Biogeosciences
Discussions

Interactive comment on "Distribution of planktonic biogenic carbonate organisms in the Southern Ocean south of Australia: a baseline for ocean acidification impact assessment" *by* Thomas W. Trull et al.

Thomas W. Trull et al.

diana.davies@csiro.au

My recommendation is that the authors need to further elucidate in the manuscript the distinction between particulate material and 'living biomass'. Most particulate pools (POC, PIC and BSi) contain variable contributions of both living biomass (i.e. organisms) and detrital material. In the case of PIC, detached coccoliths (e.g.) can be a significant fraction of the total pool and their small size conveys very slow sinking speeds. In the case of diatoms, empty or broken frustules may stay in suspension (or as part of the cell chain) after the organic material has been removed. Similar comments may

be made about the larger biogenic organisms (foram fragments, juvenile shells, radiolarian tests). While the particulate concentrations of PIC and BSi represent well the (historical) production of biogenic material from coccolithophores and diatoms, as well as the other groups examined here, their relationship to 'living biomass' is not necessarily direct and may break down seasonally and spatially. Recognising that this may occur, for example in post-bloom conditions, is an important caveat that should be clear to the reader.

Agreed, and we added the following sentence to the Introduction: We also note that our technique does not distinguish between living and non-living biomass, and thus is more representative of the history of production than the extent of extant populations at the time of sampling.

Ln 107-108: The calcite content of these different strains of Emiliania huxleyi also differ significantly (see Poulton et al., 2011 for estimates or Muller et al., 2015 for measurements), which may have strong implications for PIC production in S Ocean coccolithophore blooms (e.g. Poulton et al., 2013). Agreed, and we have added a sentence acknowledging this issue and these results: Of course, Emiliania huxleyi itself comes in several strains even in the Southern Ocean, with differing physiology, including differing extents of calcification [Cubillos et al., 2007; M. N. Muller et al., 2015; M.N. Muller et al., 2017; Poulton et al., 2013; Poulton et al., 2011].

Ln 263: Missing full stop between 'cell' and 'Calibration'. Full stop inserted.

Ln 468-470: The POC:PIC ratio given is relatively low, especially for the S Ocean strain: Muller et al. (2015) reports values of 0.83 for over-calcified strains, 1.5 for normal Atype and greater than 2 for the B/C type reported in the S. Ocean. Maybe the authors could add in a statement on the sensitivity of their estimates to cell POC:PIC ratios– and also how detached coccoliths may actually counteract high cellular POC:PIC ratios.A

Agreed. We have replotted Figure 4b using the POC:PIC ratio of 1.5 for the Southern Ocean morphotype A, and added discussion on latitudinal variations in morphotypes,

associated POC:PIC ratios, and their implications for our conclusions: The relatively small POC contribution from coccolithophores is only weakly sensitive to the ~3-fold variation [M. N. Muller et al., 2015] of POC/PIC ratios among Emiliania huxleyi morphotypes. Using the lower value of 0.83 observed for over-calcified forms that occur in the northern SAZ would reduce the POC contribution there but still leave it co-dominant with diatoms, and using the higher value of 2.5 observed for polar morphotype C would increase the POC contribution in Antarctic waters, but still leave it overwhelmed by the diatom contribution (Figure 4b). The relative contributions to total POC are also sensitive to the POC/PIC ratio chosen for diatoms (which vary significantly across genera; [O. Ragueneau et al., 2002; Olivier Ragueneau et al., 2006]). For these reasons, the relative dominance is best viewed on the log scale of Figure 4, and while keeping in mind the considerable scatter.

Ln 518-519: Biometric measurements have confirmed the low PIC per coccolith for the different morphotypes/strains (see Poulton et al., 2011 and/or Charalampopoulou et al., 2016; see also Muller et al., 2015 (as cited)). Agreed, and we have added a clause acknowledging these results: Early work in the South Atlantic found that SPIC values appeared to exceed ocean PIC by a factor of 2-3 [W M Balch et al., 2011], and based on a handful of samples it was suggested that this might reflect a lower amount of PIC per coccolith [Holligan et al., 2010], and it has since been confirmed that polar coccolithophores can have low PIC contents [Charalampopoulou et al., 2016; M. N. Muller et al., 2015; Poulton et al., 2011].

Ln 573: Please correct Emiliania Huxleyi to Emiliania huxleyi. Corrected as requested

Ln 622: Light utilization may be another important factor as there are pigment differences between E. huxleyi strains (see Cook et al., 2011) We added this possibility to the existing sentence, citing the work of Zhang et al., 2015, who measured light responses for coccolithophores: Coccolithophores, especially the most common species Emiliania huxleyi, have been studied sufficiently in the laboratory to allow possible important controls on their niches and especially their calcification rates to be proposed,

including temperature, pH, pCO2, calcite saturation state, light, and macro- and micronutrient availability [Bach et al., 2015; Feng et al., 2016; Mackinder et al., 2010; M. N. Muller et al., 2015; Müller et al., 2017; Schlüter et al., 2014; Schulz et al., 2007; Sett et al., 2014; Zhang et al., 2015].

Ln 653-655: Charalampopoulou et al. (2016) concluded that temperature and light were strong drivers of coccolithophore distribution and calcification across a latitudinal transect in Drake Passage (whilst also acknowledging the role of iron). Have the authors considered the role of (seasonal) light availability? We added this possibility and citation, while also stating that we did not have data sufficient to consider it further: Many properties that might influence coccolithophore productivity decreased strongly and close to monotonically from north to south across the Southern Ocean for our voyages (Figure 6). These include temperature (from 23 to -0.4 C for our samples), salinity (from 35.6 to 33.6, with tight correlation with alkalinity, not shown - data available in the Supplementary Material), pH (from 8.20 to 8.08 on the free scale), and the saturation state of calcite (from 5.22 to 2.12). The strong correlation of these properties means that it is not easy to separate their possible influences on coccolithophore distributions, without relying on specific thresholds or quantitative response models. This problem of correlations among drivers has been noted before in examining transect data across Drake passage, where more detailed measurements of coccolithophore properties augmented with incubation studies found temperature and light were the most probable drivers of coccolithophore abundance and calcification rates [Charalampopoulou et al., 2016]. Our lack of information on the availability of light (mixed layer depth was determined only on the two hydrographic sections), iron, or individual species and strains, makes deducing a possible influence of ocean acidification on coccolithophore distributions from our spatial distribution data even more difficult. We also reiterated the probable importance of light at the end of this section: Further progress in understanding the controls on coccolithophore abundances in the Southern Ocean is clearly needed. At present temperature, light, and competition with diatoms for iron appear to be the strongest candidates (at least for southward expan-

sion [Charalampopoulou et al., 2016; Gafar et al., 2017]; with nitrate a strong influence on the location of the northern oligotrophic boundary; [Feng et al., 2016]).

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