PCB and DDT Residues in a Mediterranean Pelagic Food Chain

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For several years data have been accruing on the distribution of chlorinated hydrocarbon pollutants in marine ecosystems. An overall picture of ambient levels in biota, water and sediments is now emerging (IDOE 1972); however, despite the vast amount of data collected to date, questions still arise as to whether certain pollutants such as chlorinated hydrocarbons are indeed biomagnified through the marine food web. Evidence both for and against trophic concentration of PCB and DDT compounds has been cited (ROBINSON et al. 1967; HARVEY et al. 1972, 1974; IDOE 1974; BAIRD et al. 1975; ANDRUSHCHENKO et al. 1975; SCHAEFER et al. 1976; ADDISON 1976). The answer to this question remains unclear due to lack of adequate knowledge about the relative importance of food and water in the uptake of these compounds as well as the fact that conclusions are often confounded by comparing pollutant concentrations in successive links in the food chain sampled at different geographical locations and/or at different points in time. The situation is further complicated by complex prey-predator relationships that exist in many marine communities. In the present study we have tried to eliminate some of these problems by examining PCB and DDT residue concentrations in species belonging to a relatively well-defined pelagic food chain sampled at one point in space and time.

MATERIALS AND METHODS

All organisms were collected on a single night during November 1974 at a station approximately 5 km off the coast of Villefranche-sur-Mer, France. Between 2100 and 2300 hours macrozooplankton and nekton were fished by making several oblique tows between 100 m depth and the surface with an Isaacs-Kidd midwater trawl. Microplankton was sampled simultaneously by towing a 1 meter plankton net (76 µm aperture) at the same depth as the Isaacs-Kidd trawl. Pre-cleaned glass and metal implements were used to sort species in order to avoid contaminating the samples with PCBs. Although extreme care was taken to avoid unnecessary contact of the samples with plastic materials, some contact inevitably occurred between the organisms and the nylon plankton nets. Cross contamination of PCBs between plankton and nylon nets can occur (HARVEY and TEAL, 1973); however, extraction of the plankton nets used in our study indicated that PCB contamination from this material would be negligible.

Samples were analyzed following the procedures outlined in the PESTICIDE ANALYTICAL MANUAL. All samples were frozen, lyophilized and pulverized in preparation for extraction. In the case of the

Bulletin of Environmental Contamination & Toxicology,
0007-4861/78/0019-0244 $1.20

larger organisms such as shrimp and fish, several individuals from the same net haul were pooled to form the sample. Samples of microplankton (0.1-1.5g dry), euphausiids (1-8g dry), shrimp (7-12g dry), and fish (6.3g dry) were subjected to extraction with hexane in a Soxhlet extractor (8 hours at 4 cycles/hour). Interfering substances were eliminated from the hexane extracts by chromatography on Florisil and by treatment with concentrated H_2SO_4. It was not necessary to remove fatty substances by acetonitrile/hexane partitioning. Hexane extracts were then concentrated to a convenient volume (usually 0.2-0.5 ml) in a Kuderna-Danish concentrator, and analyzed by gas chromatography. The presence of DDT residues was confirmed by dehydrochlorination in methanolic KOH. Precautions were employed to ensure that contamination from chemicals, apparatus and glassware was negligible. Routine procedural blanks were run concurrently with samples; the results were always less than 10% of the sample values. Quantitation was carried out by relating sample strip chart peak heights to those of standard solutions. In the case of PCBs the sum of the heights of 6 peaks corresponding to the 6 major peaks of the standard were used for calculations. If a peak was missing in the sample chromatogram it was counted as zero in the summation. A surface water sample (200 ℓ) was also collected at the same time as the animals and analyzed for PCB and DDT compounds. The analysis was carried out according to the method of HARVEY and STEINHAUER (1976). The PCB concentration (DP-5) was 2.5 ng/l, a value which is considered representative for these waters (ELDER 1976); however, DDT compounds were not detected.

