Supplementary Material Overview

Figure S1. Maps comparing ship sampled particulate inorganic carbonate in the coccolithophore size fraction (PIC01; dots) with satellite Chl estimates (SChl, map colours) for each voyage leg. The SChl estimates are averages for the month preceding the start of the voyage leg. Black lines are front locations (see main text and Figure 1 for front names).

Figure S2. Filtration time and volume variations for both PIC size fractions with latitude.

Table S1. Particle compositions (S, T, PIC50, PIC01, POC, PON, BSi)

Table S2. Seawater properties at particle collection sites (S, T, DIC, Alk, $Si(OH)_4$, H_3PO_4, HNO_3)

Text: Evaluation of the possible problem of filter clogging and filtration system design discussion

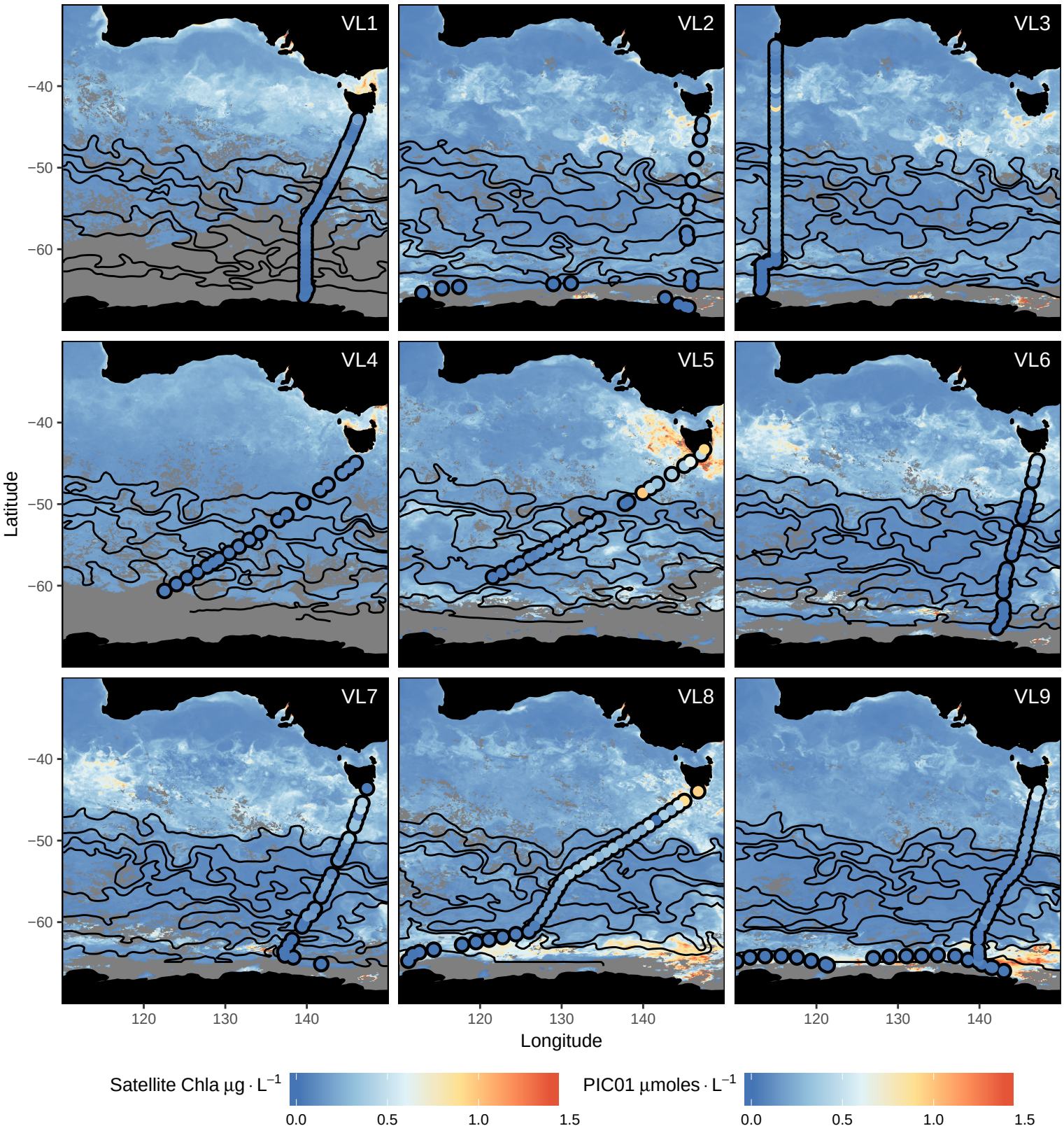
In brief:

