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International Council
for the Exploration of the Sea.

C.M. 1971/N:10
Marine Mammals Committee

ORGANOCHLORINE RESIDUES IN SEALS IN THE NORTH SEA

by

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Introduction

In an earlier report to ICES[1], the presence of high concentrations of organochlorine pesticide residues in seals and porpoises on both sides of the Atlantic and in the North Sea was recorded. A later report to FAO[2] gave additional data on the concentrations of polychlorinated biphenyls (PCBs) in seals, as obtained by an improved analytical technique. The concentrations of both pesticides and PCBs increase in a north-to-south direction from the Arctic down the east coast of Canada, and down both the west and east coasts of the United Kingdom. The southeast and the northwest coasts of England, and also the Baltic, are areas where high concentrations of both DDT and PCB residues are found.

This report summarises the data so far obtained on seals in the North Sea area, and compares them with analyses from seals in the Norwegian Arctic and the Baltic.

Methods

Most of the samples were obtained from seals killed in culling operations, or captured in salmon nets. A few have been from seals found dead. For analyses, blubber has been used, organochlorine compounds being preferentially concentrated in lipids. The samples were deepfrozen prior to analyses, with the exception of a few samples obtained outside the United Kingdom. The latter samples were immersed in 5% aqueous formalin for one-two days, and the formalin drained off before despatch by post, being deep-frozen on receipt.

The analytical technique, involving hexane extraction, removal of fats, separation of PCBs from most pesticide residues, and gas chromatographic analyses, was described in an earlier paper[2]. The commercial PCB formalin Aroclor 1254 (Monsanto Limited) has been used to calculate PCB concentrations, being the type considered to proximate the PCB pattern in seals most closely, although there is some difference in the pattern in most samples.

Results and Discussion

The data obtained are summarised in Table 1. Although three different species are included, and in several instances numbers of individuals are small, a trend in contamination level from north to south can be seen. The concentrations given for ringed seals in the Norwegian Arctic area are similar to those found in samples from the Canadian Arctic. Harp seal pups from east of Jan Mayen Island were also found to contain similar levels. The common seal pups from Shetland contained marginally more PCBs, but the Orkney grey seals were significantly higher in both DDT-group and PCB residues. The seals from the Scottish east coast were still higher in all three types of residues, and farther south, off the coast of East Anglia, the highest concentrations of both total DDT and PCBs were found.

The trend in contamination levels follows roughly the degree of industrialisation in the adjacent land areas. Sewage sludge containing industrial wastes is one known source of PCBs in the marine environment, and it has been estimated[3] that approximately 1 ton of PCBs could be dumped per annum in sludge outside the Thames estuary.

The concentration of organochlorine residues in individual seals will be dependent on the concentration in food, and on the quantity of food eaten, and in addition on rates of metabolism and excretion of the various compounds. It is commonly found in birds and terrestrial mammals that an equilibrium is reached between the concentration in food and that in the consumer, the latter concentration being dependent to some extent on physical condition, and the lipid level in the body. As lipid reserves are utilized during periods of stress, the stored organochlorines are recirculated and may produce toxic effects, while also being subject to some degradation or excretion.

In seals certain differences are apparent, as compared with residue levels found in birds and terrestrial mammals. The major difference is in the proportion of DDT found, compared with that of its two degradation products, TDE and DDE. The DDT residues in seals have in many instances been confirmed by alcoholic alkaline hydrolysis to DDE. Jensen et al[4] also found that up to 50% of the total DDT in Baltic seals was in the form of p,p̄-DDT. In other warm blooded animals DDE is the major residue, DDT being a minor component. Cod and salmon, on which grey seals feed, do not show the same high proportion of DDT as is found in the seals.

One difficulty in explaining the apparent difference between seals and other species is that the samples of seal blubber used in the analysis cannot be assumed to represent blubber from all regions of the body. It is possible that a proportion of the blubber is never recirculated, and therefore not representative of an equilibrium state (between blubber and mobile lipid) existing at the time of sampling, but at some earlier date. However, analysis of several organs or tissues, of different lipid contents, from one seal generally gives similar concentrations of a particular organochlorine compound when expressed in terms of extractable lipid rather than original tissue. This suggests that the subcutaneous fat is not different from the lipid in other parts of the body.

As it is inconceivable that the seals can synthesise DDT from its metabolites, the higher proportion of DDT in seals, as compared with their food, may result from a preferentially greater excretion rate of DDE and TDE. The degree of accumulation of organochlorines, from food fish to seal blubber can be some 50 to 200 times, but on a lipid basis the accumulation from fish to seals is usually less than ten-fold. Thus, a seal eating several hundred times its own weight, over a period of years, even with a partial excretion or metabolism of residues, could accumulate residue concentrations such as those found in the seals examined.