RESULTS AND DISCUSSION

Food chain inter-relationships among the pelagic organisms examined in our study have been relatively well defined (CASANOVA 1974; LAGARDERE 1976). Microplankton serve as food for the omnivorous macroplanktonic euphausiid, Meganyctiphanes norvegica, which in turn is preyed upon by the carnivorous decapod shrimp Sergestes arcticus and Pasiphaea sivado. M. norvegica and other pelagic crustaceans make up the bulk of the diet of the myctophid fish, Myctophus glaciale. Examination of the stomach contents of these species immediately after collection verified that these feeding relationships were occurring at the time the samples were taken.

Concentrations of PCBs as DP-5 and p,p' -DDE in these organisms are given in Table 1. In general, the levels of these chlorinated hydrocarbons in zooplankton and nekton do not differ markedly from those reported for similar species in the Atlantic and Pacific oceans (HARVEY et al. 1974; BAIRD et al. 1975; CLAEYS et al. 1975).

TABLE 1

Chlorinated hydrocarbons in pelagic organisms collected in November 1974 off Villefranche-sur-Mer, France

Organism	Wt. ratio wet/dry	p,p' -DDE (µg/kg dry weight)	PCB	†† PCB C.F.
*Microplankton	10.4	†N.D.	4500	170,000
Meganyctiphanes norvegica	5.0	26	620	50,000
Sergestes arcticus	4.0	15	470	47,000
Pasiphaea sivado	4.2	5	210	20,000
Myctophus glaciale	3.2	1	50	6,000
(Surface water)		N.D.	(2.5 ng/l)	

* Principally copepods, unidentified small crustaceans, chaetognaths, phytoplankton and detritus

† N.D. = not detectable = < 0.5 µg/kg

†† Concentration factor defined as ppb wet PCB in organism/ppb PCB in water

Considered on a whole organism, dry weight basis, our data show that PCB and p,p' DDE concentrations are not biomagnified in this particular food chain. In fact, an approximate 100-fold reduction in PCB concentration is noted between microplankton and myctophid fish. We did not analyze the lipid content of our samples, hence, the possibility exists that chlorinated hydrocarbon concentrations based solely on lipid weight may not show the same trophic relationship.

Neither DDT nor its metabolites was detected in the surrounding water or the microplankton. Their absence in microplankton was further corroborated by the fact that none of these compounds could be detected in fecal pellets produced by M. norvegica which had been feeding on the same microplankton population (ELDER and FOWLER 1976). On the other hand, p,p' -DDE was detectable in the euphausiids, shrimp and myctophid fish. The reason for these differences is not immediately clear. The absence of DDT compounds in the water is most likely a reflection of their seasonal rather than continuous input.

