Auxiliary materials for "Estimating the benthic efflux of dissolved iron on the Ross Sea continental shelf"

Text S2: Sensitivity analysis of the flux calculations

Flux of dissolved iron (dFe) from the benthos at each station was calculated by fitting dFe concentration data between 200 m depth and the deepest sample depth to equation (2) from the manuscript, and using this to extrapolate both dFe concentration and the gradient of dFe concentration to the seafloor. The gradient of dFe concentration was then combined with model-derived k_z values for the upper surface of the bottom vertical layer to calculate flux from the benthos. Here we discuss how changing each of these parameterizations affects our results. The results are summarized in Table S3, below.

1) Use of the dFe concentration profile:

Gradients of dFe concentration at the seafloor were calculated by first fitting dFe measurements between 200 m depth and the deepest sample to equation (2), thus avoiding any influence on the concentration profile by biological uptake of dFe in the upper ocean. It is possible that this depth range could be extended up to 100 m depth as the dFe concentration gradient in the 100–200 m depth interval was generally small. Doing so has a minimal effect on the results of fitting equation (2) and on the resulting values from equation (3), changing the range of $\partial[\mathrm{dFe}]/\partial z$ values from (7–732) × 10^{-4} μmol m^{-4} to (7–739) × 10^{-4} μmol m^{-4}, with the median value changing from 83 × 10^{-4} μmol m^{-4} to 81 × 10^{-4} μmol m^{-4}. In turn, this changes the geometric mean flux by only 2.8%, from 0.36 μmol m^{-2} d^{-1} to 0.37 μmol m^{-2} d^{-1}.

As stated in the manuscript, the equation fitted to measured dFe concentrations to extrapolate the profile to the seafloor (i.e. equation (2)) has no physical basis. An alternative approach would be a simple straight-line fit to the two deepest dFe measurements and using the gradient of this line as ∂[dFe]/∂z at the seafloor. Using this approach generally gives a lower seafloor estimate of ∂[dFe]/∂z, resulting in a range of flux estimates of 2.1×10^{-3} µmol m^{-2} d^{-1} to 3.33 µmol m^{-2} d^{-1}, with a 58% decrease in the geometric mean flux to 0.15 µmol m^{-2} d^{-1}. However, the accuracy of this alternate approach suffers in that both the height above the seafloor of the deepest sample, and the depth interval between the two deepest samples, varied by station. Given that the profiles of measured dFe concentration do exhibit a change in gradient with depth, the straight line fit will thus estimate the concentration gradient at different points of the dFe profile for different stations. For this reason, we favored the approach outlined in the manuscript.

2) Temporal variability in k_z:

Model-derived, station-specific k_z values used for the flux calculations were summertime averages, using model data for the 90-day period 29 November 2011 to 26 February 2012. The model provides daily averages of k_z, which over the 90-day time period show significant temporal variability at some stations, with relative standard deviations ranging from 46–287% (see Figure S2, below). Thus, using the average summertime k_z value is considered to be a better estimate to use in flux calculations than the k_z values corresponding to each station on the day of sampling.

An alternative approach would be to apply a regional average k_z value to our ∂[dFe]/∂z data. Using all daily k_z values during the 90-day period for the 37 stations of >400 m water depth gives a median regional k_z value of 2.0×10^{-4} m^2 s^{-1}. Applying this to the calculated ∂[dFe]/∂z values gives a geometric mean flux from areas of the shelf >400 m deep of 0.12 μmol m^{-2} d^{-1}, or ~35% of the value based on station-specific k_z values. We consider the use of station-specific k_z values to be the more appropriate method of calculating shelf-wide fluxes as, despite the large temporal variability in k_z at some stations, there is still regional variability evident, which is a function of differences in the modeled bottom circulation at various locations, including significant variability in the tidal circulation across the Ross Sea continental shelf (e.g. Figure 2b in *Padman et al.* [2003]).

