*, 1990; Woodley *et al.*, 1991; Hargrave *et al.*, 1992; Muir *et al.*, 1993; Vetter *et al.*, 1993; Wang-Andersen *et al.*, 1993; Gabrielsen *et al.*, in press). Polychlorinated biphenyls (PCBs), DDT-components, chlordanes (CHLs), hexachlorocyclohexane (3 HCH-isomers) and hexachlorobenzene (HCB) are among those chemicals wich are transported from antropogenic sources in industrialised areas to the Arctic environment (Bidleman *et al.*, 1981; Iversen, 1984; Oehme & Ottar, 1984; Barrie, 1986; Hargrave*et al.*,1988; Pacyna & Oehme, 1988; Bidleman *et al.*, 1989; Patton *et al.*, 1989; Oehme, 1991). The levels of OC-pollutants in marine mammals from the Atlantic Arctic areas, are normally much lower than corresponding levels found in different species living in industrialised coastal areas, like the Baltic Sea and the Wadden Sea, except for the top predator, polar bear (Norheim *et al.*, 1992). Although a lot of information already exsists on OC-contamination in Arctic marine mammals, few investigations have been carried out in the eastern Atlantic Arctic (east of Greenland).

The metabolism of the different OCs (PCBs, DDTs, CHLs, HCHs, dioxins, etc) differs between different species, even between species belonging to the same family (Safe, 1984; Boon *et al.*, 1991; Tatsukawa, 1992). Thus, the OCs are "filtered" through the food web resulting in different OC-patterns between species. In environmental monitoring programs, biological data such as age, sex, reproduction cycle, feeding behaviour, nutritional status and health status, as well as information relative to location and date of catch, are important and essential when interpreting analytical OC-results.

This paper reports OC levels in different marine mammals sampled between 1988 and 1994 along the coast of Norway (from mid-Norway and northward) and in the Norwegian Arctic, mostly as parts of the Marine Mammal Programme (MMP) in Norway. The main purpose of this presentation/paper is to give a general overview of the present state on OC-contamination in marine mammals from the Norwegian Arctic areas.

MATERIALS AND METHODS

Animals examined for OC-contamination from 1988 to 1994 are listed in table 1 together with the collaborators at the different projects who in most cases were responsible for collecting the material. Figure 1 shows a map where all the northern sample locations listed in table 1, are noted. Most animals were killed for scientific purpose, except harbour seals from 1988 (found dead during an epizootic), grey seals from Froan 1991-1993 (blood samples and blubber biopsies taken from live animals), walrus (blubber biopsies taken from live animals), polar bears 1992-1993 (blood samples and blubber biopsies taken from live animals) and different whale species found dead along the coast.

All animals presented in Table 1 have been analysed for OC contaminants, but preparation of the results are not yet finnished for all groups. Levels of OCs in harbour porpoise will be presented by Lars Kleivane and effects of PCBs on grey seals from the Froan area will be presented by Bjørn Munro Jenssen at this meeting, and will not be referred in this paper.

Table 1: List of different marine mammals analysed for OC-contaminants between 1988 and 1994. Location of catch (see figure 1), year and/or time of year, number of animals, collaborators and references to publications (published, in press or in prep.). All of the material is well characterised.

SPECIES	LOCATION	YEAR	Collaborator	N	SUM
Harbour seal	Oslo fiord	1988	0 (publ.A)	35	
Phoca vitulina	Southern Norway	1988	"	26	
	Western Norway	1988	"	18	
	Jarfiord, Finnmark	1988/89	1	9	
	Vesterålen	1990	2	8	**96**
Grey seal	Jarfiord, Finnmark	Oct 1989	1	14	
Halichoerus grypus	"	Jan/Mar 1990	"	10	
	Vikna, Trøndelag	Mar. 1989	"	6	
	Froan, Trøndelag	1991	3 (publ.E)	17	
	"	1992	3	7	
	"	1992	"	61	
	"	1993	"	42	**157**
Harp seal	Skjånes, Finnm.	Feb 1988/89	1	13	
Phoca groenlandica	Jarfiord	Jan/Mar 1990	"	38	
	The West Ice area	Mar. 1990	4 (in prep.D)	20	
	Barents Sea, north	Sep. 1990	2	22	
	"	June/July 1992	"	10	
	The East Ice area	Apr/May 1993		42	**145**
Ringed seal	Jarfiord	Jan/Mar 1990	1	12	
Phoca hispida	Barents Sea, north	Sep. 1990	2	5	
	Svalbard	1992	5	13	**30**
Hooded seal					
Cystophora cristata	The West Ice area	Mar. 1990	4 (in prep.D)	27	**27**
Walrus	Svalbard	1991	6	16	
Odobenus r. rosmarus	"	1992	"	53	**69**
Harbour porpoise	Kattegatt	1988/89	7 (publ.B)	12	
Phocoena phocoena	Western Norway	1988/89	"	15	
	Tufjord, Finnmark	1988/89	"	7	**34**
Minke whale	Barents./Finnm.	1988/89	2	37	
Balaenoptera	"	1992	"	72	
acutorostrata	"	1993	"	64	**173**
Polar bear	Svalbard	1978-1989	6 (publ.C)	24	
Ursus maritimus	"	1992	6 (publ.F)	33	
	"	1993	"	40	**97**
Whales					
different species	Norwegian coast	1989-1993		17	**17**
TOTAL NUMBER OF ANIMALS					**845**

0) N.H. Markussen, Univ. of Oslo. 1) K. I. Ugland, Univ. of Oslo. 2) T. Haug, Univ. of Tromsø. 3) B. M. Jenssen, NINA Trondheim. 4) T. Øritsland, Norw. Inst. Marine Res., Bergen. 5) Norw. Polar Res. Inst., AMAP 6) Ø. Wiig, Museum of Zoology, Oslo. 7) A. Bjørge, NINA Oslo. Publications: A) (Skaare *et al.*, 1990) B) (Kleivane *et al.*, in press) C) (Norheim *et al.*, 1992) D) (Espeland & Skaare, In prep.) E) (Jenssen *et al.*, 1994) F) (Skaare *et al.*, in prep.)