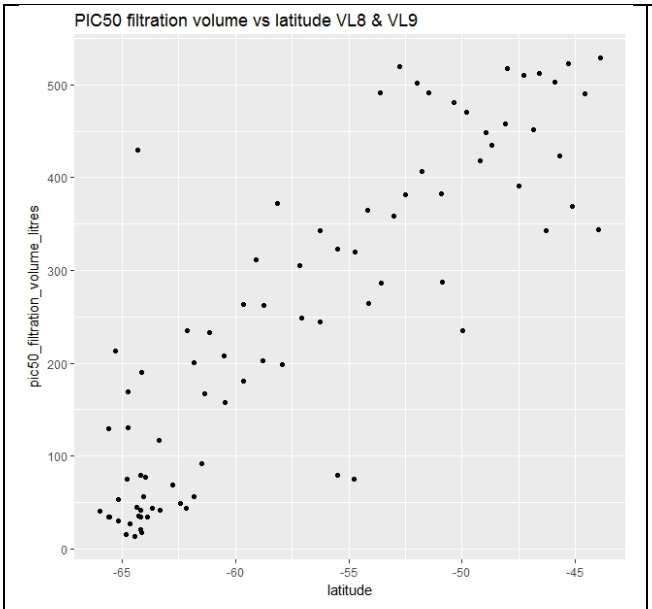
1. We were aware of the potential problem of clogging and designed our filtration processes to minimize it. We do not consider that clogging was a problem.
2. If clogging retained PIC on the 50 um filter, than our PIC01 estimates would too low and our PIC50 estimates would be too high. Because the fraction of total PIC on the PIC50 mesh was generally quite small (10% or less), this possible redistribution does not affect any of our conclusions.

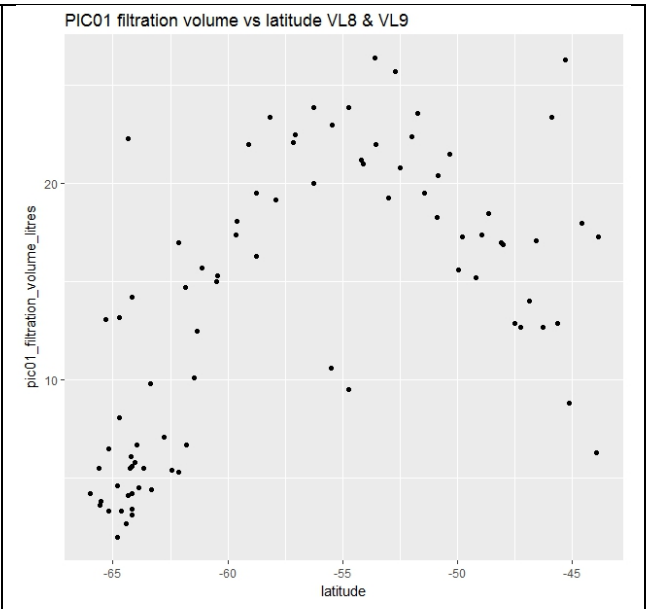
In detail:

