We thank the reviewer for their valuable feedback. Below you find our detailed response (in blue italic).

General comment

The manuscript presents multi-factorial experiments to examine the potential impacts of ocean warming and Fe availability under future climate change scenarios in two different regions of the Southern Ocean. The manuscript demonstrates that warming does have an impact on phytoplankton growth and community structure, but that under many cases these impacts are less than the effect of Fe under current temperatures. The results raise discussion points for how additional factors, such as Manganese and light, should be studied in combination to provide a better understanding in future studies.

Overall the manuscript is very well put together, with my only main concern being that statistical tests between treatments focused primarily on bulk concentrations and not on the differences in rates (i.e. chlorophyll derived growth rates, nutrient drawdown rates etc).

We looked at the net growth rates in combination to the bulk comparisons we made: i) for phytoplankton group specific net growth rates, please see our response to Reviewer's specific comment on this topic (comment on line 522), (ii) for the other variables (chlorophyll, dissolved and particulate metal concentrations) we had limited time points, preventing proper rate calculations, and (iii) statistical analysis based on nutrient drawdown rates rather than final concentrations gave the same results (with the exception that temperature was on the brink of being a significant factor affecting Si in bioassay A2, while it was a significant factor based on bulk concentrations, i.e., p= 0.08 for rates vs 0.02 for bulk concentrations). We thus did not add the nutrient drawdown rates to the manuscript, but will add total nutrient drawdowns to the Supplements.

This study was also quite unique in that it reports not only changes in dissolved trace metal concentrations in the treatments but also changes in particulate trace metal concentrations. However, I could not find any reporting on contributions of lithogenic fractions from the initial starting water which may impact some of the particulate results.

The initial lithogenic fraction of particulate trace metals was higher in Amundsen Sea compared to the Weddell Sea (e.g., ca. 80 – 90 % vs ca. 30% for pFe). Please note that the lithogenic concentration did not change during the experiments, i.e. background concentration remains the same, and as such does not affect comparison between the treatments. Please also see our replies to later comment (on line 434) regarding this topic.

There are some more general comments about areas that require some greater clarity or further expansion in the PDF.

Specific comments:

-line 47. I would raise the idea that you should be comparing statistically the growth rates between treatments, rather than just the bulk concentrations. I think this could definitely strengthen your conclusions and overcome any different initial starting points in bulk concentrations that may be impacting the results.

See our first reply on the same topic.

-line 70. Sallee et al. 2021 report trends of increasing stratification at depth. Would this not impact supply of Fe from below the Ferricline?

We agree that an increasing stratification at depth could also impact the supply of Fe from below the Ferricline, adding uncertainty to predictions of future iron concentrations that are nevertheless expected to increase. We will change lines 65 onwards (changes from original manuscript are underlined for clarity): "Trace metal supply in the Southern Ocean follows a strong seasonal cycle where in winter Fe is replenished via deep water-mixing (Tagliabue et al., 2014) or sediment resuspension in coastal areas (Boyd et al., 2012), to be quickly depleted again by phytoplankton uptake in the next season. Predicted increases in stratification may weaken dFe supply to surface waters from below (Sallée et al. 2011), however, this is still uncertain as increased stratification might not have a strong effect or might even increase turbulent nutrient fluxes associated with breaking

internal waves (van Haren et al., 2020). Additionally, increased stratification effects may be counteracted by a deepening of mixed layer depths (Sallée et al., 2021) and changes in gyre-scale circulations (Misumi et al., 2013). In general, Fe limitation for Antarctic phytoplankton is predicted to be at least partially relieved in the future (Bazzani et al., 2023) …"

-line 73. There are also expected changes in atmospheric supply from areas such as Patagonian dust (Li et al., 2008; Portner et al., 2022).
Note that future climate conditions could decrease dissolution rates (Demasy et al., 2024, Frontiers in Marine Science).
While the supply of iron from Patagonian dust to the Southern Ocean is predicted to increase, this may not necessarily enhance dFe concentrations in our study regions. This is because future climate conditions are expected to decrease the dissolution rates of particulate iron (pFe), potentially counteracting the increased dust input (Demasy et al., 2024). It is important to note that both the changes in dust supply and dissolution rates are uncertain, and the overall impact on dFe concentrations in the Southern Ocean remains unclear. Since the input of dFe from Patagonian dust is very uncertain, and dFe concentrations added via dust would be comparably small (Lancelot et al., 2009, Biogeosciences, Vol 6 (12)), we decided to not include this into the Introduction.

