

Introduction

This volume, the first special issue of the *Journal of Cetacean Research and Management*, traces the work of the IWC (International Whaling Commission) Scientific Committee on the issue of chemical pollutants and cetaceans. It culminates in the major research initiative, POLLUTION 2000+, agreed by the Committee and the Commission at the 1999 Annual Meeting held in Grenada.

The involvement of the IWC in the issue of pollutants and cetaceans goes back to 1981 when, in response to work by the Scientific Committee, the Commission passed a Resolution noting the potential threats to whale species (particularly sperm whales) raised by heavy metals, PCBs and other organochlorines and calling for governments to initiate research on the subject (IWC, 1982).

The issue was placed as a standing item on the Committee's agenda and in 1984, the Committee adopted a standard approach for the collection of samples and presentation of results for organochlorine analyses (IWC, 1985). The following year, a Working Group was established to consider the question of whale habitats and in particular, chemical pollution (IWC, 1986). It was noted that although there had been a number of studies measuring levels of pollutants in cetacean tissues, not enough emphasis had been placed on (a) ensuring consistency of methodology and reporting of the variables that affect interpretation of levels (e.g. age, sex, reproductive condition, health) and (b) on studies to examine mechanisms and effects. The Working Group also considered the question of whether cetaceans could be considered as useful indicators of the 'health of the ocean environment'. It agreed that, while cetaceans were not suitable for monitoring global ocean pollution in a strict sense, it may be possible to obtain some information on trends in certain pollutants. Finally, the Working Group considered the question of the suitability of samples from stranded animals for pollutant analysis. There are problems in considering stranded animals and their tissue levels as being representative of those characteristic of the true population and the Working Group recommended that, where alternatives exist, these should be used. However, in some areas and for some species there may be no alternative; in these circumstances, such samples may provide an insight into the magnitude of the species' exposure to pollutants, although the representativeness of the sampled animal should be carefully considered taking into account its particular characteristics (e.g. estimated post-mortem time, likely cause of death, nutritive condition, pathology). The Committee adopted the report of the Working Group.

Despite these initiatives, pollutant studies subsequently received relatively little attention in the Committee, largely due to efforts being concentrated on the development of the Revised Management Procedure (e.g. Donovan, 1995; IWC, 1999) as part of the Comprehensive Assessment (Donovan, 1989) arising out of the decision for a pause in commercial whaling. In 1993, work on pollutants was again considered but this time in the broader context of the overall effects of environmental change on cetaceans (IWC, 1994). This was partly due to some concern that environmental factors had not been taken sufficiently into account in the development of the RMP. In response, the Committee drew attention to the work it had already carried out in this regard as well as the results of some additional simulations. Environmental threats affect all species of cetaceans, not merely those subject to direct capture. Indeed, the most vulnerable species to such threats would be those species already reduced in numbers - in the context of the RMP these would be populations for which zero catch limits would be set even if the RMP was to be applied. The Committee stressed that the Commission would have to contemplate response strategies outside the direct management of whaling activities if it wished identified threats to be

alleviated. These may include local measures in terms of habitat protection or much wider action with respect to global threats.

In the context of environmental change, the Committee noted several areas that would require consideration, including: global warming; ozone depletion; pollution (e.g. chemical and noise); direct and indirect effects of fisheries; coastal development and tourism. It recognised, of course, that the question of synergistic and cumulative effects would need to be addressed. Given the broad nature of the subject, it was agreed to focus initially on two subjects: chemical pollution; and environmental change and ozone depletion. Subsequently, two workshops have been held. The first, on chemical pollution, forms the basis of this volume. The report of the second workshop is given in IWC (1997).

An important factor in the decision to hold a workshop on chemical pollutants was the fact that in modern times man has introduced over 200,000 synthetic chemicals into the environment and has profoundly altered the availability to living organisms of naturally occurring elements (e.g. mercury). An undetermined but significant portion of these chemicals are not rapidly degradable, have been incorporated into food webs and have a demonstrable or suspected detrimental impact on living organisms. Chemical pollutants are widely recognised as perhaps having one of the most potentially pervasive impacts on wildlife.

