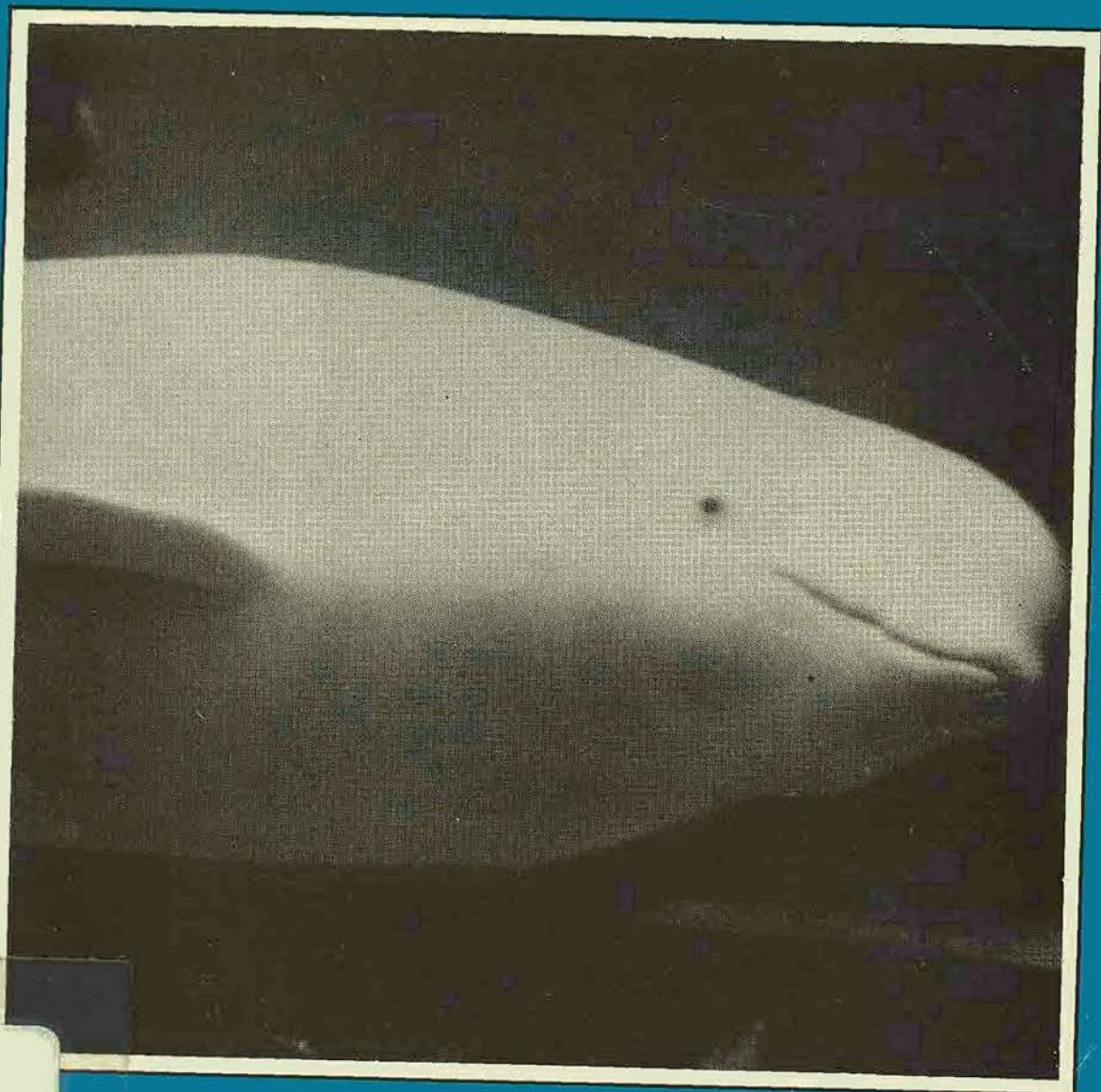


# Review of Contaminants in Marine Mammals



Marine Mammal  
Technical Report Number 2



1991

**ICES/IOC/UNEP  
REVIEW OF CONTAMINANTS IN  
MARINE MAMMALS**



Compiled and edited for

United Nations Environment Programme  
Oceans and Coastal Areas  
Programme Activity Centre  
P.O. Box 30552  
Nairobi, Kenya

UNEP. 1991. ICES/IOC/UNEP Review of Contaminant in Marine Mammals.  
United Nations Environment Programme, Nairobi

This document has been prepared by an ICES/IOC Group, which finalized its work at a meeting in Copenhagen on 18-20 May 1987, funded by UNEP. The document was thereafter reviewed by the ICES Advisory Committee on Marine Pollution and approved, with minor amendments. The text contained herein is that of the final document, which will be published in due course.



The preparation of this document has been commissioned by the Oceans and Coastal Areas Programme Activity Centre (OCA/PAC) of the United Nations Environment Programme (UNEP) under project FP/5102-86-02.

The designations employed and the presentation of the material in the document do not imply the expression of any opinion whatsoever on the part of UNEP, ICES or IOC concerning the legal status of any State, Territory, city or area, or its authorities, or concerning the delimitation of its frontiers or boundaries. The document contains the views expressed by the authors acting in their individual capacities and may not necessarily reflect the views of UNEP, ICES or IOC.

For bibliographic purposes, this document may be cited as:

Contaminants and marine mammals: a review. Marine Mammal Technical Report Number 3. UNEP/ICES/IOC, Nairobi 1991. Copyright: 1991 United Nations Environment Programme

Reproduction of this publication for education or other non-commercial purposes is authorized without prior written permission from the copyright holder.

Reproduction for resale or other commercial purposes is prohibited without the prior written permission of copyright holder.

ISBN 92-807-1277-2

Available from: United Nations Environment Programme  
Oceans and Coastal Areas  
Programme Activity Centre  
PO Box 30552  
Nairobi, Kenya

## Preface

The Governing Council of the United Nations Environment Programme (UNEP) adopted on 28 May 1984 the Global Plan of Action for the Conservation, Management and Utilization of Marine Mammals as a timely and valuable framework for policy planning and programme formulation by the international community.

The Plan covers five areas of concentration, namely: policy formulation; regulatory and protective measures; improvement of scientific knowledge; improvement of law and its application and enhancement of public understanding; and a series of 38 recommendations.

One of the recommendations of the Action Plan, no. 8, calls on UNEP and the Food and Agriculture Organization (FAO) to commission a consultant to study and review what is known about the contamination of marine mammals and to invite the International Council for the Exploration of the Sea (ICES) and the Intergovernmental Oceanographic Commission (IOC) to cooperate in the preparation of a review of information about occurrence of contaminants in marine mammals tissue.