It may also be worth mentioning what impact you expect temperature may have on bacteria, i.e., siderophore production?
Temperature does not seem to have a direct effect on siderophore production in the Southern Ocean (Sinha et al., 2019). At the same time, ocean acidification may lead to pH levels where siderophore production is lowered, already at a pH of 7.5, siderophore production was lower compared to production levels at a pH of 8.5 (Sinha et al. 2019). This may be (partly) countered by enhanced siderophore concentrations due to increased growth rates of the siderophore-producing bacteria with warming (Sinha et al. 2019). We suggest addingthe following to the Discussion (section 4.3): "Furthermore, the availability of dFe is likely changing due changes in sources (see introduction) but is also influenced by siderophore production (reviewed by Gledhill & Buck 2012, Frontiers in Microbiology, Vol 3) but warming of the Southern Ocean does not seem to have a direct effect (Sinha et al., 2019, Journal of Basic Microbiology, Vol 59 (4)). Warming likely increases the growth rates of siderophore producing bacteria (Sinha et. al. 2019), but this may be countered by reduced siderophore production due to ocean acidification (Sinha et al. 2019)."

-line 16. Were large grazers removed before filling the containers? If not, what would you expect their impact to be on the results.
Water was not filtered before filling the cubitainers (to avoid contamination risk), thus large grazers were not removed. We will add the following to the Discussion section 4.4: "Since the seawater was not filtered before distribution to the cubitainers to reduce contamination risk, there is a chance (although small, Voronina et al., 1994, Polar Biology, Vol 14) that large grazers were introduced to the incubations. We did not specifically sample for large grazers but did not notice any on the filters for Chl a and POC. Large grazers can be expected to graze on larger phytoplankton (Hansen et al. 1994, Limnology and oceanography, Vol 39 (2)), thereby reducing phytoplankton net growth. This would be most noticeable for the F and TF treatments, given the positive response of larger phytoplankton to Fe addition. Our results would then be underestimating the effect of Fe enrichment. Moreover, grazing would likely enhance with temperature (e.g. Lewandowska and Sommer, 2010, Marine Ecology Progress Series, Vol 405; Karakuş et al., 2022, Journal of Geophysical Research: Biogeosciences, Vol 127 (10)), further reducing (and underestimating) net growth rates of larger phytoplankton specifically in the TF treatment. "
Moreover, if the (typically low abundance) large grazers were present it likely would have resulted in large variation between the replicates.

-line 182. I think you should add a statement here that these were in custom built deck incubators as I didn't first understand this. Then the reader can go to the SI for all the extra details

Thank you for pointing this out. We will add the following as a first sentence to section 2.2 Bioassay setup: "Incubations were performed in custom built deck incubators (see Supplement Bioassay Setup for more information)."

-line 298. Is there any way to ascertain sigmaPSII from this method? As this information could help to provide more insight into the interacting effects of Fe and light from your experiments. If it is not a standard output then do not worry.
Unfortunately, it is not possible to ascertain sigmaPSII from the instrument we used here.

-line 301. Schuback et al. 2021 recommend low light adaptation to remove any impacts of quenching. Did you subsample for photopshysiology at night or during the day?
If you subsampled during the day, what impact may you think this dark adaptation would have on the final Fv/Fm values you recorded?
Thank you for the reference. The incubations were usually sampled during the day, but we also had light during the night, which could potentially have led to slight underestimation of Fv/Fm, more so for the Weddel Sea as light intensities for Amundsen Sea Bioassays were already low. However, earlier tests with different phytoplankton including polar phytoplankton did not show an effect of different dark-adaptation times (mentioned in original manuscript, line 303).