3) Depth variability of k_z:

The model-derived values of k_z used in estimating fluxes pertain to the top surface of the bottom-most vertical layer of the physical circulation model. As such, the values generated by the model relate to heights of 3.8–10.7 m above the seafloor, depending on the station water depth. As the study aims to estimate dFe flux from the near bottom layer, the variability of k_z with depth needs to be considered.

The model is able to calculate k_z values for each of the 24 vertical layers, giving a vertical profile of k_z values at each station. Profile shapes vary by station, but all show an increase in k_z with depth between the deepest two model layers. By carrying out a straight line fit to the two deepest k_z values at each station and extrapolating it to the seafloor, rough estimates of seafloor k_z have been calculated for each station. As expected, these values are slightly higher than those given in the main text, with a range from 1.3×10^{-4} m^2 s^{-1} to 78.5 m^2 s^{-1}, and a median of 10.8 m^2 s^{-1}. As a result, the geometric mean flux for the Ross Sea shelf area (>400 m water depth) calculated using this method is 47% higher at 0.52 μmol m^{-2} d^{-1}.

Table S3: Summary of sensitivity analysis of dFe flux from the seafloor.

	Geometric mean flux for Ross Sea shelf stations >400m deep (µmol m^{-2} d^{-1}).
Station-specific, 90-day averaged k_z at top of deepest model layer; ∂[dFe]/∂z at seafloor. **(used in manuscript)**	0.36
As above, but ∂[dFe]/∂z from a fit to dFe measurements from 100 m to seafloor.	0.37
As above, but ∂[dFe]/∂z from a straight line fit to two deepest dFe measurements.	0.15
Shelf-averaged k_z at top of deepest model layer; ∂[dFe]/∂z at seafloor	0.12
Station-specific k_z values extrapolated to seafloor; ∂[dFe]/∂z at seafloor.	0.52

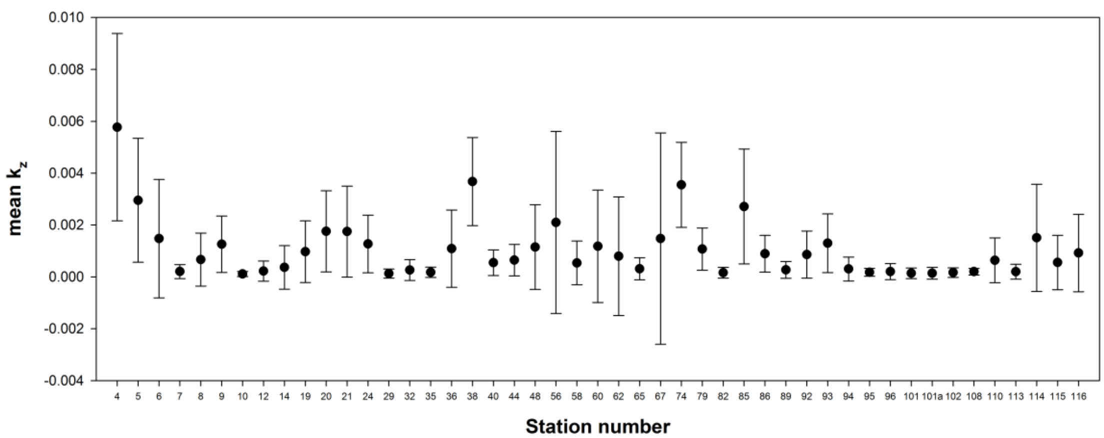

Figure S2: Temporal and spatial variability of k_z values. Data shown are model-derived station-specific mean (± one standard deviation) k_z values for the 90-day period 29 November 2011 to 26 February 2012 for the upper surface of the bottom vertical layer of the model.

References

Padman, L., S. Erofeeva, and I. Joughin (2003), Tides of the Ross Sea and Ross Ice Shelf cavity, *Antarct. Sci.*, *15*(1), 31-40, doi:10.1017/S0954102003001032.