At the Second Consultative Meeting on the Protection of Marine Living Resources Geneva (Gland), 28-30 October 1985, ICES and IOC agreed to undertake the review related to recommendation 8. The review was finalised at a meeting in Copenhagen, 18-20 May 1987, with the scientists who participated in the working group. The document has been reviewed and approved for publication by the ICES Advisory Committee on Marine Pollution.

The report is available from UNEP, ICES and IOC free of charge to anyone actively involved in marine mammals conservation. Any corrections, amendments or suggestions for improvements should be forwarded to:

Director  
Oceans and Coastal Areas Programme Activity Centre (OCA/PAC)  
United Nations Environment Programme P.O. Box 30552  
Nairobi, Kenya

It is the joint hope of UNEP, IOC and ICES that this review of contaminants in marine mammals will prove a significant contribution to the implementation of the Global Plan of Action for the Conservation, Management and Utilization of Marine Mammals.



# INTRODUCTION

As part of its Global Plan of Action for the Conservation of Marine Mammals, UNEP recommended that a review of the effects of environmental contaminants on marine mammals should be conducted. It was suggested that ICES should be approached to conduct this review. In 1985 ICES and IOC agreed to carry out such a review, and this document was prepared by members of appropriate Working Groups of ICES and IOC with financial support from UNEP. In addition, ICES convened a Joint Meeting of Biologists and Chemists Concerned with Contaminants in Marine Mammals in Copenhagen in February 1987. That meeting was primarily concerned with sample collection and analysis and the need for intercalibration. The report of the meeting is attached as Annex 2.

In this document, the known and suspected effects of various classes of contaminants on marine mammals are reviewed. The document then considers in more detail the evidence linking organochlorine contamination with reproductive and immunological disruption in marine mammals, evaluates the problems in interpreting this evidence and suggests what further work is necessary to clarify the situation. The document speculates about future changes in environmental levels of key contaminants and the effects these may have on marine mammals. It then makes suggestions about procedures for the collections and analysis of material from marine mammals. Finally, some recommendations are made for further research and management action.

## CONTAMINANTS AND THEIR EFFECTS

Marine mammals are usually top predators and are, therefore, the ultimate victims of any bioaccumulation process. In addition, most species have large stores of fat, which act both as an insulating layer and as an energy reserve, in their blubber. Lipophilic contaminants can accumulate in this tissue and may then be released at high concentrations when the energy reserves are mobilized. These factors may make marine mammals particularly vulnerable to the effects of certain types of contaminant.

For the purpose of this review, environmental contaminants can be conveniently divided into three classes: contaminants known to affect other vertebrates but which we believe do not directly affect marine mammals; contaminants known to affect other vertebrates and which are implicated as the cause of certain anomalies in marine mammal populations; and contaminants whose effect on vertebrates is, at present, poorly known but which, by analogy with other compounds which are known to be harmful, may be important in the future. Each of these classes will be briefly reviewed in the following paragraphs.

## Contaminants known to be important for other vertebrates but considered to be less important for marine mammals

Many trace metals are known to have physiological effects on vertebrates. Levels of these metals (and also organochlorines) in marine mammals from the northern hemisphere have been reviewed by Wagemann and Muir (1984). Levels of mercury and cadmium in excess of 400 mg/kg have been recorded in seals, sometimes from remote areas. Although mercury is usually present in fish as methyl mercury, its most toxic form, this forms only a small proportion of the mercury that is found in seal and whale tissue. It has therefore been suggested that marine mammals have some mechanism for de-methylating methyl mercury. Certainly there is experimental evidence that seals can tolerate a relatively high intake of methyl mercury (Ronald et al., 1975; Ronald and Tessaro, 1976; Tessaro and Ronald, 1976). In addition, Koeman et al. (1973 and 1975) found that mercury and selenium were present in equimolar concentrations in the liver and brain of a wide range of marine mammals. Selenium is known to protect against some of the toxic effects of mercury. There have been a few cases where marine mammals have received chronically high levels of trace metals from a local discharge and subsequently died. For example, eight common seals (*Phoca vitulina*), that had been found dead in a period of two weeks in 1969 in a certain area in the Netherlands, probably died as the result of a local accidental discharge of a mercury contaminated disinfectant used for agricultural purposes (Koeman et al., 1971).

There is little evidence of hydrocarbon spillage effecting marine mammals. There are a few anecdotal reports of grey seal (*Halichoerus grypus*) pups becoming encased in tar and drowning, and it likely that the baleen plates of mysticete whales could become fouled if they were to surface in the middle of an oil slick. Coastal-dwelling seals, especially pups, may be vulnerable to the ingestion of heavy oils, and gastric ulceration as a result of this has been recorded in French common seals (Babbin and Duguay, 1985). However, none of these events appears to occur with worrying frequency. The possible consequences for marine mammals of habitat damage caused by oil spills will not be considered further in this document.

## Contaminants known to be important for other vertebrates and suspected of being important for marine mammals

Organochlorines, particularly the polychlorinated biphenyls (PCBs) and the DDT family, but also chlorinated camphenes, dichlorobenzenes, dibenzofurans and dioxins, are known to be important and persistent environmental contaminants. Some of the breakdown and combustion products of these compounds are also known to be toxic. All these compounds are lipophilic and may, therefore, accumulate in the fatty tissue of marine mammals and their prey. From laboratory experiments on species other than marine mammals, these compounds are known to interfere with both the hormonal and immune systems. These compounds are known to induce microsomal enzyme activity in liver; this



may disrupt stero-idogenesis or catabolism of steroid hormones, and may have an effect on reproduction and the immune system. This evidence will be reviewed in detail in the section on *Experimental studies on effects of organochlorines on other mammals*.

High levels (in excess of 100 mg/kg) of these compounds have been recorded in the blubber of a number of marine mammals. In several cases, these high levels have been associated with reproductive abnormalities and complex disease syndromes. The evidence for a direct link between these two phenomena will be reviewed in more detail later. However, although there are problems in interpreting some of the data, the weight of evidence is sufficient to suggest that organochlorines are a principal cause of reproductive failure in marine mammals.

## **Contaminants which may be important for marine mammals**

There are a number of organic compounds whose structures are sufficiently similar to the chlorinated biphenyls that they might be expected to have similar effects. Other compounds which may be important are the diphenyl sulfones, the chlorinated xanthenes, chlordanes, chlorinated naphthalenes, and chlorinated products from the wood and paper pulp industry (see Section 8 of Annex 2).

# **ORGANOCHLORINE CONTAMINATION AND MARINE MAMMALS**

There are four cases where organochlorine pollution has been implicated as a cause of reproductive or disease problems in a marine mammals population: Californian sea lions; harbour seals in the Dutch Wadden Sea; ringed, grey and harbour seals in the Baltic Sea; and beluga whales in the St. Lawrence River in Canada. Each of these cases will be reviewed separately.

