matters arising

PCB concentrations in North Atlantic surface water

CONCENTRATIONS of polychlorobiphenyls (PCBs) have supposedly[1] declined 40-fold over wide regions of the North Atlantic from levels of about 30 ng l^{-1} in 1971–72, to 0.8 ng l^{-1} in 1973–74. This decline has been attributed[1] to the restriction of sales of PCB for non-captive uses during the period 1970–73, both in Europe and in North America. Much as we would like to believe these conclusions, they seem unfounded to us, and they seem to ignore the dynamics of the PCB–seawater system.

From estimates of PCB concentrations in 0.3 μm filtered seawater from 41 North Atlantic stations, Harvey *et al.* estimated a standing stock of dissolved PCB in the upper 200 m of the North Atlantic of 2×10^4 tonnes (t) in 1972 (ref. 2) in addition to whatever quantity was bound up with <0.3 μm of particulate material; they suggested that the latter could increase the amount of PCB in the 1972 standing stock by 10%.

Using the reported 40-fold decline in the PCB concentration, and a model based on a simple exponential loss-rate we have derived a mean residence time, r, for PCB in seawater in the North Atlantic. Our model simulates the loss process on a daily basis by reducing the standing stock, S, by S/r. A range of values of r was tested to discover the value which reduced S ($=2\times10^4$) by 97.5% (= 40-fold) at the end of 365 d. The model indicated a mean residence-time of just under 100 d. In order for such a system to sustain the reported standing stock of 2×10^4 t, this value of r requires an annual input of 7.3×10^4 t (representing the loss from the stock over 365 d).

That seems absurd in relation to what is known about the total production of PCB during the period 1960–71 (Table 1) because it suggests that a standing stock of the magnitude reported by Harvey *et al.* could only be achieved if the total world production of PCB were put continuously into the North Atlantic.

For a more reasonable explanation for this result, two possibilities should be considered: first, that the analytical results are not correct, so that the 1971–72 data (24–41 μg l^{-1}) are too high or the 1973–74 data (0.8–2.0 μg l^{-1}) are too low; or, second, that the extrapolation from individually correct data to a standing stock for the whole North Atlantic is at fault.

It seems relevant to note that three different analytical methods were used to obtain the two sets of data, that no evidence is presented on the repeatability of individual data and that, at least for the 1971–72 data, 36 of the 52 samples were collected with buckets at the water surface and so must have included an unknown and variable quantity of material from the surface microlayer which is known to be highly enriched with hydrocarbons even in the open ocean[3].

Further, if the results from the 1971–72 analyses proved to be too high to be representative of water between the surface and a depth of 200 m over the North Atlantic as a whole, it would also resolve the paradox that has been evident for some years between those data and the relatively low values (about 1.0 ng l^{-1}) reported from coastal waters of the generally rather contaminated California Current[4] and those (<10.0 ng l^{-1}) from the Irish Sea[5], a region likely to be relatively highly contaminated.

The extrapolation from the two sets of data to two levels of standing stock for the whole North Atlantic (which is based simply on an estimate of the volume of the 0–200 m layer of that ocean) also seems to be not very well founded. The data are log-normally distributed, and so extrapolation would have been more appropriate from the geometric rather than the arithmetic mean; such a statistical distribution is likely to be a result of the very high degree of variability within regions (Harvey[2] reports a range of 1–150 μg l^{-1} over a distance of only 80 km in the open Atlantic) or to the fact that both the 1971–72 and 1973–74 data comprise regional clusters of stations, each cluster being widely separated from others, so that there was little geographical correlation within or between the two sets of data. Even the two sets of data, one in each period, derived from the work of Quinn *et al.*[3] are widely separated: in 1971 they came from a line between Newfoundland and Iceland, but in 1973 they came from the Sargasso Sea. We therefore suggest that the data and interpretations presented by Harvey *et al.*[1] are insufficient evidence on which to base the deduction that recent partial controls on uses of PCBs have already produced a dramatic decrease in the contamination of the upper layers of the open Atlantic Ocean.

Table 1 Global production (t × 10^4) of PCB, assuming US production to be half of global production[6]

1960	1961	1962	1963	1964	1965	1966	1967	1968	1969	1970	1971
3.44	3.32	3.48	4.06	4.62	5.50	5.90	6.84	7.52	6.94	7.72	3.66

ALAN R. LONGHURST
PHILIP J. RADFORD

Institute for Marine Environmental Research,
Plymouth PL1 3DH, UK

1 Harvey, G. R., Steinhauer, W. G., and Miklas, H. P., *Nature*, **252**, 387 (1974).
2 Harvey, G. R., Steinhauer, W. G., and Teal, J. M., *Science*, **180**, 643 (1973).
3 Bidleman, T. F., and Olney, C. E., *Science*, **183**, 516 (1974).
4 Goldberg, E., *NSF IDOE Baseline Conference*, 11 (National Science Foundation, Washington, DC, 1972).
5 *The Seabird Wreck in the Irish Sea, Autumn, 1969*, Natural Environment Research Council, Series C (4),, 14 (1971).
6 *Polychlorinated Biphenyls in the Environment* (US Department of Commerce, Washington, DC, 1972).

HARVEY AND STEINHAUER REPLY—We disagree with Longhurst and Radford[1] that our analytical results are incorrect. After several comparisons of the different methods, analytical standards and reproducibility (± 20%) we are quite certain that our data are correct as they stand. It is relevant that during 1971–72, when about 30 ng l^{-1} PCB was being measured we were also measuring 1 ng l^{-1} or less in tapwater and groundwater. Also, in 1973–74 we measured PCB concentrations of 30–300 ng l^{-1} in polluted estuaries near Boston, USA, at a time when North Atlantic values had declined to 0.8–2.0 ng l^{-1}. Clearly, the methods were capable of determining PCB concentrations present in different water masses over a wide range of values during the period in question.

We now agree, however, that our previous extrapolation was not justified. In the light of some recent data it seems that each area of the North Atlantic (the central gyre, doldrums, trades, and so on) is characterised by clusters of similar PCB concentrations which roughly correlate with salinity, wind direction and latitude[2]. As we do not have data from north of 45° N since 1972, nor from south of 20° N before 1973, our extrapolation from an average concentration to the