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Interactive comment on "Can whales mix the ocean?" *by* T. J. Lavery et al.

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This paper offers a 'back-of-the-envelope' calculation of the amount of mixing caused by 80 sperm whales near Hawaii. The key is equation (1). I do not understand why this equation estimates diapycnal diffusivity, nor is there a reference to guide me. It contains nothing about to stratification, energy or any of the usual things used in such estimates. They are all hidden in the volume of the wake, estimated by (2) for which no reference or justification is given. It well known that the properties of wakes in a stratified fluid depend strongly on the stratification, yet this again appears nowhere in (2). Furthermore, the calculation does not include the depth of whale diving. Surely this must matter since whales will mix only the region where they dive (except maybe for wave radiation) and if they dive deeper their efforts must be spread out over a wider region with less mixing in each region.

For example, I can estimate that for a whale with cross sectional area of 20mˆ2 moving through the water of density rho=1024 at V=1.5 m/s with a drag coefficient of Cd=0.2, the work required is W=rho*0.5*Cd*Vˆ3= 7000 W. This is not unreasonable since a person uses several hundred watts walking and whales are a lot bigger. Also 0.2 is a pretty low drag coefficient consistent with whales being efficient swimmers. The Froude number of whale V/ (N R)=100 (where R=5m is its diameter and N=0.003 1/s is the stratification) so it is safe to ignore stratification in this calculation. 80 Whales work at 5e5 W. A volume of 10ˆ4 kmˆ2 to a depth of 500m is 5x10ˆ12 mˆ3 or M=5x10ˆ15 kg, so the average rate of work is W/M= E= 10ˆ-10 W/kg energy input into the water. Using a slightly submaximal mixing efficiency of 0.1, K=0.1 * E / Nˆ2, where N is the stratification. In the upper ocean, where nutrient flux matters, Nˆ2=1e-5 sˆ-2 is a reasonable number, yielding K=1e-6 mˆ2/s. This is just what they estimate, but by entirely different means. So I don't think their number is completely unreasonable, but I don't understand how they got it.

The paper is unacceptable for publication in its current form. However, the topic is certainly of interest and I encourage the authors to resubmit with a much stronger section on the estimation of diffusivity. In particular, the previous work on whale wakes needs to be reviewed in much greater detail so that their calculations are more rigorous and understandable. Some estimates of uncertainties might also be helpful.

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