## **Californian sea lions**

In the early 1970s, sea lions (*Zalophus californianus*) in southern California exhibited a high rate of premature births. In females producing full-term pups, PCB and DDE residue levels in blubber tissue were 6.6 and 8.0 times lower, respectively, than those in females giving birth prematurely (DeLong et al., 1973). In the same population, a considerable number of animals showed a *Leptospira* infection, which is known for its pregnancy interrupting properties (Gilmartin et al., 1976). Studies on enzymes, which could indicate an effect of *Leptospira* on reproductive success, did not reveal a conclusive finding on the



unique role of that pathogen (Martin et al., 1976). An observed imbalance in the atomic ratio of Hg-Br-Se further complicated the picture (Martin et al., 1979).

It has been suggested that the immunosuppressive properties of PCBs - probably enforced by the DDT family (Friend and Trainer, 1970) - and the effect of *Leptospira* on liver function and reproductive performance could have caused premature pupping. Howard et al (1983) also suggested that immunosuppression in marine mammals of the Californian coast could have been caused by organochlorines.

In summary it can be concluded that the occurrence of premature pupping is clearly related with high blubber concentrations of PCBs and DDE. It is not possible, however, on the basis of the information at present available, either to separate the effects of high PCB and DDE residue concentrations from the occurrence of *Leptospira* infection or to draw conclusions on the combined effect of these factors.

## Harbour seals in the Dutch Wadden Sea

The population of harbour seals in the Dutch part of the Wadden Sea has collapsed in the past 35 years. The original decline was due to overhunting, but studies of population dynamics in different parts of the Wadden Sea (Reijnders, 1978) revealed that in the last two decades pup production was very low in Dutch harbour seal populations compared with the stable population in Schleswig Hostein (Federal Republic of Germany). A comparative toxicological study on levels of heavy metals and selected organochlorines (Reijnders, 1980) in tissues of seals from the western and northern parts of the Wadden Sea showed that the main difference was the ability of PCBs to interfere with mammalian reproduction led to the hypothesis that PCBs might be responsible for the lowered pup production in the Dutch seal population.

To test this hypothesis, two experiments were started at the Research Institute for Nature Management in the Netherlands. In the first experiment, two groups of seals were fed a natural diet differing in levels of PCBs. Group 1 received fish from the western part of the Wadden sea and group 2 received fish from the Atlantic, resulting in a seven-fold higher daily intake of PCBs in group 1. The reproductive success, after approximately two years, was significantly lower in group 1 than in group 2. Blood samples were taken regularly for hormone analyses to detect which phase of the reproductive cycle was affected and also whether hormonal regulation as such was affected. The hormone studies showed that the reproductive cycle was interrupted in the post ovulation phase, around the time of implantation (Reijnders, 1986).

Concurrently, three groups of mink were respectively fed a standard diet, a standard diet plus a mixture of refined commercial PCBs (Clophen A60 and A30), and a standard diet plus the same fish from the western part of the Wadden Sea which were fed to the seals. The results showed that reproduction was inhibited at very low levels of PCB intake (25

micrograms per day). Moreover, the effects of commercial PCBs were identical to those of the fish from the Wadden sea.

After completion of the first experiment, group 1 received 'clean' Atlantic fish for approximately 1 1/2 years. Preliminary results show that the reproductive success increased in that period, implying that the adverse effect of the polluted fish is, to some extent, reversible.

In summary, it is concluded that the low pup production in the Dutch harbour seal population is related to feeding on fish from that polluted area. The available epidemiological and experimental data on effects and levels of PCBs in seals and mink fed on fish from this area suggest that these pollutants or associated compounds are the main cause of this failure.

## Seals in the Baltic Sea

The populations of ringed seals (*Phoca hispida*), grey seals, and harbour seals in the Baltic Sea have declined substantially during this century. Originally the decline was the result of hunting. However, since the early 1970s, although a number of countries have halted all killing of seals, there has been no increase and some populations have continued to decline (Helle, 1986).

Based on the available data from laboratory experiments, it was suggested that reproductive failure among Baltic seals was related to the severe burden of organochlorines in the Baltic (Helle et al., 1976a, 1976b). The finding of aborted seal pups (Olsson et al., 1975) was comparable to similar reports from the Californian coast. Concerns about low fecundity were confirmed when it was found that less than 25% of mature female ringed seals sampled between 1973 and 1979 were pregnant (Helle et al., 1976a, 1976b; Helle, 1980). Of the non-pregnant animals, a high proportion had abnormalities (occlusions and stenoses) of one or both uterine horns which made them partly or totally sterile. Similar abnormalities have been found in Baltic grey and harbour seals (Olsson, 1978).

High average levels (in excess of 60 mg/kg) of both PCBs and DDT are recorded from Baltic seals, and the animals with reproductive anomalies had significantly higher levels of PCBs than those without (Helle et al., 1976b). Bergman and Olsson (1986) have documented a suite of pathological conditions associated with hyperadrenocorticism in a high proportion of seals found dead or drowned in nets along the Swedish Baltic coast. They attributed this to the effects of PCBs, and possibly other chlorinated hydrocarbons, on glucocorticoid levels and the immune system.

A study of skeletal deformities and bone erosion in the skulls of adult Baltic grey seals showed that samples collected after 1960 has a significantly higher frequency (50%) of deformities compared to a sample collected in the Baltic before 1960 and reference material from adult British grey seals. Both these latter groups had less than 10% anomalies



(Bergman et al., 1986). The findings were associated with the earlier reported disease complex of hyperadrenocorticism. The world production of DDT and PCBs increased exponentially during the 1950s and 1960s.

## **Belugas in the St. Lawrence Estuary**

Martineau et al. (in press) report that the population of belugas (*Delphinapterus leucas*) in the Estuary of the St. Lawrence River has failed to increase following a reduction of hunting in the 1960s and complete protection since 1979. The observed proportion of calves in that population is lower than in the population in Alaska (Béland et al., 1987). Martineau et al. (1987) found levels of PCBs and DDT in excess of 100 mg/kg in the blubber of stranded whales, but these animals tended to have thinner blubber layers than have been reported from other populations. These animals showed a high incidence of pathological conditions (Martineau et al., in press), and one whale had a bladder cancer similar to that recorded from humans working in the same area (Martineau et al., 1985). The high incidence of pathological conditions has been attributed to immunosuppressive effects of organochlorines and the cancer to the carcinogenic effects of benzopyrenes. It was suggested (Martineau et al., 1987) that the apparent low reproductive rate of the St. Lawrence belugas is also due to the effects of organochlorines.

## **Experimental studies on effects of organochlorines on other mammals**

In the past, several experiments have been carried out in order to study the impact of organochlorines on mammals. In this review it is obvious that reproductive failure and immunosuppression have been suspected to be caused by high burdens of organochlorines in marine mammals from various areas. For that reason, it is of interest to find out what experimental evidence there is to support such findings in wild populations.