The only other data published on seals from the North Sea area appear to be those of Koeman and van Genderen[5], who found 9.6-27.4 ppm of total DDT (uncorrected for PCBs) in the fat of three common seals from the Netherlands coast. These values are similar to those given in this report for the East Anglian seals. The data of Jensen et al[4] on Baltic seals are compared in Table 2 with grey seal data from the North Sea, showing that while the DDT levels are similar, PCB levels are significantly greater in the North Sea area.

Although dead or dying seals have been found to contain very high concentrations of residues in their fat, there is as yet no evidence that the organochlorines have themselves been responsible for the condition of the seals. Nevertheless a seal weakened by starvation or disease, and absorbing a high proportion of its blubber, may be subjected to the additional stress of high concentrations of organochlorine compounds in the lipid fraction of the blood.

Where samples of seal blubber become available either through culling operations or from dead seals, analysis of such material may be useful in indicating the level of contamination of the particular marine environment by organochlorine compounds. However, in many areas of the North Sea, particularly in some coastal regions, seals, whatever the species, may be comparatively rare and may be protected. In such areas it will be difficult to obtain sufficient numbers of samples for analysis. Furthermore seals, in common with many other marine species, may travel considerable distances during migration, and consequently the degree of contamination should not be identified too closely with the actual location at the time of sampling. This is a fundamental difficulty in selecting any species as suitable for monitoring pollution, but seals have the virtue, from this standpoint, of accumulating high concentrations of some pollutants, a factor of some importance to the analyst.

References

1.	Holden, A. V.	1969	ICES, C.M. Fisheries Improvement Committee Doc. No. E:22, (mimeo).
2.	Holden, A. V.	1970	Proceedings of FAO Technical Conference on Marine Pollution, Rome. Paper FIR:MP/E-63.
3.	Holden, A. V.	1970	Nature, 228, 1220.
4.	Jensen, S., Johnels, A. G., Olsson, M. and Otterlind, G.	1969	Nature, 224, 247.
5.	Koeman, J. H. and van Genderen, H.	1966	J. appl. Ecol., 3(Suppl.) 99.

TABLE 1

Organochlorine residues in seal blubber samples from the North Sea
(Means and ranges in parts per million tissue)

Source	Species	No.	% Fat	Dieldrin	DDE	TDE	DDT	PCB
Arctic (Norway)	Ringed	2	84 (75 - 92)	0.18 (0.15 - 0.20)	0.8 (0.7 - 0.8)	0.24 (0.18 - 0.30)	1.4 (0.9 - 1.8)	1.5 (1 - 2)
Shetland	Common (pups)	4	80 (69 - 88)	0.06 (0.06 - 0.07)	1.3 (0.7 - 1.7)	0.13 (0.08 - 0.18)	1.2 (0.8 - 1.7)	4 (2 - 6)
Orkney	Grey	8	69 (43 - 90)	0.18 (0.06 - 0.31)	6.4 (1.4 - 12.1)	0.60 (0.17 - 0.97)	6.0 (1.3 - 11.0)	18 (3 - 30)
E. Scotland (Aberdeen - Montrose)	Grey	16	77 (45 - 91)	0.83 (0.46 - 1.7)	9.7 (4.2 - 19.1)	0.93 (0.54 - 1.5)	9.5 (3.8 - 15.7)	38 (12 - 88)
E. England (Farne Is.)	Grey	1	78	0.5	3.0	0.9	9.0	67
	Grey (pups)	5	81 (67 - 87)	0.46 (0.20 - 0.59)	6.6 (3.3 - 10.3)	0.86 (0.46 - 1.17)	5.6 (2.6 - 7.6)	40 (25 - 50)
(Wash)	Common (pups)	12	71 (66 - 80)	0.33 (0.16 - 0.66)	2.8 (1.4 - 4.1)	0.44 (0.28 - 0.73)	3.3 (1.8 - 4.9)	15 (7 - 24)
(Scroby)	Grey	2	79 (76 - 82)	2.3 (1.8 - 2.8)	16.4 (10.1 - 22.6)	2.6 (1.3 - 3.8)	20.7 (15.7 - 25.7)	123 (100 - 146)
	Common	3	83 (74 - 89)	0.23 (0.19 - 0.26)	14.0 (7.3 - 23.2)	0.83 (0.75 - 0.89)	9.1 (7.6 - 10.3)	131 (93 - 185)

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TABLE 2

Comparison of DDT and PCB residues in North Sea and Baltic seals
(Concentrations in parts per million blubber)

Source	Species	No.	% Fat	Total DDT	PCB
Gulf of Finland	Grey (pups)	2	60	25	3.9
Gulf of Bothnia	Ringed	2	54	63	6.8
Stockholm Archipelago	Grey	3	27	36	6.1
Baltic proper	Common and Grey	2	52	66	15
Orkney	Grey	8	69	13	18
E. Scotland	Grey	16	77	20	38
E. England Farne Is.	Grey (pups)	5	81	13	40
Scroby	Grey	2	79	40	123