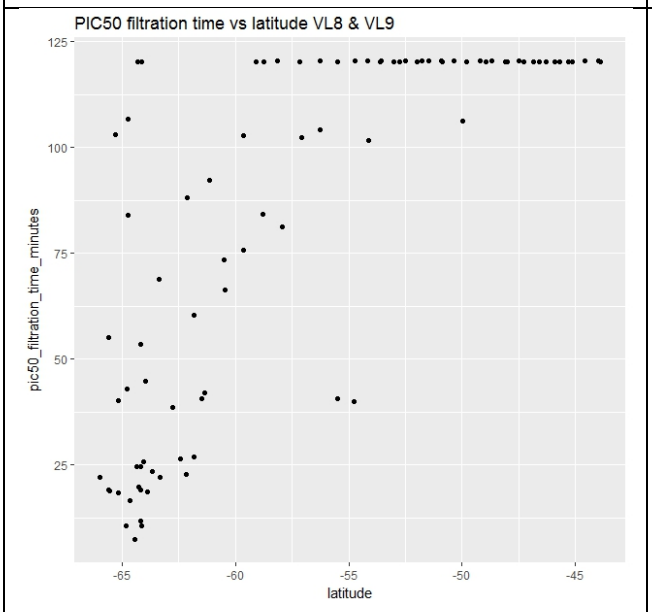
It is challenging to create a filtration system capable of filtering water across the diverse conditions of the entire Southern Ocean. Our filtration system evolved over time, partly to deal with the issue of filter clogging. The first leg (VL1) was a purely sequential filtration system where the volume of water filtered was sometimes limited by either filter clogging, so that insufficient material was obtained on the other filter. For this reason prior to VL2 we added a pressure relief valve between the 50um and 1um filters which allowed large volumes of water to pass through the 50um filter and bypass the 1um filter. The second improvement prior to VL6 was the introduction of digital flow meters which recorded instantaneous flow rates. The final improvement prior to VL8 was the introduction of electronically controlled ball valves that stopped filtration when flow rates fell below threshold values (0.5 L min^{-1} high flow PIC50 sample and 0.05 L min^{-1} low flow PIC01 filter). We believe these stop thresholds are very conservative and the filters are not truly clogged at this stage. Using our final configuration of the system, on VL8 & VL9, samples from the lower latitudes (approx. 44 - 50°S) have reasonably high levels of 1-50 µm particles which can reduce flow rates

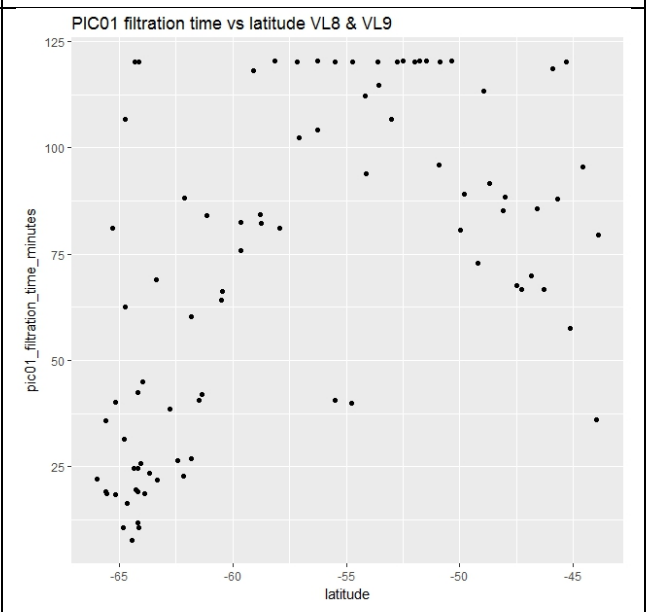
through the 1 µm filter below our cut-off threshold of 0.05 L min^{-1} prior to the 2 hour filtration time limit (Figure S2). However, very large volumes of water pass through the 50 µm filter (Figure S2). In mid latitudes (approx. 50 - 58°S) flow rates remain high through both filters and most samples filter for 2 hours (Figure S2). At high latitudes (approx. 58 - 68°S) flow rates through the 50 µm filter often reduced rapidly to the 0.5 L min^{-1} cut-off threshold because the 50µm filter collects many large chain forming diatoms. In our filtration system this shuts down filtration through both filters which is reflected in the low filtration times and volumes (Figure S2). Ideally we would like to filter larger volumes of water at high latitudes which may require a filtration system capable of switching to a second 50 µm filter or a larger diameter filter. For VL8 & VL9 with their conservative cut-off thresholds we believe that clogging of the 50 μm filter and retention of smaller particles is unlikely. The picture is less clear for earlier legs where instantaneous flow rate data was not available and flow rate cut-off thresholds were not used. However, the data across all voyages shows quite consistent trends in PIC concentration and the PIC50/PIC01 ratio, suggesting negligible compromising of the observations, especially given the seasonal variations in total biomass sampled by the different legs. The filtration times and volumes for all PIC samples are included in Table S1.

