A reply to A. Doury

We appreciate the opportunity to respond to some points raised by A. Doury in relation to our own study. We do not intend to discuss how realistic our release hypotheses are. They were obviously designed to relate to the French underground testing of nuclear bombs, a practice fortunately halted some time ago that has very little chance of being revived again. In that sense the present debate is now only of academic interest.

We agree with A. Doury that horizontal and vertical mixing processes are far more complex than expressed and parameterized in our study, which used constant diffusion coefficients. We disagree with the approach taken by A. Doury for a number of reasons.

With the exception of upwelling and downwelling regions, vertical current velocities in the ocean are generally quite small. The most important factor for vertical transport of conservative tracers is vertical mixing. Its parameterization is therefore crucial to the success of any model. Our parameterization has been used successfully in a number of studies by others, which produced good agreement with observations. We tested our model of the South Pacific Ocean with tritium data and again found good agreement with the observed distribution of tritium.

We concur with A. Doury that a relationship exists between time and the size of the dispersing cloud and consequently the horizontal diffusion coefficient. This has been derived from field experiments with, for example, Rhodamine B and is well established knowledge. However, it is important to note that such experiments and the derived relationships describe the spreading of the diffusive material close to the source (the near-field behaviour). Our study was concerned with the far-field distribution when horizontal dispersion of the tracer is dominated by the advective field and turbulent diffusion becomes relatively unimportant (a number of authors therefore occasionally propose to omit horizontal diffusion altogether). Using a constant diffusion coefficient is certainly acceptable for such a situation. The cross-over point between near-field behaviour and far-field behaviour is found where the two approaches give identical concentrations. According to Doury (his Table 1) this occurs somewhere near 100-200 km from the source. Rather than disproving our results, Doury’s calculations complement ours by giving more accurate estimates for the near-field, where the concentrations turn out to be much higher than estimated by our model.

Finally, we agree with A. Doury that the current velocities used in our model

re on the small side and not necessarily representative for currents that might be found at a particular place and time. Again, Doury's comments on current features in the vicinity of Polynesia are of importance when the near-field distribution is considered but do not influence the far-field situation, where eddies and contortions are represented through long-term means. Our decision to base the circulation data on a numerical model was motivated by a desire not to assume possible but unverifiable current patterns. We considered a circulation derived from physical principles and based on the equations of motion the next best option, even if it has its intrinsic limitations. A better approach would require an eddy-resolving model, in which all contortions are resolved and all velocities are therefore realistically large. Experience with such models shows that they change the circulation in some regions, particularly in the equatorial zone, in western boundary currents and in the Circumpolar Current, but not in the centres of subtropical gyres.

In summary, Doury's study is a valid addition to our results. It gives more accurate (and significantly higher) estimates of cesium concentrations in the vicinity of Polynesia but does not invalidate our findings for the remainder of the South Pacific.