Several studies have disclosed the effect of DDTs and PCBs on the hormonal balance and reproduction of various mammalian species, such as mouse (Orberg and Kihlström, 1973; Orberg et al., 1972); Orberg and Lundberg, 1974); rabbit (Hart et al., 1971); rat (Linder et al., 1974); mink (Ringer et al., 1972; Platonow and Karstad, 1973; Aulerich and Ringer, 1977; Kihlström et al., 1976; Jensen et al., 1977; Bleavins et al., 1980; den Boer, 1983; Olsson, 1987; Reijnckers, 1986); piglets (Platonow et al., 1976); and rhesus monkey (Barsotti et al., 1976). Some of the reports found that DDT alone had no measurable effects on the reproduction rate but PCBs, given in similar dosages and of a magnitude comparable to levels occurring in natural fish, did. Whether the effect was caused by PCBs alone or by impurities of the PCBs, such as dibenzofurans, is not clear. In some of the mink studies it was shown that implantation occurred at a normal rate but the pregnancy was interrupted and resorption products were found in the uterus.

Some studies have revealed altered glucocorticoid levels in rats fed PCBs (Wassermann et al., 1973a; Wassermann and Wassermann, 1972). A reduced activity of the immunological system has also been found (Wasserman et al., 1979). To a lesser degree, DDT has also been found to lower the immunological response (Wassermann et al., 1973b).

From this, it can be concluded that DDT and especially PCBs (and/or its impurities) do affect mammalian reproduction, hormonal balance and the immune system.

## PROBLEMS IN THE INTERPRETATION OF CASE HISTORIES

Superficially, the effects which have been attributed to organochlorines in the four case histories described above appear to be rather dissimilar. However, a coherent explanation has begun to emerge. There is good experimental evidence from other mammals, and now from harbour seals (Reijnders, 1986), that organochlorines interfere with normal hormonal cycles. There is also evidence from laboratory studies that these compounds can affect the immune system (see Experimental studies on effects of organochlorines on other mammals). In seals this can interfere with successful implantation of the embryo following diapause; it could also lead to increased embryonic mortality or premature birth. Premature births have been recorded not only in the Californian sea lion but also in Baltic seals in the 1970s (Olsson et al., 1975). The low incidence of such records in the Baltic may be more a result of the low probability of finding premature pups in ice-breeding animals than of the infrequency of such births. Embryonic mortality or premature birth may leave minor wounds on the uterine wall. Such wounds may be more liable to infection in seals with high PCB levels because of the known immunosuppressive effect of these compounds. The build-up of scar tissue around these wounds could lead to stenosis.

The interpretation of these findings is made more difficult by certain analytical problems, and the fact that organochlorine levels in blubber may not necessarily reflect the circulatory levels which are affecting target organs.

Most estimations of PCB levels have been based on a comparison of chromatograms of blubber samples with those produced by specific commercial mixtures of PCBs from packed-column gas-liquid chromatography. There are 209 different individual PCB congeners and the combination of congeners in seal tissue will not be identical to that in the commercial mixtures. As a result, this kind of analysis may produce a biased estimate of the PCB concentration in seal tissue. A more reliable approach is to use capillary column chromatography to estimate the concentration of individual congeners (see *Sampling and Analysis Procedures* 6 and Annex 2), but many laboratories are not equipped to do this. A comparison of the organochlorine analyses made by different laboratories is desirable.



Blubber is a complex tissue and it is known that organochlorine concentrations in blubber are affected by an individual's age, sex, health, reproductive condition and diet. Many published analyses of organochlorine levels in marine mammals do not provide the information on these variables which is necessary for a proper interpretation of the recorded levels.

Nevertheless, there is enough internal consistency in the analyses which have been performed in the seal case studies described in Section 3 to be reasonably confident about the general conclusions that have been reached.

## **FUTURE TRENDS IN ENVIRONMENTAL LEVELS OF ORGANOCHLORINES**

The discussion in the previous two sections have identified organochlorines as important contaminants in marine mammals. However, for two of the major contaminants, the production of PCBs and the use of DDT in OECD countries have been banned for a number of years. So it might be concluded that problems caused by these compounds should now be reduced, at least in the northern hemisphere.

A general decline in DDT and PCB levels in fish and fish-feeding birds from the Baltic Sea has been observed in the last 20 years (Olsson and Reutergardh, 1986) and there is some evidence that their levels in one Baltic seal population may also have declined (Stenman and Helle, 1987). However, there are now signs that this decline has levelled off and new inputs of some organochlorines have been identified. Levels of PCBs in the Dutch Wadden Sea have remained roughly constant. This illustrates the fact that the effectiveness of local controls on emissions of these compounds may be compromised by atmospheric input and riverine run-off from more distant areas.

In addition, large quantities of organochlorines are bound up in the sediment in areas where there were discharges of organochlorines in the past. The role of these deposits is not fully understood. Although the manufacture of PCBs has been tightly controlled for a number of years, there are still many manufactured goods in circulation which contain large quantities of these compounds. Often these goods are not adequately labelled and sudden large releases of PCBs may occur when they are disposed of. There is need for a greater awareness of the potential harm such accidental releases can cause.

DDT is still used in developing countries. Governments whose agricultural industry makes use of these compounds should be aware of the potential effect they can have on their own, or their neighbours', populations of marine mammals.

# SAMPLING AND ANALYSIS PROCEDURES

The discussion in *Problems in the interpretation of case histories* has highlighted how difficult it can be to interpret data on concentrations of organochlorines in tissue samples from marine mammals. There is a clear need for a greater consistency in the way such samples are collected and analysed. In addition, it is possible that the problems which have been observed are caused by breakdown products of PCBs, such as methyl sulfonated and hydroxylated organochlorines, or impurities of PCBs, such as dibenzofurans, rather than the PCBs themselves. It is desirable to analyse samples for these specific compounds, although only a few laboratories have the facilities to do so.

It is now possible to provide detailed guidelines for the collection of blubber samples from seals. Much less is known about the distribution of organochlorines in cetaceans and it can only be recommended that samples of the entire blubber layer from skin to underlying muscle are taken from a number of sites on each animal.

The age, sex, length and reproductive status of every animal which is sampled should be recorded. Blubber thickness or, ideally, sculp (skin and blubber) weight should be measured as an indication of condition. If possible, a full veterinary autopsy should be conducted so that data on the histology and morphology of "normal" animals, as well as those with pathological conditions, can be accumulated.

If the aim of a study is to provide information for comparison of contaminant burdens with other geographical areas, it would be useful to concentrate sampling on seals which are weaned and feeding independently, but are less than one year old. Such animals are likely to show less individual variation than other age-classes and are often selectively caught in fishing gear.