-line 303. What impact do you think this UP water could have on the cells? Are there any risks of cell rupture due to contact with low saline UP water? Would rinsing the cuvette with the actual incubation water have not reduced this risk?
UP water was removed from the cuvette by shaking and placing the cuvette upside down on lint-free paper towels to remove last droplets. Technical replicates were measured for each sample, and the cuvette was not rinsed between technical replicates. We tested in response to your comment for potential effects of remaining UP water droplets and found no significant difference in F_v/F_m values between technical replicates (non-parametric Kruskal-Wallis ANOVA, p = 0.95). We will add this to the Material and Methods section: "The cuvette was rinsed with ultra-pure (UP) water between samples, which was removed by shaking the cuvette and placing it upside down on lint-free paper towels to remove any remaining droplets (testing technical replicates did not show a significant effect of UP rinsing, non-parametric Kruskal-Wallis ANOVA, p = 0.95)."

-line 304. What was the % range of your blanks relative to Fm?
We used 0.2 µm filtered seawater sample for blanking (Cullen and Davis 2003, L&O Bulletin, Vol 12 (2)). The % range for the Weddel Sea bioassays was on average 13%, while for the Amundsen Sea bioassays it 46%. The highest % were measured in bioassay A2 where chlorophyll concentrations were lowest, resulting in having to adjust the photo-multiplier to higher settings with higher blanks. Overall, the Fv/Fm values did not differ majorly when blanks were higher compared to lower.

-line 410. Did W1 have a larger initial diatom abundance compared to the other experiments?
Yes, W1 did indeed have a larger initial diatom abundance compared to the other Bioassays, see line 497 in the original manuscript.

-line 434. This is thus assuming that all of the particulates is biogenic in nature. Did you calculate the contribution of lithogenic particles in your incubation water?
It is also important to consider how much of this is also authigenic as well.
We will add the following text to the Material and Methods section 2.5, following line 262: "The lithogenic fraction and concentration of pFe and other particulate metals discussed was determined by assessing the ratio between the particulate metal of interest and particulate aluminium (pAl), assuming all pAl originates from crustal material using the approach described in more detail in van Manen et al (2022). For example, we are using the observed pFe/pAl ratio in the samples and the

known crustal ratio of 0.21 mol mol^{-1} (Taylor and McLennan, 1985, The continental crust) to calculate the lithogenic pFe fraction and concentration, see supplemental data (Table S10) for more details." And: "The EDTA oxalic acid wash used on particulate samples prior to filtration should effectively remove surface-bound metals, also minimizing the authigenic Fe fraction" following line 246.

In the Results (following line 435), we will add that lithogenic particles provided a consistent background that did not affect observed changes between the treatments, and we will add the respective data to the Supplements.

-line 476. Did you attempt to calculate any Chl-a or POC derived growth rates from the experiments? Significant differences between treatments may become clearer, especially when you log transform the rates. Just a suggestion to help tease apart whether some of the small not significant changes you see here may actually be significant between treatments.
Because we only have sampled at the start and the end of the bioassays for both Chl a and POC, calculating derived growth rates is not appropriate and would not help teasing those effects apart.

-line 522. I would also add the same suggestion here to calculate the growth rates of abundances for your different groups and log transform for statistical comparison.
The net growth rates for the different phytoplankton populations showed largely comparable results (based on statistics) as the comparisons based on abundances on the last day of the incubations. Still, we agree that addition of these net growth rates is helpful, and we will add them to the Results section (changes from original manuscript are underlined for clarity):