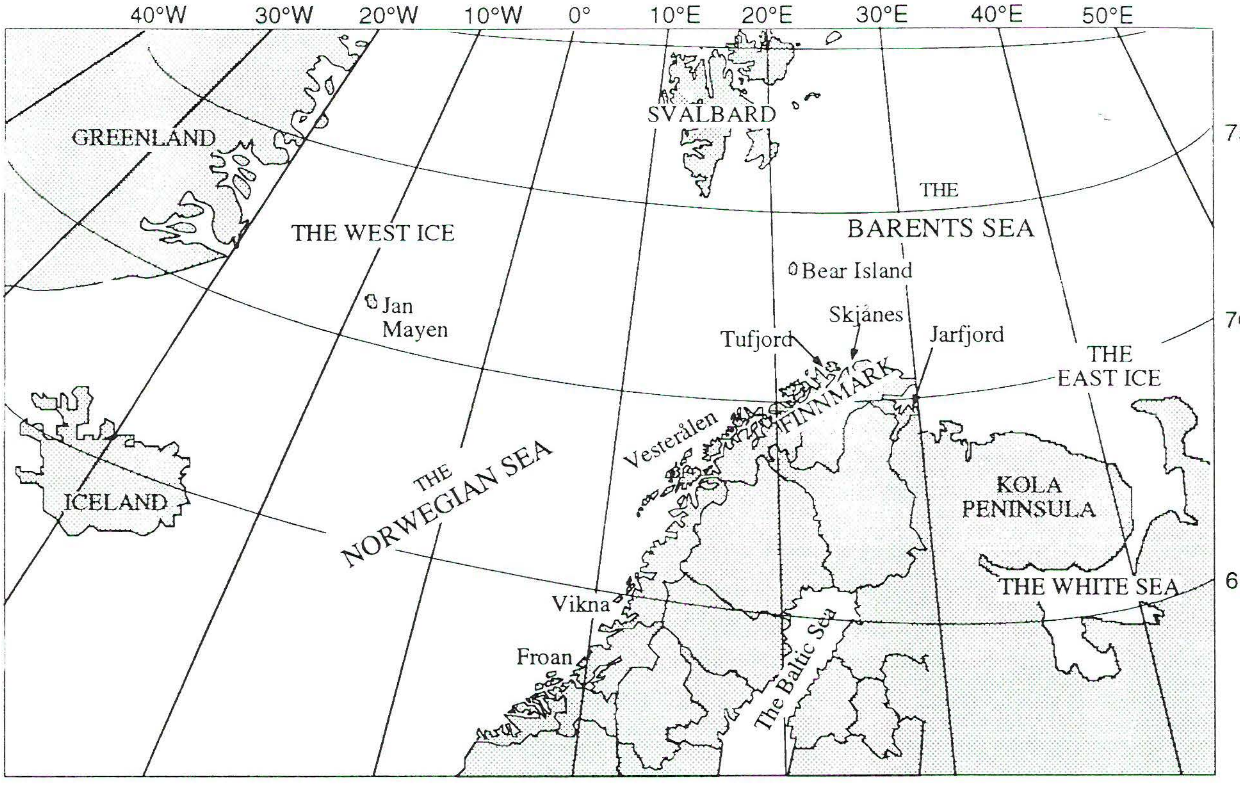

Figure 1: Map showing the different sampling locations for marine mammals from the Norwegian coast (mid-Norway and northward), Norwegian Arctic areas, the East Ice, and the West Ice listed in Table 1, page 3.

Analytical procedure

Samples of the all marine mammals were homogenised with an Ika Ultra Turrax™. Samples were weighed and extracted two times with cyclohexane and acetone using an ultrasonic homogenizer (4710 series, Cole-Parmer) followed by cleanup with sulfuric acid as described by (Brevik, 1978) with some modifications (Skaare *et al.*, 1988). Samples were automatically injected on a Carlo Erba, HRGC 5300 Mega series equipped with a split/splitless injector, a 25 m/0.32 mm i.d. Ultra 1 column (Hewlett-Packard Comp., before 1992), a 60 m/0.25 mm i.d. CP-SIL 8 for PCBs (Chrompack) and a Carlo Erba ^{63}Ni- electron capture detector. Helium (before 1992) and hydrogen were used as carrier gas (2 ml/min) and the split ratio was 1:30 of 1 µl. The chromatographic data was calculated using the software Maxima 820 Chromatography Workstation (Millipore Waters) on an Olivetti PC M290.

All samples (blubber in most cases) were analysed for 22 PCB-congeners (ΣPCB), IUPAC nos: -28, -52, -74, -99, -101, -105, -110, -114, -118, -128, -138, -153, -156, -157, -170, -180, -187, -194, -206 and -209; 5 DDT components and metabolites (ΣDDT): *p,p´*- DDT, *p,p´*- DDE, *p,p´*- DDD, *o,p´*- DDT and *o,p´*- DDD; chlordanes (ΣCHL): heptachlor, heptachlor epoxide, oxy-chlordane and trans-nonachlor; hexachlorocyclohexane-isomers (ΣHCH): α-HCH, ß-HCH and γ-HCH; and hexachlorobenzene (HCB). In most cases only the most abundant groups of OCs: ΣPCB, ΣDDT and ΣCHL will be referred. Details will be available in publications in the near future.

Analytical quality assurance (AQA)
The laboratory has participated in several intercalibration tests. Good analytical quality for determination of *p,p´*- DDE, ß-HCH, total PCBs, and the major PCB-congeners in human milk was confirmed by successful participation in interlaboratory tests organized by WHO/UNEP (The World Health Organisation/ United Nations Environmental Programme) in 1982 and 1992. Participation in the four steps of the ICES/IOC/OSPARCOM (*International Council for Exploration of the Sea/ International Oceanographic Commission/ Oslo-Paris Commission)* test on marine material, placed the laboratory in good and acceptable groups compared to the other participating laboratories.