If possible, a sub-sample of all tissues that are collected should be archived and stored at as low a temperature as possible in case it is later shown that compounds which are not now being measured are important contaminants.

It was noted that a recommendation has been made that ICES sponsor an intercomparison programme for the chemical analysis of chlorobiphenyl (CB) congeners in marine mammal tissue. This programme will be conducted in three phases: (1) analysis of standard solutions of CBs, (2) analysis of a fish oil certified for specific CBs, which is expected to be available from the EEC Bureau of Community Reference (BCR) within the next few years, and (3) analysis of a seal blubber oil certified for CBs by BCR, to be available in 3-4 years. Laboratories conducting analyses of CBs and other organochlorines in marine mammal tissues should follow the requirements of good laboratory practice, including an appropriate quality assurance programme (see, e.g., Vijverberg and Cofino, 1987). It was also noted



that data from ICES monitoring programmes on contaminants in fish and shellfish have shown that different fat extraction techniques give different results on the amount of fat in the tissue analysed; these differences create problems in interpreting data on organic contaminants from different laboratories and can be expected to cause similar problems when comparing data on contaminants in marine mammals.

Ideally, the distribution of individual PCB congeners should be measured using capillary column gas chromatography. However, this will be impractical for many laboratories and they will have to use packed column methods. These laboratories should be aware of the potential problems with this method and should, if possible, periodically arrange for representative samples to be sent to a laboratory capable of analysing for the individual congeners. UNEP should consider subsidizing these comparative analyses.

Reports of these analyses should contain enough information so that organochlorine concentrations can be expressed on a wet weight basis, and in relation to fat content, as well as information on blubber thickness, age, and sex.

## CONCLUSIONS AND RECOMMENDATIONS

Although high levels of many environmental contaminants have been recorded in the tissues of marine mammals, only one group - the organochlorines - appear to have caused significant problems. The DDT family and the PCBs, or possibly some of their breakdown products or impurities, are known to cause reproductive failure, disrupt the metabolism of steroid hormones, and affect the immune system of many vertebrate species. There is now convincing evidence, although much of it is circumstantial, that they have similar effects on marine mammals, particularly seals. A working hypothesis for the mode of action of these compounds has been developed, based on a combination of laboratory and field data, but the precise biochemical mechanism has yet to be identified.

Although the production and use of these compounds in Europe and North America has been substantially reduced, environmental levels in some areas are still high and there is still a continuing low-level input. DDT is still used in developing countries and this could pose a threat to local marine mammal populations.

The following recommendations are made:

- 1) In order to provide a better understanding of the precise mechanism by which organochlorines interfere with steroid metabolism and the immune system, further research is required. This should be done by a combination of laboratory, experimental and field studies. The ACMP, whilst recognizing the difficulties emphasizes the value of experiments with live seals. It is likely that the mode of action of these compounds is related to

their structure. Accordingly, modelling of structure-activity relationships may allow assessments of the likely impact of similar chemicals before they are produced and released to the environment.

2) More information is required on the way organochlorines pass from food to blood to blubber and the target organ or system. Ideally, such work should be combined with studies of diet and feeding distribution.

3) Future studies of organochlorines in marine mammals should follow the guidelines for sampling and analysis in Section 5. Laboratories which are unable to analyse for individual PCB congeners should regularly send representative samples to laboratories which are skilled in the use of glass capillary column chromatography and which follow the procedures of the European Community Bureau of Reference (see Section 7 of Annex 2). This will ensure a comparable central database. UNEP should consider subsidizing these analyses. There is a need for standardized method of fat extraction from blubber and ICES or IOC should consider conducting a review of these methods.

4) Pending the organization and successful completion of an intercomparison exercise for chlorobiphenyls in seal blubber (*Organochlorine contamination and marine mammals*, Annex 2), a single laboratory should analyze material collected from seals in Greenland, West Scotland, the Firth of Clyde, the Faroe Islands, the Bay of Fundy, the Gulf of St. Lawrence, the Baltic Sea and the Wadden Sea.

5) There is a need for a more sensitive indicator of environmental stress in marine mammals than the failure of reproduction or the lesions caused by immune imbalance. The research described in Recommendation 1 may identify this.

6) PCBs and probably DDT, do appear to be responsible for detrimental effects on marine mammals. It is clear that the use of DDT continues in several parts of the world and PCBs are often disposed of in an uncontrolled way instead of being destroyed at the end of their useful life. It is these types of practice which must be curtailed if continued effects on marine mammals are to be prevented.

7) There is a need for greater awareness that some products now in circulation contain considerable quantities of PCBs which could be released into the environment when they are disposed of. Accordingly, it is recommended that such products be labelled as containing PCBs, or that a list of products which may contain these compounds be provided to the bodies which advise potential users.

8) The seal populations in the Baltic Sea and the Dutch Wadden Sea have been reduced to low levels, in part because of the effects of organochlorine pollution. It is recommended that every effort should be made to allow these populations to recover. Specific recommendations for the Baltic populations were made by the ICES Working Group on Baltic Seals and by the Advisory Committee on Marine Pollution in its 1986 report (ICES, 1987).



## REFERENCES

- Aulerich, R.J. and Ringer, R. K. 1977. Current status of PCB toxicity to mink, and effect on their reproduction. *Arch. Environment. Contam. Toxicol.* 6:279-292.
- Babbin, Ph. and Duguy, R. 1985. Intoxication due aux hydrocarbures ingères par *Halichoerus grypus* et *Phoca vitulina*. ICES, Doc. C.M.1985/N:12.
- Barsotti, D.A., Marlar, R.J. and Allen, J.R. 1976. Reproductive dysfunction in Rhesus monkeys exposed to low levels of polychlorinated biphenyls (Aroclor 1248). *Fd Cosmet. Toxicol.* 14:99-103.
- Béland, J., Michaud, R., and Martineau, D. 1987. Recensements de la population de bélugas du Saint-Laurent en 1985 par embarcations. *Rap. tech. can. sci. halieut. aquat.*, No. 1545.
- Bergman, A. and Olsson, M. 1986. Pathology of Baltic grey seal and ringed seal females with special reference to adrenocortical hyperplasia: Is environmental pollution the cause of a widely distributed disease syndrome? *Finnish Game Res.* 44:47-62.
- Bergman, A., Olsson, M., and Reiland, S. 1986. High frequency of skeletal deformities in skulls of the Baltic grey seal. ICES, doc. C.M. 1986/N:15.
- Bleavins, M. R., Aulerich, R.J., and Ringer, R.K. 1980. Polychlorinated biphenyls (Aroclors 1016 and 1242): effect on survival and reproduction in mink and ferrets. *Arch. Environmental. Contam. Toxicol.* 9:627-635.
- Boer, M. den, 1983. Reproduction decline of harbour seals: PCBs in the food and their effect on mink. *Ann. Rep. RIN* (ed. Rossum, T. van): 77-86. Rijksinstituut voor Natuurbeheer, Leersum, The Netherlands.
- DeLong, R.L., Gilmartin, W.G., and Simpson, J.G. 1973. Premature births of Californian sea lions: associated with high organochlorine pollutant residue levels. *Science* 181:1168-1169.
- Friend, M. and Trainer, D.O. 1970. Polychlorinated biphenyls: interaction with duck hepatitis virus. *Science* 170:1314-1316.
- Gilmartin, W.G., DeLong, R.L., Smith, A.W., Sweeney, J.C., DeLappe, B.W., Riseborough, R.W., Griner, L.A., Dailey, M.D., and Peakall, D.B. 1976. Premature parturition in the Californian sea lion. *Journal of Wildlife Diseases* 12:104-115.