Line 526 - 552 of the original manuscript will be changed to: "Phyto 19 increased in abundance and share (Fig. 6a) specifically in the temperature treatments, with net growth rates of 0.40 ± 0.08 d^{-1} and 0.52 ± 0.005 d^{-1} for the T and TF treatments (compared to 0.35 ± 0.11 d-1 and 0.30 ± 0.09 d-1 for C and F treatments, p < 0.04) and final abundances of 2,800 and 3.500 cells mL^{-1} for T and TF (compared to 1,700 and 1.300 mL^{-1} for C and F, p < 0.01). Phyto 3 also showed higher abundance-derived net growth rates with warming (0.33 ± 0.13 and 0.32 ± 0.002 vs 0.26 ± 0.06 d^{-1} for the T, TF and C treatment, respectively), but with abundances being only significantly higher for the TF treatment (776 ± 37 vs 542 ± 107 cells mL^{-1} for TF and C treatments). Phyto 24 was positively impacted by Fe addition, particularly the TF treatment resulted in higher net growth rates and final abundances (i.e., 0.32 ± 0.09 vs 0.15 ± 0.06 d^{-1}, and 595 ± 62 vs 361 ± 9 cells mL^{-1} for TF compared to the C treatment; p < 0.05). When converted to cellular carbon based on cell volume using 237 and 196.5 fg C µm^{-3} as conversion factors for Pico- and Nanophytoplankton, respectively (Fig. 6e), the strong positive response of the phytoplankton to the TF treatment was mostly due to this larger-sized Phyto 24 (average diameter of 19 µm, p = 0.01, stat: 0.92) and to smaller extent Phyto 19 (p < 0.01). Bioassay A2 presented the highest share of picoeukaryotes, especially Phyto 3 (59 % compared to max. 18 % in the other bioassays, Fig. 6b). Only few treatment-specific responses were recorded. Phyto 19 increased somewhat with warming (p = 0.04), and Phyto groups 16 and 17 showed increased net growth rates with dFe addition (0.31 ± 0.22 and 0.23 ± 0.06 vs 0.09 ± 0.16 and 0.31 ± 0.06, 0.30 ± 0.06 and 0.23 ± 0.06 for the F, TF and C treatments of Phyto 16 and 17, respectively, p < 0.02 for both). The phytoplankton populations in W1 were distributed more equally (Fig. 6c), with higher abundances of especially Phyto 16 and 17 for the Fe addition treatments (p < 0.05, most pronounced for TF with average abundances of 3,103 ± 1,290 vs 948 ± 218 cells mL^{-1} and 2,041 ±572 vs 1,158 ± 216 cells mL^{-1} for Phyto 16 and 17 in the TF vs C treatments, respectively). Their specific net growth rates were up to 2.2-fold higher for the Fe addition treatments than the control (0.29 ± 0.02, 0.38 ± 0.10 and 0.20 ± 0.02, and 0.16 ± 0.02, 0.21 ± 0.06 and 0.09 ± 0.02 d^{-1} for the F, TF and C treatment of Phyto 16 and 17). When expressed in carbon, Phyto 16 was still a recognisable indicator species (p = 0.03) but at the same time the larger-sized Phyto 21 (average cell diameter of 10 um) and diatoms Phyto 22-24 (13-19 µm) showed clear positive responses to Fe addition (Fig. 6g, p < 0.05 for all). Net growth rates were largely comparable for these phytoplankton groups: 0.23 ± 0.02, 0.19 ± 0.01, 0.17 ± 0.04, 0.20 ± 0.05d^{-1} for Phyto 21-24 in the F treatment (and similar net growth rates in the

TF treatment) compared to 0.09 ± 0.07, 0.14 ± 0.03, 0.04 ± 0.04, 0.12 ± 0.02 in the C treatment, respectively (p < 0.03). Bioassay W2 also showed a distinct shift in favour of Phyto 16 and Phyto 17 (away from Phyto 13) with Fe addition, already early in time (Table S8), both for abundances and cellular carbon (Fig. 16d, h, p < 0.01 for all). The F treatment net growth rates of Phyto 16, 17 and Phyto 13 were 0.42 ± 0.02, 0.34 ± 0.03 and 0.21 ± 0.09 d^{-1} (again with similar growth in the TF treatments) compared to 0.20 ± 0.03, 0.17 ± 0.04 and 0.37 ± 0.02 d^{-1} in the C treatment (p < 0.03). Diatoms 23 and 24 also responded positively to Fe addition with ~2-fold higher net growth rates than the control (Fig. 16h, p < 0.01). Phyto 23 net growth rates were 0.37 ± 0.06 and 0.39 ± 0.04 d^{-1} for F and TF compared to 0.19 ± 0.06 d^{-1} for the C treatment (p = 0.004), and Phyto 24 net growth rates were 0.38 ± 0.08 and 0.32 ± 0.05 for F and TF treatments vs 0.22 ± 0.09 for the C treatment."