RESULTS AND DISCUSSION

Comparing OC-levels in different species
Figure 2 shows the mean level of ΣPCB and ΣDDT in blubber/adipose tissue from marine mammals from the Norwegian Arctic compared to some terrestrial mammals and corresponding levels in Norwegian women.

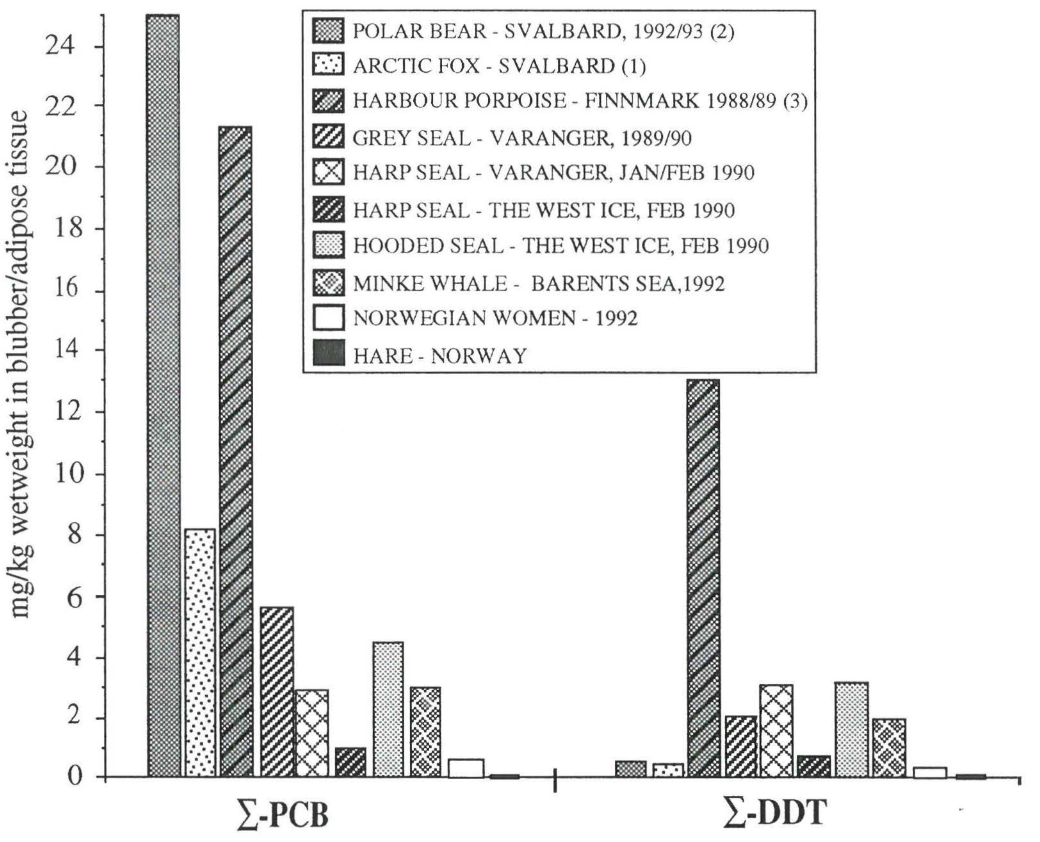

Figure 2: Mean levels of ΣPCB and ΣDDT in blubber/adipose tissue from different marine mammals from the Norwegian Arctic compared to corresponding levels in Norwegian women and hare. All samples but the samples of harbour porpoise, have been analysed using basically the same method of ΣPCB and ΣDDT identification and quantification at the Norwegian College of Veterinary Medicine/National Veterinary Institute. (1) Skaare *et al.*, in prep.; (2) Wang-Andersen *et al.*, 1993; (3) Kleivane *et al.*, in press.

The mammals from the marine environment, generally contained much higher levels of OCs compared to the terrestrial hare (*Lepus timidus*) and humans (Norwegian women). This difference between OC-contamination in the marine and most terrestrial environments has been known for a long time. Polar bear is a top predator in the marine food web, eating almost exclusively blubber of different seal species. This is reflected in the highest levels of ΣPCB among the animals listed in figure 2. The levels of ΣDDT in polar bear (and arctic fox) are in contrast the lowest levels found, probably caused by a different metabolizing capacity compared to the seals and the whales. The arctic fox (*Alopex lagopus*) from Svalbard are partly dependent on marine food sources (sea birds, ringed seal cubs and seal carcasses left by polar bears) and contains higher amounts of ΣPCB than a fox feeding on terrestrial food (Wang-Andersen *et al.*, 1993). The high levels of ΣPCB and ΣDDT found in harbour porpoises compared to the much lower levels in the grey seals, are difficult to explain. These two species are both feeding on fish in coastal waters, and should therefore undergo a similar exposure to OC-contaminants. The porpoise may have a different metabolizing system causing lower excretion rate than in the grey seals. Possible geographical diffrences in the OC-distribution through the Atlantic Arctic are seen when comparing harp seals from the Barents Sea region and from the West Ice area. Female harp seals from the West Ice contained 1/3 to 1/2 the levels of ΣPCB and ΣDDT found in animals from the Barents Sea (fig.2).

SEALS

Ranges of ΣPCB and ΣDDT levels (mg/kg wet weight) in blubber from 5 different seal species are given in Figure 3. Concentrations in all groups are lower compared to corresponding levels found in seal species from the Baltic (Jensen *et al.*, 1969; Paasivirta & Rantio, 1991; Blomkvist *et al.*, 1992) and the Wadden Sea (Reijnders, 1980; Storr-Hansen & Spliid, 1993), and are generally below 10 mg/kg. Harp seals from the West Ice (adult females) seems to be the least contaminated group with respect to these OCs, and contains half the levels found in adult hooded seal females caught at the same time of year and at the same location.

