Biogeosciences Discuss., 9, C8732–C8734, 2013
www.biogeosciences-discuss.net/9/C8732/2013/

Biogeosciences
Discussions

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

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Received and published: 4 March 2013

We thank the referee for her/his rigorous evaluation of the manuscript. In response to her/his comments we have made a suite of modifications that have improved the quality of the manuscript. Below we have included our response to every specific comment of the referee as well as a description of the proposed changes to the final manuscript (the original referee comments are included in inverted commas for reference).

1. "First, I don't immediately understand the relevance of (1) to an effective diffusivity estimate". Further details have been added to better explain the novel methodology we present. We have altered our terminology to better reflect that we are estimating Darwinian mixing, which is the amount of water entrained by the whale moving through the water. Our model is thus a behavioural model. We have added a paragraph into Section 2.2 to explain Darwinian mixing and have highlighted that nutrient stratification

is not considered in Eqn 1 but rather is considered in Eqn 6 in Section 2.4. Further information has been added to explain the various parameters that contribute to our model.

We have added a classical fluid dynamics model by D'Asaro to estimate diapycnal diffusivity in order to provide a comparison for our novel methodology of estimating Darwinian mixing, which is the diapycnal diffusion caused by a swimming animal. As the models return the same estimation we can be confident that the new methodology adequately estimates Darwinian mixing.

2. "It might help the reading of (2) for the readers to be reminded of what a Strouhal number is and how it is used to compute the size of the tail stroke". A description of the Strouhal number and the parameters that constitute the Strouhal number are included in Section 2.2.

3. "What does the estimate of sperm whale mixing (10ˆ-6 mˆ2/s) imply about the injection of kinetic energy by swimming whales into the environment"? Referee #4 (Prof. D'Asaro) has kindly outlined a model that estimates mixing by calculating the rate of kinetic energy injection. As this is a more established methodology for calculating diapycnal mixing, we have added Prof. D'Asaro's model under Section 2.3 Model Validation. The inclusion of this alternative model offers the reader confidence that the novel methodology adequately estimates the mixing by sperm whales and provides an alternative framework for comparing the energy input by whales with previous studies.

4. "The suggestion of the constancy of whale induced flux to the structure is interesting. However, it is important I think to compare this estimated flux not only to biologically mediated processes but physical ones. In particular, a background diffusivity of a few times 10ˆ-5 m/s as is thought to be driven by the ubiquitous internal wave field, is similarly persistent in time (probably) yet appears to be at least 10 times larger than that due to the whale associated diffusivity. Is there a reason that the role of whales stands out in spite of this comparison". Sperm whales inhabit waters of depth greater

than 1000m and thus input nutrients in the open ocean. As breaking internal waves are typically restricted to the continental shelf, they are not likely to be inputting significant amounts of nutrients into the open ocean. We have more explicitly stated that we are considering the open ocean inhabited by sperm whales and have discussed breaking internal waves in this context in Section 4.2.

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