- Hart, M.M., Adamson, R. H., and Fabro, S. 1971. Prematurity and intrauterine growth retardation induced by DDT in the rabbit. *Arch. Int. Pharmacodyn.* 192:286-290.
- Helle, E. 1980. Lowered reproductive capacity in female ringed seals (*Pusa hispida*) in the Bothnian Bay, northern Baltic Sea, with special reference to uterine occlusions. *Ann. Zool. Fennici* 17:147-158.
- Helle, E. 1986. The decrease in the ringed seal population of the Gulf of Bothnia in 1975-1984. *Finnish Game Res.* 44:28-32.
- Helle, E., Olsson, M, and Jensen, S. 1976a. DDT and PCB levels and reproduction in ringed seal from the Bothnian Bay. *Ambio* 5(4):188-189.
- Helle, E., Olsson, M, and Jensen, S. 1976b. PCB levels correlated with pathological changes in seal uteri. *Ambio* 5(5-6):261-263.
- Howard, E.B., Britt, J.O., Matsumoto, G.K., Itahara, R., and Nagano, C.N. 1983. Bacterial Disease. In: Howard, E.B. (ed.). *Pathology of marine mammals diseases*. Vol. 1, CRC Press, Inc. Boca Raton, Florida:69-79.
- ICES, 1987. Report of the ICES Advisory Committee on Marine Pollution, 1986. *Coop. Res. Rep.* No. 142:32-40.
- Jensen, S., Kihlström, J. E., Olsson, M, Lundberg, C. and Orberg, J. 1977. Effects of PCB and DDT on mink (*Mustela vison*) during the reproductive season. *Ambio* 6:239.
- Kihlström, J.E., Olsson, M., and Jensen, S. 1976. Effekter på högre djur av organiska miljögifter. Organiska miljögifter i vatten. *Nordforsk.* 2:567-576
- Koeman, J.H., Canton, J.H., Woustra, A., Petters, W.H.M., de Goeij, J.J.M, Zegers, C., and van Haften, J.J. 1971. Mercury in the Dutch littoral environment (in Dutch). *TNO-nieuws* 26:402-409.
- Koeman, J.H., Petters, W.H.M, Smit, C.J., Tijoe, P.S., and de Goeij, J.J.M 1973. Persistent chemicals in marine mammals. *TNO-nieuws* 27:570-578.
- Koeman, J.H., van de Ven, W.S.M., de Goeij, J.J.M., Tijoe, P.S., and van Haften, J.L. 1975. Mercury and selenium in marine mammals and birds. *Science of the Total Environment* 3:279-287.
- Linder, R.E., Gaines, T.B., and Kimbrough, R.D. 1974. The effect of polychlorinated biphenyls on rat reproduction. *Fd Cosmet. Toxicol.* 12:63-77.



Martin, J. H., Elliott, P.D., Anderlini, V.C., Girvin, D., Jacobs, S.A., Risebrough, R.W., DeLong, R.L., and Gilmartin, W.G. 1976. Mercury-selenium-bromine imbalance in premature parturient Californian sea lions. *Marine Biology* 35:91-104.

Martineau, D., Lagacé, A., Massé, R., Morin, M., and Béland, P. 1985. Transitional cell carcinoma of the urinary bladder in a beluga whale (*Delphinapterus leucas*). *Can. Vet. J.* 26:297-302.

Martineau, D., Béland, P., Desjardins, C., and Lagacé, A. 1987. Levels of organochlorine chemicals in tissues of beluga whales (*Delphinapterus leucas*) from the St. Lawrence Estuary, Québec, Canada. *Arch. Environ. Contam. Toxicol.* 16:137-147.

Martineau, D., Lagacé, A., Béland, P., Higging, R., Armstrong, D., and Shugart, L.R. (in press). Pathology of stranded beluga whales (*Delphinapterus leucas*) from the St. Lawrence Estuary, Québec, Canada. *J. comp. Pathol.*

Olsson, M. 1978. PCB and reproduction among Baltic seals. Proceedings from the Symposium on the Conservation of Baltic Seals in Haikko, Finland, April 26-28, 1977. *Finnish Game Res.* 37:40-45.

Olsson, M. 1987. PCBs in the Baltic Environment. In: Waid, J. S. (ed.), *PCB and the Environment*. CRC Press. Vol. III, Chapter 7:181-208, Boca Raton, Florida.

Olsson, M., Johnels, A.D., and Vaz, R. 1975. DDT and PCB levels in seals from Swedish waters. The occurrence of aborted seal pups. In: *Proceedings from the Symposium on the Seals in the Baltic*. June 1974. Lidingö, Sweden, Nat. Swed. Environ. Prot. Bd. PM 591.

Olsson, M. and Reutergardh, L. 1986. DDT and PCB Pollution Trends in the Swedish Aquatic Environment. *Ambio* 15(2):103-109.

Orberg, J., Johansson, N., Kihlström, J.E., and Lundberg, C. 1972. Administration of DDT and PCB prolongs oestrous cycle in mice. *Ambio* 1(4):148-149.

Orberg, J. and Kihlström, J.E., 1973. Effects of long-term feeding of polychlorinated biphenyls (PCB, Clopen A 60) on the length of the oestrous cycle and on the frequency of implanted ova in the mouse. *Environm. Res.* 6:176-179.

Orberg, J. and Lundberg, C. 1974. Some effects of DDT and PCB on the hormonal system in the male mouse. *Environm. Physiol. Biochem.* 4:116-120.

Platonow, N. S. and Karstad, L.H. 1973. Dietary effects of polychlorinated biphenyls on mink. *Canad. J. Comp. Med.* 37(4):391-400.

Platonow, N. S., Meads, E.B., Liptrap, R.M., and Lotz, F. 1976. Effects of some commercial preparations of polychlorinated biphenyls in growing piglets. *Can. J. Comp. Med.* 40(4):421-428.