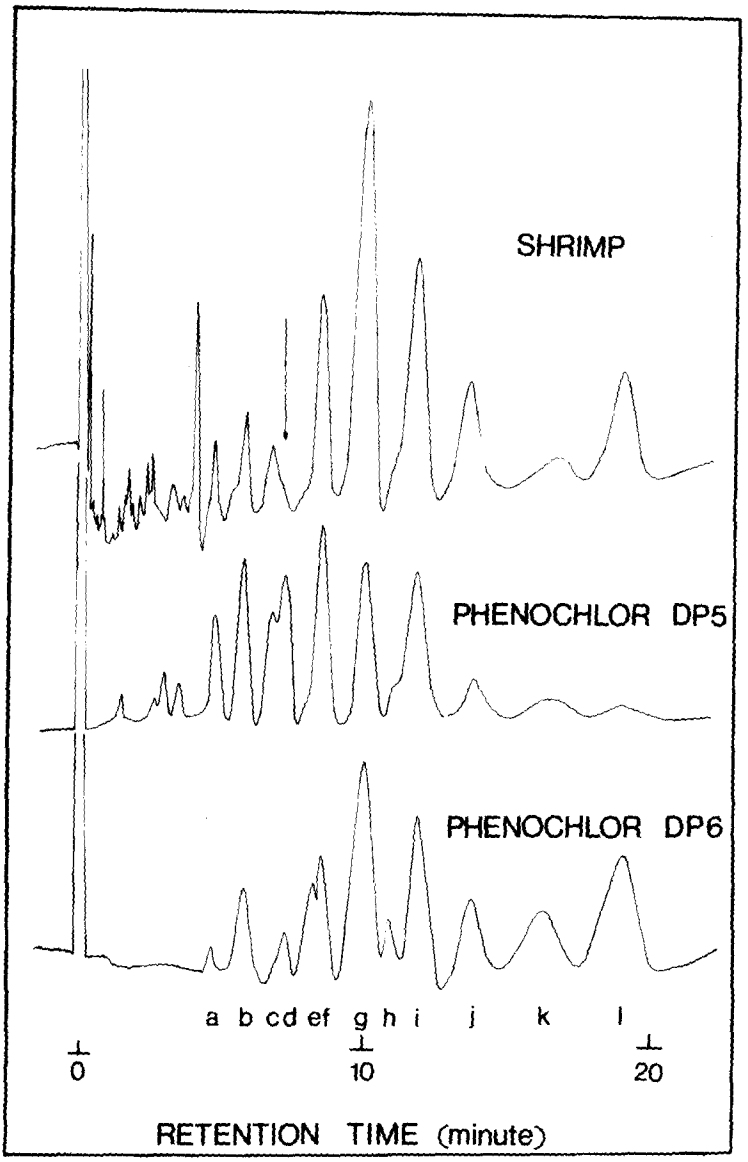

FIG. 1. Gas chromatograms of PCB standards and extract of the pelagic shrimp, Pasiphaea sivado. The arrow indicates the peak (d) which is diminished relative to standard PCBs. GLC conditions: Varian 2100 gas chromatograph; Nitrogen carrier gas (flow rate 40ml/min). ^{63}Ni ECD detector. Oven temperature: 200°C. Injector and detector temperature 250°C. Column: 2m x 4mm id, glass; 10% DC 200 on Gas Chrom. Q.

The residue p,p' -DDE is a common end product of p,p' -DDT metabolism, hence, the presence of this residue in the macrozooplankton and nekton was probably the result of an earlier incorporation of DDT compounds. The lack of any DDT residues in the microplankton could also be a reflection of the seasonality of DDT influx, especially if DDT and its metabolites are lost rapidly from this population either metabolically or through population turnover. We consider this explanation only as tentative since there are many other factors which could complicate the picture.

There is some evidence that P. sivado may selectively absorb, excrete or metabolize certain PCB isomers. Chromatograms for all samples closely resembled Phenochlor DP-5 or Phenochlor DP-5 plus Phenochlor DP-6. In the case of P. sivado however, at least one peak (peak d, Fig. 1) was definitely diminished in height relative to both DP-5 and DP-6. A similar observation was made by CLAEYS et al. (1975) for extracts of the pink shrimp, Pandalus jordani, collected off the northwest coast of the United States.

Results from our survey of PCBs and DDTs in one specific segment of the marine food web support the contention that chlorinated hydrocarbons do not undergo trophic biomagnification as one proceeds up the food chain. It must be remembered, however, that accumulation through the food chain is probably only one of several factors affecting the concentration of these compounds in pelagic organisms (IDOE 1974; BAIRD et al. 1975; SCHAEFER et al. 1976; ADDISON 1976). Nevertheless, in the case in which food intake is the predominant route, it is evident that only by sampling organisms at the same time and from the same water mass will it be possible to acquire a clearer picture of the actual trends in trophic level concentrations of chlorinated hydrocarbons.

ACKNOWLEDGEMENTS

The International Laboratory of Marine Radioactivity operates under a tripartite agreement between the International Atomic Energy Agency, the Government of the Principality of Monaco and the Oceanographic Institute at Monaco. This study was sponsored in part by the United Nations Environment Programme, UNEP Contract No. FP/0503-76-09 (978). Support for the present work is gratefully acknowledged. We thank the Zoological Station, Villefranche, for shiptime.

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