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Biogeosciences Discussions

Interactive comment on "Interannual variability of pteropod shell weights in the high-CO_2 Southern Ocean" *by* D. Roberts et al.

D. Roberts et al.

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We thank referee #2 for a constructive review and insightful suggestions for additions to our paper. Ocean acidification is, as the review notes, a pressing issue in marine science and in situ observations of calcification in marine organisms are limited. Our particular contribution to this field is the first interannual time series collection of in situ pteropod shell data from the Southern Ocean. Pteropods may be a particularly sensitive group of calcifiers, and our data are from a region where the first effects of ocean acidification on marine calcifiers may be seen (McNeil and Matear, 2008). We acknowledge that our data set is limited by technology and remoteness to discrete samples at variable intervals over the last decade and does not represent a continuous record of pteropod flux. This raises two issues, as referee # 2 observes: 1) data collection and analysis limitations and 2) attribution and magnitude of observed changes in our

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dataset. We discuss each issue below:

1) We only have a small dataset of Limacina helicina antarctica forma antarctica shells (97 specimens spread over 5 sample seasons, with only 3, 11 and 1 specimens collected in 1999/2000, 2000/01 and 2005/06 respectively) and the trend line appears to be heavily influenced by a large flux of large specimens in January 1998. However, our statistical analyses account for these limitations i.e. we use non-parametric methods that make no implicit assumptions about underlying distributions for our non-uniform sampling periods and limited sample sizes. We also acknowledge the difficulty of quantifying within-sample error distributions and characterising seasonal variability in the dataset.

Referee # 2 mentions extreme annual variability in distribution and shell-size of pteropod assemblages, and suggests the variability in timing of our sediment trap collections may have contributed significantly to the observed temporal shell weight distribution. To address the possible influences on shell weight of season, pteropod patchiness and growth variability, referee #2 suggested we determine whether size-specific (width) shell weights have decreased over the observation period. We have determined mean shell diameter and shell diameter range (minimum – maximum) for each morphotype in each sediment trap cup sample and will include this information in our revised manuscript and supporting material along with our shell weight observations. We found no significant temporal trend in shell size for Limacina helicina antarctica forma antarctica. These data suggest that observed interannual changes in shell weight for Limacina helicina antarctica forma antarctica are not significantly influenced by shell size. Similarly, no significant temporal trend was found in mean shell size for forma rangi. We reiterate here that we are using flux-weighted means for whole pteropod shell weight and size in order to account for sediment-trap cup collection time differences.

2) Referee # 2 questions whether the observed decline in mean shell weight for Limacina helicina antarctica forma antarctica between 1997 and 2006 can be attributed

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to a change in calcification rate given the small change in mixed layer carbonate concentration observed between 1995 and 2001. The reduction in carbonate concentration observed at 47°S implies a reduction in the saturation state for aragonite of ˜ -0.2/decade. This is consistent with other estimates of decadal-scale carbonate saturation decrease due to anthropogenic CO2 uptake in this region (McNeil et al., 2001; Matear and Lenton, 2008). Consequently, if the ˜ 35% decadal reduction in pteropod shell weight we estimate is attributable to a change in carbonate saturation, it implies a sensitivity in pteropods approximately five times greater than inferred for the calcite-secreting planktonic foraminifer Globigerina bulloides (Moy et al., in press) in the same water masses. We know that aragonite is less stable than calcite (Mucci, 1983) therefore aragonite producers are likely to respond to ocean acidification more markedly than calcite producers in the same water masses. We acknowledge that we cannot unambiguously attribute the measured change in shell weight to a decline in calcification exclusively. Our revised manuscript will examine additional alternative causal mechanisms for the interannual change in weight measured in forma antarctica. We note, however, that whatever the mechanism responsible, the small rate of decline measured is statistically significant and discernable.

We will draw attention to the limitations highlighted by referee # 2 regarding data collection and analysis throughout our revised manuscript and amend our discussion to include a greater range of possible causal mechanisms, which may include internal population variability. Whatever the causes of pteropod shell variability, our dataset serves as a valuable and timely benchmark against which future change in an important marine calcifier group can be measured in an area particularly vulnerable to ocean acidification.

References: Matear, R. J. and Lenton, A.: Impact of Historical Climate Change on the Southern Ocean Carbon Cycle, J. Climate, 21(22), 5820–5834, doi:10.1175/2008JCLI2194.1, 2008.

McNeil, B. I. and Matear, R. J.: Southern Ocean acidification: A tip-

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ping point at 450-ppm atmospheric CO2, PNAS, 105(48), 18 860-18 864, doi:10.1073/pnas.0806318105, 2008.

McNeil, B. I., Tilbrook, B. and Matear, R. J.: The accumulation and uptake of anthropogenic CO2 in the Southern Ocean south of Australia between 1968 and 1996, J. Geophys. Res., 106, 31432–31445, 2001.

Moy, A.D., Howard, W. R., Trull, T. W., Bray, S.: Reduced calcification in modern Southern Ocean planktonic foraminifera, Nature Geoscience, in press.

Mucci, A.: The solubility of calcite and aragonite in seawater at various salinities, temperatures, and one atmosphere total pressure, Am. J. Sci., 283, 780–799, 1983.

Interactive comment on Biogeosciences Discuss., 5, 4453, 2008.