As cetaceans are long-lived, have extensive fat stores and are often top predators, some species carry tissue pollutant levels that are among the highest recorded. This has obviously raised concern over the potential impact of these chemicals on the long-term survival of the affected species and populations. Responding to this concern, in the last three decades a substantial effort has been made in establishing the levels of exposure, tissue levels and dynamics of the main chemical pollutants in marine mammals. However, the complexity of the processes involved in the storage, detoxification and physiological action of the wide variety of chemicals currently present in the environment has impeded the establishment of a clear link between observed tissue concentrations and their actual effects on cetacean individuals and hence populations.

The Workshop on Chemical Pollutants and Cetaceans was held in Bergen in March 1995 with over 40 participants from 10 countries. The primary aim of the Workshop was to carry out a multidisciplinary assessment of the significance of chemical pollutants for cetaceans. The specific objectives of the Workshop were therefore to: (i) critically review and synthesise current knowledge on pollutants in marine mammals; (ii) to identify tools to investigate cause-effect relationships; and (iii) to develop initiatives aimed at determining the actual impact of pollutants on cetacean populations and facilitate the design of a monitoring scheme.

Given the different disciplines represented at the Workshop, it was agreed to concentrate on those areas where the necessary expertise was available. The Workshop did not address the following subjects, which were referred to a later workshop or workshops: (1) oil pollution; (2) marine debris; (3) sewage related pathogens; (4) nutrient related environmental alterations; and (5) radionuclides.

The Workshop was structured around three major items: key-note presentations to provide an overview of the disciplines represented; a review of direct and indirect effects of chemical pollutants on cetaceans including research implications of the review; and implications of the findings of the Workshop - including recommendations - for the future work of the Scientific Committee and the Commission.

The key-note speakers addressed factors affecting variability of persistent pollutant levels; metabolism of organochlorines in mammals; incidence of cancer in cetaceans; epidemiology/epizootics and contaminants; and the significance and potential of biomarkers in marine mammal toxicology.

Two categories of effects of chemical pollution on cetaceans were considered: direct effects, either lethal or sublethal; and indirect effects. There is no indication of acute poisoning of cetaceans. Sublethal effects considered included: (a) increased susceptibility to disease; (b) impairment of reproduction and early development; (c) immune suppression; (d) cancer induction and mutagenic effects; (e) changes in behaviour; and (f) occurrence and extent of epizootics.

In its review on indirect effects, the Workshop primarily discussed effects of pollutants on cetacean prey species and the role of prey as a source of pollutant exposure to cetaceans. In the absence of significant data the workshop's review on effects culminated in a series of research recommendations. In addition, the Workshop devoted considerable effort to considering future research on a number of topics including: synergistic/cumulative effects; exotic compounds; adequacy of present monitoring; further evaluation of the relationship between toxic burdens and impacts; risk and hazard assessment techniques; and trends in global pollution.

The Workshop developed a comprehensive list of recommendations, which addressed further research as well as implications for the work and involvement of the Scientific Committee and the Commission. Given the relative inertia after its initial examination of this question in the mid-1980s, the Workshop stressed the need to ensure that the impetus generated by its report and recommendations should not be lost.

The main conclusions from the Workshop were that: (1) there are sufficient data on adverse effects of pollutants on other marine mammals and terrestrial species to warrant concern for cetaceans; (2) a considerable amount of fundamental research is needed to adequately address the question of the effects of pollutants on all cetaceans; and (3) if any progress is to be made within a reasonable time frame, a multidisciplinary, multinational, focussed programme of research is required that concentrates on those species where there is most chance of success.

