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### Predicting the Fate and Effects of Chlorinated Hydrocarbons in a Coastal Marine System—South-East Indian Ocean

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## PREDICTING THE FATE AND EFFECTS OF CHLORINATED HYDROCARBONS IN A COASTAL MARINE SYSTEM—SOUTH-EAST INDIAN OCEAN

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Blubber samples of dolphins collected in the south-east Indian Ocean all show traces of the persistent organochlorine compounds. The bottlenosed dolphin, which feeds close to shore, showed consistently higher levels than the common dolphin, which feeds further offshore. For both species, female cetaceans transfer approx. 80% of their residue load to their offspring during lactation. The DDE/*t*-DDT ratios indicate an 'ageing' of DDT in marine mammals from the south-east Indian Ocean, implying no major recent input of DDT to this region. The usefulness of organochlorines as chemical tracers in determining biological parameters is illustrated.

**KEY WORDS:** Chlorinated hydrocarbons, cetaceans, DDE/*t*-DDT ratio.

### INTRODUCTION

The sea is the ultimate repository of terrestrial matter, including the vast array of man-made chemicals introduced annually. Of considerable concern to marine ecosystems are the stable chlorinated hydrocarbon compounds, such as the industrial polychlorinated biphenyls (PCBs), the insecticides DDT (and its analogues), dieldrin and chlordane. These synthetic chlorinated hydrocarbons have a low water solubility, a high lipid/water partition coefficient as expressed by their  $K_{ow}$  values, and do not readily undergo metabolic transformation. The transfer of these lipophilic compounds among various compartments in the marine environment is controlled not only by these properties but also by the nature (physical and chemical) of the environment. For a group of compounds such as the PCBs, the rates of metabolism and disposition are heavily influenced by congener structure as indicated by the positions of chlorination.

The identification of lipid tissue as a major sink for chlorinated hydrocarbon residues should allow for the monitoring of concentrations in this compartment to provide information about actual exposure levels as well as about changes in exposure level with time. Although this generalised model is fairly well accepted, only a few of the transfer processes have been described in any more than qualitative terms. Of the suite of organisms used for such monitoring, marine mammals are among the most suitable. They have a long life span, are at the highest trophic level in the ocean and are probably potential bioindicators of the average pollution load of the waters they inhabit.

The common dolphin (*Delphinus delphis*) is neritic along the south-east coast of southern Africa, occurring over the entire continental shelf seaward of the coastline between 34°S, 22°E and 27°S, 33°E. The bottlenosed dolphin (*Tursiops truncatus*) is widely distributed in the nearshore coastal waters of the Indian Ocean and is frequently encountered along the south-east coast of southern Africa.

Blubber samples of animals caught accidentally in anti-shark nets set off prime beaches, were analysed for residues of the lipophilic chlorinated hydrocarbons PCBs and DDT. A total of 133 common dolphin blubber and 100 bottlenosed dolphin blubber samples were analysed. The residue data obtained are utilised to describe trends and possible changes in environmental contamination during the period 1980–1987.

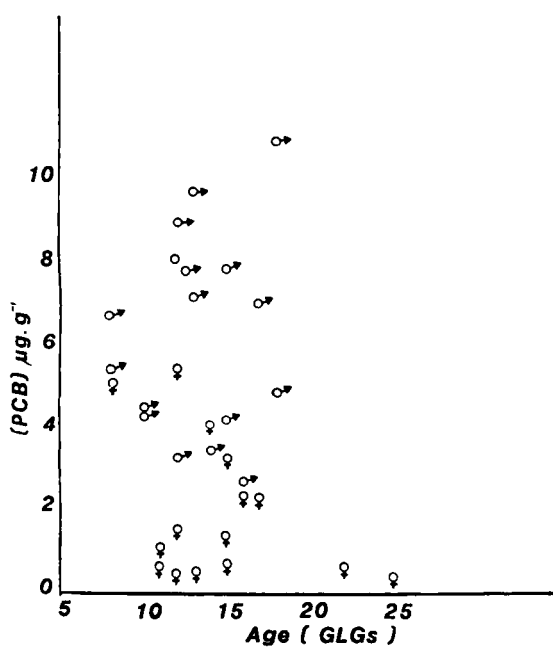
## RESULTS AND DISCUSSION

A difference in the accumulation pattern of PCB and *t*-DDT (DDT+DDD+DDE) between males and females was evident. In males, residue concentrations in the blubber increased with age, whereas in female cetaceans, the residue concentrations showed a sharp decline at approximately the age of sexual maturity (Figures 1 and 2). A significant difference was found between residue levels in females before and subsequent to their first or second ovulation.