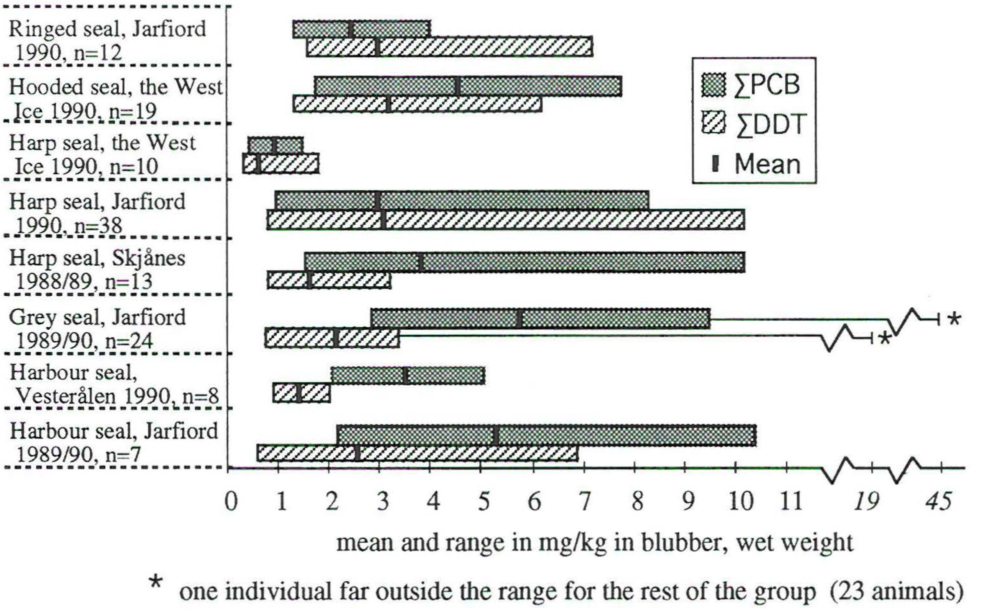

Figure 3: Mean and range levels of ΣPCB and ΣDDT (mg/kg wet weight) in blubber from different seal species from the Barents Sea region (caught on the coast of Finnmark) and from the West Ice areas.

These species differences within the same area are probably caused by different food preferences and different migration patterns. Seals sampled along the coast of northern Norway at the locations of Vesterålen, Skjånes and Jarfjord shows approximately the same range for ΣPCB with the lowest levels found in ringed seals and in harbour seals from Vesterålen. The lower levels in these harbour seals could reflect a possible decreasing gradient from south to north along the Norwegian coast with a small increase in seals caught near the Russian border (Figure 4). For grey seals the similar pattern is seen between animals from Vikna (mid-Norway) and Jarfjord where one male animal exceeding the range for the rest of the group with more than 4 times higher level of ΣPCB (45 mg/kg) (Figure 3 and 4). This individual could be a migrating seal from a more contaminated location in Russia, or the high OC-levels could be of coincidal character.

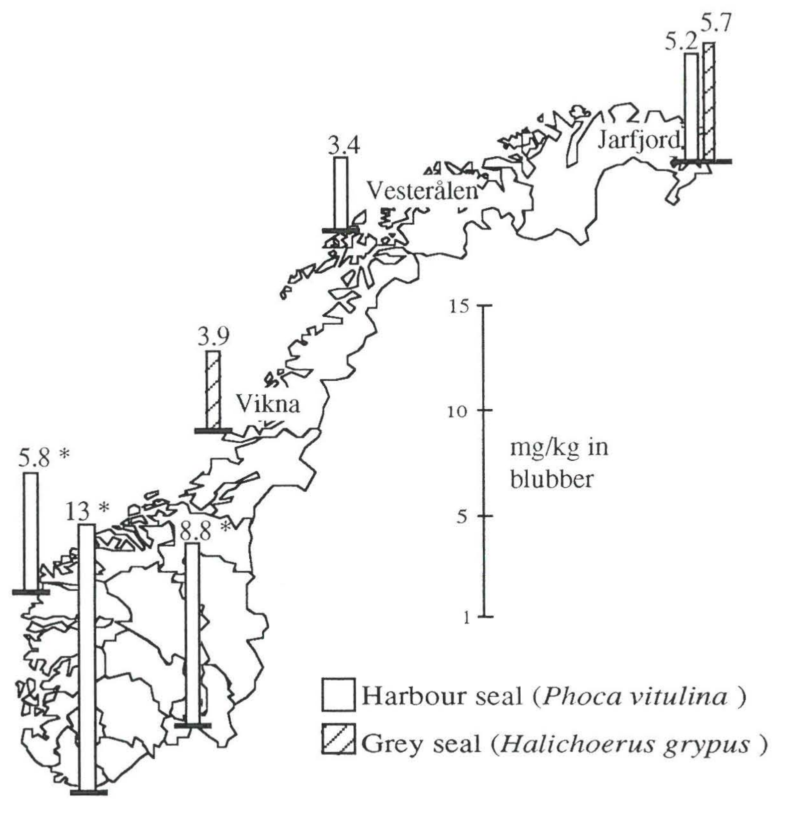

Figure 4: Mean levels of ΣPCB (mg/kg wet weight) in blubber from the two coastal seal species, harbour seal and grey seal caught along the Norwegian coast 1988 to 1990. (*) Skaare *et al.*, 1990.

The Arctic species, harp and ringed seal shot in Jarfjord, seems to be more contaminated with DDT-compounds compared to the two coastal seals (Figure 3). On average ringed seal and harp seal (juveniles, < 2 years of both) contained more ΣDDT than ΣPCB (Figure 3 and 5). Grey seals from Jarfjord and harbour seals from Vesterålen contained the lowest ΣDDT levels [range: 0.7 - 3.4 (19) and 0.9 - 2 mg/kg wet weight] relative to ΣPCB levels [range: 2.9 - 9.5 (45) and 2 - 5.1 mg/kg wet weight].