In order to forward this work, the editors of this volume and the co-convenor of the Workshop developed a proposal for future work and submitted this to the Scientific Committee and the Commission (Aguilar *et al.*, 1998). That proposal was reviewed and accepted by the IWC and is reprinted in this volume. However, we would like to stress that by concentrating on the Workshop's primary recommendation and focal species, it was not implied that work on other pollution related matters and other species should be discontinued. For example, the work in progress on North Pacific minke whales appears promising.

It was clear from the Workshop (and indeed from the discussion in the mid-1980s) that establishing a relationship between the tissue pollutant levels observed and their potential harmful effects at the individual and population level is extremely difficult for cetaceans. In other taxa, such studies have commonly required experimentation with live animals. For both ethical considerations and the practical impossibility of keeping in captivity the number of individuals necessary to produce the desired statistical certitude, this has not been possible for cetaceans. The research proposal of Aguilar *et al.* (1998) tries to overcome this difficulty. The rationale behind the proposal was to study a number of variables indicative of chemical impact in selected cetacean populations of the same species subject to a gradient of pollutant exposure. The proposal focused on pollutants for which there is already extensive information both on levels and potential effects. The species selected were the three considered by the Workshop: bottlenose dolphins, harbour porpoises and white whales, plus an additional species, the Amazon river dolphin, chosen to specifically address the possible impact of heavy metals. These species all include populations subject to pollutant gradients and from which adequate sampling is feasible. The ultimate aim is to try to produce a predictive model that, with the necessary caution, may be applied to other cetacean species.

Given the acceptance of the outline proposal, the Committee agreed to hold a Workshop to develop a more detailed and costed proposal for the Commission. That Workshop was held in Barcelona in March 1999 and its report is the final report included in this volume.

At the Barcelona Workshop, the following short-term objectives were identified for POLLUTION 2000+:

- (a) to select and examine a number of biomarkers of exposure to and/or effect of PCBs and try to determine whether a predictive and quantitative relationship with PCB levels in certain tissues exists;
- (b) to validate/calibrate sampling and analytical techniques to address such questions for cetaceans, specifically
 - (i) determination of changes in concentrations of variables with post-mortem times;
 - (ii) examination of relationships between concentrations of variables obtained from biopsy sampling with those of concentrations in other tissues that can only be obtained from fresh carcasses.

Given these objectives and the levels of resources and effort necessary to examine them, it was agreed that the work should be divided into two phases - information from Phase 1 is important in providing the calibration/validation tools necessary to better focus and design Phase 2. Data from Phase 1 will provide information not only essential for completing Phase 2 of POLLUTION 2000+ but also of fundamental importance to many research programmes examining issues of chemical pollutants and cetaceans. Phase 1 concentrates largely on Objective (b) above and comprises two sub-projects: (1) effect of post-mortem time; and (2) relationship between information obtained from biopsy samples with that obtained from live-captured animals or carcasses (either from bycaught or freshly stranded animals).

Highest priority will be accorded to sub-project 1. Changes in levels of contaminants and indicators of exposure are known to occur after death due to the inevitable physiological changes and breakdown of tissue. It is essential that these changes are quantified to determine the effect of post-mortem time on levels in the various tissues if the implications of measured levels of these in animals whose time to death is uncertain are to be correctly interpreted with respect to concentrations in the living animal.

The initial focus of POLLUTION 2000+ will now be on the harbour porpoise and the bottlenose dolphin. Sample size considerations precluded the inclusion of the white whale and the Amazon river dolphin as had been planned earlier, but studies on these species (and indeed others) are important and may be included in future phases of this iterative project. Interested groups are encouraged to undertake such studies.

Production of this volume has occurred over a number of years but we believe that its value is considerably enhanced now that it includes the full development of a focused research programme arising out of the valuable review developed at Bergen. It is vital that such fundamental research is carried out if we are to expand pollutant studies of cetaceans from merely documenting levels of pollutants in various tissues. We hope that the relevant governments and institutions co-operate financially and scientifically to ensure that this work is completed as soon as possible.

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