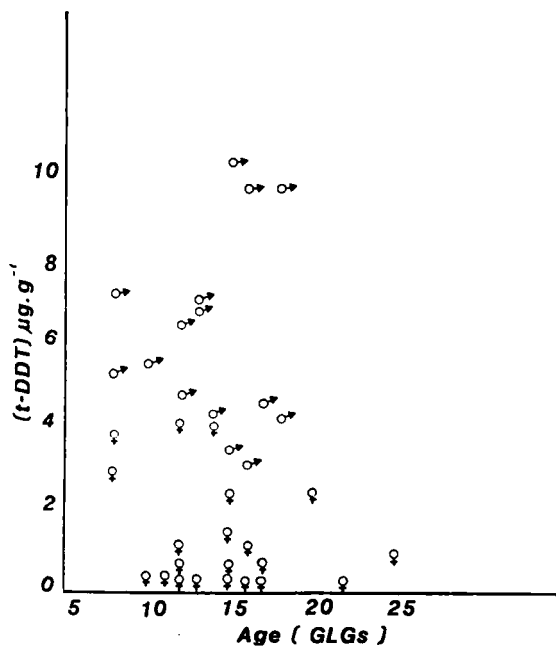
A decline in PCB levels with time is clearly evident in both species when allowance is made for variation of residue concentrations with age, sex and condition (Figure 3). There was a sharp decline in *t*-DDT levels in bottlenosed males from 1980 to 1985, with an apparent increase for the period 1986/1987 (Figure 4). This increase is also evident in the *t*-DDT residue levels in the bottlenosed females. Residues of both *t*-DDT and PCB declined from 1980 to 1985 in the common dolphin. There is a significant difference between mean *t*-DDT and PCB concentrations in the blubber of males of the common dolphin and the bottlenosed dolphin and the juveniles of the two species ( $P < 0.05$ ). This would seem to indicate a higher contaminant load in the coastal waters than in the open ocean.

Female cetaceans transfer the major portion of their PCB and *t*-DDT residue load to their offspring through lactation. The more lipid-soluble PCB components appear to be transferred less efficiently than the DDT group. However, this could not be proved conclusively because of the small sample size. The toxic congeners 77, 118, 114, 105, 156 and 189 and the aryl hydrocarbon hydroxylase (AHH) inducers, congeners 170, 128 and 138 were amongst the congeners detected in the blubber samples.

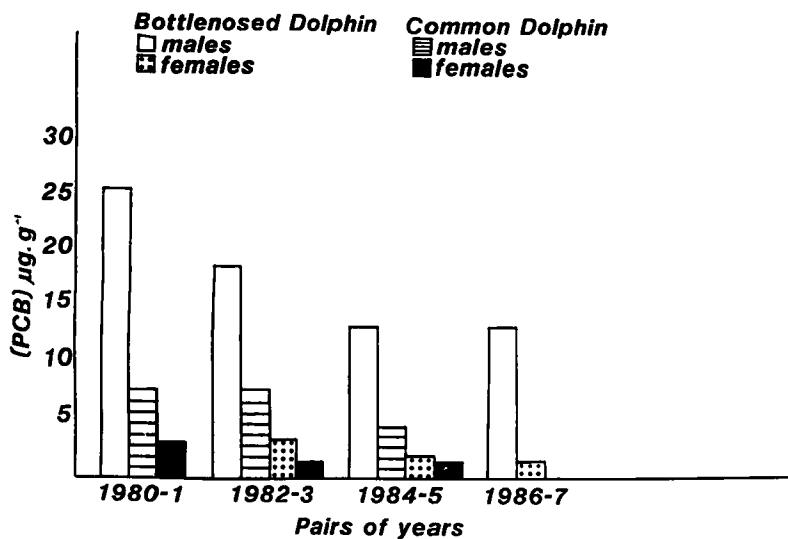
It has been reported that DDT levels in a population can be monitored by observing trends in the proportion in which DDE occurs in the samples (1,2). The DDE/*t*-DDT ratio for female common dolphins over the period 1980 to 1985 varied between 0.81 and 0.94 (Figure 5), with the lowest ratio of 0.81 observed for the years 1980 and 1982. The DDE/*t*-DDT ratio in male common dolphins decreased from 0.83 in 1980 to 0.77 in 1981, after which it increased to a value of 0.99 in 1985. In male bottlenosed dolphins the DDE/*t*-DDT ratio decreased from



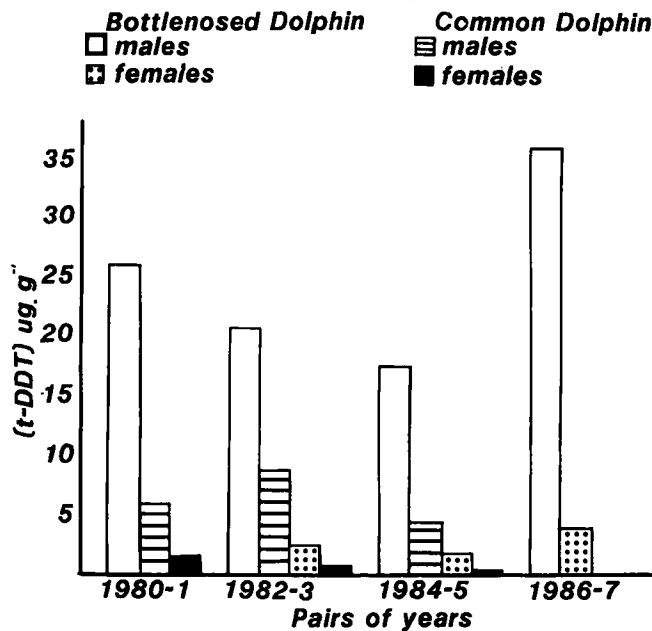
**Figure 1** Polychlorinated biphenyl concentrations ( $\mu\text{g}\cdot\text{g}^{-1}$  wet weight) in blubber of male (♂) and female (♀) common dolphins (expressed as the number of growth layer groups).



