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Comment

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

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Received and published: 2 September 2012

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 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.

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For example, I can estimate that for a whale with cross sectional area of 20m^2 moving through the water of density $\rho=1024$ at $V=1.5$ m/s with a drag coefficient of $C_d=0.2$, the work required is $W=\rho*0.5*C_d*V^3=7000$ 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 $R=5\text{m}$ 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 10^4 km² to a depth of 500m is $5x10^{12}$ m³ or $M=5x10^{15}$ kg, so the average rate of work is $W/M= E= 10^{-10}$ W/kg energy input into the water. Using a slightly submaximal mixing efficiency of 0.1, $K=0.1 * E / N^2$, where N is the stratification. In the upper ocean, where nutrient flux matters, $N^2=1e-5$ s⁻² is a reasonable number, yielding $K=1e-6$ m²/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.

Interactive comment on Biogeosciences Discuss., 9, 8387, 2012.

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