Reijnders, P.J.H. 1978. Recruitment in the harbour seal (*Phoca vitulina*) population in the Dutch Wadden Sea. *Neth. J. Sea Res.* 12:164-179.

Reijnders, P.J.H. 1980. Organochlorine and heavy metal residues in harbour seals from the Wadden Sea and their possible effects on reproduction. *Neth. J. Sea Res.* 14:30-65.

Reijnders, P.J.H. 1986. Reproductive failure in common seals feeding on fish from polluted coastal waters. *Nature* 324:456-457.

Reijnders, P.J. H. 1987. Environmental impact of PCBs in the marine environment. In: *Proceedings International Conference on Environmental Protection of the North Sea, Organic chemicals*, paper 5:1-15.

Ringer, R. K., Aulerich, R.J., and Zabik, M. 1972. Effects of dietary polychlorinated biphenyls on growth and reproduction of mink. Reprints of papers presented at 64th Nat'l Meeting. *American Chemical Society*, Vol. 12(2):149-154.

Ronald, K. and Tessaro, S.V. 1976. Methyl mercury poisoning in the harp seal (*Pagophilus groenlandicus*). Doc. ICES, C.M. 1976/N:8.

Ronald, K., Uthe, J.F., and Freeman, H. 1975. Effects of methyl mercury on the harp seal. Doc. ICES, C.M. 1975/N:9.

Stenmann, O. and Helle, E. 1987. Etat des populations phoques dans la mer Baltique. *Rapport Préliminaire pour la Conférence des Spécialistes des phoques organisée par le Conseil Internationale de la Chasse*. Oslo. Avril 1987.

Tessaro, S. V. and Ronald, K. 1976. The lesions of chronic methyl mercury poisoning in the harp seal (*Pagophilus groenlandicus*). Doc. ICES, C.M. 1976/N:7.

Vijverberg, F.A.J.M. and Cofino, W.P. 1987. Control Procedures: Good Laboratory Practice and Quality Assurance. *ICES Techniques in Marine Environmental Sciences No. 6*.

Wagemann, R. and Muir, P.C.G. 1984. Concentrations of heavy metals and organochlorines in marine mammals of northern waters: Overview and evaluation. *Can. Tech. Rep. Aquat. Sci.* No. 1279.

Wasserman, D. and Wassermann, M. 1972. Ultrastructure of adrenal zona fasciculata in polychlorinated biphenyl (PCBs) receiving rates. *17th International Congress of Occupational Health*, Buenos Aires.



Wassermann, D., Wassermann, M., Cucos, S., and Djavaherian, M. 1973a. Function of adrenal gland-zona fasciculata in rats receiving polychlorinated biphenyls. *Env. Res.* 6:334-338.

Wassermann, M., Wassermann, D., Cucos, S., and Miller, H. J. 1979. World PCBs map: Storage and effect in man and his biologic environment in the 1970s. In: Nicholson, W. J. and Moore, J.A. (eds.). Health effects of halogenated aromatic hydrocarbons. *Annals of the New York Academy of Sciences* 320:69-124.

Wassermann, M., Wassermann, D., Kedar, E., Djavaherian, M., Cucos, S., and Ventura, S. 1973b. Effects of organochlorine compounds on serum proteins. *Bull. Environm. Contam. Toxicol.* 10:42-50.

# **ANNEX 1**

## **ICES/IOC/UNEP REVIEW OF CONTAMINANTS IN MARINE MAMMALS**

### **List of Participants**

For ICES Dr. John Harwood (Chairman)  
Sea Mammal Research Unit  
c/o BAS  
Madingley Road  
Cambridge CB3 0ET  
UNITED KINGDOM

Dr. Mats Olsson  
National Museum of Natural History  
Box 5007  
104 05 Stockholm  
SWEDEN

Dr. Peter Reijnders  
Research Institute for Nature Management 1790 AB Den Burg  
Texel  
NETHERLANDS

For IOC Dr. Richard Addison  
Department of Fisheries & Oceans  
Bedford Institute of Oceanography  
P.O. Box 1006  
Dartmouth, N.S. B2Y 4A2  
CANADA



## **ANNEX 2**

### **ICES JOINT MEETING OF BIOLOGISTS AND CHEMISTS CONCERNED WITH CONTAMINANTS IN MARINE MAMMALS\***

(Copenhagen, 12 - 13 February 1987)

#### **1 OPENING OF MEETING**

The Chairman, Dr. L. Reutergardh, opened the meeting at 9.30 hrs on 12 February 1987 and welcomed the participants.

##### **1.1 Presentation of Participants**

The participants introduced themselves and indicated their main areas of relevant scientific work.

##### **1.2 Agenda**

The Agenda was adopted as proposed.

#### **2 OVERVIEW OF CONTAMINANTS IN MARINE MAMMALS**

The paper "Overview of organochlorine Compound Analysis in Marine Mammals" by L. Reutergardh and A. Knap was presented by Dr. Reutergardh. He outlined the contents and the sources of information. He indicated that the review did not cover Californian sea lions, polar bears or sea otters. The current report also cites certain publications for which the full references are not listed, due to the time constraints for preparing this report (this will be updated).

The following points were clearly identified:

- 1) A lack of reported Good Laboratory Practice (GLP) prevented a real comparison of data.
- 2) Samples had been taken of animals at different life stages, sex and fecundity—information on which was not always reported.
- 3) The number of specimens was often small.
- 4) Quantification problems were evident, in particular, a disregard for the use of internal standards and little or no inter laboratory comparison.

\*Only the body of this report has been reproduced here. The full report is contained in ICES Doc. C.M.1987/E:3.

5) Mammal blubber is a substantially different matrix from the tissues of other marine biota and additional, more detailed studies are necessary before the data analysis can be taken any further.

This overview will be revised by the authors to take account of the order of the tables (to be ranked by species) and the abbreviations used. Further comments would be welcomed.

The meeting also took note of an earlier overview paper by Drs. R. Wagemann and D.C.G. Muir, "Concentrations of Heavy Metals and organochlorines in Marine Mammals of Northern Waters: Overview and Evaluation," (*Can. Tech. Rpt. Fish. and Aqu. Sci.* No. 1279 (July 1984)). This overview covered papers published up to 1981 on contaminant levels in marine mammals from northern waters, while the report presented included the southern hemisphere as well.

### 3 PATHOLOGICAL CHANGES IN BALTIC SEALS IN RELATION TO CONTAMINANTS FOUND

Dr. M. Olsson tabled the paper "Pathology of Baltic Grey seal and Ringed Seal Females with Special Reference to Adrenocortical Hyperplasia: Is environmental pollution the cause of a widely distributed disease syndrome?" (A. Bergman and M. Olsson. *Finnish Game Res.* 44, 47-62 (1985).