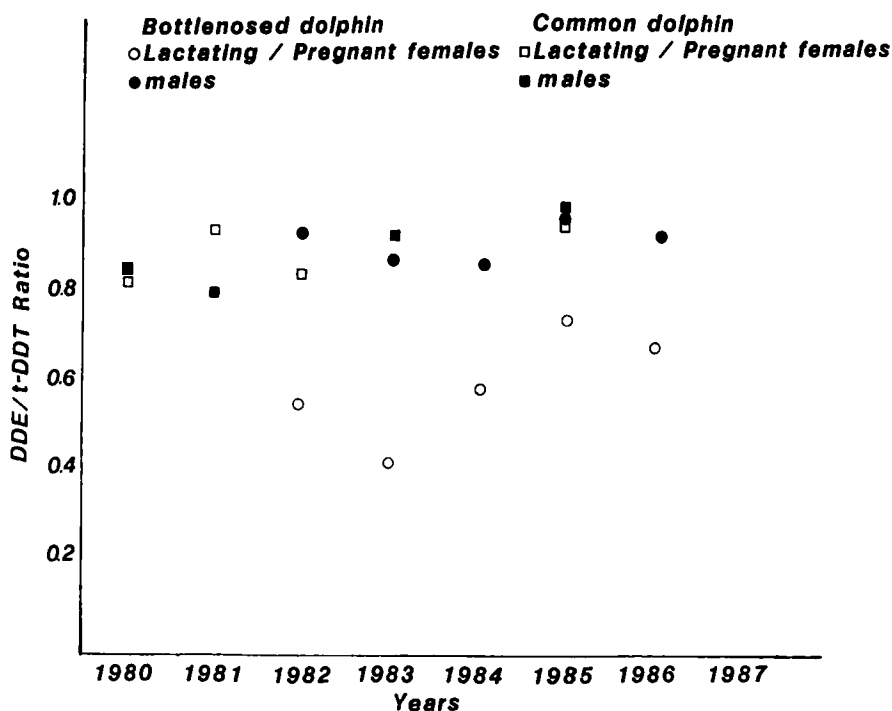
**Figure 2** *t*-DDT concentrations ( $\mu\text{g}\cdot\text{g}^{-1}$  wet weight) in blubber of male (♂) and female (♀) common dolphins (expressed as the number of growth layer groups).



**Figure 3** Comparison of PCB concentrations in blubber of common and bottlenosed dolphins during the period 1980–1987 (Concentrations expressed as  $\mu\text{g.g}^{-1}$  wet weight).



**Figure 4** Comparison of *t*-DDT concentrations in blubber of common and bottlenosed dolphins during the period 1980–1987 (Concentrations expressed as  $\mu\text{g.g}^{-1}$  wet weight).



**Figure 5** DDE/t-DDT ratios for male and reproducing females of the common and bottlenosed dolphins during the period 1980–1987.

0.93 in 1982 to 0.88 in 1983–1984; increased to 0.97 in 1985 and decreased to 0.91 in 1986. Reproductive female bottlenosed dolphins had the lowest DDE/t-DDT ratios (Figure 5). The ratio showed a decrease from 0.57 in 1982 to 0.42 in 1983 and although, next, there was a steady increase in the ratio, a lower ratio was again observed for 1986 (0.68). The high ratios of 0.9 suggests that no recent significant input has occurred in the open ocean or shelf areas, whereas the lower ratio observed in the female bottlenosed dolphins could be explained by a more recent input into the coastal waters.

## CONCLUSIONS

In conclusion it can be said that although isolated and localised contamination does occur, in general, the terrestrial load to the oceans has not caused a detectable increase in the PCBs and *t*-DDT load in the coastal marine ecosystem in the south-east Indian Ocean. One area of concern is the relatively high contaminant load transferred during lactation to the calf. The consequences of this load to a calf are at present unknown. It is not impossible that calves exposed to high doses immediately after birth may not survive.

This study has evidenced contamination by compounds that are known to induce severe reproductive dysfunction. Despite the fact that a female may become

reproductive soon after losing a calf, the loss of even one year of reproductive potential may be important to populations already under stress.

### *References*

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