Age and sex aspects

No significant increase in the OC-levels with age for males, and no significant difference in OC-levels between sexes were found in any of the examined seal material. This can be explained by a balance between OC intake and OC excretion at the relatively low levels found in these animals. In harp seal, the juvenile animals (< 1 year) of both sexes from Jarfjord contained higher levels of all OCs compared to adults (> 6 years) (Figure 5). A similar pattern for ΣPCB levels was found in harbour seals (*Phoca vitulina*) from Denmark/Schlesvig-Holstein with a decrease from juveniles to subadults (Reijnders, 1980). Details on seasonal variation and some age aspects of OCs in the harp seal will be presented at this meeting (Espeland *et al.*, 1994).

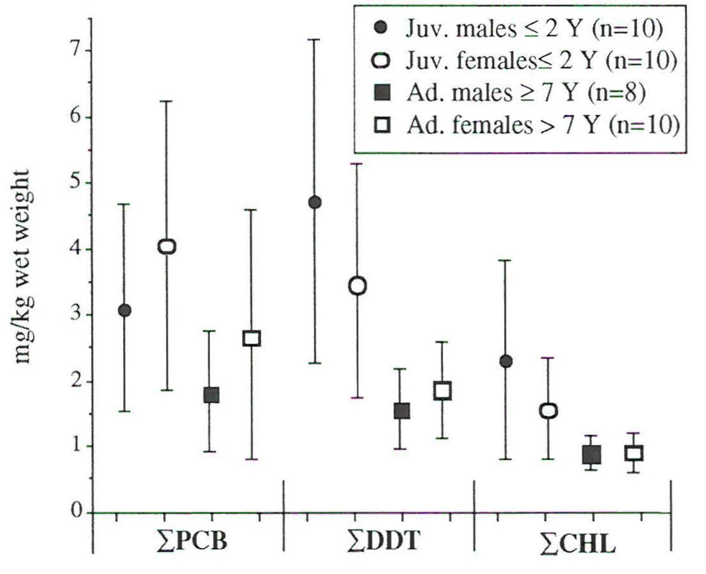

Figure 5: Mean levels and standard deviation of ΣPCB, ΣDDT and ΣCHL (mg/kg wet weight) in blubber from juvenile and adult harp seals caught in the Jarfjord January-March 1990.

WALRUS

The samples from walrus were taken as skin/blubber biopsies from live animals and it could be discussed if the OC levels obtained from these samples are comparable to the corresponding levels found in blubber samples from other seal species. The lipid content in the biopsies was very low, 0.3 - 5.9 % (Table 2) compared to 80 - 95 % in blubber samples from seals, probably due to the large thickness of the walrus´ skin which in some

Table 2: Percent lipid and levels of ΣPCB, ΣDDT and ΣCHL (mg/kg fat weight) in skin/blubber biopsis from 26 male and female walrus (*Odobenus rosmarus rosmarus)* taken from live animals at Svalbard 1992. Levels are given in mean (median) and range (min-max).

	% lipid in biopsis	mg/kg fat weight in biopsis of: ΣPCB	ΣDDT	ΣCHL
median	**1.41**	**8.88**	**3.46**	**1.61**
mean	***1.76***	***11.5***	***4.34***	***2.02***
range	(0.27 - 5.92)	(ND - 39.4)	(ND - 23.1)	(ND - 7.39)

cases can reach 6 cm at the neck (King, 1983). Levels of ΣPCB, ΣDDT and ΣCHL on fat weight (f.w.) basis were therefore generally high in some samples and close to the detection limit in those with low lipid content (Table 2). Mean and median as well as range values of OCs are generally higher compared to other seal species in the Barents Sea region.

Most walrus´ feed on a low trophic level on benthic animals like bivalve molluscs (*Mya truncata, Saxicava arctica, Serripes groenlandicus*), but some animals seem to eat young ringed seals or bearded seals (*Erignathus barbatus*) (King, 1983). This variation in diet at a low and at a high trophic level should be expected to give some variation in OC-levels and may be the explanation of some of the high levels of ΣPCB (39.4 mg/kg f.w.) and ΣDDT (23.1 mg/kg f.w.). Similar results have been reported by Segstro *et al.*, (personal communication, D.C.G. Muir) in walrus from the Canadian Arctic.

MINKE WHALE

Table 3: Levels of ΣPCB and ΣDDT (mg/kg wet weight) in blubber from male and female minke whales (*Balaenoptera acutorostrata*) from the Norwegian scientific catches along the northern Norwegian coast and in the Barents Sea region during 1988/89 and in 1992. Levels are given in mean (median) and range (min-max).

Year	**ΣPCB:**		**ΣDDT:**	
numbers	Males	Females	Males	Females
1988/89 n=17/20	**2.7 (2.3)*** (0.63 - 5.93)	**1.1 (1.0)** (0.47 - 1.94)	**2.3 (1.9)** (0.54 - 5.79)	**1.2 (1.2)** (0.49 - 5.93)
1992 n=31/30	**3.7 (3.3)** (0.54 - 8.28)	**2.0 (1.9)** (1.13 - 4.05)	**2.4 (2.2)** (0.46 - 4.86)	**1.4 (1.2)** (0.57 - 2.88)

* **mean (median)**
(min - max)

No significant difference ($p>0.05$, Wilcoxon signed-rank) in ΣPCB and ΣDDT levels was found between minke whales caught during 1988/89 and in 1992 (Table 3). Minke whales from the Norwegian scientific catch in 1992 were shot at 5 different locations off the coast of northern Norway and in the Barents Sea area (names of locations in Figure 6A/B). Mean levels of ΣPCB, ΣDDT and ΣCHL in blubber samples were generally higher in males than in females when comparing all 61 animals (31 males and 30 females) caught in 1992. Females from Finnmark/Kola contained lower levels (significant, $p<0.05$, Wilcoxon signed-rank) of ΣDDT and ΣCHL compared to the Svalbard group (Figure 6B). For males, higher levels of OCs were found in animals taken around the Bear Island, compared to animals from the coast of Finnmark (significant, $p<0.05$) to the Kola peninsula (Figure 6A).