Dr. Olsson presented a clear informative overview of the pathological changes in grey seals. Several kinds of pathological changes have been found, such as kidney changes (Glomerulopathy), local chronic intestinal ulcers, occlusion and stenosis of uterine lumens, benign tumours in uterus (leiomyoma), claw deformation and fractures, skin changes (alopecia) sometimes with similarities to chloracne, deformed and severe erosion of jaw bone and adrenocortical hyperplasia. The lesions occur in combination in the animals studied and at a high frequency. The findings indicate the disease complex hyperadrenocorticism.

Historical records indicated a possible causal relationship with chlorinated organic contaminants (pollutants), in particular PCBs. This temporal link was also substantiated by the spatial distribution of these effects which follows that of the present known levels of PCBs. Other causal links have been investigated, including physical stress, metal contamination, and other organochlorines.

There was a strong link between biological effects and chemical contamination with PCBs, and it was agreed that this seriously warrants further investigation. The main most



urgent requirement is for an agreed protocol for chlorobiphenyl (CB) congener analysis and agreement between member laboratories through intercomparison.

Sites requiring further interlaboratory pathological and chemical investigations of seal tissues were identified as follows: Greenland, West Scotland, Firth of Clyde, Faroe Islands, Bay of Fundy, and Gulf of St. Lawrence, Baltic Sea and Wadden Sea.

#### **4 TRACE METALS IN MARINE MAMMALS**

Trace metals in marine mammals were considered. From the information available there was no evidence that these substances should have adverse effects on marine mammals at the concentrations found. Though high levels of cadmium have been found in kidneys of some species of marine mammals, the severe symptoms found in terrestrial mammals have not been seen.

#### **5 REPORT FROM THE EUROPEAN SEAL GROUP**

R. Dietz reported on the European seal group meeting. This group consists of scientists working with seal research. The question of assessing population size, pathological changes and the high levels of trace metals found in seals from Greenland had been discussed at the meeting. A report from the meeting should be sent to the Marine Mammals Committee. The trace metal concentrations in seals from Greenland could be a potential threat to the Greenlanders who consume reasonable amounts of seal tissue. So far, no adverse effects had been observed.

#### **6 PLANAR MOLECULES IN MARINE MAMMALS IN RELATION TO PATHOLOGICAL CHANGES**

There was a discussion on planar molecules and their potential biological activity. New information was recently available (Tanabe et al. (*Int. J. Environ. Anal. chem.* (in press))) from Japan in which planar molecules of similar dimension and spatial configuration to 2,3,7,8-tetrachlorodibenzo-p-dioxin (TCDD) (10 x 3 Å) could be accepted by TCDD receptors, e.g., 3,4,3',4'-tetrachlorobiphenyl. It is recommended that a further review of this subject area be made.

#### **7 NEED FOR AN INTERCOMPARISON PROGRAMME ON DETERMINATION OF CHLOROBIPHENYLS**

A need for an interlaboratory intercomparison programme for the chemical analysis of CB congeners in marine mammal tissue was clearly identified. The following programme is recommended:

1) The Group recommended that two sources of blubber (200 kg) each, from an area of high and low CB contamination, be identified and prepared according to an agreed protocol. This should be done in conjunction with EEC Community Bureau of Reference (BCR) who will support their preparation to undertake stability and homogeneity trials, after which the blubber oil will be offered for certification by BCR. This programme may take 12-36 months depending on the progress of the BCR Working Group on CB Analysis. MCWG members should support this programme by offering assistance where necessary.

Participants from Denmark and Sweden agreed to deliver cost estimates for sampling such material from Greenland and the Baltic Sea, respectively. The estimates, as well as an estimate of the processing cost of the seal oils, should be sent to the Chairman not later than 27 February 1987, for further discussions with BCR.

2) The group recommended that, in parallel with the activities in (1), above, ICES member laboratories involved in CB analysis using capillary chromatography, particularly of marine mammal tissue, should agree on a programme of intercalibration along the following lines:

a) To agree a commitment in writing from the member laboratories to a 2- to 3-year programme.

b) To undertake an intercalibration of standard CB solutions, using internal standards.

c) To repeat step (b) where necessary, with discussions on methods and improvements, until the agreed level of variance is reached. Members who are also members of the BCR Group (or any other established group undertaking CB intercomparisons) should be encouraged to assist.

d) When agreement on the standards has been achieved, to carry out determinations of chlorobiphenyls in a certified fish oil, which should, at that time, be available from BCR.

e) When agreement on fish oil has been achieved, to conduct determinations of chlorobiphenyls in a certified seal blubber oil, certified by that time through BCR.

The group recommended that 1 to 3 laboratories undertake the analysis of blubber tissue from samples taken from the areas identified in Section 3, above, to provide a relatively comparable data set for the biologists studying the pathological effects. These laboratories are most likely to have a high level of quality control and may also be members of BCR working Group on Cb Analysis.

## 8 OTHER ISSUES

The Group recommended that, while every progress should be made in verifying any causal link between the pathological effects and the concentrations of CBs in seals, other



potential pollutants should not be ignored. In addition to planar molecules, the other compounds/groups identified were:

- Diphenyl sulphones (monomer/polymer).
- Chlorinated xanthenes.
- Chlorinated products from the wood and paper pulp industry.

The Group also recommended that closer cooperation be encouraged between biologists and analytical chemists, both at the institute and the working group level, to minimize the continuing practice of biologists undertaking analytical chemistry and chemists making biological assessments, with the inevitable misinterpretation of the others' discipline. Joint meetings, such as this, should be a regular feature of ICES activities related to pollution, and the Group recommended that it meet again in one year.

Prof. K. Palmork offered to provide a critical review on hydrocarbons in marine mammals. The Group readily accepted this kind offer.

The representative from Sweden volunteered to analyse seal blubber from seals caught in the areas identified in Section 3. Delegates concerned with the problem will be informed through ICES and urged to take advantage of this opportunity. A precise description of sampling procedure will be supplied at the same time. The aim of this study is to compare the levels of organochlorines in the blubber of seals taken from the Baltic Sea with those from the other areas.

## 9 RECOMMENDATIONS

The Joint Meeting recommended that

- the planar molecules accepted by the TCDD receptor should be further reviewed;
- two blubber oils should be processed in cooperation with BCR, as outlined in Section 7.1;
- an intercalibration exercise according to Section 7.2 should be conducted a coordinator identified;
- blubber tissue from the hot spot areas mentioned in Section 3 should be analyzed;
- the causality of toxicants and pathological effects should be further investigated, as outlined in Section 8;

- a closer co-operation between biologists and chemists should be developed in a suitable forum.

## **10 CLOSURE OF MEETING**

The Chairman thanked the participants for their contributions and cooperation in this meeting.



Photo cover acknowledgment:  
Beluga in Miami seaquarium, Florida, UA  
Copyright issued by FAO, Rome, Italy