Line 694 to:
"GLM analysis revealed that temperature alone was a significant factor for total phytoplankton abundances, however more specifically, only Phyto 3, Phyto 19 and Phyto 22 abundances displayed significant positive responses to temperature alone (T treatment of Amundsen Sea Bioassays).

And line 714 to:
"Phaeocystis antarctica showed higher net growth rates for Fe-addition treatments in both bioassay W1 and W2, however, the effect was not very apparent and overall, P. antarctica seemed to handle the other treatments consistently well."

Moreover, we will add how the phytoplankton abundance-derived net growth rates were calculated in the Material and Methods section: "Phytoplankton net growth rates were calculated using exponential trendlines. For total abundances, the full incubation period was taken into account (i.e., day 1 - 6 for Amundsen Sea and day 2 - 8 for Weddell Sea bioassays). Starting abundances were taken prior to filling of the cubitainers and hence not taken into account. For the phytoplankton group specific rates only those time points (>3 but most often 4-5 time points) with a consecutive increase in abundances were selected."

-line 623. There may be higher Mn requirements for reactive oxygen species, but there is also a Mn requirement for photosynthesis. So if you provide more Fe, and phytoplankton can build more reaction centers then their Mn requirement will also increase. See Raven 1990.
Please see response to the next comment.

-line 628. The work of Hawco expands on this idea, that if you just relieve Fe limitation then you likely force phytoplankton into Fe limitation due to the requirements of both TMs in photosynthesis.
So indeed your higher dMn at A1 meant that the phytoplankton community here was not forced into Mn limitation.
I think you need to be more explicit here about the Fe and Mn requirements of photosynthesis and how your initial Mn concentrations impacted your results.
We thank the Reviewer for pointing out that the Fe and Mn requirements of photosynthesis is not explicit yet. We will add to section 4.2 lines 628 onwards: "This duality in the pMn:POP ratios is not surprising as Mn demand may not only increase under Fe stress, but it should also increase with Fe addition, as both Mn and Fe are required for photosynthesis (Raven 1990, New Phytologist, Vol 116, McCain 2021, Hawco et al. 2022). Hence, in an environment with low Mn concentrations, Fe addition can consequently lead to Mn limitation (e.g., Hawco et al., 2022). Dissolved Mn concentrations at the start of bioassay A1 were relatively high, and indeed pMn:POP ratios increased with Fe addition, while concentrations of dMn decreased during the experiment. However, the low (potentially phytoplankton growth limiting) dMn concentrations in Weddell Sea bioassays from the start might have prevented a noticeable positive effect of Fe addition on dMn uptake. The higher biomass and cell abundance after Fe addition in these experiments implies the community had to make due with less Mn per cell than in the treatments without Fe addition (likely resulting in relatively low Mn quota despite elevated demand), potentially explaining why there was an increase in the pMn:POP ratios in

the C and T treatments of W2, whereas this was not observed in W1 with even lower dMn starting concentrations. Such variation in apparent Mn demand and quotas likely reflects adaptive changes in nutrient uptake and storage mechanisms under nutrient stress but could also be due to different phytoplankton community compositions and/or environmental conditions."