Age was not available for these animals when this was written, but according to animal length, the male whales from the Bear Island seem to be older than the other male groups, which could be a reasonable explanation for the higher OC-levels. Migration to different locations in southern areas north of the Equator in the winter time, may also influence the OC-levels. The composition of DDT-components in the male groups also showed a different pattern for the animals caught around the Bear Island. The relative amount of the metabolite *p,p´*- DDE is conciderably lower in these animals compared to the two other groups (Figure 7). This lower proportion of *p,p´*- DDE also indicates different exposure to OCs for this group of males.

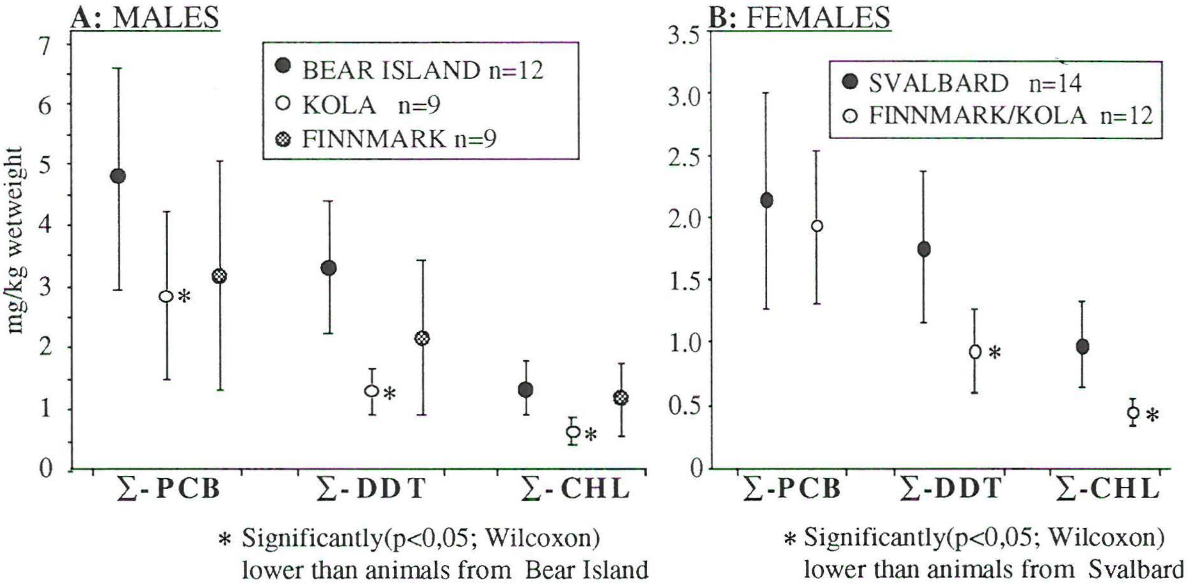

Figure 6 A/B: Mean levels and standard deviation of ΣPCB, ΣDDT and ΣCHL (mg/kg wet weight) in blubber from **A:** males and **B:** females of minke whales shot at different locations off northern Norway and in the Barents Sea region during the Norwegian scientific catch in 1992. Note: Different scale on the y-axis for males (0 - 7 mg/kg) and females (0 - 3.5 mg/kg).

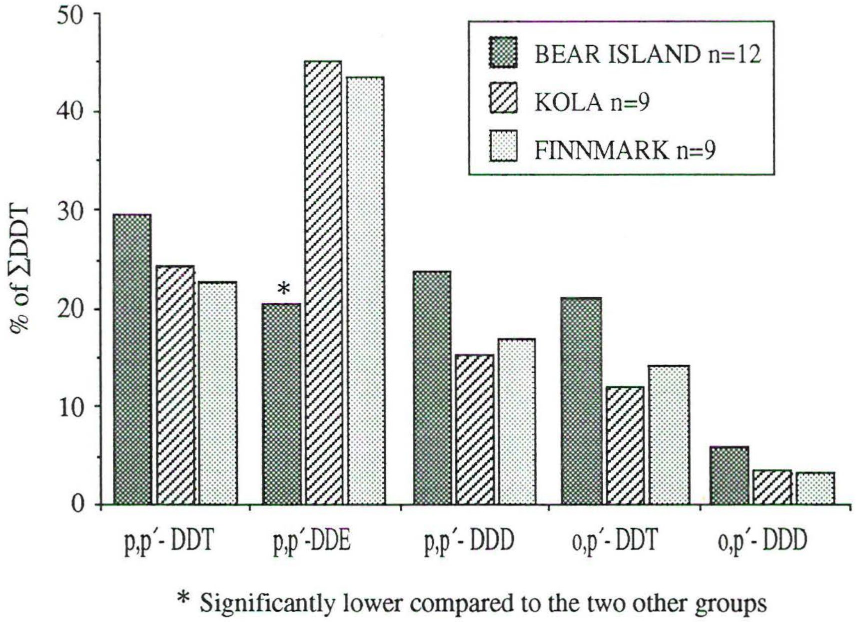

Figure 7: Mean relative amounts (% of ΣDDT) of *p,p´*- DDT, *p,p´*- DDE, *p,p´*- DDD, *o,p´*- DDT and *o,p´*- DDD in blubber from male minke whales caught at three different locations in the Barents Sea region during the Norwegian scientific catch in 1992.