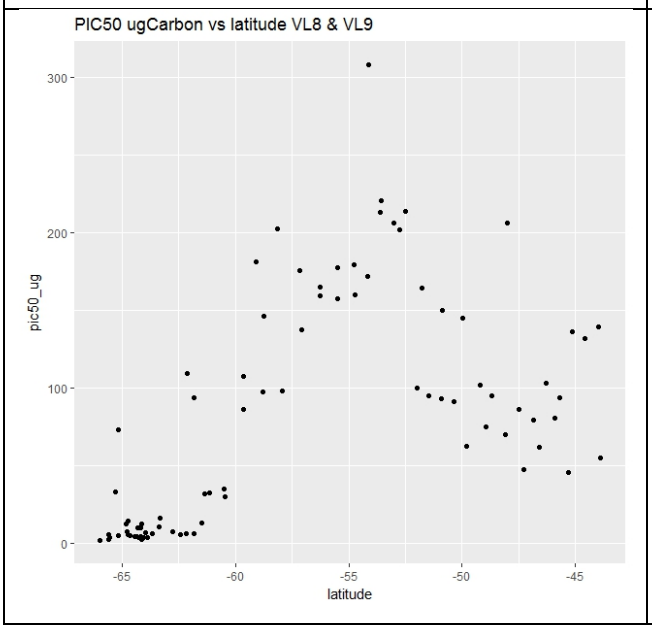

VL1
VL2
VL3
VL4
VL5
VL6
VL7
VL8
VL9
−40
−50
−60
Latitude
120
130
140
Longitude
Satellite Chla µg · L−1
0.0
0.5
1.0
1.5
PIC01 µmoles · L−1
0.0
0.5
1.0
1.5

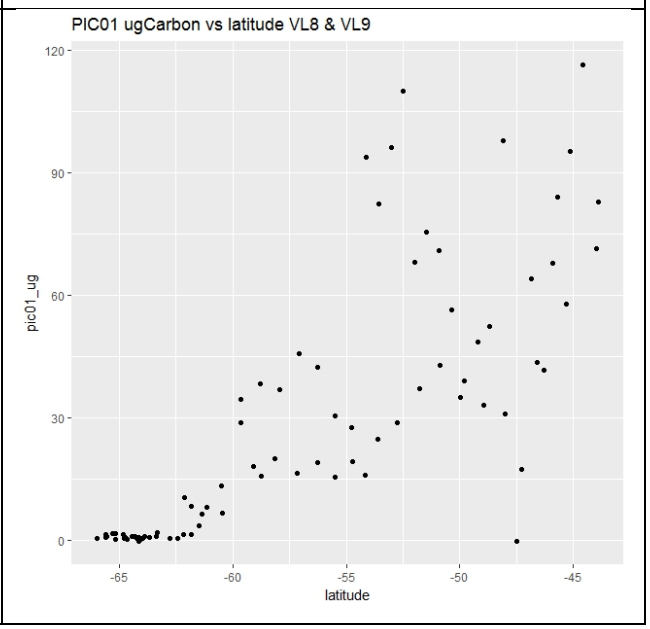

PIC50 filtration volume vs latitude VL8 & VL9
pic50_filtration_volume_litres
latitude


PIC01 filtration volume vs latitude VL8 & VL9
pic01_filtration_volume_litres
latitude


PIC50 filtration time vs latitude VL8 & VL9
pic50_filtration_time_minutes
latitude


PIC01 filtration time vs latitude VL8 & VL9
pic01_filtration_time_minutes
latitude


PIC50 ugCarbon vs latitude VL8 & VL9
pic50_ug
latitude


PIC01 ugCarbon vs latitude VL8 & VL9
pic01_ug
latitude