-line 648. I would be hesitant to call them non-essential metals. Zinc plays an important role in both intracellular CO2 transport and phosphate cycling, where copper and cadmium can be substituted in its place occasionally. Our growing understanding of these metals in other metabolic processes, outside of photosynthesis, means that whilst they may not be at limiting concentrations in the Southern Ocean, they still have a strong role to play in phytoplankton growth.
The Reviewer is correct, we only meant Cd is non-essential, Zn and Cu definitely are. We added now that by essential metals we refer to manganese, zinc and copper, and by non-essential to cadmium.

-line 661. Do you think warming and/or Fe would have impacted the bacterial community which may be contributing to the reported POC concentrations?
We checked bacterial abundances (based on flow cytometry enumeration) and whilst temperature did not affect bacterial abundances significantly, iron led to higher abundances in both Weddell Sea bioassays (4.6 and 5.0 x 10^5 cells mL^{-1} for Fe addition treatments in W1 and W2 compared to 3.3 and 4.1 x 10^5 cells mL^{-1} for non-Fe treatments). However, bacterial carbon made up less than 3% of the reported POC concentrations. We will add the following to the results section, when talking about POC (line 482 onwards): "Only bioassays W1 and W2 showed a significant increase in bacterial abundances with Fe addition (final abundance 4.7 ± 0.9, 4.5 ± 0.5 vs 3.1 ± 1.0 and 4.7 ± 0.6, 5.4 ± 0.2 vs 4.4 ± 0.1 for F, TF vs C treatments in W1 and W2, respectively). However, bacteria did not have a major effect (less than 3%) on total POC concentrations." Furthermore, we will also add to the Materials and Methods: "Samples for bacterial abundances were fixed with EM-grade glutaraldehyde (0.5% final concentration; Sigma- Aldrich, Zwijndrecht, The Netherlands), flash-frozen in liquid nitrogen and stored at -80°C until analysis using flow cytometry (Marie et al.; 1999). Bacterial carbon concentrations were calculated assuming 12.4 fg C $cell^{-1}$ (Fukuda et al.; 1998, Applied and environmental microbiology, Vol 64 (9))."

-line 669. I wonder whether you could use the different light conditions to make any inferences about how climate change is expected to alter light availability. Whilst I know it was not one of your specific treatments, the different conditions between your study areas may provide some insight.
For instance, there is conflicting evidence of both shallower and deeper mixed layers which could alter light availability in the future. Coupled with the idea of the Southern Ocean being more cloudy.
We will add the following to the discussion, following line 674:
"Future light conditions in the Southern Ocean will vary for the different regions, e.g. lower sea ice coverage may enhance light availability (Leung et al., 2015, Biogeosciences, Vol 12 (19); Petrou et al., 2016, Journal of Plant Physiology, Vol 203; Krumhardt et al., 2022), whereas increased cloud coverage in the Antarctic Circumpolar Current region would reduce it (Grise et al., 2013 Geophysical Research Letters, Vol 40; Kelleher and Grise, 2021, Atmospheric Science Letters, Vol 23 (1); Krumhardt et al., 2022). Moreover, there are conflicting reports about whether mixed layer depths will increase (Leung et al., 2015) or decrease (Krumhardt et al., 2022), which directly impacts light conditions for the phytoplankton. Our results from the low light bioassay A2, showing only a small effect of Fe on phytoplankton, suggest that in regions or periods with low light, Fe increase will not drastically stimulate phytoplankton growth. This highlights the importance of including light availability in Southern Ocean ecosystem (modelling) predictions."

-line 754. Where your two study sites in similar bloom phases to make them comparable? If not, what impact do you think it has on the results?
The bioassays in the Amundsen Sea were initiated in late February, which is towards the end of the reported bloom period (Arrigo et al., 2012, Deep Sea Research Part II: Topical Studies in Oceanography, Vol 71). The Weddell Sea bioassays were initiated in late December/early January,

which is during the start of the bloom (von Berg et al., 2020, Geophysical Research Letters, Vol 47 (11)). The bloom phases were thus not comparable. We will add this information to the Material and Methods section. The differences we found between the two regions seem, however, more driven by differences in light availability, trace metal co-limitation and starting phytoplankton community. We will address this point briefly in the Discussion (line 658 onwards): "The Weddell Sea bioassays exhibited stronger Chl a accumulation, a stronger increase in F_v/F_m and increased phytoplankton abundances in response to Fe addition than the Amundsen Sea bioassays, which is likely due to the lower dFe concentrations (and hence higher degree of Fe limitation for the phytoplankton typical for the Weddell Sea) at the start of the incubations. Indeed, given that the Weddell Sea bioassays were performed early in the productive season, these results imply more severe Fe limitation in the Weddell Sea whereas any Fe limitation in the Amundsen Sea likely only develops later in the season."