Comparing OC levels in minke whales caught in the Barents Sea region with OC levels in other marine mammals in this area are to a certain degree possible. But the different migration during winter time to areas along the coast of Africa, north of the Equator for the whales in contrast to the stationary seals, has to be taken into consideration. However, the minke whale is known to feed mainly on fish along the Norwegian coast during spring-autumn (Lydersen *et al.*, 1991) and is thereby placed at the same stage of the food web as most seal species. This is also reflected in similar OC levels between minke whale and most seal species in the Barents Sea area (Figure 3 and 6).

POLAR BEAR

The polar bear is at the top of the marine food chain, and is an important indicator of the existing bioaccumulation of persistent pollutants in the Arctic biota. Biopsies of subcutaneous fat from adult male polar bears (≥ 7 years) at Svalbard 1990-1993 contained the highest mean levels of ΣPCB (28 mg/kg fat weight, Table 4) among the examined animals in this paper (Skaare *et al.*, in prep.). The PCB levels were comparable to the corresponding levels found in polar bears from Svalbard between 1978 amd 1989 (Norheim *et al.*, 1992) but were higher compared to corresponding levels in pooled polar bear samples from the Canadian Arctic (3 - 8 mg/kg fat weight) (Norstrom *et al.*, 1988).

Table 4: Levels of ΣPCB and ΣDDT (≈100% *p,p´*- DDE) (mg/kg fat weight) in subcutaneous fat (biopsis) from polar bears caught alive at Svalbard during 1990-93. Levels are given in mean (median) and range (min-max). (Skaare *et al.*, in prep.).

	ΣPCB	**ΣDDT** (ppDDE)
Juveniles, 1-2 years	**10.4 (8.66)**	**0.64 (0.53)**
males/females, n=5	(4.81 - 16.1)	(0.30 - 1.12)
Subadults, 3-6 years	**16.7 (13.5)**	**0.32 (0.25)**
males/females, n=20	(5.45 - 36.7)	(<0.002- 0.86)
Adult females,	**14.9 (9.19)**	**0.34 (0.28)**
≥7 years, n=19	(3.23 - 41.5)	(<0.002- 1.22)
Adult males,	**27.8 (23.9)**	**0.28 (0.24)**
≥7 years, n=16	(8.50 - 57.5)	(<0.002- 1.01)

ΣPCB levels were significantly higher ($p<0.05$, Tukey-Kramer) in adult males compared to adult females (≥ 7 years). The OC pattern in the polar bear is unique among mammals (Boon *et al.*, 1991; Norheim *et al.*, 1992). This is especially clear with regard to the metabolism of DDT, where the biomagnification factor (BMF) from prey to predator is below 1 (BMF<1) (Muir *et al.*, 1988; Boon *et al.*, 1991; Norheim *et al.*, 1992). In Figure 8, this is illustrated were levels of ΣPCB and ΣDDT in ringed seal (important prey, especially blubber) and polar bears are compared. Furthermore, relatively high levels of oxychlordane are detected in the polar bear population at Svalbard (Norheim *et al.*, 1992; Skaare *et al.*, in prep.). The same chlordane component was also registerd at relatively high levels in an other Arctic mammal inhabiting Svalbard, the arctic fox (Wang-Andersen *et al.*, 1993). Among industrial waste products, very low levels of PCdioxin congeners

(PCDDs) and no detectable amounts of PCdibenzofurans (PCDFs) were found in polar bears from Svalbard (Oehme *et al.*, 1988).

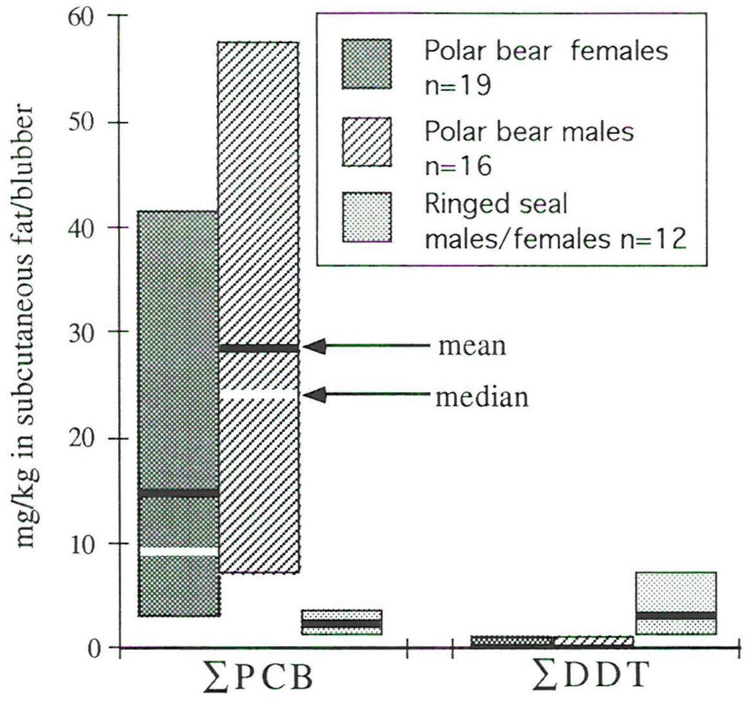

Figure 8: Mean levels (and standard deviation) of ΣPCB, ΣDDT and ΣCHL in subcutaneous fat biopsis of male and female polar bear (mg/kg fat weight) from Svalbard 1992/93 compared to corresponding levels the possible food item: blubber samples of ringed seal (mg/kg wet weight) from the Jarfiord, northern Norway 1990.

PCB CONGENER PATTERNS

Interspecies differences were found in PCB congener pattern depending mainly on differences in prey preferences and metabolizing capacity. However, in this presentation no detailed discussion will be given as to the differences observed. Figure 9 shows the mean relative amounts of a selected group of the most abundant PCB-congeners in minke whale, grey seal, harp seal and polar bear. Large differences are found between the sea living animals and polar bear with a tendency of increased accumulation of PCB-153 (2,2´,4,4´,5,5´-hexaCB) and the higher chlorinated congeners; PCB-180 (2,2´,3,4,4´, 5,5´- heptaCB), PCB-170 (2,2´,3,3´,4,4´,5,-heptaCB) and PCB-194 (2,2´,3,3´,4,4´, 5,5´-octaCB) in the polar bears.