-line 760. I think this may warrant some further expansion as to where and when Fe input may increase. Maybe you also need to discuss here what would be the case if Fe inputs do not increase under future climate change scenarios. Would rising temperatures alone lead to significant ecological shifts?

Regarding differences in dFe input: In the Amundsen Sea, increased Fe input is likely to occur due to enhanced glacial melt and runoff, particularly during the summer months when melting is most pronounced (Van Manen et al., 2022). Increases in seawater temperature may affect the availability of dFe for phytoplankton, since temperature affects the oxidation of the bioavailable Fe(II) to Fe(III) (e.g. Millero et al., 1987, Geochimica et Cosmochimica Acta, Vol 51 (4)), however, Aflenzer et al. (2023) did not observe a lower bioavailability of added dFe with increased temperatures. In the Weddell Sea, Fe input may increase through upwelling of Fe-rich deep waters and meltwater from ice shelves, but this is less certain (Klunder et al., 2011, Deep Sea Research Part II: Topical Studies in Oceanography, 58 (25-26)). Seasonal variations in sea ice cover and glacial melt will play a significant role in determining the timing and magnitude of Fe input in these regions.

We will add this to the Introduction (line 73 original manuscript)

Regarding the effect of only temperature: Temperature alone showed a limited effect on phytoplankton, with only 3 phytoplankton groups (Phyto 3, Phyto 19 and diatom Phyto 22) increasing in abundances, and only Phyto 19 showing a consistent effect. Still, these groups represent pico-sized as well as larger phytoplankton (2, 8.1 and 13.3 µm diameter). Earlier studies also showed temperature to have only a limited effect on (natural) phytoplankton communities (Rose et al., 2009). Indirect effects of warming (e.g. locally high ice-melt induced freshening, dFe increase) will likely have larger impact on phytoplankton community compositions. Ice-melt induced freshening already led to a shift from diatom to cryptophyte and flagellate dominated communities in the Western Antarctic Peninsula region (reviewed by Deppeler and Davidson 2017), and increased dFe concentrations will affect phytoplankton community composition even more so when combined with temperature increases (this study; Rose et al. 2009). Furthermore, the availability of dFe is likely changing due changes in sources (see introduction) but is also influenced by siderophore production (reviewed by Gledhill et al., 2012) but warming of the Southern Ocean does not seem to have a direct effect (Sinha et al., 2019). Warming likely increases the growth rates of siderophore producing bacteria (Sinha et. al. 2019), but this may be countered by reduced siderophore production due to ocean acidification (Sinha et al. 2019). Overall, predictions about future conditions and their consequences are complex and have large uncertainty, but it seems likely conditions will be temporally and spatially heterogenous with varying changes in temperature and availability of Fe (and light). For example, while the warming of surface water in the Amundsen Sea has already been observed, Weddell Sea surface temperatures for the deep basin seem relatively stable at the moment with significant warming only below 700 m (Strass et al., 2020 Journal of Climate, Vol 33(22)). However, upwelling of this warm water leads to local temperature increases in notably coastal regions (Darelius et al., 2023), potentially increasing future temperatures by over 2 °C warmer in troughs that connect the open

ocean to ice shelfs (Teske et al., 2024), increasing not only temperatures but likely also glacial melt derived Fe supply. This makes it prudent to assess not only individual, but also combined effects of increasing Fe and temperature as discussed in the next section.

We will add these arguments to the Discussion (section 4.3).