Of the most toxic congeners analysed in the present work, the mono-*ortho* substituted PCBs, PCB-118 (2,3´,4,4´,5-pentaCB) and PCB-105 (2,3,3´,4,4´-pentaCB) seem to be eliminated in the bears compared to the relatively high amount found in the grey seal, harp seal and minke whale. In contrast the mono-*ortho* congeners PCB-156 (2,3,3´,4,4´,5-hexaCB) and PCB-157 (2,3,3´,4,4´,5´-hexaCB), seem to appear in more equal amounts in the four species (Figure 9). Three of the most accumulated congeners in polar bear (PCB-153, -180, -194) contains no vicinal hydrogen atoms, a criterion for epoxidation and further metabolizing in the animals (Boon *et al.*, 1991).

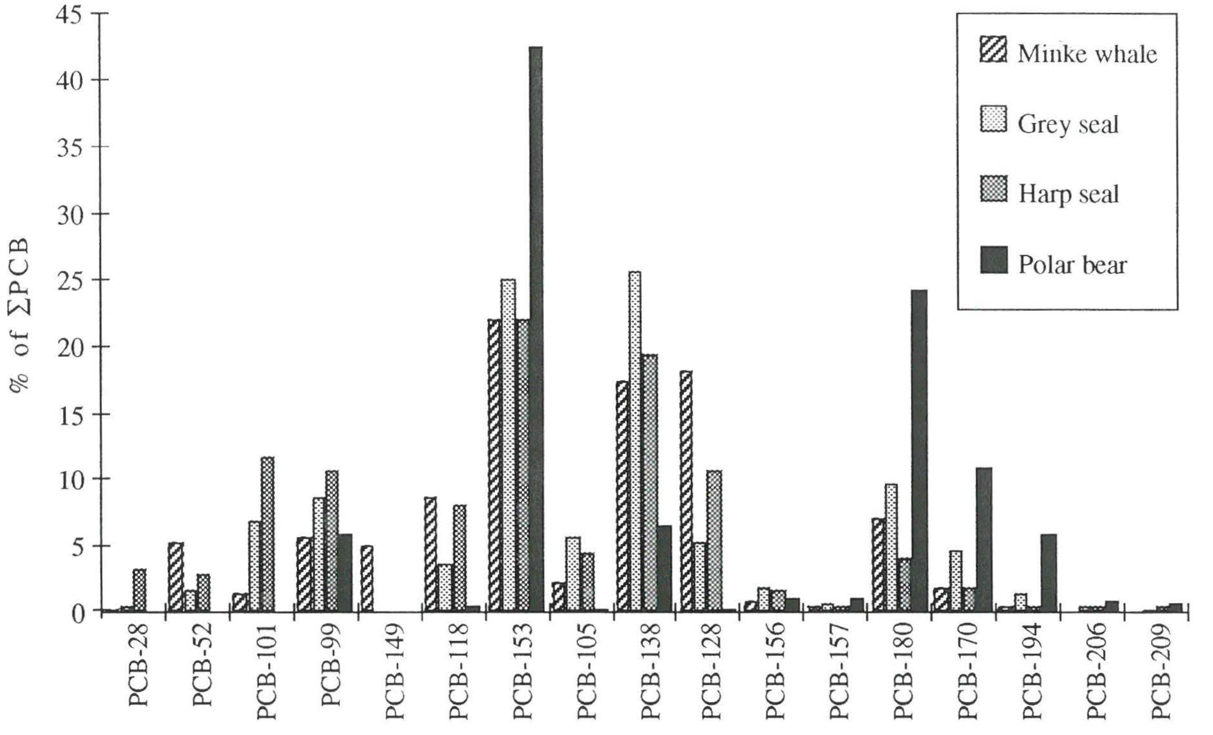

Figure 9: Mean PCB-congener pattern (percentage contribution of each PCB congener to ΣPCB) in both sexes of minke whale (1992), grey seal (1989/90) and harp seal (1990) caught off the coast of Finnmark, Norway and polar bear (1992/92) caught at Svalbard.

In the seals, PCB-153 and PCB-138 (2,2´,3,4,4´,5´-hexaCB) are the two most abundant congeners contributing between 20-25 % each to the ΣPCB (Figure 9). The PCB congener pattern in the minke whale differs from that of seals in that they contain more of PCB-52 (2,2´,5,5´-tetraCB), PCB-149 (2,2´,3,4´,5´,6-hexaCB, only found in minke whales) and PCB-128 (2,2´,3,3´,4,4´-hexaCB). This difference in PCB congener pattern between minke whales and seals in spite of some similarities in food sources, could be explained by the migration of the whales and probably a completely different exposure to PCB congeners during the winter. In addition, differences in metabolizing capacity may also play a role.

SUMMARY

Levels of OCs in marine mammals from the Norwegian Arctic reported in this paper are on a general basis moderate to low in different seal species and minke whale (< 10 mg/kg in blubber). However, high levels of particularly PCBs, were found in polar bear at Svalbard (3-57 mg/kg in fat) and harbour porpoise caught in Tufjord, Finnmark (21 mg/kg in blubber).The present results reveal a further need for monitoring the input of OCs to the Arctic fauna. The ongoing studies on polar bears at Svalbard (Skaare & al., in prep.) and grey seals at Froan (Jenssen & al., 1994) using blood samples and blubber/fat

biopsies from live animals, makes monitoring of animals from small populations possible avoiding unnecessary killing. Monitoring animals from larger stocks (minke whale, harp seal, hooded seals, ringed seals) should be possible in the future in combination with catching activities. Studies on the possible effects of OC body burden on the different species, particularly the more contaminated polar bear and harbour porpoise, should be encouraged.

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